



**Domestic Water System
Source of Supply/Treatment Study
Report**

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Prepared by:

Hazen

Hazen and Sawyer
In partnership with Ed Means Consulting, LLC and Michael J. McGuire Inc.



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Acronyms

ABBREVIATION	DEFINITION
AACE	American Association of Cost Engineering
AFY	Acre-Feet per Year
Alum	Aluminum Sulfate
ANSI	American National Standards Institute
AOP	Advanced Oxidation Process
AWWA	American Water Works Association
BAF	Biological Active Filtration
BAT	Best Available Technology
BVs	Bed Volumes
CARB	California Air Resources Board
CCL3	Third Contaminant Candidate List
CCL4	Fourth Contaminant Candidate List
CCPP	Calcium Carbonate Precipitation Potential
CDP	Criterion Decision Plus
CEQA	California Environmental Quality Act
CIMIS	California Irrigation Management Information System
CIP	Clean-in-place
CMAR	Construction Manager at Risk
CO ₂	Carbon Dioxide
Cr ₆	Hexavalent Chromium, also known as chromium 6
CRRF	Central Resin Regeneration Facility
CT	Contact Time
CVCC	Coachella Valley Conservation Commission
CVMSHCP	Coachella Valley Multi Species Habitat Conservation
CVWD	Coachella Valley Water District
CWA	Coachella Water Authority
DAF	Dissolved Air Flotation
DBCP	Dibromochloropropane
DBP	Disinfection Byproduct
DCPA	Dimethyl Tetrachloroterephthalate
DDW	Division of Drinking Water
DOC	Dissolved Organic Carbon
EBCT	Empty Bed Contact Time
ED	Electrodialysis
EDR	Electrodialysis Reversal
FBR	Fluidized Bed Reactor



FPA	Flavor Profile Analysis
FTE	Full Time Equivalent
FXB	Fixed or packed Bed Reactor
GAC	Granular Activated Carbon
GAMA	Geotracker Groundwater Ambient Monitoring and Assessment
gpm	Gallons per minute
GRF	Groundwater Replenishment Facility
HAA	Haloacetic acids
HAL	Health Advisory Level
HPC	Heterotrophic Plate Count
HRL	Health Reference Level
ID-1	Improvement District-1
IWA	Indio Water Authority
IXTP	Ion Exchange Treatment Plant
LRAA	Locational Running Annual Average
MCL	Maximum Contaminant Level
MGD	Million gallons per day
MHI	Median Household Income
MIB	1-Methylisoborneol
MVP	Mid-Valley Pipeline
MWD	Metropolitan Water District of Southern California
MDWC	Myoma Dunes Mutual Water Company
NaOH	Sodium Hydroxide
NDEA	n-Nitrosodiethylamine
NDMA	n-Nitrosodimethylamine
NDPA	n-Nitrosodipropylamine
NEPA	National Environmental Policy Act
NL	Notification Level
NOM	Natural Organic Matter
NPV	Net Present Value
NPW	Non-Potable Water
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OSG	On-Site Generation
PACl	Polyaluminum Chloride
PCE	Perchloroethylene, also known as tetrachloroethylene
PDD	Peak Daily Demand
PHG	Public Health Goal
POE	Point-of-Entry



POU	Point-of-use
ppb	Parts per billion
RCF	Reduction Coagulation Filtration
RCMF	Reduction Coagulation Microfiltration
RCRA	Resource Conservation and Recovery Act
Regen	Regeneration
RO	Reverse Osmosis
RTCR	Revised Total Coliform Rule
RTW	Rothberg, Tamburini and Winsor
SBA	Strong Base Anion Exchange
SCADA	Supervisory Control and Data Acquisition
SCAQMD	South Coast Air Quality Management District
SDWA	Safe Drinking Water Act
SMI	Sulfur Modified Iron
SPEIR	Subsequent Program Environment Impact Report
STLC	Soluble Threshold Limit Concentration
Study	Source of Supply/Treatment Study
SWP	State Water Project
SWRCB	California State Water Resources Control Board
TCLP	Toxicity Characteristic Leaching Procedure
TCP	Trichloropropane
TDS	Total Dissolved Solids
TEL	Thomas E. Levy
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
THM	Trihalomethanes
TOC	Total Organic Carbon
TTHM	Total Trihalomethanes
TTLC	Total Threshold Limit Concentration
UCMR3	Unregulated Contaminant Monitoring Rule 3
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
UV	Ultraviolet
VOC	Volatile Organic Compound
WBA	Weak Base Anion Exchange
WDR	Waste Discharge Requirements
WMP	Water Management Plan
WQTS	Water Quality and Treatment Solutions
WRP	Water Reclamation Plant



Executive Summary

Coachella Valley Water District (CVWD) conducted a Source of Supply/Treatment Study (Study) from December 2013 to January 2015 to determine the optimal source of supply and treatment to comply with current, proposed, and reasonably anticipated Federal and State drinking water regulations.

CVWD is currently in compliance with State and Federal drinking water regulations. On July 1, 2014, the California Water Boards Division of Drinking Water (DDW) enacted a new Chromium 6 (Cr6) maximum contaminant level (MCL) of 10 micrograms per liter. CVWD is anticipating that 31 of its 98 active groundwater wells will exceed the Cr6 MCL. Other constituents that occur naturally in Coachella Valley groundwater, including arsenic, fluoride, uranium, and salinity, have presented challenges when providing domestic water that meets California's stringent drinking water standards and elevated nitrate levels in some local groundwater has resulted in removing some wells from service. In the future, other constituents of concern may exceed current regulatory levels or new/reduced regulatory levels. This Study considered which constituents may be of greatest concern for current and future compliance and options for addressing these constituents.

The most immediate need for the CVWD domestic water supply is to achieve compliance with the new Cr6 regulation. The Study evaluated the options available to CVWD for compliance with this regulation, and with potential future drinking water regulations, including:

1. Non-treatment options
2. Groundwater treatment
3. Colorado River surface water treatment
4. Point-of-use/point-of-entry (POU/POE) treatment

The most immediate need for the CVWD domestic water supply is to achieve compliance with the new Chromium 6 regulation.

Non-Treatment Options

Several non-treatment options were evaluated to determine if they could address constituents of concern and provide adequate domestic water supply, including operating without impacted wells, well modifications to minimize constituents of concern, and drilling replacement wells in a less impacted area.

Operating without the 31 Cr6 impacted wells would cause significant domestic water supply deficiencies in some pressure zones. These deficiencies could not be overcome during peak daily demand periods with storage or transfer from other zones, making this approach infeasible.

Because Cr6 concentrations are uniform with depth in many of the wells, the modification of well screens is also not a feasible compliance strategy for CVWD. Other areas have Cr6 in older deep groundwater and nitrate in the shallow water. Further, production would be limited if wells were modified to draw water that avoided both constituents.



Drilling replacement wells in an area less impacted by Cr6 and turning off impacted wells is feasible from a supply and aquifer impact standpoint. Analysis showed that the area least impacted by current regulatory limits was the Date Palm pressure zone, and that the aquifer could sustain the yield required for the replacement wells. However, this approach was ruled out due to the significant demands that this number of wells would have on groundwater in the area and the large diameter and costly pipelines that would be necessary to accommodate such a large portion of the supply coming from one pressure zone. With pipelines, additional wells, and land acquisition, the cost is estimated at \$286 million.

Treatment Options

Groundwater Treatment

Several options for implementation of groundwater treatment were evaluated, including wellhead treatment at individual locations and clustered treatment by piping wells together to shared treatment facilities. To determine the optimal groundwater treatment approach for CVWD, costs of treatment and non-cost factors were evaluated.

The State of California identifies three Best Available Technologies (BAT) for removing Cr6:

- Ion exchange - strong base anion (SBA) and weak base anion (WBA)
- Reduction followed by coagulation and filtration - reduction/coagulation/filtration (RCF) or reduction/coagulation/microfiltration (RCMF)
- Reverse osmosis (RO)

BAT and other potential treatment options were evaluated but SBA and WBA were selected as the preferred treatment approach based on costs, waste disposal, operations and maintenance complexity, space requirement and compatibility with neighborhoods, water loss, and flexibility of the technology for removing constituents that are currently regulated or on the regulatory horizon.

SBA was identified as offering the most advantages for groundwater Cr6 treatment at most CVWD wells. SBA treatment includes pre-filters, resin vessels, final pH adjustment, and disinfection. The SBA resins used for treatment must be regenerated when they reach a target treated water concentration of Cr6. Evaluation showed resin could be regenerated at a Central Resin Regeneration Facility (CRRF) for cost savings and operational streamlining when compared with a regeneration facility at each site. Resin would be removed from the vessels at a frequency varying from once every few weeks to once every few months (depending on the well site), would be brought to the central facility for regeneration, and would then be loaded back into the resin vessels at the well sites. Regeneration waste can be treated at the CRRF, with non-hazardous liquid waste evaporated in ponds on site or disposed off-site, and hazardous solid waste taken off-site to a licensed disposal facility.

WBA treatment was identified as advantageous at two locations due to higher groundwater sulfate concentrations and the more frequent regeneration that would be necessary if SBA were used at those locations. The WBA process involves pre-filters, carbon dioxide for pH adjustment, resin vessels, aeration for final pH adjustment, and disinfection. WBA resin is not regenerated, but instead is replaced every one



to three years. Extended life exceeding one year has been confirmed in CVWD groundwater pilot testing. Economies of scale were found in clustering wells for these two WBA treatment locations.

Colorado River Surface Water Treatment

As described in the 2010 Water Management Plan (WMP) Update and 2014 WMP Status Report, CVWD plans to use surface water as part of the domestic water portfolio within the next 25 years. This study investigated how surface water treatment could be integrated into the supply to simultaneously achieve goals of Cr6 compliance and supply diversification.

The surface water treatment approach was analyzed based on Colorado River water quality, prior pilot testing results, and treatment experience at other water agencies. Blending of surface water and groundwater, similar to the approach used in the Coachella Valley for the past 40 years at recharge sites, offers advantages in decreasing total dissolved solids (TDS) and Cr6. Several treatment options were feasible, but cost savings could be realized over conventional treatment by using dissolved air flotation and microfiltration. Granular activated carbon (GAC) was recommended to allow continued use of free chlorine secondary disinfection in the CVWD system.

Eight potential surface water treatment locations were evaluated and two sites were included in the final analysis: Mid-Valley and East Valley. The Mid-Valley location would draw from the Mid-Valley Pipeline in Palm Desert and could be beneficial in supplying an area with groundwater overdraft and many wells impacted by Cr6. The East Valley location would be next to the Coachella Canal in La Quinta and could be expanded to supply future growth anticipated in that portion of CVWD's system.

Point-of-Use Treatment

POU devices attached directly to water faucets in customer homes for drinking and cooking are allowed for water systems serving fewer than 200 service connections, systems for which centralized treatment is not feasible within three years, and where centralized treatment costs are higher than certain median household income requirements. The water systems or its contractor must own, control, operate, and maintain the POU devices. While the implementation of POU devices are technically feasible, their use would be challenging due to implementation and maintenance requirements and would require regulatory/legislative change. Potential costs were analyzed to determine if regulatory/legislative change is warranted.

Treatment Option Evaluation

To compare potential treatment approaches, the following six scenarios were developed:

- Scenario 1 – Groundwater treatment at clusters of wells
- Scenario 2 – Groundwater treatment at individual wells
- Scenario 3 – Surface Water Treatment Plant in Mid-Valley with the balance of groundwater treatment at individual wells



- Scenario 4 – Surface Water Treatment Plant in East Valley with the balance of groundwater treatment at individual wells
- Scenario 5 – Point-of-use treatment
- Scenario 6 – Surface Water Treatment Plants in Mid-Valley and East Valley with the balance of groundwater treatment at individual wells

These scenarios were compared based on critical evaluation criteria by the project team in a series of workshops. Sensitivities of weightings for the factors were tested. Evaluation criteria agreed upon included conceptual cost, operational complexity, diversification of CVWD water resources and treatment approaches for domestic supply, public acceptability and environmental acceptability, implementation complexity, operational flexibility, and water quality benefits in addition to Cr6 treatment now and in the future.

Figure ES-1 presents the conceptual capital cost estimates for each scenario, which have a +50% to -30% accuracy range. **Figure ES-2** shows the conceptual costs on an annualized basis, including capital and Operations and Maintenance (O&M) costs over a 20-year life cycle.

Individual well treatment (Scenario 2) represents the lowest overall cost to CVWD for achieving compliance. Economies of scale in clustered treatment facilities (Scenario 1) were not overcome by the extensive pipelines required to cluster wells, distribution system upgrades necessary to redistribute treated water from the clusters, and additional land to house larger facilities since most existing well sites are too small for clustered treatment.

Surface water treatment combined with individual well treatment (Scenarios 3, 4, and 6) would provide domestic supply diversification, but it is significantly more expensive than Scenario 2.

Point-of-use treatment (Scenario 5) was the least favorable of the scenarios due to cost (high annualized cost due to continuing O&M costs), regulatory hurdles, and implementation complexity. While deemed feasible in terms of implementation (though not yet having regulatory approval), POU treatment at each connection was found to be cost prohibitive on a life cycle basis compared with wellhead, clustered, or surface water treatment options.

In summary, Scenario 2 was the recommended option, consisting primarily of SBA treatment at individual well sites with a CRRF. Two WBA clusters were identified that make economic and operational sense. There is also one opportunity to blend well water with distribution system water in an on-site tank to take advantage of existing infrastructure to minimize Cr6 concentrations. This approach provides CVWD with the most cost-effective and flexible compliance strategy for the current constituent of concern (Cr6) and future constituents of concern. For purposes of obtaining project funding to design and construct Scenario 2, an estimated \$200 million was recommended.

Ion Exchange Treatment was selected as the recommended alternative with SBA at 23 well sites with a Central Resin Regeneration Facility, 2 WBA facilities treating 6 wells, and blending of 1 well with lower Chromium 6 water.

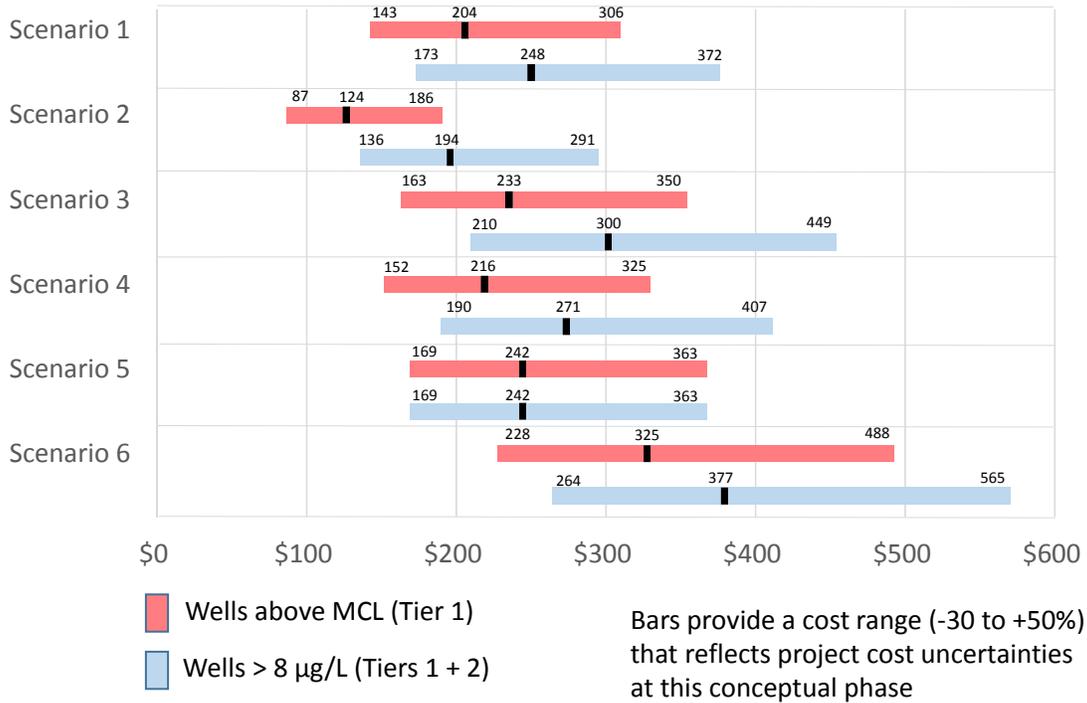


Figure ES-1. Cost comparison of scenarios – Capital (\$ Millions)

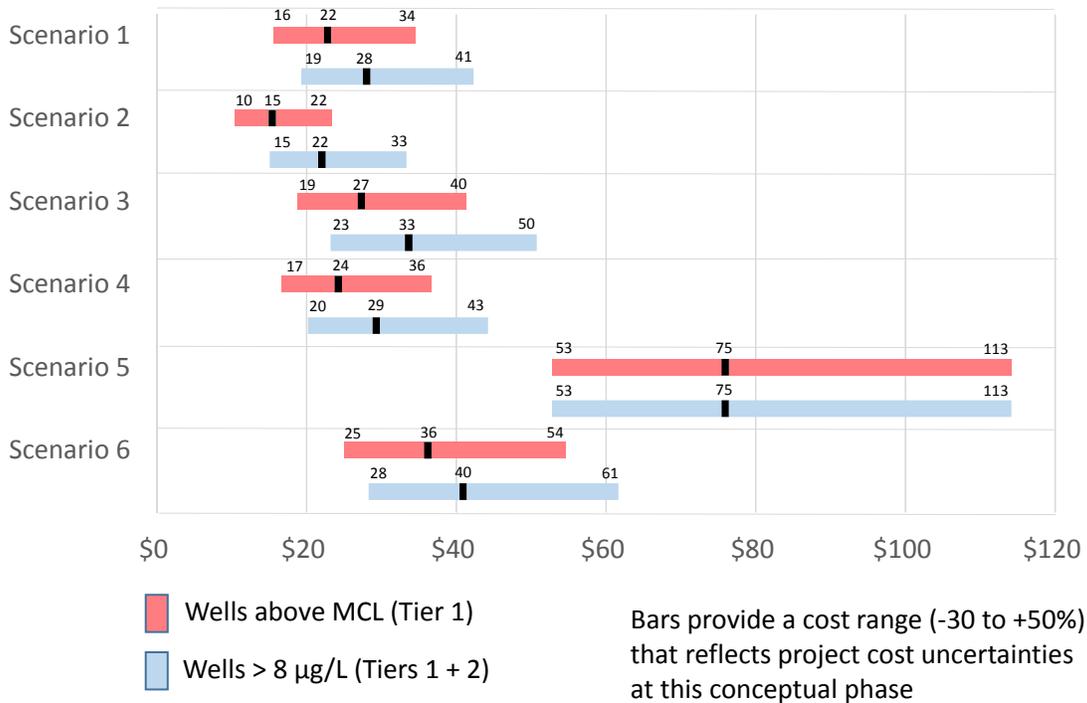


Figure ES-2. Cost comparison of scenarios – Annualized Capital and O&M Cost (\$ Millions)



Implementation of Selected Alternative

Conceptual designs were prepared for the primary treatment processes selected by CVWD in the series of workshops held throughout the project. The study report contains conceptual designs for each of the components selected for the compliance plan (SBA, WBA, and CCRF). The conceptual design forms the basis for design of the facilities.

Environmental constraints associated with implementing Cr6 treatment at locations across the Coachella Valley study area were identified in accordance with California Environmental Quality Act (CEQA) guidance (i.e., the CEQA Checklist). Impacted areas that may require evaluation and, perhaps, mitigation were highlighted. It does not appear from this constraints analysis that there are any “fatal environmental flaws” related to construction and operation of the project as currently defined. These sites are not expected to be precluded for development or site improvements.

To move CVWD toward Cr6 compliance as quickly as possible, preliminary design began in January 2015. Key steps in the implementation at the conceptual level include the following, with the end goal of construction completion and start-up of all facilities by June 2019:

- Preliminary design – February to August 2015
- CEQA certification – February 2015 to May 2016
- Contractor selection – April to July 2015
- Detailed design – July 2015 to May 2016
- Preconstruction – September 2015 to May 2016
- Construction & Start-Up– June 2016 to June 2019

Tier 2 Cr6 Wells and Other Constituents of Concern

Tier 1 wells require immediate treatment to achieve compliance with the Cr6 MCL. Tier 2 wells have concentrations between 8 and 10.4 µg/L and meet the MCL. An analysis of past total chromium and Cr6 test results for CVWD wells indicate Cr6 levels are stable or declining slightly over time. It is recommended that CVWD continue to monitor these wells and implement wellhead treatment if Cr6 levels increase above the standard in the future. The capacity to handle future treatment at Tier 2 sites using the CRRF was included in the conceptual design.

Other constituents of concern identified in CVWD groundwater that have current regulatory limits and may be susceptible to lower regulatory limits or rising groundwater concentrations in the future include nitrate, arsenic, perchlorate, and Volatile Organic Compounds (VOCs). The technology most applicable to the various constituents of concern in CVWD’s groundwater wells is SBA, since Cr6, nitrate, arsenic, and perchlorate are all anions removable by ion exchange. Treatment of Cr6 using SBA is advantageous over treatment of nitrate and arsenic due to lower waste volumes generated and smaller treatment footprint.

Should perchlorate treatment become necessary in the future, removal with single-pass perchlorate-selective resins would be preferable to regenerable SBA due to difficulty in removing perchlorate from waste brine.



VOCs in wells would require processes such as aeration and/or granular activated carbon, in addition to the nitrate treatment required for many of the VOC impacted wells, making treatment costly.

Nitrate concentrations were observed to be rising in several wells and may require replacement with new wells in the future. Two wells were identified that could be modified to draw from a lower nitrate concentration depth in the aquifer. Replacement of other nitrate impacted wells would avoid costly treatment in challenging residential areas. Areas in the Date Palm zone and three locations in the Valley and Cahuilla zones that are at lower risk for constituents of concern including nitrate and Cr6 were identified based on cross-section analysis in different areas of the Coachella Valley.

Unregulated constituents of reasonably anticipated regulatory significance in CVWD groundwater include chlorate, strontium, and vanadium. Among Cr6 treatment options, the ability to address strontium and vanadium is most compatible with the use of regenerable ion exchange (SBA), particularly with the CRRF approach for brine treatment and disposal. Additional vessels and on-site regeneration equipment may be needed to address these constituents, depending on the potential future regulatory levels. Chlorate is a disinfection by-product and susceptibility to this constituent of concern can be minimized by continued use of calcium hypochlorite disinfection.



1. INTRODUCTION

Coachella Valley Water District (CVWD) provides domestic water, wastewater (sanitation), non-potable water (wastewater reuse and Colorado River water), irrigation/drainage, stormwater and groundwater management services to a population of 300,000 throughout the Coachella Valley in California. The Coachella Valley relies on a combination of local groundwater, Colorado River water, State Water Project water, and wastewater reuse to meet water demands. CVWD provides domestic water service to approximately 108,000 residential and business customers.

CVWD is at a crossroads for selecting the portfolio of domestic water supply and associated water treatment to meet current and future domestic water demands. The purpose of this report is to determine the optimal source of supply and treatment for CVWD to comply with current, proposed, and reasonably anticipated Federal and State drinking water regulations. This project evaluated the options available to CVWD, including; (1) non-treatment options, (2) groundwater treatment, (3) Colorado River water treatment, and (4) point-of-use/point-of-entry (POU/POE) treatment.

This report provides an analysis of:

- Groundwater well quality
- Non-treatment options for achieving regulatory compliance
- Treatment options
- Scenarios for system-wide compliance
- Compliance projects and future projects

CVWD is currently in compliance with State and Federal drinking water regulations. At the beginning of this study (December 2013), a draft hexavalent chromium (Cr6) MCL of 0.010 mg/L (10 µg/L) was proposed. On July 1, 2014, the WaterBoards Division of Drinking Water (DDW) final Cr6 Maximum Contaminant Level (MCL) became effective at this level. CVWD is anticipating that 31 groundwater wells will exceed the Cr6 MCL. In the future, other constituents of concern may exceed current regulatory levels or new/reduced regulatory levels. This analysis considered which constituents may be of greatest concern for future compliance and options for addressing these constituents.

In this study, scenarios were developed to achieve compliance with the Cr6 MCL. Non-treatment, groundwater treatment, surface water treatment, and point-of-use options were evaluated to build complete solutions that could be compared. The scenarios were evaluated in terms of cost, operational complexity, diversification of CVWD water resources and treatment approaches for domestic supply, public acceptability and environmental acceptability, implementation complexity, operational flexibility, and water quality benefits in addition to Cr6 treatment now and in the future. Finally, conceptual designs were prepared for the primary treatment components selected by CVWD.



2. DOMESTIC SOURCES OF SUPPLY

Water for CVWD's domestic supply is extracted from the Coachella Valley groundwater basin, which is comprised of 5 sub-basins. The CVWD domestic system currently has 98 active wells and 2 new wells serving 41 pressure zones. Of these, 12 pressure zones have wells located within the zones they serve. **Figure 2-1** shows the CVWD distribution system pressure zones. Pressure zones with the greatest number of active wells include Valley, Sky Mountain, and La Quinta.

Inactive wells that are not in use due to water quality issues are also shown in **Figure 2-1**. This study considered whether these wells might be brought back online with treatment. Wells that are inactive due to other reasons such as mechanical issues are not shown.

The domestic system does not directly serve Colorado River surface water to customers, although surface water is recharged into the aquifer through groundwater replenishment at three locations using Colorado River water.

The distribution system is configured for local demands to be met from geographically distributed wells in a pressure zone. The system has the ability to transfer water between pressure zones but, in general, the system is not set up for large scale water transfer between zones and over long distances. This was a significant factor in the analysis of available treatment options since it affects the ability to transfer surpluses in some pressure zones to alleviate deficiencies in other zones. Most wells have single speed pumps and are cycled in and out of service to match demand, based on reservoir levels.

The supply capacity of the well system (i.e., excluding standby capacity) is 267,000 acre-feet per year (AFY)¹. Annual average demand is 115,000 AFY while peak demand is 229,000 AFY. The supply is equivalent to 117% of peak demand (notwithstanding the overdraft conditions that occur in portions of the valley, as discussed later). Although the overall supply is adequate, some pressure zones have localized supply deficiencies in peak demand periods, which are addressed with water transfers from adjacent zones (e.g., Mission Hills, Valley and Bombay Beach pressure zones).

Of the three zones with deficiencies in peak demand periods, the Valley and Mission Hills zones can be supplied from the adjacent Date Palm and Sky Mountain zones. The Date Palm and Sky Mountain zones have a collective surplus of over 9,400 gpm, which is sufficient to make up the combined deficit of 6,600 gpm in Valley and Mission Hills. Bombay Beach, which has a deficit of 600 gpm, can be supplied from the adjacent Mecca zone, which has a surplus of over 1,700 gpm. Improvements to intrazonal transfer facilities, including upgraded pressure reducing valves, are planned to allow Date Palm and Sky Mountain to better supply the Valley and Mission Hills deficits.

¹ Akel Engineering Group Inc, 2015.



The 2014 Status Report for the Water Management Plan (WMP)² predicts that future population growth will be concentrated in the East Valley as existing agricultural land is converted to residential use. The WMP identifies population growth from under 500,000 people in 2010 to approximately 920,000 in 2045, with the timing of future growth uncertain. The impact of the additional population on water demand will be partially offset by the reduction in water demand for agricultural use. The overall water demand is predicted to grow from slightly more than 600,000 AFY in 2010 to just under 760,000 FY in 2045.

The WMP highlights additional impacts that may be observed on water demands with future development in the cities of Coachella and Indio, as well as the development of tribal lands. The WMP recommends that the long term projected domestic supply deficit from growth should be overcome through a combination of methods, including:

- Water conservation: Areas for water conservation include agricultural conservation, urban conservation, and golf course conservation.
- Additional supplies: Potential additional supplies include the Colorado River, State Water Project Exchange water, acquisition of future imported supplies, increased use of recycled water, canal water loss reduction, desalinated water, stormwater capture, and development of local groundwater supplies for non-potable use.
- Source substitution: Substitution of an alternate source of water to reduce groundwater pumping, for example recycled water for non-potable use and indirect potable reuse, use of Colorado River for golf courses, agriculture, or urban domestic supply.
- Groundwater recharge: Four potential locations have been identified for groundwater recharge, including Whitewater, the Thomas E. Levy Facility (TEL), Martinez Canyon and a potential new site to be operated by the City of Indio. The total potential for recharge was estimated to range between 160,000 AFY and 190,000 AFY.
- Water quality improvements: Urban water treatment, recharge water quality improvement, groundwater quality and treatment
- Other management activities: Includes data monitoring and management, drainage control, source water protection programs, and stakeholder involvement

These management plan elements discussed in the WMP are necessary to meet the future water demands in the Coachella Valley as increased uncertainties arise that affect water demands. These uncertainties include decreased agricultural use, population growth, water quality, and the reliability of programs for importing water.

² MWH/CVWD 2014, Status Report for the 2010 Coachella Valley Water Management Plan Update.



3. DOMESTIC SOURCE WATER QUALITY

The water quality in CVWD's groundwater wells varies across the large geographic service area. Water quality concentrations were evaluated with respect to current, proposed, and reasonably anticipated Federal and State drinking water regulations for domestic water.

One of the first steps in compiling groundwater well data from numerous sources was to create a database for analysis. Components of the database, which is presented in Appendix A, include:

- Well identification
- Design capacity
- Pump test production rate (2012 and 2013)
- Average production rate (2012 and 2013)
- Water quality constituents
- Available land at well sites
- Spatial coordinates (latitude and longitude)

Using this data, active wells were analyzed in terms of regulated constituents of concern above limits (Section 3.1), regulated constituents of concern below limits that may be of future concern due to increasing groundwater concentrations or potentially lower future regulatory limits (Section 3.2), and unregulated constituents of concern with reasonably anticipated regulatory significance (Section 3.3). Inactive wells were also analyzed to identify opportunities to beneficially use these wells with non-treatment (blending) or treatment.

3.1 REGULATED CONSTITUENTS OF CONCERN CURRENTLY ABOVE LIMITS

CVWD's active wells are currently in compliance with all MCLs. A number of groundwater wells are anticipated to exceed the Cr6 MCL by October 2015 based on quarterly compliance sampling. The following section provides an analysis of Cr6 concentrations and locations.

3.1.1. CHROMIUM-6

The Cr6 MCL is 0.010 mg/L (10 µg/L), with compliance based on the running annual average of four quarterly samples taken from points-of-entry into the system. Based on the listed MCL and number of significant figures, 10.4 µg/L is considered in compliance and 10.5 µg/L, which would be 11 when rounded up, is out of compliance. CVWD elected to categorize wells by tiers according to Cr6 concentrations:

- Tier 1 - wells with greater than 10.4 µg/L Cr6
- Tier 2 - wells between 8 and 10.4 µg/L Cr6
- Tier 3 - wells below 8 µg/L Cr6



Table 3-1 provides the breakdown of active wells in each of the three tiers: 31 in Tier 1, 25 in Tier 2, 42 wells in Tier 3, and 2 wells that remain to be classified. To minimize financial impacts to customers, CVWD elected to plan treatment only for wells that are expected to be out of compliance based on existing data. Wells falling into the Tier 2 and Tier 3 categories are currently in compliance with the Cr6 MCL. In this Study, treatment options for the Tier 2 wells were considered should the wells rise in concentration and exceed the MCL in the future.

Only wells exceeding the MCL are initially identified for treatment. This approach necessitated a flexible treatment approach with future compatibility to add treatment in case other wells go out of compliance.

Figure 3-1 provides a Cr6 gradient map of concentrations in the Coachella Valley. Cr6 data for individual wells is provided in **Figure 3-2** for active and inactive wells. In general, the trends of Cr6 occurrence reflect elevated concentrations in Sky Valley and the Mid Valley. Areas near recharge facilities and the Salton Sea are lower in Cr6.

3.2 REGULATED CONSTITUENTS OF CONCERN CURRENTLY BELOW LIMITS

While current concentrations are below MCLs in active wells, CVWD has had to address several constituents of concern in the past including:

- Nitrate
- Arsenic
- Volatile Organic Carbon (VOCs)
- Total Dissolved Solids (TDS)
- Fluoride

In addition, several other constituents are currently regulated with MCLs but have lower health advisory limits, Public Health Goals (PHGs), or reference levels than the MCLs. These constituents of concern considered in this Study include:

- Perchlorate
- Antimony
- Selenium
- Uranium

Pending new regulations on these constituents include a future United States Environmental Protection Agency (USEPA) regulation on perchlorate and the grouping of carcinogenic VOCs.

A brief description of data for each constituent in active and inactive production wells is provided below. Maximum contaminant levels and public health goals are summarized in **Table 3-2** for these constituents. Data reviewed primarily included CVWD compliance sampling and Unregulated Contaminant Monitoring Rule (UCMR3) sampling. In addition, Geotracker Groundwater Ambient Monitoring and Assessment



(GAMA) reported results for Coachella Valley production wells were reviewed to provide a broader picture of concentrations in the Valley beyond CVWD data.

3.2.1. NITRATE

When nitrate concentrations exceed half of the MCL, CVWD increases the monitoring frequency to ensure concentrations do not exceed the MCL. Wells become candidates for inactivation when nitrate levels exceed 40 mg/L as nitrate. Figure 3-3 shows locations of elevated nitrate concentrations in the CVWD service area. Table 3-3 lists active groundwater wells with concentrations above half the nitrate MCL. Impacted wells are primarily in the Valley and La Quinta zones, in the area of known nitrate observed in the past. Appendix B provides historical trends of nitrate concentrations in wells with elevated concentrations.

Ten wells, including one with Cr6 concentrations above the regulatory limit (Well 5711-2), have nitrate concentrations above half the MCL. Nitrate concentrations in this well has increased in the past decade but appears to have stabilized. The other eight wells have lower Cr6 concentrations. Well 5708-1 increased to a peak of 38 mg/L nitrate in 2014 but has since dropped to half the MCL. Well 5630-1 reached 24 mg/L nitrate in 2014 but decreased to below half the MCL in 2015. Well 5639-1 reached 40 mg/L nitrate in January 2015 and is being closely monitored. Well 5656-1 has been steadily rising but remains below the MCL. Well 5662-1 has increased over the past decade but has been below the MCL consistently for the past 5 years. Well 5667-1 has been fairly constant between 22 and 28 mg/L nitrate from 2012 to present. Well 5670-1 has been increasing over the past 15 years and appears to be fairly stable in the past 5 years, and is below the MCL. Well 5673-1 has been decreasing from a peak of 31 mg/L nitrate to a current concentration of less than 20 mg/L nitrate. Well 5709-1 increased from 2006 to 2014 but has since stabilized at 20 to 25 mg/L nitrate. Wells will continue to be monitored and taken off line as necessary.

To avoid nitrate concentrations in new groundwater wells, CVWD now drills deeper wells because aquifer zone sampling had shown nitrate concentrations are greatest in the upper aquifer zone. Additional discussion of this approach is provided in Section 4.

Inactive wells were also reviewed in this study to evaluate their potential treatment or use in blending as part of the Cr6 compliance. Table 3-4 provides a summary of inactive wells with elevated nitrate concentrations. Many of these inactive wells are in the Valley zone, and some have co-existing VOC concentrations.

3.2.2. ARSENIC

Arsenic concentrations in CVWD wells were evaluated to determine the areas prone to elevated arsenic if regulatory levels decrease or groundwater concentrations increase. All active and inactive wells are currently below the detection limit of 2 µg/L except those listed in **Table 3-5** and **Table 3-6**, respectively. Wells above 10 µg/L already have ion exchange treatment to remove arsenic. In general, the areas of CVWD's system that has exhibited elevated arsenic concentrations are the Middleton Road, Mecca, and Bombay Beach pressure zones (**Figure 3-4**).



Evaluation of Cr6 treatment options at Tier 1 Wells 6728-1, 6805-1, and 6808-1 was conducted with the potential future need to remove arsenic in mind, including treatment approach and space for future facilities. The need for additional arsenic treatment is not anticipated on active wells unless the arsenic regulatory limit is decreased in the future. Any newly drilled wells in the areas identified with elevated arsenic levels will need treatment to reduce arsenic levels.

3.2.3. VOCs

VOCs, including tetrachloroethylene (PCE), dibromochloropropane (DBCP), and 1,2,3-trichloropropane (TCP), are found in some CVWD wells. One active well has a detectable VOC concentration (DBCP) of 0.03 µg/L, as listed in **Table 3-7**. The MCL for DBCP is 0.2 µg/L, so this well is below the MCL.

A number of wells have been taken offline due to DBCP and PCE, mostly in the Valley pressure zone (**Table 3-8, Figure 3-5**). Many of these inactive wells also have elevated nitrate concentrations and would require multiple treatment processes.

3.2.4. TDS

TDS concentrations reflect the salt concentration in water. TDS is a non-health based limit regulated by a secondary MCL that is a recommended range of less than 500 to 1,000 mg/L to avoid aesthetic concerns by customers. In general, groundwater TDS concentrations in Coachella Valley groundwater are less than 500 mg/L. By comparison, the TDS concentration of Colorado River water in the Coachella Canal has been 700 to 800 mg/L in the past 5 years.

Several areas of the CVWD system have elevated TDS concentrations, including the West Shores pressure zone near the Salton Sea, the areas near the Groundwater Replenishment Facilities (GRFs), as shown in **Figure 3-6**.

The West Shores pressure zone has three wells with high TDS, which is related to their proximity to the high TDS surface water and groundwater at the Salton Sea (**Table 3-9**). These wells all have low Cr6. CVWD plans to address the high TDS in this system by joining the Improvement District 11 (ID-11) system to the existing Cove system (i.e., the primary CVWD system) and discontinuing the use of these wells. This effort should begin in early 2016.

CVWD recharges the groundwater basin using Colorado River water at three GRFs, including:

- Whitewater GRF in the West Valley
- Mission Creek GRF, Mission Creek Subbasin
- Thomas E. Levy GRF in the East Valley

The Whitewater GRF began replenishing the West Valley aquifer in 1973, having added more than 2 million AF together with Desert Water Agency. Higher TDS concentrations have been observed near recharge facilities, reflecting TDS increases related to Colorado River water groundwater replenishment. **Figure 3-**



7 provides a map showing the proximity of the Whitewater GRF to the nearest groundwater wells. TDS concentrations for the nearby groundwater wells are listed in **Table 3-10**.

The TEL GRF began recharging Colorado River water into the aquifer in 1997, recharging 147,485 AF during that time (Engineer's Report, 2014)³. Well 6729-1 (0.3 miles from the facility) has a TDS level of 700 mg/L, reflecting TDS concentrations consistent with Colorado River water. The groundwater in the area is reported by CVWD to move at a horizontal rate of approximately 1 mile every 7 years, consistent with the rise in TDS for this well. In general, the groundwater flow is reported to be in the south/southeast direction. **Table 3-11** provides a list of wells within a 7 mile radius to TEL GRF that could be used for blending in a surface water treatment plant (discussed in Section 6). **Figure 3-8** depicts the wells on a map. The TDS in Wells 6729-1 and 6728-1 is expected to increase to a concentration approaching the TDS of Colorado River water recharged into the GRF basins (projected to be controlled to levels below 879 mg/L in accordance with the U.S Bureau of Reclamations Colorado River Salinity Control Program⁴), accompanied by a decrease in Cr6. Wells 7802-1 and 7803-1 that are down gradient of the TEL GRF are anticipated to observe negligible change in TDS in the near horizon because of the distance from the TEL GRF and the production zone. The other active wells are anticipated to have relatively minor changes in TDS caused by TEL GRF recharge, due to the well locations being up gradient of the TEL GRF.

The influence of recharge can be seen in water quality data (**Figure 3-9**), which shows the change in sulfate and Cr6 in Well 6729-1 as recharge volume is increased at the TEL GRF. Sulfate is a good marker of TDS, with a much higher sulfate concentration in Colorado River water than natural groundwater. This figure demonstrates the dual trend of increasing sulfate (and hence TDS) and decreasing chromium as a result of recharge. CVWD has reported that the increase in TDS in areas impacted by the GRF facilities has not elicited customer complaints.

3.2.5. PERCHLORATE

Perchlorate is currently regulated at 6 µg/L MCL in California, with no federal limit. A lower PHG was announced in 2015 decreasing the concentration from 6 µg/L to 1 µg/L, which might trigger a lower California MCL in the future. The USEPA also intends to regulate perchlorate in the future.

CVWD groundwater monitoring results show non-detect concentrations of perchlorate in all active wells using a detection limit of < 4 µg/L. CVWD conducted special perchlorate sampling using a lower detection limit of 1.4 µg/L, and found three wells (two that are currently active) out of 80 wells sampled with detectable perchlorate concentrations (**Tables 3-12** and **3-13**). These two active wells, 4523-1 and 4563-1, are both in the Date Palm pressure zone and have shown water quality fingerprints of historical Colorado River recharge from the Whitewater facility.

³ Engineer's Report on Water Supply and Replenishment Assessment: Lower Whitewater River Subbasin Area of Benefit, 2013-2014. April 2013.

⁴ US Department of the Interior Bureau of Reclamation, Upper Colorado Region, 2005. Quality of Water – Colorado River Basin, Progress Report No. 22.



The GAMA database reported non-detect perchlorate concentrations in 82 wells (a range of different method detection limits were used in these tests, from 0.5 to 6 µg/L). Perchlorate was detected below 1 µg/L in 9 wells, ranging from 1 to 6 µg/L in 10 wells, and above 6 µg/L in 9 wells. CVWD production wells in the same areas as the elevated GAMA database information, including wells in the Middleton Road zone and two in Lake Cahuilla, do not reflect these elevated concentrations with the exception of one inactive well in Lake Cahuilla that had a perchlorate concentration of 5.4 µg/L.

Perchlorate is also introduced into drinking water via sodium hypochlorite solutions. While perchlorate is formed during the electrolysis of on-site generated (OSG) hypochlorite, recent research⁵ indicated that OSG systems are not likely to be significant contributors of the perchlorate burden in drinking water plants. However, bulk hypochlorite can be a significant source of perchlorate for water agencies. The calcium hypochlorite solid form of chlorine has been found to generate less chlorate, compared with sodium hypochlorite liquid that can form chlorate and perchlorate when exposed to high temperatures and with age. Given CVWD system operation and the use of free chlorine for secondary disinfection, the use of calcium hypochlorite offers advantages to CVWD and minimizes potential impacts of future regulatory limits on perchlorate.

While perchlorate does not appear to be a major concern given available data, CVWD can minimize the potential need for perchlorate treatment in the future by continuing to use calcium hypochlorite disinfection. Slightly elevated perchlorate concentrations have been observed in several Date Palm zone wells influenced by Colorado River recharge, and impacts of a potential lower perchlorate MCL should be considered when future wells locations are selected.

3.2.6. ANTIMONY

Antimony is regulated with a federal and California MCL of 6 µg/L. California has a Public Health Goal (PHG) of 0.7 µg/L. CVWD monitoring in active wells has shown non-detect antimony concentrations (< 6 µg/L). Since the method detection limit (6 µg/L) is higher than the PHG, it is unclear how many wells would be impacted by a new regulatory limit if imposed at the PHG concentration. Data in the GAMA database showed that antimony was non-detect in 63 wells (multiple detection limits of unknown and 6 µg/L), detected and below 0.7 µg/L in 3 wells, and detected between 0.7 µg/L and 6 µg/L in 2 wells. Based on the available results from CVWD and the GAMA database, antimony does not appear to be a concern for CVWD at this time.

3.2.7. SELENIUM

Selenium has a current federal and California MCL of 50 µg/L and a California PHG of 30 µg/L. Selenium was non-detect in 53 wells (many method detection limits were used, ranging from 0.1 to 5 µg/L), and

⁵ Stanford, B. D., Pisarenko, A.N., Snyder, S.A., and Gordon, G. 2011. Perchlorate, bromate and chlorate in hypochlorite solutions: Guidelines for utilities. *Journal AWWA*, 103:6.



above the detection limit in 46 wells to a maximum of 4 µg/L. Based on the available results from CVWD, selenium does not appear to be a drinking water regulatory concern in groundwater for CVWD at this time.

3.2.8. FLUORIDE

Federal fluoride regulatory standards include an MCL of 4.0 mg/L and a secondary MCL of 2.0 mg/L based on cosmetic effects on teeth. California has a primary MCL of 2.0 mg/L. The California WaterBoards DDW recommends an optimal level of 0.7 mg/L for systems that practice fluoridation, with a dosing control range of 0.6 to 1.2 mg/L. Natural fluoride is found in groundwater throughout the Coachella Valley and levels above 2.0 mg/L are common in wells close the San Andreas fault system, Desert Hot Springs Subbasin, and the eastern most areas of the Mission Creek and Whitewater River Subbasins. These areas are avoided when locating CVWD supply wells. Levels found in groundwater served from CVWD's existing wells are near the optimal level of 0.7 mg/L. CVWD has removed several wells from service due to elevated fluoride levels. Several existing wells that exceed 1.2 mg/L, but fall below 2.0 mg/L, are listed in **Table 3-14**. The need for fluoride treatment is not anticipated in CVWD wells as long as areas with elevated fluoride are avoided when locating new wells.

3.2.9. URANIUM

Uranium is regulated with an MCL of 20 pCi/L in California and a federal MCL of 30 µg/L. The California Office of Environmental Health Hazard Assessment (OEHHA) has established a PHG for uranium of 0.5 µg/L. A conversion factor of approximately 0.9 pCi/µg applies for uranium, resulting in an MCL of approximately 22 µg/L. CVWD groundwater wells have variable concentrations of natural uranium, ranging from non-detect to 14.5 µg/L (four wells were above half the MCL, listed in **Table 3-15**), below the California and federal MCLs. No regulatory actions for uranium are anticipated at this time.

3.2.10. SUMMARY

Cr6 is the only constituent of concern that is currently present in active wells above the regulatory limit. Regulated constituents of past concern that were identified in some of CVWD's wells include nitrate, arsenic, VOCs, and TDS. Ten wells are being monitored more frequently for elevated nitrate concentrations, with two that appear at risk for exceeding the regulatory limit in the future. Arsenic concentrations in wells in the Middleton Road, Bombay Beach, and Mecca zones show several wells above the MCL but each is currently treated by CVWD. Three other wells have levels above the arsenic detection limit of 2 µg/L but they are less than half the MCL. VOCs are present in some wells at concentrations below the MCLs, and typically co-occur with nitrate. TDS concentrations are high in several wells near the Salton Sea, and CVWD plans to address the high TDS in this system by joining the ID-11 system to the existing Cove system and discontinuing the use of these wells. TDS is increasing in recharge areas due to higher TDS in Colorado River water, but groundwater blends with surface water to provide aquifer recharge and an acceptable blend for the maximum benefit to customers.

Other constituents of concern, including perchlorate, antimony, selenium, fluoride, and uranium, were also analyzed in this Study. Perchlorate concentrations are below the current regulatory limit but may be a concern if the limit is reduced; use of calcium hypochlorite can minimize perchlorate introduced by



disinfection. Fluoride concentrations in wells are lower than the MCL and are not of concern if CVWD continues to site wells in areas without elevated fluoride. Antimony and selenium concentrations are low in CVWD wells. Uranium concentrations are mostly low in CVWD wells, with levels above half the MCL in four wells. Overall, these additional constituents are not anticipated to be a drinking water regulatory concern for CVWD.

3.3 UNREGULATED CONSTITUENTS OF CONCERN WITH REASONABLY ANTICIPATED REGULATORY SIGNIFICANCE

On the federal level, the Safe Drinking Water Act (SDWA) has several upcoming major regulatory actions that may impact which constituents are regulated in the future, including the preliminary regulatory determinations from the third Contaminant Candidate List (CCL3), the draft fourth Contaminant Candidate List (CCL4, draft due in late 2014/early 2015), and the Six-Year Review in 2016.

A draft preliminary determination of intent to regulate was released by USEPA in October 2014 and included negative determinations for four constituents and only one positive determination, which was for strontium. Nitrosamines and chlorate are opined by the American Water Works Association (AWWA) to likely be included in the third Six-Year Review. Nitrosamine regulation is uncertain due to high source contribution from food (AWWA, 2014).

A summary of regulatory and reference levels for constituents of concern with reasonably anticipated future regulatory significance is provided in **Table 3-16**. A brief description of data for each constituent is provided below, including identification of constituents of future concern to CVWD.

3.3.1. 1,4-DIOXANE

1,4-dioxane has a Notification Level (NL) of 1 µg/L in California. CVWD reported non-detect values for 1,4-dioxane (< 0.07 µg/L) in all active wells monitored (9 wells). The GAMA database also reported non-detect concentrations for 1,4-dioxane in all supply wells tested in the Coachella Valley (9 wells); however multiple detection limits were provided (unknown, 6, 13 and 35 µg/L). Based on the available results from CVWD and the GAMA database, 1,4-dioxane does not appear to be a concern for CVWD at this time.

3.3.2. COBALT

Cobalt has no MCL, NL or PHG in California; thus, the potential regulatory level is unclear (if any). CVWD monitored 8 wells for cobalt and all of them were non-detect (< 1 µg/L). The GAMA database reported results for 32 wells and only 2 wells contained detectable cobalt (both 0.02 µg/L). Based on the available results from CVWD and the GAMA database, cobalt does not appear to be a concern for CVWD at this time.



3.3.3. CHLORATE

The USEPA has published a health reference level (HRL) of 210 µg/L for chlorate, though this has been criticized due to the USEPA's assumption that only 20% of chlorate exposure is attributable to drinking water. The recent draft regulatory determination (October 2014) included a statement from the USEPA regarding the uncertainty around total dietary exposure, indicating that any MCL could be significantly different from the HRL. Chlorate has a notification level (NL) of 800 µg/L in California and has a World Health Organization guideline value of 700 µg/L. CVWD has monitored chlorate in 8 active wells, with results ranging from non-detect (< 20 µg/L) to 80 µg/L, all well below the NL of 800 µg/L. No chlorate data were available for the Coachella Valley from the GAMA database.

The predominant source of chlorate in finished drinking water is through the use of chlorine dioxide, bulk hypochlorite, and OSG hypochlorite. Chlorate is a byproduct of chlorine dioxide treatment and is a decay product in hypochlorite solutions. Several mechanisms for controlling chlorate formation in bulk hypochlorite have been identified, including minimizing storage time, diluting stored solutions with softened water, maintaining stored bulk hypochlorite pH between 11 and 13, and/or cooling bulk hypochlorite during warmer months. Given CVWD system operation and the use of free chlorine for secondary disinfection, use of calcium hypochlorite (which has not been shown to produce chlorate) offers advantages to CVWD and minimizes potential impacts of future regulatory limits on chlorate.

3.3.4. MANGANESE

Manganese is a metal for which the USEPA and California has a secondary MCL of 50 µg/L. It is on the USEPA CCL4 and concerns have been raised about health impacts from manganese. Based on data from wells (less than the detection limit of 20 µg/L), CVWD groundwater is not impacted by manganese and does not appear to be a concern for CVWD at this time.

3.3.5. MOLYBDENUM

Molybdenum has a health advisory level (HAL) of 40 µg/L with no MCL, NL or PHG in California. CVWD monitored 8 wells for molybdenum and the results ranged from 8.7 to 14 µg/L, all well below the HAL. The GAMA database reported monitoring results for 39 wells. Molybdenum was detected in 38 wells, including two wells with molybdenum above 40 µg/L, which is not observed in CVWD groundwater wells. Based on the available results from CVWD, molybdenum does not appear to be a concern for CVWD at this time.

3.3.6. NITROSAMINES

Nitrosamines do not have a federal HAL or reference level. Three nitrosamines (n-nitrosodiethylamine: NDEA, n-nitrosodimethylamine: NDMA, and n-nitrosodipropylamine: NDPA) have NLs in California of 10 ng/L. NDMA has a PHG of 3 ng/L in California. No nitrosamines are currently regulated with a MCL in California but do require customer notification if the NL is exceeded. No nitrosamines data were available from CVWD. All the wells tested and reported in the GAMA database have non-detect NDMA (< 5 ng/L). Based on the available results from CVWD, the GAMA database, and the use of free chlorine as the disinfectant, nitrosamines do not appear to be a concern for CVWD at this time.



3.3.7. STRONTIUM

Due to its potential role in decreasing bone density especially in sensitive life stages such as early childhood, strontium has a HRL of 1.5 mg/L or 1,500 µg/L. In California, strontium currently has no public health goal, notification level or MCL. It is unclear at what level strontium would be regulated. In CVWD's wells, strontium concentrations ranged from 150 µg/L to 2,000 µg/L with all but one sample below the HAL. The GAMA database reported strontium detected in 69 wells, with two wells above the HAL. Strontium in Colorado River water is observed at approximately 1,000 to 1,200 µg/L. Strontium does not appear to be a regulatory concern for CVWD groundwater. However, Colorado River water recharged areas and surface water may have potential regulatory concern if strontium is regulated in the future near the HAL.

3.3.8. VANADIUM

Vanadium has a NL of 50 µg/L in California. Vanadium was detected in all CVWD active wells in the range of <3 – 39 µg/L. The GAMA database reported vanadium non-detect in 9 wells (< 3 µg/L), below 50 µg/L in 84 wells, above 50 µg/L in 2 wells. Vanadium is not a concern if regulated at the current California NL. Because some wells are near the NL, vanadium removal by treatment technologies was evaluated in this Study and is discussed in Section 5.

3.3.9. DCPA

One datapoint in the CVWD active well database shows a positive concentration for dimethyl tetrachloroterephthalate (DCPA), which is an herbicide. Based on the UCMR data, USEPA chose not to regulate DCPA because it does not represent a meaningful opportunity for health risk reduction. Further, the measured DCPA concentration was much lower than the Reference Level. DCPA is not considered a contaminant of future regulatory concern for CVWD wells based on available data.

3.3.10. 1,2,3-TRICHLOROPROPANE

1,2,3-TCP is a volatile organic compound for which California has a PHG and NL. Based on UCMR data for 21 wells, CVWD groundwater is not impacted by 1,2,3-TCP and does not appear to be a concern.

3.3.11. SUMMARY

Several constituents with reasonably anticipated regulatory significance were evaluated in CVWD groundwater and surface water sources. Many of these constituents are not of concern based on concentrations and regulatory or reference levels. Those identified as potentially of concern include strontium, chlorate, and vanadium. Strontium was recently listed in the draft USEPA regulatory determination; elevated strontium concentrations are observed in Colorado River water and recharge-influenced areas compared with native groundwater. The potential for future strontium regulatory action would argue against siting all groundwater wells in the recharge areas with less Cr6 but higher strontium concentrations. Strontium is expected to be more challenging to treat than Cr6 (discussed in Section 5).



Chlorate is also of concern in terms of future regulatory actions as part of the disinfection by-products (DBP) rule. Chlorate concentrations in CVWD's system are low, and it is recommended that CVWD continue the practice of tablet chlorination to minimize chlorate concentrations that would be introduced by sodium hypochlorite and to avoid gaseous chlorination in residential areas.

Vanadium concentrations in the wells were less than the current California NL. Vanadium removal by Cr6 treatment technologies was evaluated in this Study (Section 5).

3.4 DISINFECTION STRATEGY TO MINIMIZE BY-PRODUCT CONSTITUENTS OF CONCERN

CVWD uses free chlorine in the distribution system as a secondary disinfectant. A mix of application strategies is employed for providing secondary disinfection, including calcium hypochlorite tablets at most well sites, several gaseous chlorine systems, and several liquid sodium hypochlorite systems.

The large number of wells, the hot desert environment at CVWD, and the strategy of pumping into hillside tanks for gravity feed support the continued use of free chlorine disinfection compared with use of chloramines. Nitrification is enhanced in warmer water due to degradation of chloramines, and extended detention times in tanks would exacerbate nitrification. CVWD's groundwater is of excellent quality with respect to low total organic carbon, which yields low disinfection by-products under current operations with free chlorine. A change to chloramines is not necessary and would increase operational requirements to minimize water age and trim free ammonia.

CVWD has had positive experiences with calcium hypochlorite tablet feeders at numerous well sites, in terms of maintaining a consistent disinfectant residual and ease of use. Gaseous chlorination systems at several wells are being replaced due to safety concerns in residential areas. CVWD requested that this Study evaluate the advantages and disadvantages of potential disinfection strategies. A comparison of the strategies is presented in **Table 3-17**.

The USEPA adopted a Revised Total Coliform Rule (RTCR) on February 13, 2013. The State of California is preparing a draft RTCR regulation package and will adopt the RTCR in the near future. No minimum detectable residual is currently anticipated by California WaterBoards. The focal point of the RTCR will be prevention and correction of fecal contamination. The RTCR provisions are not anticipated to change the recommended disinfection strategy.

Based on this analysis, continued use of calcium hypochlorite tablets at well sites is recommended. The systems provide the necessary secondary disinfection with minimal operational requirements and disinfection by-product formation in the CVWD climate.



3.5 CONCLUSIONS

Analysis of CVWD groundwater and surface water sources in the context of current, proposed, and reasonably anticipated Federal and State drinking water regulations showed that Cr6 is of current and most immediate concern, impacting 31 of CVWD's 98 active wells.

Cr6 is the only constituent that is currently present in active wells above the enforceable regulatory limit, besides arsenic that is being treated. In addition to active wells with treatment, arsenic concentrations are present in the East Valley near the Salton Sea but are at levels lower than half of the current MCL. Nitrate is increasing in several wells and CVWD will continue to monitor these wells to avoid exceeding the nitrate limit. VOCs are present in some wells at concentrations below the MCLs, and typically co-occur with nitrate. Perchlorate concentrations are below the current regulatory limit but may be a concern if the limit is reduced. TDS concentrations are high in several wells near the Salton Sea, and CVWD plans to address the high TDS in this system by joining the ID-11 system to the existing Cove system and discontinuing the use of these wells. TDS is increasing in recharge areas due to higher TDS in Colorado River water, but groundwater blends with surface water to provide aquifer recharge and an acceptable blend for customers. A significant benefit of this blend is the reduction of Cr6 levels that occur naturally in local groundwater above the regulatory limit. Constituents of concern with reasonably anticipated regulatory significance that are a potential concern for CVWD based on available data, current reference levels, and CVWD practices include strontium, chlorate, and vanadium.

Evaluation of the three disinfection practices used by CVWD at different well sites showed that calcium hypochlorite tablets offer advantages to CVWD in minimizing disinfection by-product formation for constituents that are reasonably anticipated to be regulated (i.e., chlorate and perchlorate), compared to liquid sodium hypochlorite. Primary factors include the warm temperatures in a desert environment and intermittent use of wells. Although also yielding lower by-products with better dosing control, gaseous chlorine is not recommended due to the location of many well sites in residential neighborhoods.

Based on this analysis, non-treatment and treatment options were evaluated for constituents of concern to achieve maximum benefit for CVWD customers (Sections 4 and 5). The potential for additional facilities to address reasonably anticipated future regulatory levels, in addition to facilities needed to address current regulatory levels, were considered.



4. NON-TREATMENT OPTIONS

Before considering treatment options for addressing constituents of concern in the groundwater supply, non-treatment opportunities to achieve regulatory compliance were investigated. These opportunities included (1) abandoning wells, (2) drilling new wells, and (3) modifying existing wells. Each is discussed in the subsections that follow.

4.1 OPERATING WITHOUT IMPACTED WELLS

Evaluation of compliance options began with an analysis of domestic system deficiencies if wells expected to be out of regulatory compliance (i.e., Cr6 impacted wells) were turned off to achieve compliance. Two different analyses were conducted:

- Tier 1 wells (31 wells): Cr6 concentrations exceeding 10.4 µg/L
- Tier 1 and Tier 2 wells (56 wells): Cr6 concentrations exceeding 8 µg/L

Under average flow conditions, most zones can meet demands without using the impacted wells. The exceptions are La Quinta, Lake Cahuilla and Sun City, which have a high percentage of impacted wells.

Under peak demand conditions, removing all Tier 1 and Tier 2 wells from service would create a supply deficiency in nine pressure zones, while removing only the Tier 1 wells from service would create a supply deficiency in eight pressure zones. The system-wide impact of removing all wells above 10.4 µg/L from service would create a system-wide deficit of 34,500 gpm, or 50 million gallons per day (MGD). **Table 4-1** lists the supply impacts identified through hydraulic modeling for each zone under these conditions. Appendix C contains additional details of the hydraulic modeling performed by Akel Engineering Group.

Hydraulic modeling of the Sky Mountain pressure zone was conducted to evaluate the potential to address peak demand periods by storing water from the non-impacted wells during non-peak periods. The Sky Mountain zone was selected for this simulation because it has a smaller deficit relative to demand than other impacted zones. The results of the analysis demonstrated that, in addition to the current available storage of 9.5 million gallons in the zone, at least 35 million gallons of additional storage would be required to address peak demands. The shortfall would be exacerbated if longer than typical peak demand periods were observed. Therefore, the option of attempting to overcome supply deficits through additional storage of water was not considered a viable solution for CVWD.



4.2 DRILLING NEW WELLS

As shown in Section 4.1, abandoning wells with Cr6 above the regulatory limit would require replacement with alternate supplies. The potential to drill new wells was considered, including potential locations for new wells and distribution system network upgrades that would be necessary since the system is designed for diffuse placement of wells.

Todd Groundwater used CVWD's regional MODFLOW groundwater model to evaluate the impacts of drilling new wells in an area in the Date Palm pressure zone less impacted by Cr6 to replace impacted wells in other areas (Appendix D). As shown in Section 3, the Date Palm pressure zone has lower Cr6 and nitrate concentrations (at depth), and is influenced by Colorado River recharge. The analysis assumed that 17 new wells each with a capacity of 3,100 gpm could be installed to replace all of the Tier 1 impacted wells (27 wells, excluding the 4 Tier 1 wells in the Sky Valley zone). The Sky Valley pressure zone wells were excluded from this analysis because the systems are not connected.

The groundwater analysis indicated that operation of the new wells would produce a drawdown of the water level in the area of the new wells. This drawdown would increase over time and would stabilize at a maximum of 29 feet in the area with the highest concentration of new wells. This drawdown would be lower in areas farther from the new wells. The analysis did not identify any wells in the area with screen levels above the predicted drawdown, indicating that this drawdown would not prevent the use of CVWD's existing production wells.

The CVWD distribution system was built with individual wells scattered throughout the valley with localized smaller pipelines, rather than with clustered wells in wellfields and large transmission mains. The existing distribution pipe network does not have sufficient capacity to transfer the additional water produced by 17 new Date Palm wells to the other pressure zones. **Figure 4-1** shows a schematic arrangement of new pipelines that would be necessary to distribute the water for the 17 new Date Palm wells. The new pipeline arrangement would involve over 40 miles of new pipelines with sizes up to 60 inches in diameter. Parts of the alignment would cross Interstate 10, the Union Pacific Railway and the Whitewater Storm Channel. **Table 4-2** presents a conceptual level cost estimate for these new pipelines. Costs include mainline pipelines as well as an allowance for the cost of upgrading distribution networks to connect to the mainline pipelines. Additional costs would be necessary for drilling wells and acquiring land. Since future growth is expected to be mostly in the east, the augmented distribution system might require additional upgrades in the future to match increased demand in the east.

As discussed in Section 3, drilling new wells in an area like the Date Palm zone (where recharge decreases Cr6 concentrations) could expose CVWD to potential future regulatory concerns like strontium and perchlorate. If treatment is required for strontium in the future, costs are expected to be higher than for Cr6 treatment due to more frequent regeneration (discussed in Section 5). In addition, the large number of wells that would be needed in the Date Palm pressure zone would result in increased demands that would further stress ongoing efforts to stabilizing groundwater supplies in this area.

Based on this analysis, drilling new wells was not identified as the primary solution for Cr6 compliance due to cost, implementation complexity, and future regulated constituents of concern. However, drilling



new wells, including in the Date Palm zone, should be considered on a case-by-case basis when wells exceed regulatory limits in the future or if additional supply is needed.

To evaluate lower risk locations for drilling new wells in the future, Todd Groundwater prepared cross sections of existing wells and concentrations (Appendix D). The locations for cross sections were selected to investigate trends throughout the valley. The cross sections were oriented to allow analysis of trends of constituents of concern at different depths in adjacent wells. Based on the analysis in Section 3, parameters investigated included Cr6, nitrate, TDS, sulfate, arsenic, perchlorate, VOCs, and strontium.

The results of the cross section analysis supported previous CVWD hypotheses regarding the distribution of constituents of concern. Both nitrate and Cr6 are broadly distributed throughout the main pressure zones. Cr6 is more prevalent in deeper wells. Nitrate is more prevalent in shallow wells, and the historical trends suggest that it is gradually migrating downward in areas. TDS and sulfate tend to be elevated in in groundwater near the fault system, in perched groundwater throughout the eastern Coachella Valley and in the Desert Hot Springs subbasin, and in portions of the Thousand Palms and Oasis subareas⁶. TDS and sulfate are also higher in wells that are influenced by CVWD's recharge facilities where below ground blending occurs with surface water and groundwater. Lower levels of Cr6 are also observed in areas influenced by this blending.

Both Cr6 and nitrate also showed some horizontal distribution, i.e. there were areas where levels of a particular constituent showed a trend at the same depth across a cross section. However, these horizontal trends are not absolute, particularly in the case of Cr6. Following these trends suggests that careful site selection could reduce the probability that constituents of concern would be encountered in new wells, although it would not completely eliminate this possibility. The Todd Groundwater report (Appendix D) includes identification of several areas with reduced likelihood of encountering constituents of concern. These favorable areas are relatively limited in size and therefore do not offer a complete alternative to on-site treatment for Cr6 compliance and provision of adequate water supply. However, they are useful as a guide when selecting sites for future wells to add capacity to existing zones or to replace existing wells that are no longer productive.

4.3 MODIFICATION OF EXISTING WELLS

One potential strategy for minimizing constituent of concern concentrations in wells is to install packers in existing wells to extract water from an aquifer layer containing lower concentrations. Todd Groundwater evaluated this strategy by assessing constituent of concern concentrations as a function of well screening depth and considering likelihood of success in isolating layers based on the lithology and water quality (Appendix D).

⁶ California Department of Water Resources, Valley Investigation, Bulletin 108, July 1964.



The analysis revealed that modification of existing well screens is not a feasible compliance strategy for CVWD to address Cr6 or nitrate. Because Cr6 concentrations are uniform with depth in many of the wells, the modification of well screens is not a feasible compliance strategy for CVWD. Other areas have Cr6 in older deep groundwater and nitrate in the shallow water, and production could be limited if wells were modified to draw water that avoided both constituents. Only two potential wells were identified that may benefit from well modification for nitrate should concentrations rise in the future – 5656-1 and 5670-1 (which are Tier 3 Cr6 wells).

It is recommended that CVWD continue the program of analyzing water quality in well depths during drilling, and screen at depths with lowest constituents of concern concentrations based on treatment considerations (discussed in Section 5).

4.4 CONCLUSIONS

Three large-scale non-treatment options were considered in this Study, including increasing storage to allow the system to operate without impacted wells, drilling new wells in areas with low Cr6 concentrations and modifying existing wells to prevent intake of water with constituents of concern.

Operating the system without the impacted wells would require significantly increasing storage. This would be very expensive and also would leave the system vulnerable to running out of water if periods of peak usage were longer than anticipated. This is not considered a viable option.

Drilling replacement wells in new areas would require major augmentation of the existing CVWD distribution system to allow the transmission of large quantities of water from the less impacted zones in the west to the more impacted zones in the east. The cost of these changes are high and implementation would be challenging. In addition, since future growth is expected to be mostly in the east, the augmented distribution system might require additional upgrades in the future to match increased demand in the east. Finally, other constituents of concern with reasonably anticipated regulatory significance including strontium and perchlorate are higher in the recharge area where Cr6 and nitrate are lower. For these reasons, drilling replacement wells to turn off impacted wells is not recommended.

A more detailed evaluation of the spatial distribution of constituents of concern identified areas within impacted zones with lower probability of encountering high concentrations. These areas can be considered when the need arises to drill additional wells in the future, either to replace existing wells that have stopped producing or to provide additional supply.

Finally, modifying existing wells to prevent intake of Cr6 or nitrate is not considered a feasible compliance strategy for CVWD. Analysis showed uniformity of Cr6 concentrations in screened depths in some areas not lending to packer effectiveness, and continuous screened depths in coarse-grained sediments would not enable well modification in some pressure zones to avoid nitrate. Further, reduction in production capacity of the wells could occur with well modification.



Overall, this analysis showed that large-scale non-treatment options are not a primary solution for CVWD to achieve compliance with the Cr6 MCL. It is recommended that CVWD use the information developed by Todd Groundwater in this Study to identify areas for future well drilling that have lower risk of constituents of concern.



5. TREATMENT OPTIONS

As discussed in Section 4, large-scale non-treatment options are not viable as a compliance strategy for CVWD. Several alternative treatment options were evaluated and the findings are presented in this section. Section 5.1 provides an analysis of Cr6 concentrations used for the treatment evaluation. Section 5.2 presents an evaluation of treatment technologies, including removal of constituents of concern identified in Section 3.

5.1 BASIS FOR TREATMENT EVALUATION

For the active wells, Cr6 data were analyzed to identify wells with historical maximum Cr6 concentrations in the three tiers, Tier 1: greater than 10.4 µg/L, Tier 2: 8 -10.4 µg/L, and Tier 3: less than 8 µg/L. From April to June 2014, CVWD performed additional sampling to evaluate certainty in the Cr6 groundwater quality data, primarily for wells with concentrations between 8 and 10.4 µg/L.

Table 5-1 lists the individual active wells for each Cr6 category, including the following data:

- Cr6 range – minimum and maximum concentrations for historical data from 2000-2014
- Average Cr6 concentration – average value of historical data available from 2000-2014
- 90th Percentile Cr6 concentration – 90th percentile value of historical data available from 2000-2014, which eliminates outliers that are unrepresentative
- First Cr6 compliance concentration (January 1, 2015) or recent Cr6 concentration used for compliance (grandfathered data)
- Design Cr6 – recommended Cr6 concentration to be used as design criteria for the well should treatment be necessary (maximum concentration or 90th percentile if outliers skewed the historical trend)

Selection of the design Cr6 concentration was based on maximum concentrations (refer to Appendix B for plots of historical data used in the analysis). This margin of safety was important because the groundwater flow is not treated entirely; the facilities include bypass of a portion of the flow around the treatment unit to minimize treatment costs. Regular monitoring of the raw water is recommended for wells that are classified Tier 2. Should levels exceed the MCL, treatment may be required.

One well (5725-1) was specified as 90th percentile rather than maximum. This well was sampled ten times in spring 2014 to determine the Cr6 concentration since the past concentrations were close to the MCL. Results from 2014 showed that none of these ten data points exceeded the MCL. As a result, CVWD elected to classify well 5725-1 a Tier 2 well despite a historical maximum over 10.4 µg/L.



Based on this analysis, a total of 31 Tier 1 wells and 25 Tier 2 wells were identified. For conservatism in planning, four wells (4611-1, 5603-1, 5682-1, and 5708-1) that had most recent concentrations below 8 µg/L but historical values between 8 and 10.4 µg/L were also classified as Tier 2 wells.

5.2 TREATMENT TECHNOLOGIES

Three technologies are listed by DDW as Best Available Technologies (BATs for Cr6 removal from drinking water, including:

- Ion Exchange (strong base anion exchange, SBA, and weak base anion exchange, WBA)
- Coagulation filtration with reduction (also called reduction coagulation filtration, RCF, or reduction coagulation microfiltration, RCMF)
- Reverse osmosis (RO)

In addition, several other emerging technologies were evaluated in this study for applicability to CVWD in achieving regulatory compliance, including:

- Biological treatment
- Adsorptive media
- Electrodialysis reversal (EDR)

Each of the BATs and emerging technologies were investigated to assess their effectiveness, waste residuals, and ability to address variability in water quality. Relevant studies and/or applications that have been reported or published are summarized in a table for each technology in the sections that follow.

5.2.1. STRONG BASE ANION EXCHANGE (SBA)

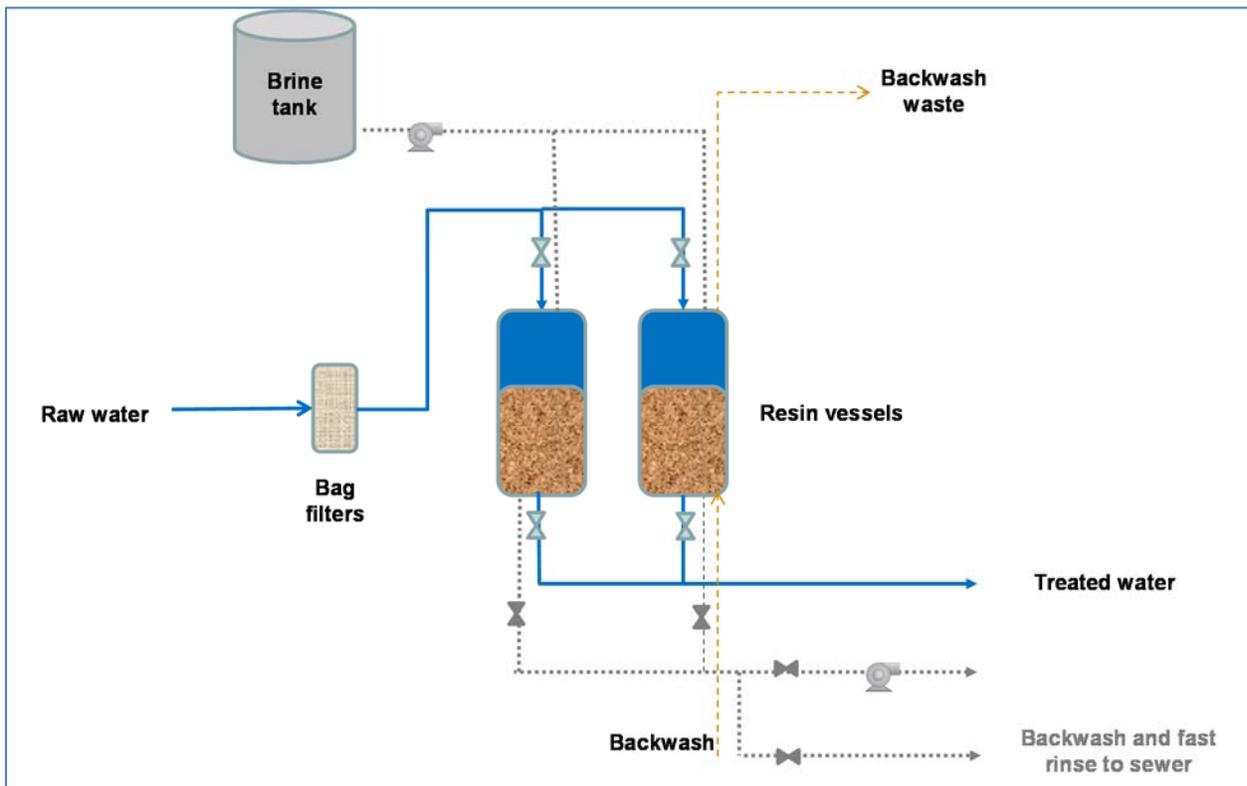
A schematic of the SBA treatment process is shown on the following page. Bag filters (strainers) are used to remove particles from the groundwater, and to help minimize pressure drop through the resin bed and reduce the need for backwashing. Cr6 in the treated water (i.e. the resin vessel effluent) gradually increases over time as the resin capacity for Cr6 is exhausted. When the treated Cr6 concentration reaches the treatment target level, the resin must be regenerated or replaced.

SBA resin is typically regenerated using a salt (brine) solution. During regeneration, Cr6 is eluted off the resin into the brine, and the resin's Cr6 capacity is restored. Residuals include spent brine and rinse wastewater (slow rinse and/or fast rinse). Spent brine disposal is often the greatest challenge for SBA applications due to its high chromium and TDS concentrations. Brine is a hazardous waste in California unless chromium and other hazardous constituents are precipitated, in which case the brine can become non-hazardous although the precipitates are often hazardous. Options to treat and/or minimize spent brine volume are discussed in more detail in Section 5.2.5. Backwash is sometimes used to loosen up the resin bed before regeneration or to stratify the media; however, this step is not universally applied.



Instead of regeneration, the SBA process can be operated as a single-pass media. This approach calls for disposal of the resin once treated Cr6 reaches the target level. In this case, spent resin is the only residual. However, a single-pass approach can be prohibitively expensive compared to regeneration due to resin costs.

As mentioned above, sulfate has been reported to have an adverse effect on resin capacity for Cr6. **Figure 5-1** shows the correlation between sulfate and resin bed volumes for breakthrough to 2 µg/L and 8 µg/L. **Figure 5-1** reflects data reported in the literature for various SBA resins and water qualities. Overall, the number of resin bed volumes of water treated decreases dramatically with increases in sulfate concentration. For sulfate concentrations of 20 mg/L, the estimated number of bed volumes to reach 2 µg/L is approximately 11,000. For sulfate concentrations of 50 mg/L, the estimated number of bed volumes to reach 2 µg/L is approximately 4,600.



Schematic of Unit Processes in the SBA Treatment Process

SBA resin is not sensitive to the raw water pH for effective Cr6 removal (unlike WBA resin), which eliminates the need for pre-treatment pH adjustment. However, post-treatment pH adjustment may be necessary, especially when the treated water quality is corrosive to piping materials. Calcium carbonate precipitation potential (CCPP) or Langelier Saturation Index below zero can be used as indicators of water corrosivity.



Alkalinity is removed by the resin for a short period during each resin service cycle after regeneration, which results in reduced pH in treated water. Treated water alkalinity and pH typically return to a level consistent with the raw water concentration in a day.⁷ If multiple vessels are operating in parallel or water is bypassed around treatment with final blending, sudden changes in alkalinity and pH can be minimized. Alternatively, pH of the treated water can be adjusted to ensure the water is not corrosive to the distribution system piping.

Case studies of SBA are summarized in **Table 5-2**. SBA has been tested extensively from bench- to full-scale for Cr6 removal, including by CVWD⁸. All studies showed SBA can remove Cr6 effectively and consistently below 10 µg/L.

Spent brine has been reported to be a non-RCRA (Resource Conservation and Recovery Act) hazardous waste due to the high Cr6 concentrations. Spent brine can be either disposed of as a non-RCRA hazardous waste at a high price or can be treated to remove Cr6 before disposal. Residuals management is a critical part of Cr6 treatment by SBA, which is an experience confirmed by CVWD's operation of their SBA systems for arsenic removal. Strategies to minimize residual volumes include regeneration optimization, segmented regeneration, and brine recycle with or without treatment (Section 5.2.5). For SBA with brine recycle, water loss is anticipated to be 0.007 to 0.05% of the treated water flow for Cr6 removal from CVWD's wells, depending on well water quality and regeneration frequency.

5.2.2. WEAK BASE ANION EXCHANGE (WBA)

A schematic of the WBA treatment process is shown on the next page. Like SBA systems, bag filters are typically used to remove particles to minimize pressure drop in the resin bed and minimize backwashing. WBA requires a low pH (6.0) to effectively remove Cr6. At a higher pH, Cr6 is still removed; however, the resin capacity is less and breakthrough occurs earlier. Carbon dioxide (CO₂) or acid (sulfuric or hydrochloric) can be used to lower the pH. The CO₂ or acid dose is dependent on water quality, primarily alkalinity and pH in raw water. A high alkalinity and high initial pH would require a high CO₂ or acid dose. Use of an online pH meter combined with CO₂ or acid feed rate monitoring is effective for good pH control.

WBA resin removes Cr6 from water and converts Cr6 to Cr3 whereas SBA retains Cr6⁹. Cr6 concentrations in the treated water (i.e. the resin vessel effluent) gradually increase over time as the resin capacity for Cr6 becomes exhausted. When the treated Cr6 concentration reaches the treatment target level, the resin needs to be replaced. WBA resins are not regenerated due to the presence of Cr3 on the resins and difficulty in regeneration.

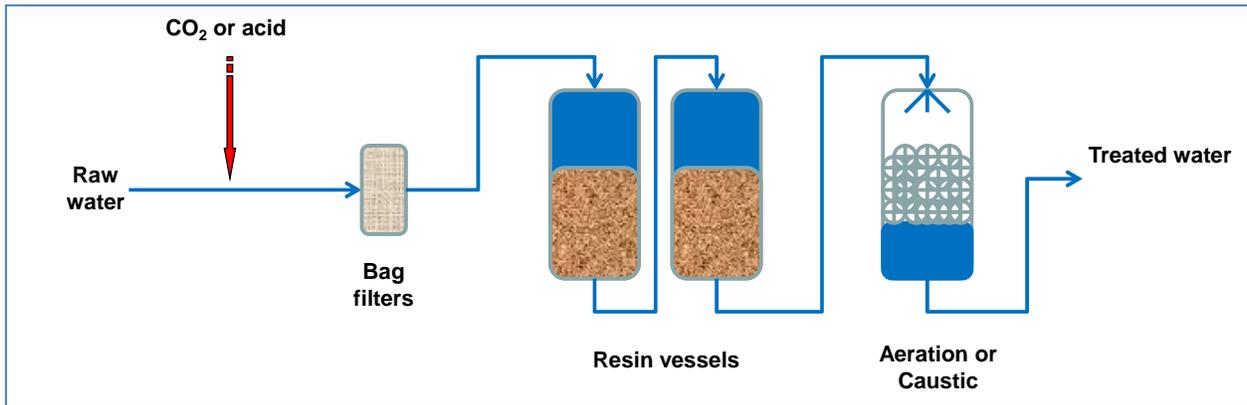
⁷ Clifford, D., Lin, C.C., Horng, L.L. and Boegel, J. 1987. Nitrate removal from drinking water in Glendale, Arizona. EPA/600/S2-86/107.

⁸ Chowdhury, Z., Bigley, S., Porter, K.L., Francis, C., Imamura, G., Blute, N., Rhoades, J., Westerhoff, P., and Bowen, A. 2015. Evaluation of Technologies for Hexavalent Chromium Removal and Development of a Compliance Planning Approach. Water Research Foundation, Reports 4445 and 4516.

⁹ McGuire, M.J., Blute, N.K., Qin, G., Kavounas, P., Froelich, D., and Fong, L. 2007. Hexavalent Chromium Removal Using Anion Exchange and Reduction with Coagulation and Filtration. Awwa Research Foundation.



Select WBA resins have a much greater Cr6 capacity than SBA resins. For example, WBA resins may last for more than one year while SBA resins typically need to be regenerated every few weeks. A lead/lag configuration is typically applied to maximize resin usage in the lead vessel. After the resin in the lead vessel is replaced, the two vessels are switched (i.e. the previous lag vessel serves as the lead). Post-treatment pH adjustment is necessary to raise pH so that the treated water quality is not corrosive. Aeration can be used if CO₂ was used to decrease the pH, and caustic can be used if acid was used to decrease pH.



Schematic of Unit Processes in the WBA Treatment Process

Case studies for WBA are summarized in **Table 5-3**. WBA has been tested extensively from bench- to demonstration-scale (425-gpm) for Cr6 removal. All studies have shown that WBA can effectively and reliably remove Cr6 to below 10 µg/L. Resin life varies based on raw water qualities, resins, and test conditions. pH 6.0 was shown to be effective for Cr6 removal. A lower pH of 5.5 did not show improved Cr6 removal compared to pH 6.0.¹⁰ In addition, Cr3 leaching at a lower pH of less than 5.5 is a concern.¹¹ Thus, pH 6.0 is considered the optimal pH condition, and an effective operating range has been 5.8 to 6.1 at Glendale, CA.

WBA residuals include spent resin, flush water generated at resin replacement and potentially backwash wastewater (although backwash is not expected unless the well is a sand/silt producer). Spent resin is expected to be a non-RCRA hazardous waste due to a high chromium concentration above the California

¹⁰ Najm, I., Brown, N.P., Seo, E., Gallagher, B., Gramith, K., Blute, N., Wu, X., Yoo, M., Liang, S., Maceiko, S., Kader, S., and Lowry, J. 2014. Impact of Water Quality on Hexavalent Chromium Removal Efficiency and Cost. Water Research Foundation.

¹¹ McGuire, M.J., Blute, N.K., Qin, G., Kavounas, P., Froelich, D., and Fong, L. 2007. Hexavalent Chromium Removal Using Anion Exchange and Reduction with Coagulation and Filtration. Awwa Research Foundation.



Total Threshold Limit Concentration (TTLC), as shown in CVWD pilot testing¹². Addition of absorbent material to sequester water is expected to be necessary, and may avoid a low-level radioactive waste characterization, rendering the spent resin a technologically enhanced naturally occurring radioactive material (TENORM) waste. In this case, the spent resin would need to be disposed of at a non-RCRA, hazardous waste landfill that accepts TENORM waste.

Wastewater (either flush or backwash waste) is expected to be non-hazardous, which can be discharged to a sewer, blow off location, or trucked offsite without treatment. For WBA, water loss is predicted to be less than 0.01% of the treated water flow for Cr6 removal from CVWD's wells.

One of the WBA resins (Dow PWA7) leached formaldehyde above the 100 µg/L California notification level when fresh resin was installed at Glendale. Dow recently revised their resin preconditioning procedure, which was tested and found to be effective in a pilot study to control formaldehyde leaching. Formaldehyde leaching did not occur with the other two resins (Purolite S106 and ResinTech SIR-700).

Because aeration is often used with WBA and groundwater can contain radon, a review of potential regulations on aeration emissions was conducted. Analysis (including discussion with the South Coast Air Quality Management District) did not find any standards at the federal or California levels regulating radon emission from drinking water treatment facilities.^{13,14} Radon in drinking water is currently not regulated by USEPA or California, although USEPA proposed an MCL of 300 pCi/L in 1999.⁵ Radon emission from drinking water treatment is likely to be sufficiently diluted by proper venting. A USEPA report assessed the risk of off-gas exposure from treating drinking water to remove radon for 20 water systems. The report found the estimated number of fatalities from treatment plant off-gas emissions to outdoor air was *de minimis*.⁶ Good ventilation surrounding aeration is recommended to manage radon in aeration off-gas.

5.2.3. REDUCTION/COAGULATION/FILTRATION (RCF) AND REDUCTION/COAGULATION/MICROFILTRATION (RCMF)

A schematic of the RCF treatment process is shown on the following page. The RCF process consists of ferrous iron addition and a reduction tank that provides time for ferrous reduction of Cr6 to Cr3 and coagulation, hypochlorite addition (or aeration) to oxidize remaining ferrous to ferric, polymer addition to a rapid mixing tank to enhance floc formation, and granular media filtration or microfiltration (without polymer). During the RCF process, Cr6 is reduced to Cr3 by ferrous iron and is co-precipitated or adsorbed by iron hydroxides, which are then removed by filtration.

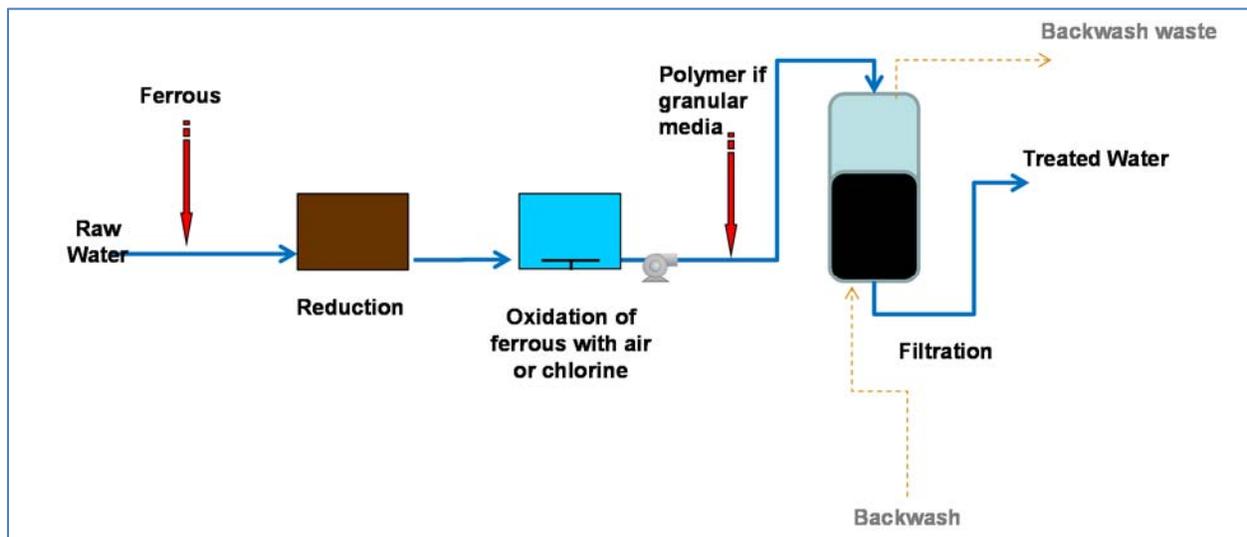
¹² Chowdhury, Z., Bigley, S., Porter, K.L., Francis, C., Imamura, G., Blute, N., Rhoades, J., Westerhoff, P., and Bowen, A. 2015. Evaluation of Technologies for Hexavalent Chromium Removal and Development of a Compliance Planning Approach. Water Research Foundation, Reports 4445 and 4516.

¹³ USEPA, 1999. Technologies and Costs for the Removal of Radon from Drinking Water. EPA 815-D-99-004.

¹⁴ USEPA, 2012. Report to Congress: Radon in Drinking Water Regulations.



The reduction step effectively converts Cr₆ to less than 1 µg/L, leaving Cr₃ in the water. Granular media filters can consistently remove the Cr₃ to below 5 µg/L, while microfiltration can remove Cr₃ to below 1 µg/L. The process with granular media filters is referred to as “RCF”, and with microfiltration is referred as “RCMF”. Filter backwash wastewater contains chromium (Cr₃), which may be directly discharged to the sewer if allowed. The filter backwash wastewater can also be treated for solids removal and recycled to the head of the process as demonstrated at the City of Glendale. The dewatered solids are classified as non-RCRA, California hazardous waste due to total Cr concentration above the California TTLC but below the federal toxicity characteristic leaching procedure (TCLP) limit. Wastewaters that are generated from chemical cleaning and/or clean-in-place (CIP) need to be treated before disposal. The RCF/RCMF process with recycle is anticipated require a larger footprint than SBA or WBA.



Schematic of Unit Processes in the RCF Treatment Process

Case studies for RCF and RCMF are summarized in **Table 5-4**. RCF has been tested at demonstration scale (100 gpm) at Glendale for three years, which showed effective removal of Cr₆ to below 1 µg/L and total Cr to below 5 µg/L. Two other studies (a bench-scale test by CVWD¹⁵ and a Water Research Foundation study¹⁶) confirmed similar or improved RCF effectiveness. Ferrous iron dose and reduction time are the two primary factors affecting Cr₆ reduction. The RCMF process was pilot tested at Glendale and CVWD¹⁴. Both studies showed improved Cr removal for RCMF compared to RCF.

¹⁵ Chowdhury, Z., Bigley, S., Porter, K.L., Francis, C., Imamura, G., Blute, N., Rhoades, J., Westerhoff, P., and Bowen, A. 2015. Evaluation of Technologies for Hexavalent Chromium Removal and Development of a Compliance Planning Approach. Water Research Foundation, Reports 4445 and 4516.

¹⁶ Najm, I., Brown, N.P., Seo, E., Gallagher, B., Gramith, K., Blute, N., Wu, X., Yoo, M., Liang, S., Maceiko, S., Kader, S., and Lowry, J. 2014. Impact of Water Quality on Hexavalent Chromium Removal Efficiency and Cost. Water Research Foundation.

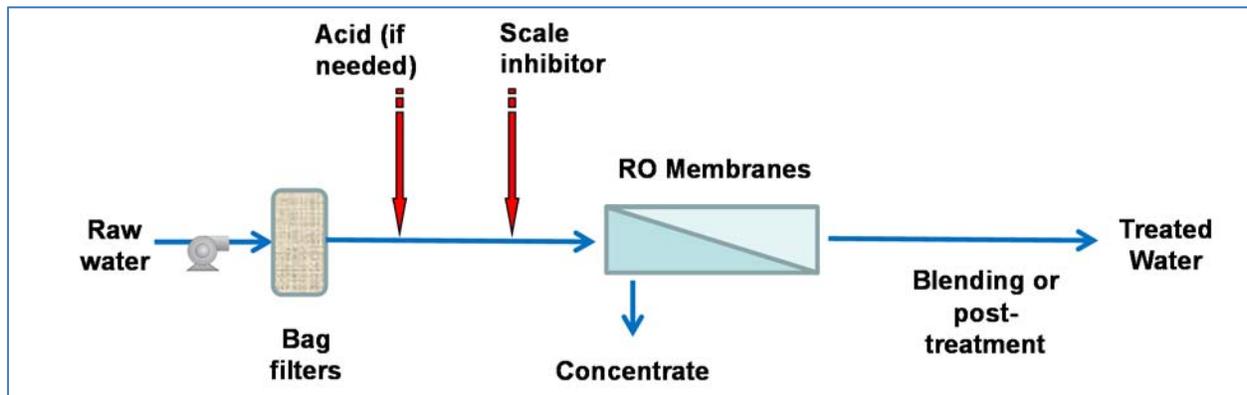


RCF and RCMF are less susceptible to water quality changes than SBA or WBA. RCF and RCMF can be adjusted to address Cr6 concentration changes by adjusting chemical doses. However, RCF and RCMF may not be resilient to flow rates significantly above the design flow rate due to necessary reduction times.

Estimates of the amount of backwash wastewater discharged to the sewer range from 3% to 5% of the RCF/RCMF influent flow. RCF/RCMF wastewater would add approximately 7% to 17% to the average daily sewage flows currently being treated at Water Reclamation Plants (WRPs) 4, 7 and 10 and would approximately triple the total chromium concentration in the biosolids from the WRPs, although biosolids would likely remain below the threshold for hazardous waste in the TTLC test (soluble threshold limit concentration, STLC, and TCLP are unknown). The high amount of wastewater produced by this process is an important drawback as water systems search for ways to use water supplies more efficiently. If solids handling processes are used to recover backwash water, additional facilities are needed on-site and operational complexity and cost increases.

5.2.4. REVERSE OSMOSIS (RO)

A schematic of the RO treatment process is shown below. RO removes contaminants by applying pressure to force water through the membranes while retaining the contaminants on the other side of the membranes. Pre-treatment may be necessary to enhance removal efficiency and/or help control membrane fouling, and post-treatment or blending is needed to stabilize the effluent with respect to corrosion in the distribution system. RO is capable of simultaneously removing a number of other contaminants or water quality parameters, such as nitrate, sulfate and chloride. The primary residual is membrane reject concentrate (low strength brine), which for groundwater systems typically accounts for 15 to 25 percent of the total feed flow. This concentrate waste results in a significant water loss.



Schematic of Unit Processes in the RO Treatment Process

Case studies for RO treatment of Cr6 are summarized in **Table 5-5**. The limited case studies are due to a lack of a Cr6 MCL in the past. Although there are many applications of RO systems, Cr6 was likely not tested or reported. RO was tested at the bench-scale at Glendale in 2002, which suggested effective Cr6 removal in the range of 74% to 99% (depending on the membrane models). More recently, RO was tested



at Hinkley as a point-of-entry and point-of-use house treatment, which effectively removed Cr6 to non-detect (0.02 µg/L). The RO brine accounted for approximately 24% of the whole flow in the whole house RO treatment system. The RO brine was a non-hazardous waste in California; however, it contained radionuclides and uranium and therefore was a TENORM waste.

5.2.5. ADSORPTIVE MEDIA

Several adsorptive media were tested for Cr6 removal as listed in **Table 5-6**. Zeolite and granular activated carbon (GAC) did not show high Cr6 adsorption capacity when tested at Glendale. For an influent Cr6 concentration of 100 µg/L, Cr6 in treated water reached 5 µg/L at approximately 600 bed volumes (BV) with a 5-min empty bed contact time (EBCT) for GAC. Zeolite media required a long EBCT of 30 minutes and de-aeration, also yielding 5 µg/L in treated water at approximately 600 BVs.

Iron adsorptive media showed promise of higher adsorption capacity than SBA resin in early bench testing at Glendale. Sulfur Modified Iron (SMI®) media in particular had a high adsorption capacity but released concentrations of iron at the time of pilot testing that required additional iron removal. Testing would be necessary to evaluate SMI® performance for Cr6 removal and system operational requirements (pH adjustment, media backwash, iron and other constituents leaching, etc.).

Another iron adsorptive media, Cleanit®, was recently pilot tested at Glendale. The treated water Cr6 concentration reached 10 µg/L at 2,446 BVs and full breakthrough at 3,096 BVs, without pre-treatment pH adjustment or routine acid regenerations. The manufacturer indicates that routine acid regenerations (e.g. weekly) before breakthrough may improve Cr6 capacity. Due to the relatively long EBCT (15 minutes), the footprint for the media vessels would be much larger than for SBA or WBA vessels (3-minute EBCT). In addition, significant iron leaching from the media was observed (above the secondary MCL for iron), which required filtration as a post treatment.

A modified activated carbon developed by ToxSorb was recently pilot tested in Indio, California for Cr6 removal. ToxSorb reports that this is the first pilot for drinking water in the United States, although the media has been applied in industrial water treatment in Israel and Italy. The pilot process consists of pre-treatment (hydrochloric acid for pH reduction and hypochlorite for oxidation reduction potential control), a media vessel, post-treatment pH adjustment using caustic soda, and a backwash and regeneration system. Preliminary data suggest treated total Cr concentrations reached 2.4 µg/L at approximately 4,800 BVs during one of the four test runs. During two other test runs, effluent total Cr concentration fluctuated between 1.9 ppb and 28 µg/L without typical breakthrough curves. The most recent fourth run showed treated total Cr concentrations between 1.1 and 10 µg/L in manually collected samples. A number of datapoints above 10 µg/L (420, 250, 63 and 59 µg/L) were observed, which ToxSorb identified to be due to autosampler collection of media and subsequent digestion of that media. Media is regenerated using acid, through the conversion of Cr6 adsorbed onto the media to Cr3, which is released into the solution. Spent brine containing Cr3 is then dosed with caustic soda to cause Cr3 precipitation. The primary residuals include spent brine, settled solids containing Cr3, and backwash wastewater. ToxSorb intends to test recycling of the spent brine back to the head of the plant due to the low volume of waste and



characterization after removal of the chromium component. CVWD concluded that this technology requires more research prior to consideration as a feasible technology for Cr6 compliance.

Adsorptive media is not a BAT technology for Cr6 and would require conditional approval from California WaterBoard's DDW and likely pilot testing at CVWD prior to use. Given the information available at this time and CVWD's commitment to achieving compliance as soon as possible with the Cr6 regulation, no clear advantages are offered over WBA, SBA, or RCF/RCMF for CVWD to justify a delay in technology selection.

5.2.6. BIOLOGICAL TREATMENT

Biological treatment for potable supplies consists of either treatment that relies on native bacteria in the water to populate filter media (i.e., biofiltration) with or without nutrient and carbon supplements, or inoculation of microorganisms into the treatment process for targeted removal of constituents that would not be otherwise removed in a cost or time effective way using indigenous bacteria.

Biological treatment for removal of inorganic constituents like nitrate and perchlorate has not gained market share in the drinking water industry at this point primarily due to costs of treatment compared with other technologies and operational considerations. Biological treatment is most beneficial for treating constituents that have challenging treatment constraints such as nitrate removal when brine discharge is costly or difficult. By comparison, biofiltration using native bacteria is more common in drinking water treatment.

Biological treatment systems can be categorized into two groups, autotrophic and heterotrophic, based on the carbon source and electron donor used by the bacteria. Autotrophic systems usually use hydrogen gas as the electron donor and inorganic carbon (e.g. alkalinity) as the carbon source and often do not require nutrient addition. Heterotrophic systems use organic compounds (e.g. acetic acid) as an electron donor and carbon source and often require nutrient addition (e.g. phosphoric acid). Most biological treatment systems applied to water treatment (primarily for nitrate and perchlorate removal from wastewater) use organic carbon compounds (i.e., are heterotrophic).

The schematic below shows a typical biological process for drinking water treatment, which uses anoxic, heterotrophic microorganisms. Acetic acid is often added as an electron donor and phosphate (in the form of phosphoric acid) is added as a nutrient. A biological contactor allows microorganisms to grow and reproduce, and contaminants are reduced in this contactor (e.g., nitrate to nitrogen gas, perchlorate to chloride, Cr6 to Cr3).

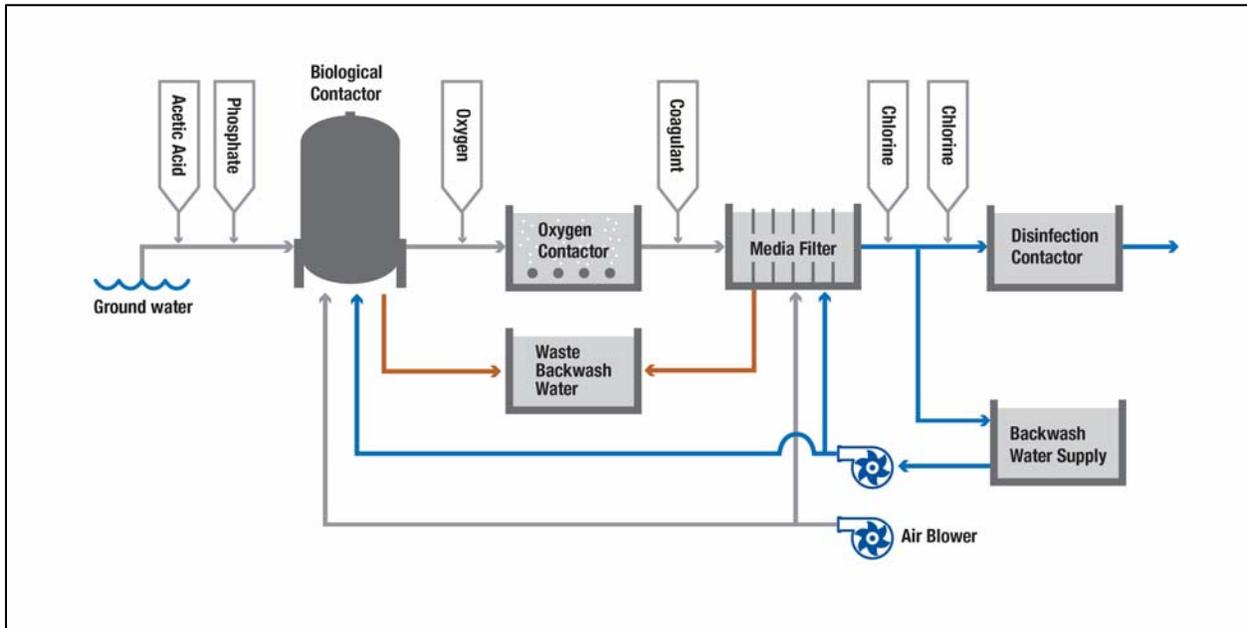
Two types of biological contactors are available, including a fluidized bed reactor (FBR) and fixed or packed bed reactor (FXB). Oxygen can be added after the biological reactor to boost the oxygen level after the anoxic process, or ozone can provide oxygen as well as oxidation of reducing compounds like sulfide that may be generated. With respect to chromium, Cr6 is converted to Cr3, which requires removal to minimize subsequent reoxidation of Cr3 to Cr6 by oxidants such as chlorine or chloramine. Coagulation and filtration are often needed to remove Cr3 as well as biomass and particles prior to distribution of treated water. A major limitation with biological treatment is the need for downstream filtration to achieve



Surface Water Treatment Rule requirements as a condition of treatment according to DDW permitting if microorganisms are inoculated into the treatment process. Residuals consist of wastewater from the biological contactor and filter backwashes. Water loss varies from 1% to greater than 10%, depending on backwash procedures and frequency.

Case studies for biological treatment of Cr6 are summarized in **Table 5-7**. All studies reported effective removal of Cr6 by biological reactors to below 5 µg/L or non-detect. However, total Cr in biological reactor effluents was often close to or above 10 µg/L. Although it is expected that total Cr can be effectively removed by coagulation and filtration (similar to RCF), little data are available on total Cr removal by post biological treatment processes. Total Cr removal would need to be validated before full-scale application of this technology.

Nitrate and perchlorate have been effectively removed by biological treatment. Thus, for water sources that contain nitrate, perchlorate and Cr6, biological treatment has the advantage of simultaneous removal of multiple contaminants and potentially generating less waste than SBA for nitrate (which reaches breakthrough much sooner than Cr6). The only full scale biological treatment system for drinking water removal of nitrate and perchlorate is in Rialto, California. However, the plant does not remove Cr6 and was therefore not included in **Table 5-7**. It is also not yet in full service operation, so no full-scale record of performance exists.



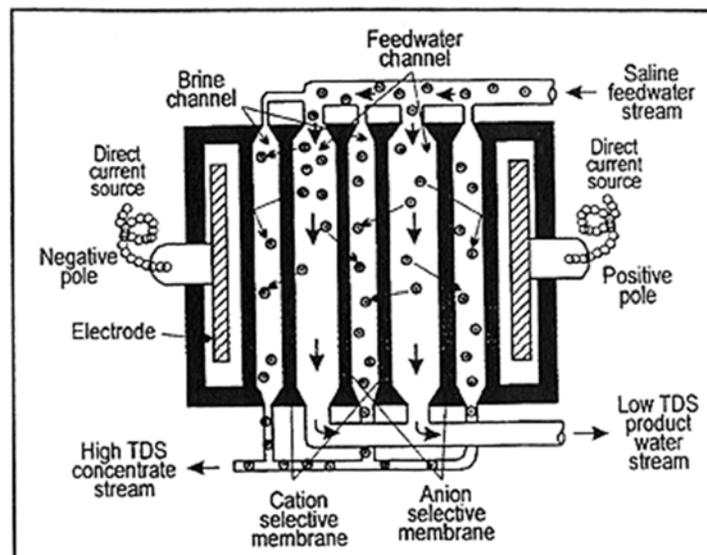
Schematic of Unit Processes in the Biological Treatment Process

Biological treatment is not a BAT technology for Cr6 and would require conditional approval from DDW and likely pilot testing. Overall, biological treatment does not appear to offer advantages over WBA, SBA, or RCF for CVWD removal of Cr6. Additional discussion is provided in Section 5.2.4 regarding nitrate removal with biological treatment.



5.2.7. ELECTRODIALYSIS AND ELECTRODIALYSIS REVERSAL (ED/EDR)

Electrodialysis (ED) is an electrically-driven membrane process in which ions are transported through ion-exchange membranes from one compartment to another under the influence of an applied electric potential difference. EDR is similar to ED, except the electrical charge to the membrane is reversed after a specific time interval to prevent membrane scaling. A schematic of the process is presented below. ED/EDR typically requires pre-treatment to removal particles and minimize membrane fouling, and post-treatment to stabilize water quality. Membranes in ED are susceptible to membrane fouling, especially when contaminants are present at relatively high concentrations. In addition to Cr₆, nitrate and uranium can also be removed by ED/EDR¹⁷. The water recovery rate for ED/EDR is 85-95%, which is higher than RO¹⁷ but lower than WBA, SBA, or RCF. Treatment of the significant brine stream and disposal of the spent membranes are two potentially complicating factors.



Schematic of the Electrodialysis Process

Source: <http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8d/desalination.asp>

ED/EDR has been used to remove and recover chromium from industrial wastewater, which can contain Cr₆ at milligram-per-liter (mg/L) to gram-per-liter (g/L) levels. One bench-scale study in India reported Cr₆ removal from 10 mg/L to below 0.1 mg/L using ED¹⁸ (**Table 5-8**). Another lab study in Italy reported Cr₆ removal to <0.01 mg/L from 25 mg/L. However, no studies have been found on microgram-per liter (µg/L)

¹⁷ American Water Works Association (AWWA), 1999. Electrodialysis and Electrodialysis Reversal. AWWA Manual M38, first edition.

¹⁸ Nataraj, S.K., Hosamani, K.M., Aminabhavi, T.M., 2007. Potential application of an electrodialysis pilot plant containing ion-exchange membranes in chromium removal. *Desalination*, 217: 181-190.



level Cr6 removal from drinking water. Although full scale applications of ED/EDR exist in Arizona, Oklahoma and California, no Cr6 removal was tested or reported in those studies. ED/EDR is not a BAT technology for Cr6, and would require conditional approval from DDW and likely pilot testing. Given the information available at this time and CVWD's commitment to achieving compliance as soon as possible with the Cr6 regulation, ED/EDR does not appear to offer advantages over WBA, SBA, RCF for CVWD.

5.2.8. CONDITIONAL APPROVAL OF NON-BAT TECHNOLOGY

Adsorptive media, biological and ED/EDR are not listed as BATs for Cr6 drinking water treatment in California. According to DDW, treatment technologies that are not specified as BATs during the regulation adoption process will generally need to receive Conditional Acceptance by DDW's Water Treatment Committee prior to full scale implementation at a public water system. The goal of the Conditional Acceptance process is to gather sufficient information in a thorough challenge test so that the committee can make a determination that the treatment process is effective and robust enough to be implemented on a full scale basis at public water systems. Studies must be conducted to demonstrate the process can effectively remove constituents of concern. The pilot studies should be conducted in sufficient detail to identify critical design and operating factors and demonstrate the relationship between these factors so that the limiting design and operational factors can be identified for specific sites and water quality conditions. Credit may be given for demonstrations completed on similar source waters elsewhere.

In addition to effective Cr6 removal, the finished water must be stabilized by pH adjustment so that the treated water will not cause corrosion issues in the distribution system. If bypass is used, it must be demonstrated that the water quality from the treatment process is consistently high, so that a blending scheme can be reliably implemented. If the water source is operated intermittently, enhanced testing is required to ensure treated water quality remains acceptable following extended rest periods.

For biological treatment processes, DDW has specified the following performance criteria to ensure simultaneous compliance with various drinking water regulations. In addition, biological treatment vendors must demonstrate the capability of the biological process and the integration of the filtration and disinfection processes to achieve these performance criteria.

- Treated water must receive 4-log virus inactivation. Inactivation must be achieved prior to the first service connection of the distribution system.
- Treated water must be coliform free. Weekly or monthly samples collected at the end of the disinfection treatment process will be required.
- Treated water must contain heterotrophic plate count (HPC) bacteria of less than 500 colony forming units per milliliter (cfu/mL). Weekly or monthly samples collected at the end of the disinfection treatment process will be required.
- Individual filtered water effluent turbidity shall be 0.3 nephelometric turbidity units (NTU) or less, 95% of the time. Continuous monitoring of filter effluent will be required.
- Corrosivity of the effluent water must be monitored and controlled prior to distribution, if necessary. Daily treated water pH reading of the plant effluent will be required.



- Distribution system disinfectant by-products samples must be collected based on the Stage 2 Disinfectant / Disinfection By-Products Rule and must comply with Locational Running Annual Average (LRAA) Total trihalomethanes (TTHM) and Haloacetic Acids (HAA5) MCLs.
- Treated water must consistently meet secondary drinking water standards for taste and odor.
- Treated water must be adequately re-oxygenated prior to distribution.

5.3 WATER QUALITY IMPACTS ON CR6 TREATMENT SELECTION

Co-occurring constituents in groundwater can affect treatment selection and operations. For example, sloughing of nitrate (i.e., chromatographic peaking) can occur with SBA for Cr6 removal. Solutions for minimizing impacts from nitrate peaking could be incorporated into the design, such as blending of treatment vessels and/or online nitrate monitoring to discharge water in excess of the MCL to waste. Potential constituents of concern that were identified in the database for some active or inactive wells were evaluated in this Study (Appendix A) and included nitrate, sulfate, pH, alkalinity, and uranium.

Many of CVWD's wells have low nitrate (less than 10 mg/L as NO_3^-) compared with the MCL of 45 mg/L as NO_3^- . While these wells do not require nitrate treatment, the impact of nitrate concentrations was considered when evaluating SBA resin for Cr6 treatment. Nitrate is removed by SBA resin for a short amount of treatment time (usually less than 200-400 bed volumes) compared with Cr6, which has a higher selectivity (typically 2,000 to 15,000 bed volumes for most CVWD wells). Once nitrate is at capacity on the resin ion exchange sites, chromatographic peaking can occur that results in release of nitrate at concentrations two to four times higher than the influent concentration.

To provide a conservative assumption in this analysis, wells exceeding 10 mg/L NO_3^- were identified as needing design features to mitigate potential chromatographic peaking (**Table 5-9**). Examples of mitigation strategies include use of online nitrate monitoring with the ability to discharge water with nitrate above the MCL, or use of multiple vessels in parallel to minimize peaking effects. In general, few of CVWD's active wells will be impacted by the additional need for nitrate monitoring or parallel vessel design.

Sulfate is another constituent that impacts SBA design and operations. Based on the previous studies conducted by Hazen and Sawyer and other teams, sulfate was found to be the key driver for SBA resin life. For WBA facilities, pH and alkalinity are important constituents in that they affect the required acid dose. CVWD water quality monitoring results for these constituents were used in the Cr6 treatment evaluation to provide CVWD with a water quality-specific assessment of treatment options and costs by well. Finally, uranium removal was considered in this Study to estimate disposal costs for treatment processes. Additional discussion on the impacts of these parameters is provided in subsequent sections.

5.4 APPROACHES FOR OTHER CONSTITUENTS OF CONCERN

Based on the review of Cr6 technologies above, the most mature, proven, and applicable technologies for CVWD include SBA, WBA, and RCF/RCMF. While Cr6 is the primary constituent that needs to be treated immediately for 31 of CVWD's active groundwater wells, other constituents were considered in assessing



technology applicability so that maximum flexibility could be attained by CVWD in addressing upcoming regulations. In addition, treatment options for rising constituent of concern concentrations were assessed.

5.4.1. REGULATED CONSTITUENTS OF CONCERN

As identified in Section 3, regulated constituents of concern to CVWD that were identified in CVWD groundwater wells include nitrate, arsenic, VOCs, TDS, and perchlorate. In California, Best Available Technologies for each of these constituents and technology applicability are listed in **Table 5-10**.

The technologies shown to be most applicable to the various constituents of concern in CVWD's groundwater wells are SBA and RO, since Cr6, nitrate, arsenic, and perchlorate are all anions removable by these processes. In addition, RO would also remove TDS but at the expense of high water loss. VOC treatment would require processes such as aeration and/or granular activated carbon, which would be in addition to other treatment. At most CVWD well sites with VOCs present, nitrate concentrations are elevated or high.

A notable difference in the operation of SBA for nitrate and arsenic compared with Cr6 is a lower number of bed volumes treated before regeneration is required. A relative comparison of SBA applicability for removal of these constituents is provided in **Table 5-11** in relative numbers of bed volumes and waste production for each of the constituents. While site and treatment goal specific analysis would be necessary to further refine this information, the summary is intended to compare feasibility of treatment for the regulated constituents of concern in CVWD groundwater to help prioritize treatment decisions if choosing between constituents of concern. For example, a typical number of bed volumes of water treated for nitrate is approximately 200-400 BV and for arsenic is approximately 1,000 BV, compared with 2,000 to 15,000 BV for Cr6 in CVWD wells. On-site regeneration would likely be necessary for nitrate and arsenic removal due to the frequency of regeneration, whereas Cr6 removal can include offsite regeneration and return of resin.

Nitrate removal at CVWD well sites would be challenging due to frequency of regeneration and hence the quantity of brine generated at the largely residential well sites. For a typical 2,000 gpm CVWD groundwater well, an estimate of brine generation is approximately one to two tanker trucks of brine per day. Brine generated from nitrate treatment would not be hazardous, but the quantities would be difficult to manage due to the lack of sewers or a brine line in CVWD's service area that can accommodate the high salt brine. Arsenic treatment would allow for a longer run than nitrate before resin regeneration, but brine produced would be hazardous as at CVWD's arsenic ion exchange treatment plants. Arsenic is more challenging to treat compared with Cr6 due to the lower number of bed volumes of throughput.

Perchlorate can also be removed by SBA, either using regenerable resin or single-pass resin. Use of regenerable resin would yield a brine containing perchlorate, which is difficult to treat and may pose a liability concern if untreated. Single-pass resin, on the other hand, has become a cost-effective alternative due to the development of high-capacity tributylamine single-pass resins that do not need regeneration.

Biological treatment was considered for applicability in Cr6 removal and also for nitrate and perchlorate (for which this treatment process is BAT). Pilot studies in drinking water treatment have shown biological



treatment to be effective for nitrate and perchlorate, and full-scale industrial experience exists for nitrate and perchlorate removal. The first full-scale drinking water treatment plant for biological removal of nitrate and perchlorate has been constructed in Rialto, California but awaits startup in 2015. Primary challenges with biological treatment that would be encountered at CVWD include the intermittent well operational strategy that may not effectively sustain the bacterial populations, the small footprint available at well sites, and added operational complexity, as summarized in **Table 5-12**.

Biological treatment was identified as having potential applicability in CVWD's system as a pre-treatment step for surface water treatment if nitrate treatment is necessary for the wells feeding the surface water treatment plant (i.e., if blending was not sufficient for decreasing nitrate concentrations). Pilot testing would be needed to determine design criteria and gain DDW permitting approval, and could be included as a component in the surface water treatment pilot.

Overall, SBA treatment is most applicable to the primary regulated constituents of concern in CVWD groundwater. SBA treatment of Cr6 is advantageous over nitrate and arsenic due to brine volumes generated, which is an important factor for CVWD due to the large number of well sites, small footprint available at many sites, and locations in residential areas where truck traffic minimization is desirable. Perchlorate removal with single-pass perchlorate-selective resins would be preferable to regenerable SBA due to difficulty in removing perchlorate from waste brine. VOC treatment would require processes such as aeration and/or granular activated carbon, which would be in addition to the nitrate treatment required for those wells.

5.4.2. UNREGULATED CONSTITUENTS OF CONCERN WITH REASONABLY ANTICIPATED FUTURE REGULATORY SIGNIFICANCE

The water quality analysis in Section 3 of this Study identified strontium, chlorate, and vanadium as constituents of concern with reasonably anticipated regulatory significance that are a potential concern for CVWD based on available data, current reference levels, and CVWD practices. Chlorate is primarily a disinfectant by-product, rather than a groundwater contaminant of concern, and can be controlled through chlorination strategies; therefore no additional treatment is anticipated.

For this analysis of technology applicability for strontium and vanadium, the following resources were reviewed (1) CVWD pilot testing data, (2) USEPA Drinking Water Treatability Database, and (3) literature.

Strontium removal is not well characterized in the literature for drinking water treatment but can reasonably be expected to exhibit removal mechanisms similar to calcium, as a divalent cation. Ion exchange may be effective using cation exchange rather than anion exchange. Higher regeneration frequency is expected compared with SBA for Cr6 (i.e., less than 1,000 BV). Other technologies expected to be successful for strontium removal include lime softening and RO. Lime softening for multiple wellhead treatment systems is challenging due to the required footprint, solids generated, and operational complexity. Softening may be more advantageous in a surface water treatment approach should strontium removal be needed. Finally, RO would also remove strontium but would result in a significant water loss.



Vanadium has been shown in pilot testing to be removed by SBA and WBA but with a resin life that is shorter than for Cr6 (less than 1,200 BV for SBA and 100,000 for WBA). This means that the same vessels and Cr6 resin could be used to remove vanadium if a future regulation is established; however, more resin regenerations (likely on-site regeneration for SBA) or replacement (WBA) would likely be necessary.

Overall, among Cr6 treatment options, the ability to address constituents of concern with reasonably anticipated regulatory significance including strontium and vanadium is most compatible with the use of regenerable ion exchange, particularly with a central resin regeneration approach for brine treatment and disposal (described as follows). Additional vessels and on-site regeneration equipment would be expected to address these constituents, contingent on the future regulatory levels.

5.5 MINIMIZATION OF RESIDUALS HANDLING AND WASTE DISPOSAL

In this study, opportunities to streamline residuals handling and waste disposal with SBA were investigated. Pilot testing at CVWD and at other utilities has shown that extended runs of more than one month can often be achieved in groundwater with low sulfate (e.g., for wells less 40 mg/L, running full time), as is present in much of the Coachella Valley. This is in contrast to the much shorter run lengths experienced for arsenic at CVWD's treatment plants and what would be expected for nitrate treatment, due to the higher selectivity of the resins for Cr6. With extended run times observed in testing, the concept of centralizing SBA resin regeneration was raised by CVWD.

A CRRF was investigated as an option to consolidate regeneration operations for the numerous wells sites into one location. Central regeneration was identified as advantageous because it offers:

- A single location of delivery for salt and other treatment chemicals
- A single location for waste disposal
- Economies of scale for spent regenerant management
- Less complexity required at each of the individual well sites, by eliminating controls and equipment required for regeneration

Several options were evaluated to move resin to the CRRF, including sluicing resin from fixed vessels at well sites, transporting resin in trailer-mounted vessels, or use of mobile vessels that can be moved by forklift. Analysis of these approaches is provided in Appendix F, and indicated similar costs when all factors are considered. The approach preferred by CVWD, to minimize resin regeneration operational demands at the numerous well sites, was sluicing resin from fixed vessels at well sites. In this approach, resin would be transported from each well treatment site to a central facility where it would be regenerated then returned to the well treatment site. Industrial treatment processes and home water softener services commonly use central regeneration facilities similar to this concept. DDW was contacted during the Study to discuss the feasibility of central regeneration, with positive feedback attained particularly because CVWD would not run the risk of cross-contamination that an industrial facility might face.



The CRRF was conceptualized to consist of three major components:

- Resin regeneration
- Spent brine disposal (with or without treatment)
- Evaporation ponds for brine minimization

Once resin is transported to the CRRF, the resin will undergo a regeneration cycle consisting of four primary steps: (1) resin backwash, (2) brine regeneration, (3) slow rinse, and (4) fast rinse. Additional conceptual-level details of central regeneration design are provided in Section 10, including components necessary in the regeneration cycle.

A benefit of central regeneration is the ability to handle waste brine in one location for many different sites. Spent brine from an SBA process contains a high TDS concentration well above CVWD's discharge permit limitations for the WRP facilities due to Regional Water Quality Control Board restrictions. Spent brine also contains high Cr6 concentrations and other metals, making the brine a likely non-RCRA hazardous waste in California without treatment. Spent brine can either be disposed as non-RCRA hazardous waste or treated to remove hazardous constituents before disposal. Slow rinse waste from an SBA process is expected to contain a relatively high TDS concentration, which may also be above the sewer discharge limit. Similar to CVWD's arsenic treatment plants, brine could be treated and disposed offsite. However, due to the warm and dry climate, availability of land, and operational flexibility offered, evaporation ponds were evaluated as a potential approach for minimizing waste volumes.

The Coachella Valley has a high evaporation rate, estimated by the California Irrigation Management Information System (CIMIS) to be approximately 71 inches per year for dry pan evaporation. Taking into account annual precipitation, the net average annual rate is 63 inches per year. Standard evaporation allows for passive water removal from the waste. During the summer, with wind, the evaporation rate can be as much as 2 inches per day. During the winter, the rate may be reduced to 0.2 inches per day.

Options are available to facilitate the evaporation process, such as semi-enhanced evaporation or enhanced evaporation, which result in a smaller evaporation pond footprint. Enhanced evaporation uses the principle that more surface area is available with droplets when the brine is sprayed, resulting in a greater rate of evaporation. From experience, the evaporation rate with even slight spraying can be up to 3 – 4 times the standard evaporation rate. An approach to semi-enhanced evaporation operates by wetting evaporation surfaces, mounted on constructed modules. A pump brings the waste brine from a holding pond to a distribution network on top of the vertical surfaces, from which the vertical strips are fed by gravity. The device uses the driving power of the wind, which drives away excess humidity from the surface to intensify the evaporation process.

Additional analysis of brine character and disposal options was recommended based on the preliminary findings of this Study to build on the limited information available in practice and the literature. CVWD initiated additional SBA brine treatment and recycling pilot testing intended to inform preliminary design of treatment facilities.



5.6 CONCLUSIONS

Overall, no technology was identified that can effectively remove all constituents of concern for CVWD, in addition to Cr6, with acceptable water loss. RO would be most likely to remove most of the constituents, but RO has a high treatment cost and water loss compared with other BATs. Ion exchange technologies, in particular SBA, was found to offer CVWD the most flexibility in treating the constituents that are currently regulated and those reasonably anticipated to be regulated in the future. WBA was identified as potentially advantageous at higher sulfate sites as shown in CVWD pilot testing. RCF and RCMF were found to be effective for Cr6 removal at CVWD and elsewhere, but did not offer as much flexibility in treating other CVWD constituents of concern and larger facilities would be needed to minimize water loss through recycle of backwash water. No advantage of non-BAT technologies was identified over existing BATs for Cr6 removal that would support additional testing and project delays to accommodate this testing.

In this Study, an opportunity to perform resin regeneration at a central facility was identified. The central facility would minimize equipment necessary at each well site for SBA and consolidate operations, which are both advantageous for CVWD. This central resin regeneration facility was also viewed as offering CVWD flexibility to address future constituents that are removed by anion or cation exchange by offering regeneration and/or brine disposal. This approach was included in the evaluation of scenarios (Section 9).



6. GROUNDWATER TREATMENT EVALUATION

Information gathered and evaluated in this report's previous sections and appendices was used to identify blending (Section 6.1) and treatment options (Section 6.2) for achieving compliance with the Cr6 MCL. For treatment, two different potential approaches were evaluated, including wellhead treatment and clustered treatment accomplished by joining wells for larger treatment facilities. Costs (Section 6.3) and non-cost factors (Section 6.4) were assessed to identify optimal treatment approaches. The analysis included both Tier 1 and Tier 2 wells for conservatism in planning.

The process for selecting blending locations and clustered treatment sites included the following steps:

1. Data were collected for all active and inactive wells that were offline for water quality concerns (i.e., not wells offline for mechanical or other failure).
2. Active wells with Cr6 greater than 8 µg/L were identified on a map by pressure zone.
3. The Compliance Tool (WRF 4445¹⁹) was used to initially identify wells within 1 mile radii and assign preliminary clusters.
4. Blending opportunities for compliance were identified where pipeline costs were less than treatment costs.
5. Satellite maps were used to identify clustering opportunities that may be greater than 1 mile but that were cost-effective and served the same pressure zone (up to approximately 3 miles). Up to 5 wells were clustered to minimize distribution system pipeline upgrades that would be necessary for larger clusters. Economies of scale from clustering were analyzed for each cluster, accounting for additional pipeline costs.
6. Water quality data were reviewed to shift wells to another cluster if it was more cost effective than treating separately or if benefits from blending of other water quality constituents (e.g., sulfate) could be achieved from the clustering.
7. Locations for treatment were identified in collaboration with CVWD staff. Preference was given to using CVWD-owned land.
8. Costs for leading approaches were developed for each treatment cluster.
9. Treatment approaches for each cluster were identified using costs and other criteria established in Criterium DecisionPlus.
10. Costs were aggregated to provide an overall cost estimate for CVWD compliance.

In addition to a predominantly clustered treatment scenario, another scenario was also evaluated in which most sites have individual treatment to minimize pipeline installation. Further, three other scenarios were assembled in which surface water treatment plant(s) were constructed in lieu of some groundwater

¹⁹ Chowdhury, Z., Bigley, S., Porter, K.L., Francis, C., Imamura, G., Blute, N., Rhoades, J., Westerhoff, P., and Bowen, A. 2015. Evaluation of Technologies for Hexavalent Chromium Removal and Development of a Compliance Planning Approach. Water Research Foundation, Reports 4445 and 4516.



treatment or using groundwater wells for blending. Each scenario was analyzed with findings reported in Section 9.

6.1 BLENDING

Blending options were first considered as a means of compliance for wells that had sufficiently low Cr6 concentrations that were located near well(s) with low Cr6 to make blending a possible strategy. Treatment capital costs would be supplanted by pipeline installation or a tank, and long-term O&M costs would be lower. All active and inactive wells were reviewed to identify opportunities for blending. Inactive wells that are offline for nitrate or TDS were considered as potential blending wells; concentrations of both Cr6 and nitrate or TDS were evaluated in blends to identify whether the blends were feasible without treatment. Inactive wells with VOCs were not included, as blending is not a common approach to addressing VOCs and additional treatment (e.g., aeration and/or granular activated carbon) might be needed for these wells.

One blending opportunity was identified to achieve compliance for a Tier 1 well. Well 6723-1 is located on a well site with a tank that is fed by other wells and has a historical Cr6 maximum concentration of 11 µg/L, which would enable blending pending permitting approval by DDW. Analysis showed that blending could be cost-effectively achieved for several Tier 2 wells shown in **Table 6-1**, should treatment for those wells be necessary in the future.

No advantages were observed for blending Tier 1 wells with inactive wells. A detailed listing of the analysis is presented in Appendix E. Should Tier 2 wells become Tier 1 wells in the future, the analysis provided in Appendix E indicates where blending may be possible. In most cases, Cr6 data in the inactivated wells is sparse and would require additional characterization before detailed planning for reactivation.

6.2 CLUSTERED VS. WELLHEAD TREATMENT

The potential for combining wells for clustered treatment was evaluated and compared with wellhead treatment. Two scenarios were developed to analyze groundwater treatment locations, including:

- Scenario 1 – groundwater treatment with well clusters
- Scenario 2 – groundwater treatment with individual wellhead treatment

For the clustered treatment analysis, wells within approximately three miles and in the same pressure zone were grouped. A major challenge with clustered treatment is the need for significant lengths of transmission pipelines to join wells, since the CVWD system was originally designed for distributed flow into the network. While these pipelines are accounted for in the cost comparison, installation and the disruption of a large number of streets was viewed by CVWD staff as unfavorable for residents. An estimate of the pipeline lengths that would be required for a clustered groundwater treatment approach for Cr6 rule compliance is provided in Section 9.



An alternative to installing large quantities of pipelines is individual wellhead treatment systems. Due to the large number of wells needing treatment (31 Tier 1, and possibly 25 Tier 2 wells), an operationally simple approach was preferred by CVWD. Experience at the three CVWD arsenic treatment plants has demonstrated the complexity of onsite regeneration for SBA and resulting downtime that would be problematic for production if it occurred on a system-wide basis.

Potential economies of scale were evaluated to determine whether clustering wells for treatment could overcome additional costs associated with pipelines. In addition, CVWD staff requested that larger facilities necessary with clustered wells include a building, similar to the IXTPs for arsenic due to neighborhood impacts from a large-scale facility. By comparison, wellhead treatment consisting of several pressure vessels and other minor equipment was judged by CVWD staff to only need screening at most sites.

A comparison of net present value (NPV) of clustered treatment versus individual wellhead treatment at two sites is provided in **Figures 6-1** and **6-2**. These groupings represent treatment costs for WBA systems at these relatively high sulfate sites. Comparison of treatment on individual wells with clustered treatment indicated that economies of scale could be realized for clustered treatment due to blended water quality, facility sizing, and labor savings.

In addition to evaluating sites for clustered wells, individual sites were also investigated to identify available land for treatment. Available land size at each well site is summarized in Appendix A. Example layouts for the technologies were produced on an example site, Well 4510-1, that has 0.67 acres of land. **Figures 6-3, 6-4, and 6-5** show how the three treatment approaches fit onto the space typically available at most well sites – SBA with offsite central regeneration, WBA, and RCF. The figures show existing facilities depicted with an (E).

The layouts demonstrate that SBA with off-site regeneration and WBA can fit on most well sites. The RCF/RCMF treatment units require more space than was available at many well sites, and in some cases would require an extension of sewer service. As part of the analysis of treatment technology applicability at the clusters and well sites, an evaluation of well site sewer capacity was conducted to investigate feasibility of RCF/RCMF backwash water disposal. These costs were included in the technology comparison.

As described previously, the amount of concentrate and backwash would waste between 3% and 5% of the groundwater. This would add approximately 7% to 17% to the average daily sewage flows currently being treated at WRP 4, 7 and 10. An estimate of the extension of sewer service to well sites for RCF/RCMF was conducted and included in the technology comparison costs.

Each cluster location was assessed to determine the closest existing sewage pipe, the size of this existing pipe, the diameter and length of new pipe that would be needed to connect to the cluster to the existing sewage pipe, and the resulting cost of these additions. Most clusters were within reasonable distance to an existing sewer (50 to 150 feet), and most of the existing sewers had enough capacity to support the additional flow. The total length of additional pipe needed for these extensions was estimated to be 8,300 feet and was included in the cost estimates for RCF and RCMF.



6.3 COST ESTIMATE BASIS

Conceptual level capital costs were generated using Hazen and Sawyer cost models, which are based on costs estimated for a range of water system sizes (100, 500, 2,000 and 7,000 gpm). Key assumptions and facility-specific cost estimates are provided in Appendix G. Factors applied for capital costs (**Table 6-2**), engineering costs (**Table 6-3**), and O&M costs (**Table 6-4**) are summarized. Due to the large number of groundwater treatment facilities, the costs were aggregated in several scenarios to enable comparison of cost effective solutions to achieve compliance (Section 9).

Estimates were developed for WBA, RCF (with and without backwash water recycle), RCMF (without backwash water recycle), and SBA (single-pass without regeneration, on-site regeneration, and central regeneration). For all technologies, a bypass flow was assumed that blends treated water with untreated groundwater for cost effective design. A Cr6 treatment goal of 2 µg/L in Cr6 treatment system effluent and 6 µg/L in the blend with bypass was assumed in this analysis. CVWD can adjust these goals as needed to maintain a treated water concentration below the Cr6 MCL.

6.4 ADDITIONAL FACTORS AFFECTING TECHNOLOGY SELECTION

Based on review of water quality data and technology applicability, a commercially available software program, Criterium DecisionPlus (CDP), was used to apply weighting and judgment to decision criteria. The software requires input from the user to determine the end goal of the decision process, decision criteria and weighting factors, and complete options with scores by criteria.

The end goal of the evaluation was to develop a ranking of the treatment technologies to decide on the best treatment option for the criteria established. Seven factors, as noted in **Table 6-5**, were selected to evaluate the treatment options, including: (1) robust treatment technology, (2) O&M complexity, (3) amount of water loss from the treatment process, (4) waste handling and disposal, (5) ability to treat other constituents, (6) footprint requirements, and (7) annualized cost. Each of the criteria were assigned weights, with a total weight of 100%. Sub-criteria and weights were assigned to support the evaluation of the key criteria. Annualized costs and O&M complexity were assigned higher weights (50% and 20%, respectively), based on input from CVWD.

The scores were input into the CDP software to generate results that consider the scoring and applied weights to determine the more favored technology according to these criteria. **Figure 6-6** shows the scoring of technologies to compare factors in addition to costs.

6.5 CONCLUSIONS

The weighting analysis revealed that SBA with central resin regeneration scored most favorably, followed by WBA. Primary drivers leading to the higher ranking of these technologies included lower annualized cost, simpler operation, smaller footprint, and less volume and complexity with residuals handling. SBA operated as single pass media scored next highest to these two leading technologies, but operational



costs make the long term cost much higher than the others. RCMF received lower scores for cost compared with SBA with CRRF, due to higher operational complexity and more challenging residuals handling (including larger waste volumes 5% waste for RCMF unless additional solids handling was installed, compared with less than 0.01% for WBA and 0.05% for SBA). RCF with recycle scored lower in annualized cost, making this option lower ranked than RCMF without recycle. RO treatment was judged to be challenging from a residuals handling perspective due to large volumes of high TDS concentrate waste, thus costs were not developed for RO.

Weighting of cost and non-cost factors for technology selection ranked SBA with central resin regeneration most favorably, followed by WBA.



7. COLORADO RIVER SURFACE WATER TREATMENT EVALUATION

Surface water treatment utilizing Colorado River water was investigated as part of the overall compliance strategy and to meet current and future CVWD domestic water supply demands. CVWD has rights to Colorado River water delivered via the Coachella Canal (**Figure 7-1**). In 2014, CVWD's Colorado River water order was 352,000 AFY, which will increase to 459,000 AFY by 2026²⁰. Colorado River water is used primarily for agricultural irrigation, golf course irrigation, and groundwater replenishment at the TEL GRF.

The 2002 WMP identified the need to utilize Colorado River Water for domestic use in response to increases in urban population and constraints on the groundwater supply. Accordingly, CVWD conducted a surface water treatment pilot study in 2008.²¹

CVWD also completed the Mid-Valley Pipeline in 2009. The Mid-Valley Pipeline transfers Colorado River water from the Coachella Canal to WRP 10 where Colorado River water is blended with recycled wastewater and distributed to golf courses via CVWD's Non-Potable Water (NPW) system. The Mid-Valley Pipeline was identified as potentially having available capacity that could be used to supply a surface water treatment plant.

CVWD also has rights of up to 138,350 AFY of water from the State Water Project (SWP). However, the actual amount allocated by the State changes from year to year due to hydrologic variability and environmental/regulatory issues. Because there is no direct connection from the SWP to CVWD's service area, this water is instead delivered to the Metropolitan Water District of Southern California (MWD). MWD then provides an equivalent quantity of Colorado River water to CVWD via the Whitewater and Mission Creek turnouts. This water recharges groundwater via surface infiltration at the Whitewater GRF and Mission Creek GRF.

This section is arranged as follows:

- An overview of Colorado River/Coachella Canal water quality, a discussion of the constituents of concern and a review of treatment processes including pre-treatment, filtration and disinfection (Section 7.1)
- A review of treatment alternatives (Sections 7.2 and 7.3)
- Analysis of possible locations for construction of surface water treatment plants and treatment plant size (Sections 7.4 and 7.5)
- Cost estimate development (Section 7.6)

²⁰ MWH. 2012. Coachella Valley Water Management Plan 2010 Update

²¹ Malcolm Pirnie. 2008 Domestic Water System Surface Water Treatment Plant Design Development Report.



7.1 WATER QUALITY

Colorado River water is used by a significant number of metropolitan areas including Las Vegas, Nevada, Phoenix and Tucson, Arizona, and throughout Southern California. More than 25 million people are supplied with water from the Colorado River in the lower basin of the river. The water is transported by open channel canals or in aqueducts from the river to the point of storage and distribution prior to treatment. For CVWD, Colorado River water is conveyed from the Imperial Dam approximately 160 miles through the All American Canal to the Coachella Canal. Water quality data from the Colorado River and the Coachella Canal were analyzed in this Study to assess treatment alternatives for the surface water supply.

Raw water quality for the Colorado River (at two locations: Lake Havasu and above Imperial Dam) and the Coachella Canal (at Avenue 52) was summarized in a series of reports^{22,23}. Key water quality data important for plant design are presented in **Table 7-1**.

In general, the supply can be characterized as a low turbidity water source with moderate levels of total organic carbon (TOC) and elevated TDS. The Colorado River Basin States have adopted TDS criteria for the Lower Colorado River Basin to serve as a flow-weighted average annual salinity goal and basis for planning future controls. The TDS criteria for the Imperial Dam location, which is the most representative along the Colorado River of water flowing into the Coachella Canal, is 879 mg/L²⁴. Currently, average concentrations in the Coachella Canal are below this TDS level (700 to 800 mg/L), but planning in this study used this TOC criteria value for assessing blending options.

Colorado River water has variable turbidity caused from silts and other silica based particles, and depending on the location where water is withdrawn can have varying levels of algae, organic matter and in some cases iron and manganese. The water tends to be high in hardness and alkalinity, making it a challenging water to treat with conventional softening or enhanced coagulation. The supply is also subject to periodic taste and odor events due to algae. Iron and manganese were ruled out as a concern in pilot testing due to their presence mostly in the particulate form in Coachella Canal water, which can be removed with filtration.

Treatment of Colorado River water is required to address typical constituents of concern that are common for most surface water treatment plants including:

- Pathogens
- Particles (turbidity)
- Natural organic matter (NOM)
- Algae

²² Malcolm Pirnie. 2008. CVWD Phase 1, 2 & 3 Surface Water Treatment Process Evaluation Reports.

²³ Black and Veatch. 2010. Posse Park Indio Water Authority Surface Water Treatment Plant Conceptual Design Report.

²⁴ US Department of the Interior Bureau of Reclamation, Upper Colorado Region, 2005. Quality of Water – Colorado River Basin, Progress Report No. 22.



- Taste and odor
- Cr6 (from groundwater being treated at the surface water plant)
- TDS

Of these potential constituents of concern, the most important from an acute health perspective is pathogens. Drinking water treatment including pathogen removal and inactivation is one of the greatest advances of the 20th century and has literally saved millions of lives. Therefore, the removal and disinfection of pathogenic organisms are of primary concern. Since pathogens are particles, turbidity is an indicator of the potential presence of pathogens in raw water and it is also an indicator of how well the treatment process is working in terms of removing particles and pathogens. Removing turbidity is thus of paramount importance.

Another major constituent of concern is NOM. NOM is the primary precursor to DBPs including trihalomethanes (THMs) and HAAs, which are regulated by the USEPA and DDW. NOM removal in treatment plants is measured as TOC.

These two parameters, turbidity and NOM, primarily drive the design and operation of surface water treatment plants. Pre-treatment processes should be designed to maximize the removal of turbidity and TOC. Raw water turbidity affects coagulant dosing requirements, operational costs associated with filter efficiency (filtered water quality and backwash frequency) for both conventional dual media filters and membrane filtration, and the amount of solids generated and consequently the cost of residuals disposal. NOM is present in all surface waters and, in addition to being the primary precursor to DBPs, it can also cause numerous adverse effects on treatment including:

- Increases in disinfectant and oxidant requirements
- Coagulant demands
- Increases in particle stability (presenting a greater challenge for particle settleability and filtration)
- Increases in residuals production
- Increases in the fouling rate of membranes
- Decreases in the adsorption of micro-pollutants by activated carbon
- Interference with ultraviolet (UV) disinfection due to impact on UV transmissivity
- Increases in color
- Increases in microbial re-growth in water distribution systems

For CVWD, other constituents that must be considered in selection of surface water treatment include algae, taste and odor compounds, and Cr6. Algal blooms are known to occur on canals off of the Colorado River. Taste and odor that arises primarily from algae (geosmin, 1-methylisoborneol (MIB), and other algal metabolites) and TDS.



7.2 TREATMENT ALTERNATIVES

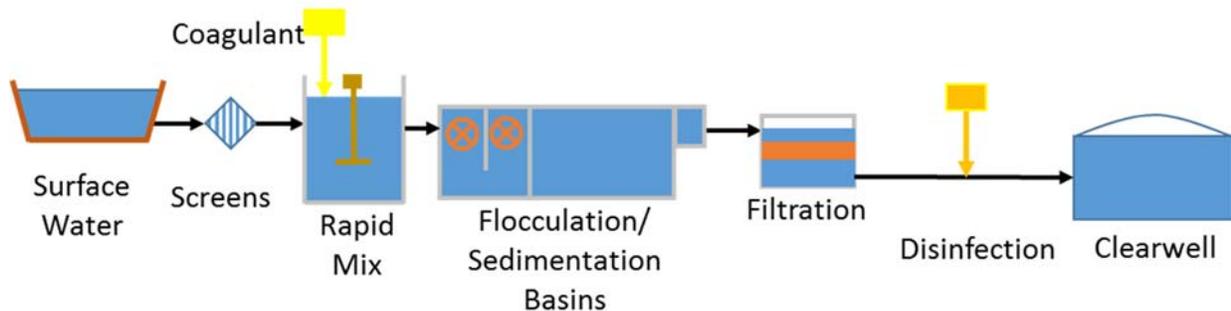
Information on Coachella Canal and Colorado River water was used to evaluate surface water treatment options. The following sections describe surface water treatment technologies and a cost-saving approach of blending surface water and groundwater.

7.2.1. BLENDING

CVWD's Phase 1, 2, and 3 Surface Water Treatment Evaluation Reports included estimates for RO treatment to decrease TDS concentrations in water from the Coachella Canal. However, an approach of blending groundwater and surface water, similar to that practiced for 40 years in the Coachella Valley at the recharge sites for beneficial use of customers, would allow for avoidance of RO in the surface water treatment facility. A blend of groundwater and surface water would be advantageous in both decreasing the TDS of the surface water and Cr6 of the groundwater.

7.2.2. TREATMENT TECHNOLOGIES

A typical conventional surface water treatment plant process is shown in the schematic below. A brief overview of the unit processes follows, then a specific analysis of each step as it relates to CVWD's selection of a surface water treatment train. For treating Colorado River water, a conventional treatment plant would consist of screening, coagulant addition and rapid mixing, flocculation, sedimentation, and rapid granular media filters. In the last 20 years, membrane filtration, using hollow fiber microporous polymeric membranes, has gained acceptance as an alternative treatment process to granular media filters.



Schematic of Typical Conventional Surface Water Treatment Plant

Screening is necessary to remove debris from Colorado River and may consist of a coarse bar screen at the canal followed by a secondary screen sized to accommodate downstream processes. For membrane pre-treatment, the manufacturers require less than 0.5 mm screens, which will typically be required downstream of the sedimentation processes.



Coagulant addition and mixing are necessary to destabilize particles and to convert dissolved NOM to particulate form so that it can be removed by clarification and subsequent filtration. The raw water turbidity and NOM levels drive the optimum coagulant dose. In some cases where the alkalinity is lower, an acid or base may be added to ensure the proper pH for coagulation. Colorado River water has high alkalinity and therefore enhanced coagulation with pH adjustment has not been common due to the volume of chemicals required.

After chemical addition, flocculation (slow mixing) is needed to promote particle growth through particle-particle contacts. The goal of flocculation in a conventional treatment plant is to make “settleable” floc, which is floc that will readily be removed in a settling basin. Typical flocculation design consists of 3 basins in series each with a 10-minute detention time for a total flocculation time of 30 minutes. The surface loading (or overflow) rate for conventional settling is in the range of 0.2 to 0.5 gpm/ft² depending on the nature of the raw water turbidity (mineral or non-mineral), the turbidity level, and water temperatures.

Filtration follows sedimentation to remove any remaining floc particles. Granular media filters typically consist of mono-media (sand) or dual-media (anthracite or GAC and sand) with loading rates of 4 to 8 gpm/ft². Alternatively, membrane filtration (microfiltration or ultrafiltration) can be used in lieu of granular media filters as the final particle removal step.

Surface water must also be disinfected in accordance with the Surface Water Treatment Rule to achieve over 3-log *Giardia* and 4-log virus inactivation or removal. A variety of primary disinfectants are available (free chlorine, chlorine dioxide, ozone), with free chlorine being most common for treating Colorado River water. Secondary disinfectants that provide a disinfectant residual in the distribution system include free chlorine and chloramine. Conventionally treated Colorado River water is proven to exceed DBP standards if free chlorine is used as a secondary disinfectant. GAC is used by some agencies treating Colorado River water to enable use of free chlorine in the distribution system, whereas others use chloramine secondary disinfectant.

7.2.2.1. PRE-TREATMENT

The first part of the treatment train through sedimentation is referred to as pre-treatment. There are several alternatives to conventional sedimentation pre-treatment are available, including plate and tube settlers, dissolved air flotation (DAF), ballasted flocculation (e.g., Actiflo), solids contact or sludge blanket clarifiers (e.g., SuperPulsators), and buoyant media or contact adsorption clarification (e.g., Trident clarifiers). All of these are high-rate processes that reduce the plant footprint and offer lower capital cost than large conventional sedimentation basins. The actual O&M cost of high rate clarification is often higher than the conventional sedimentation and should be considered in process selection. The typical hydraulic loading rate ranges for clarification alternatives are shown in **Table 7-2**. Higher loading rates correlate to smaller plant footprint.

The best treatment process for a particular raw water supply is a function of site conditions/space, raw water quality, regulatory requirements, and agency preferences. For sites with space constraints, a small equipment footprint is paramount, thus eliminating large conventional sedimentation basins. CVWD staff



indicated that footprint is not the most critical variable, as land of sufficient size is available at most of the potential surface water treatment locations.

Raw water quality (specifically turbidity and TOC) was viewed to be a major determinant in the process selection for CVWD. Guidelines for process selection based on raw water turbidity and TOC have been developed²⁵ and are summarized in **Figures 7-2** and **7-3**. **Figure 7-2** is based on average turbidity and TOC values and **Figure 7-3** is based on maximum values. While a variety of clarification options can be used prior to granular or membrane filtration, all waters can be treated via sedimentation or dissolved air flotation (DAF). Flocculated particles that are small and light are best removed via flotation while larger, heavier particles are best removed via sedimentation. Colorado River water falls within the DAF range (or the direct filtration range) under normal conditions. The level of turbidity and NOM as well as the potential for algae and other upsets along the canal such as air entrainment from the siphons could make DAF an appropriate choice for pre-treatment prior to granular media or membrane filtration. A potential risk to using DAF is that elevated raw water turbidity is expected to occur during canal cleaning, when extra attention will be needed to ensure proper coagulant dosing.

Other raw water quality parameters that affect surface water pre-treatment process selection include algae, iron and manganese, and taste and odor causing compounds. Colorado River water contains elevated algal levels of varying types that occur seasonally. Most algae, due to their tendency to float, are best removed by DAF. However, special attention will need to be given to the screens to ensure that the stringy algae are capable of being removed prior to the pre-treatment processes.

A listing of advantages and disadvantages of pre-treatment processes is provided in **Table 7-3**, followed by a relative ranking of several attributes of each process in **Table 7-4**. Note that inclined plate settlers are essentially identical in terms of process performance as conventional sedimentation except they have a much smaller plant footprint due to stacking of the plates.

As mentioned previously, optimized coagulation is needed for any of the potential pre-treatment processes to work properly. Coagulant addition destabilizes particles and converts dissolved TOC to particulate form so that it can be removed by clarification (and subsequent filtration). Commonly used coagulants include alum (aluminum sulfate), ferric chloride or ferric sulfate, and polyaluminum chloride (PACl). Alum and ferric coagulants perform similarly, with both hydrolyzing when added to water and forming metal hydroxide precipitates (aluminum hydroxide or ferric hydroxide). The amount of precipitate formed is a function of pH and the coagulant dose. The formed precipitate and the positively charged hydrolysis products react with the raw water turbidity and TOC to form floc particles. PACl mostly works through charge neutralization processes. PACl is often found to be a better coagulant for particle removal, especially in colder waters. Alum can produce high aluminum residuals under high pH conditions. Ferric coagulants work under a wider pH range than alum, but often come with manganese impurities that can cause

²⁵ Valade, M., Becker, W., and Edzwald, J. 2009. Treatment Selection Guidelines for Particle and NOM Removal. *Journal of Water Supply: Research and Technology – AQUA*, Vol. 58.6.



customer complaints. Both alum and ferric are less expensive than PACl, but produce more residuals. It is recommended that any pilot testing and design consider both alum and PACl.

In sum, pre-treatment is needed to remove dissolved and particulate matter prior to filtration. Prior pilot testing and full-scale treatment of Colorado River water has shown both conventional sedimentation and DAF to be effective approaches.

7.2.2.2. FILTRATION

A filtration process follows pre-treatment in surface water treatment to remove particles not removed via clarification. Filtration is the final barrier to particle removal and is critical to the production of high quality potable water. Filtration can be accomplished using granular media filtration or microfiltration.

Granular media filtration. Granular media filters are designed to remove particles that pass through the pre-treatment process. Granular media filters do not remove particles via straining. Particles to be removed are generally much smaller than the size of the voids between filter grains. To be removed, the particles must first be transported to the media surface, then the particles must attach to the media. Transportation mechanisms include interception, sedimentation, and diffusion depending on particle density and size. Once the particles contact the surface, they are removed via attachment forces. The efficiency of particle removal is highly dependent on the coagulation process. If the coagulant dose and pH have been optimized, excellent particle removal will occur. If not, then particles can pass through the filter, resulting in higher filter water turbidity values.

When designing granular media filters, the type, effective size, uniformity coefficient, and depth of media must be carefully selected to meet low turbidity standards. These design parameters affect the particle transport and removal processes. Typical dual-media filter beds consist of an 18- to 60-inch layer of anthracite coal on top of a silica-sand layer about 12 inches deep. Smaller media grains are generally more efficient collectors, but they are also associated with greater clean-bed head losses. Filter media designs should balance the low head loss characteristics of larger media diameters with the effective collection characteristics of smaller media to produce water with low particle content at a low head loss.

The backwash regime, including the use of surface and/or air wash, must be optimized for a given filter media configuration in order to achieve optimal filter performance. The media and backwash process impact filtered water quality during the three phases of a filter run: ripening, steady-state operation, and breakthrough. Ripening occurs during the beginning of a filter run after backwashing. It is a period of poorer filtered water quality that typically lasts between 5 and 30 minutes. As particles are removed, they act as additional collectors, which improves filtered water quality. The period referred to as steady-state operation occurs after ripening and is the period where filter effluent turbidity levels are normally below 0.1 NTU. Steady-state operation usually lasts from 24 to 72 hours or more. The breakthrough period occurs toward the end of a filter run when headloss is typically high and particles that were removed start sloughing off the media. It is important to backwash a filter prior to breakthrough. Although most standard filter media configurations work well during the steady-state portion of a filter run when coagulation is optimized, there are very real differences in filtration performance between various media configurations when coagulation is not optimized and during the ripening and breakthrough portion of the run.



Alternative filter media configurations should be pilot tested in conjunction with the upstream pre-treatment processes to ensure selection of the proper media.

Membrane Filtration. Low pressure hollow fiber micro- or ultra- membrane filtration systems have been used in water treatment applications for more than 20 years. Economies of scale, presented with the scale up of production for larger plants, along with increased competition as new manufacturers enter the market, have narrowed the cost difference between granular media filters and membranes²⁶.

Unlike granular media filters, microfiltration membranes remove particles by straining. Excellent filtered water quality (in terms of particle removal) will be achieved regardless of whether upstream coagulation is practiced. With a nominal membrane pore size of 0.2 microns or less, the membranes can achieve removal of microorganisms such as *Giardia* and *Cryptosporidium* of at least 99.99% (4 log), which can be verified during operating using membrane integrity tests.

For some raw water supplies, particularly those with relatively low turbidity, algae, and TOC levels, direct membrane filtration is a viable alternative to conventional treatment, and may negate the requirement for upstream pre-treatment coagulation, flocculation and settling processes. This is not the case for CVWD, where the raw water quality would result in low flux (production) rates and potentially excessive membrane cleaning if a pre-treatment process was not employed. Pre-treatment is also required to maximize the removal of TOC.

The filtration method selected impacts the level to which Cr6 can be removed from the supply. Cr6 removal by similar processes as surface water treatment, i.e., RCF and RCMF, have been proven at CVWD and the City of Glendale, CA. MWD conducted a pilot test in which ferrous iron was supplemented to the conventional surface water treatment process, and effective removal of Cr6 was observed. Louisville Water Company has also tested removal of Cr6 in surface water treatment (lime softening plant) through the addition of ferrous iron. Based on these studies and the mechanism of removal in the RCF/RCMF process (i.e., reduction with ferrous with 5 – 15 minutes of contact time, coagulation, oxidation of residual ferrous iron with a small dose of hypochlorite, and filtration for removal of Cr-associated particles), effective removal of Cr6 with a modified surface water treatment process is expected. Pilot testing to date has shown that MF may provide better removal of Cr-associated particles, yielding treated water Cr concentrations of less than 1 µg/L for MF compared with less than 5 µg /L for granular media filters. Use of MF can therefore shrink the necessary treatment capacity compared with granular media filters when concurrently removing Cr6.

Operationally, membrane filtration systems, given their high rejection of particles, require frequent backwashing to maintain sustainable flux and production rates. As a result, they tend to produce more backwash waste water than conventional systems and consequently operate at a lower recovery. This must be taken into consideration in design of pre-treatment sizing and bacwash recovery systems.

²⁶ Furakawa, D. 2008. A Global Perspective of Low Pressure Membranes. *National Water Research Institute* report.



For operating utilities experienced in conventional treatment systems, the use of low pressure membrane filtration systems presents a significant shift in operational and maintenance focus relative to conventional treatment systems. Membrane systems have a greater proportional investment in mechanical and electrical assets than a typical conventional plant, with highly automated operating sequences, control safeguards and on-line monitoring and instrumentation, which requires sophisticated supervisory control and data acquisition (SCADA) and automation systems. An important focus during the commissioning of a new membrane plant is to ensure that the controls and automation commissioning has been completed and correctly performed by the contractor. Many perceived difficulties of membrane plant operation can stem from this shortcoming.

Once operators who are unfamiliar with membrane systems are trained, automated systems tend to ease operations. From a maintenance standpoint, the higher level of automation and moving parts (in particular, actuated valves) is a consideration for maintenance planning.

In terms of constructability, a membrane filtration system typically requires a smaller footprint than a typical granular media filtration system. Membrane systems may be provided as a modular, skid mounted equipment that can be bolted to a slab and manifolded together, reducing civil construction costs and project schedule.

An important note is that neither of these filtration processes remove dissolved substances. Hence, if dissolved organic matter, iron, manganese, or other substances need to be removed, they need to be converted to particulate form by pre-treatment to enable removal by filtration. Although pilot testing in 2008 and experience with Colorado River water indicates that iron and manganese are not likely to be problematic, filtration can provide removal should elevated concentrations be observed in the supply. Dissolved iron or manganese, if present, would need oxidation prior to filtration. Small doses of chlorine or permanganate can accomplish this oxidation step. Pilot testing should be conducted to determine conditions that are compatible for both iron and manganese removal as well as Cr6.

A summary of the advantages and disadvantages of granular media and microfiltration is presented in **Table 7-5**. In sum, both microfiltration membrane systems and granular media filtration can meet all regulatory requirements and provide particle removal necessary for CVWD.

7.2.2.3. POST-TREATMENT

A major concern for many water agencies treating surface water, including CVWD, is taste and odor. Taste and odor events are often caused by geosmin or MIB, neither of which are effectively removed by conventional treatment. The most effective treatment alternatives for both geosmin and MIB are GAC treatment, ozone and biological active filtration, and ultraviolet radiation with peroxide to make hydroxyl radicals known as advanced oxidation process (UV/AOP). The most cost-effective option depends on other water quality concerns including DBP control, the presence of pesticides or emerging constituents, and raw water pathogen levels.

GAC can be used by CVWD for post-treatment to remove geosmin and MIB and DBP precursors, allowing for continuance of a free chlorinated system. The complexity of the CVWD system, including wells that are



spread throughout the Coachella Valley, high desert temperatures, and the need for taste and odor control make GAC for post treatment an attractive option for CVWD.

7.2.2.4. SALINITY CONTROL

Colorado River water in general has a higher TDS than a majority of groundwater wells in the Coachella Valley, except the East Valley near the Salton Sea and areas under the influence of recharged surface water. Flavor profile analysis (FPA) testing was conducted previously²⁷ using a trained panel to assess whether differences could be detected between chlorinated groundwater and Coachella Canal water, and blends of water treated with RO to decrease salt concentrations. For chlorinated groundwater (TDS of 586 mg/L in Well 6729) compared with Coachella Canal water (790 mg/L), tastes were not viewed as objectionable but differences were noted by some panelists. No statistically significant differences were observed during this testing.

It was noted by CVWD that no customer complaints have been received for groundwater with elevated TDS due to recharge, with recent concentrations observed of up to 700 mg/L in Well 6729-1 and 490 mg/L in Well 4564-1. A rapid change from a lower TDS concentration to a concentration exceeding 500 mg/L may be more noticeable by consumers. Prior consumer taste testing of Colorado River water at Tucson Water found that consumers could detect a slight but statistically significant difference between water ranging from 450 to 650 mg/L. To address potential taste and odor consumer concerns, the analysis in this study evaluated opportunities to simultaneously blend groundwater and surface water similar to CVWD's approach at recharge sites, with the benefit of achieving TDS levels that may be more acceptable to customers.

Introducing Colorado River water into CVWD's Domestic Water system will affect the wastewater systems. CVWD owns and operates six WRPs (1, 2, 4, 7, 9 and 10). The TDS of the wastewater entering the WRPs is a function of the water supply in that WRP service area. WRPs 4, 7, and 10 were reviewed in this Study because they might receive potential domestic flows for areas served by surface water treatment. WRP 10, serving the greater Palm Desert area, has specific sulfate (70 mg/L) and chloride (70 mg/L) targets, in addition to TDS (500 mg/L). WRP 7 has a TDS target of 400 mg/L but no specific sulfate or chloride limits. WRP 4 does not have specific effluent limits because TDS concentrations are significantly below those of the receiving water.

Analysis by CVWD has shown that the WRP 10 effluent from 2013 was just under the sulfate limit, and that potential surface water use in the Mid-Valley area would raise the effluent concentrations above the WRP 10 limits (**Table 7-6**). Unless the WRP 10 effluent limits are raised, implementation of surface water treatment in the Mid Valley area would require effluent RO treatment to decrease sulfate, chloride, and TDS, or WRP 10 would need to implement programs to recycle 100% of the effluent and eliminate land disposal.

²⁷ Malcolm Pirnie. 2008. CVWD Phase 1, 2 & 3 Surface Water Treatment Process Evaluation Reports.



7.2.2.5. SITE VISITS TO TREATMENT PLANTS

Trips to Scottsdale, Arizona and the MWD's Weymouth plant were made by the Project Team to tour various full-scale treatment processes and have in-depth discussions with plant operators. The Scottsdale and MWD plants were chosen because they treat Colorado River water.

The Scottsdale plant size is also in line with the capacity of the potential CVWD plant. Scottsdale has two parallel treatment facilities on the same site:

- A 50 MGD conventional plant with plate settlers and granular media filters
- A newer 20-MGD high rate DAF plant with microfiltration membranes

GAC follows both treatment trains to remove NOM/TOC and provide taste and odor control. The frequency of GAC replacement is approximately every two months. The GAC allows Scottsdale to use a free chlorine residual in the distribution system.

Drivers for process technology selection were water quality, footprint, and potential for future regulations for microbial removal. Both plants use free chlorine pre-treatment for algae control in the plant.

Although both plants experience challenges at times, overall they work well, demonstrating that either DAF or plate settlers can be used as pre-treatment processes, and either granular media filters or microfiltration can be used for the filtration process. The operators stated that they prefer the DAF/MF process; this process responds better and produces higher quality water during periods of high turbidity.

The MWD Weymouth water treatment plant is one of the largest in the country with a capacity of 520 MGD. The treatment plant has been in operation since the 1940s and treats Colorado River Water, State Project Water, or (most commonly) a blend of the two water sources. The raw water quality is fairly consistent as it is taken from Lake Matthews prior to treatment. The treatment plant uses conventional flocculation, sedimentation and granular media filtration. Although the plant meets all regulatory requirements, it is currently being upgraded with the addition of ozone pre-treatment to address challenges with State Project Water.

Operationally, the plant performs well. The coagulant is alum at a typical dose of 5 mg/L. A polyDADMAC cationic polymer is also used at a dose of 2.5 mg/L. Ferric coagulants are not used due to manganese impurities. Weymouth does not add acid to control coagulation pH, but may need to in the future to control high aluminum residuals leaving the plant. Contact time (CT) is achieved by adding chlorine before the sedimentation basins, which also controls algal growth. Chloramines are used as the final disinfectant in the distribution system.



7.2.3. RECOMMENDATIONS FOR SURFACE WATER TREATMENT

The following summarizes findings and recommendations based on reviewing the CVWD surface water treatment reports²⁸ and site visits to MWD and Scottsdale. This review was undertaken with the objective of constructing a treatment facility that will meet all goals in a cost-effective manner.

7.2.3.1. PRE-TREATMENT

The previous Phase 2 study evaluated conventional coagulation, flocculation, sedimentation and DAF as pre-treatment options. The report recommends DAF as the pre-treatment process. The raw water turbidity is typically low (less than 10 NTU) and the concentration of NOM is moderate (about 3 mg/L). Algae are often present and will likely increase as climate changes occur. DAF is more effective than settling for low turbidity waters because particle removal is a function of contact opportunities between particles and bubbles. For settling, large dosages of coagulant are needed to provide enough contact opportunities for floc to form to a size that is removed via gravity settling. The high raw water turbidity values observed during canal dredging could pose operational issues, but these are temporary events and it is assumed that the plant could be taken offline or could operate at lower capacity during such events.

Based on analysis in this study, DAF is the recommended pre-treatment process but pilot testing should be conducted to determine efficacy of DAF with microfiltration for Cr6 removal (which was not assessed in the previous pilot studies).

The Phase 2 report recommends using acidified alum. Use of carbon dioxide and alum instead of acidified alum will provide more operator control of pH. Further evaluation of PACl, which may negate the need for acid feed, is recommended.

7.2.3.2. FILTRATION

The Phase 2 report recommends microfiltration over granular media filtration. Analysis in this study supports the recommendation of microfiltration, since the plant will be used to treat groundwater for Cr6 removal. Previous studies have shown that microfiltration can consistently remove Cr6 and total Cr to less than 1 µg/L, whereas granular media filtration may only achieve less than 5 µg/L. Smaller treatment facility size is an outcome of a better removal of Cr6 by microfiltration, since less water needs to be treated to achieve the same target concentration.

7.2.3.3. POST-TREATMENT

The Phase 2 report recommends GAC adsorption to reduce TOC prior to chlorination or RO if CVWD elects to implement a TDS reduction water quality goal. The pilot study showed that GAC breakthrough occurred after one month of operation, which suggests a high changeout frequency and high associated

²⁸ Malcolm Pirnie. 2008. CVWD Phase 1, 2 & 3 Surface Water Treatment Process Evaluation Reports.



costs. Nevertheless, GAC is recommended based on analysis in this study to remove TOC and allow CVWD to continue with free chlorine secondary disinfection. Opportunities to use regenerated GAC similar to Scottsdale, which has resulted in significant cost savings, should be investigated further.

7.2.3.4. DISINFECTION

The Phase 2 report recommends the use of free chlorine as the final disinfectant due to complexities associated with converting all wells to chloramines. Based on the analysis in this Study, continued use of free chlorine system-wide is recommended.

7.2.3.5. BLENDING

The Phase 2 report concluded that RO may be applied if CVWD desires TDS reduction in Colorado River water, to maintain consistency for their consumers who currently receive lower TDS water. Based on the analysis in this Study, blending nearby groundwater with water treated at the plant is recommended to reduce TDS to acceptable levels. Blending of the water would also offer the benefit of removing Cr6 from impacted groundwater. This blending approach is similar to the practice at CVWD recharge sites, only aboveground rather than below.

Additional targeted pilot testing is recommended to accomplish several goals prior to design of the surface water treatment plant. DDW has indicated that State Revolving Fund assistance will require pilot testing of a new process. Significant surface water treatment pilot testing has already been performed by CVWD, so additional testing will specifically target the new concept of blending surface water and groundwater in a flexible facility. A small scale pilot of approximately 20-30 gpm for 6 to 12 months would allow CVWD to test a range of membranes to find the most cost effective materials and gain a better estimate of operating costs and performance before investment in a full scale plant. Goals of this pilot testing would include:

- Confirming the effectiveness of the DAF/MF treatment train at removing Cr6 in a spectrum of potential groundwater and surface water blends
- Optimizing the operating cost before selecting equipment
- Optimizing coagulant dosing
- Identifying performance expectations for MF membranes specifications and warranty
- Comparing and documenting performance of MF membranes to enable evaluation of bids and provide manufacturer confidence in competitive pricing
- Consumer panel testing of taste and odor

7.3 POTENTIAL LOCATIONS

The primary factors considered in evaluating preferred sites for the location of a surface water treatment facility included:



- Proximity to the source of supply (either the Coachella Canal, the Mid-Valley Pipeline or the Whitewater Turnout)
- Proximity to a supply of low TDS groundwater for blending (avoiding RO treatment)
- Proximity to a suitable service area with a demand for water
- Availability of sufficient size land

This Study evaluated eight potential surface water treatment sites as listed in **Table 7-7**. Four of these potential sites were ruled out because they lacked one or more of the essential characteristics. The remaining four sites were considered in greater detail as follows.

7.3.1. SUN CITY SITE

A potential site was identified adjacent to the Coachella Canal near the Sun City pressure zone (**Figure 7-4**). The advantage of this site is available land within reasonable proximity of the Coachella Canal. The site would receive surface water from the canal (1/2 mile away) and blend it with groundwater from the Sun City wells (up to 2.5 miles away).

This site would have the potential to blend water from the Sun City wells to reduce the TDS in the treated water to below 500 mg/L. The four wells currently serving the Sun City pressure zone are all impacted by Cr6 and need treatment. Treatment of approximately 40% of the groundwater would be necessary to reduce the Cr6 level of the blended water to a treatment goal of 6 µg/L.

Currently, the Sun City pressure zone does not have a supply deficit, so the addition of a surface water supply would simply displace the use of groundwater. However, the adjacent Valley zone does have a supply deficit, which could be reduced by transferring treated and blended water from Sun City.

A hydraulic modeling scenario evaluated the potential to supply water from Sun City to Valley pressure zone. This scenario requires a new 8,800 gpm pump station to transfer water from Sun City to Valley. The modeling scenario indicated that there would be a significant increase in pressure in the Valley zone near the discharge of the new pump station. An additional transmission main bypassing parts of the Valley zone would likely be necessary to alleviate these high pressures.

Use of this site would require building pipelines to convey groundwater to the surface water plant and to return treated water to the service area and to the adjacent Valley pressure zone. The main benefit of this site would be improved supply to the Valley pressure zone; however the Mid Valley and Burr Street sites better achieve this goal, as noted below. Therefore, this location was not selected by CVWD.

7.3.2. BURR STREET SITE

A potential site for surface water treatment was identified adjacent to the Coachella Canal on Indio Boulevard at Burr Street (**Figure 7-5**). This is a large site with direct access to the canal. This site would blend the surface water with groundwater from La Quinta pressure zone wells. It could also potentially receive groundwater from nearby wells belonging to the City of Indio if a regional solution is preferred.



This site has the potential to connect to the La Quinta and Valley pressure zones. The surface water from this plant could be used to alleviate the supply deficit in the Valley pressure zone. This site also has the potential to feed through the La Quinta pressure zone to Indio Water Authority (IWA) and Myoma Dunes Water Company (MDWC).

Several hydraulic modeling scenarios evaluated the potential to supply water from a new treatment facility at this site to the Valley zone. These scenarios evaluated the following cases:

- Turning off all impacted wells in the Valley zone and using the Burr Street treatment plant to replace this supply and the current Valley zone deficit. This scenario requires transferring 20,000 gpm into the Valley zone at the point of connection on Avenue 42. This transfer would create pressure increases of more than 100 psi in the distribution system near the point of connection. An upgrade to several miles of transmission mains along Avenue 42 and Washington Street would be necessary to alleviate these high pressures.
- Providing treatment to the impacted wells in the Valley zone and using the Burr Street treatment plant to replace only the current Valley Zone deficit. This scenario requires transferring 8,800 gpm into the Valley Zone at the point of connection on Avenue 42. This transfer would create pressure increases of around 30 psi in the distribution system at the point of connection. Upgrades to a portion of the transmission main along Avenue 42 would be necessary to reduce headloss to CVWD's standards.

If this site is used to provide water to the La Quinta and Valley zones, an overall plant production could be 25 MGD. Of this, 13 MGD would be treated water with the remainder being untreated groundwater as noted in **Table 7-8**. The site could receive water from seven La Quinta zone wells of which five would be Tier 1 wells and two would be Tier 2 wells. Three other Tier 1 wells in the La Quinta zone could be inactivated or reserved for emergency standby duty in this option.

This site abuts the Coachella Canal and could draw surface water directly from the canal. Approximately 6.4 miles of new pipeline would be required to transfer groundwater to the plant for blending. Approximately 2.0 miles of pipeline would be required to transfer treated water to the Valley pressure zone and approximately 4.7 miles of pipeline would be required to distribute water through the La Quinta pressure zone. Potential pipeline routes are shown in **Figure 7-6**.

The principal benefits of this site are its central location and relatively large size. This site has the potential to supply water to the Valley and La Quinta zones and could also supply water to IWA and MDWC in the future. If the sole goal is to alleviate the deficit in the Valley Zone, then the Mid-Valley site is preferable. This Burr Street site is on private land so using it would also involve land purchase.

7.3.3. MID-VALLEY SITE

A potential site was identified on CVWD property on Hovley Lane in Palm Desert (**Figure 7-7**). This property is not close to the Coachella Canal. A surface water supply is available from the Mid-Valley Pipeline (MVP), however in the longer term this pipeline is intended to provide irrigation water to golf courses in the Mid-Valley. Using the supply from the MVP to supply a surface water treatment plant would reduce the number



of golf courses that could be supplied. This site has the potential to blend water from the Cr6 impacted Valley wells and reduce the TDS level of the treated water to below 500 mg/L.

This plant would use groundwater from five impacted Valley zone wells. Potential pipeline routes are shown in **Figure 7-8**. Overall production of the plant could be 24 MGD, of which 10 MGD would be surface water and 14 MGD would be groundwater treatment. Treatment of approximately 40% of the groundwater would be necessary to reduce the Cr6 level of the blended water to a treatment goal of 6 µg/L.

The surface water from this plant could be used to alleviate the supply deficit in the Valley zone. The remainder of the Valley zone deficit would be supplied from the Sky Mountain and Date Palm zones. A hydraulic modeling scenario evaluated the impacts of the new treatment plant on the existing network. The results indicated that it would be necessary to replace 1.6 miles of existing mains with larger mains to distribute the flow from the surface water plant.

The principal benefit of this site is its strategic location in the Valley zone. This area has a supply deficit and will benefit from the addition of surface water as a supplementary source. Blending water from the two sources will simultaneously eliminate the need to treat surface water to lower TDS and reduce the need to treat groundwater to remove Cr6 via wellhead treatment. The primary drawback of this site is allocation of the Mid-Valley Pipeline for domestic supply rather than its intended use in irrigation. A secondary drawback is that this treatment plant would take up land at the WRP site that might be required for expansion of WRP 10 in the future. Third, WRP 10 effluent discharge limits may preclude its implementation without RO treatment or programs to recycle 100% of the WRP effluent to avoid land disposal.

7.3.4. EAST VALLEY SITE

Two potential surface water treatment sites were identified within the Lake Cahuilla pressure zone. One of these is on a privately owned site at Jefferson Street and Avenue 52 (**Figure 7-9**). The other is on CVWD owned property adjacent to Lake Cahuilla (**Figure 7-10**). Both of these sites are adjacent to a source of surface water. The Jefferson site is close to the Coachella Canal while the Lake Cahuilla site could withdraw water from the Lake. Both of these sites would use groundwater from impacted wells in the Lake Cahuilla and La Quinta zones to reduce the TDS of the treated water below 500 mg/L.

These sites would require the construction of long transmission mains to bring groundwater to the treatment plant and to transfer treated water to the distribution system (**Figure 7-11** and **Figure 7-12**). The mains required to serve the Lake Cahuilla site would be significantly longer than for the Jefferson site since Lake Cahuilla is farther from the majority of the impacted wells and also from the likely points of connection to the distribution system.

A surface water treatment site at one of these East Valley locations could serve water to the Lake Cahuilla and La Quinta pressure zones. It would also be well positioned to accommodate future population growth in the Lake Cahuilla and Middleton Road zones.



In one configuration considered, the treatment plant would receive groundwater from three La Quinta zone wells and four Lake Cahuilla zone wells. Total plant production could be 30 MGD, of which 11 MGD would be surface water and the remainder groundwater. Treatment of approximately 33% of the groundwater would be necessary to reduce the Cr6 level of the blended water to a treatment target of 6 µg/L.

A hydraulic modeling scenario evaluated the impacts from a new treatment plant on flows in the existing network. The simulation indicated that the existing network in the Lake Cahuilla zone could handle the new flow regime without modification. However, upsizing of some pipes in the La Quinta zone would be necessary to avoid excessive velocities and pressure drops.

Both of these sites have the benefit of being in an area with several high Cr6 wells that would benefit from blending with surface water. The sites are also in close proximity to the Coachella Canal and have easy access to surface water. It is an area that does not have a current supply deficit but is adjacent to future growth areas. The site at Lake Cahuilla is on CVWD land and would not require purchase of additional land. On the other hand, this site requires construction of additional pipelines (unlike for the Jefferson site) and is less well positioned to supply the northern part of the pressure zone. The Jefferson site is relatively small and this would make it more difficult to expand the plant in the future to accommodate increases in demand.

7.4 POTENTIAL FACILITY SIZE

Sizing for the potential treatment plant was based on the demand for water in the service area and the availability of groundwater for blending. Analysis showed that impacted Cr6 wells could be treated in the surface water treatment plant and/or used for blending, both of which would decrease Cr6 concentrations. In addition, the lower TDS groundwater supply can simultaneously be used to blend down the higher TDS in surface water, improving the aesthetic acceptability of the supply. Flow rates for each of the potential sites are shown in **Table 7-8**.

7.5 COST ESTIMATE BASIS

The Colorado River raw water supply presents treatment challenges: TOC, pathogens, algae, and taste and odors. It may also have periodic elevated levels of turbidity during canal cleaning. The treatment system ultimately designed for Coachella must be robust, cost effective, and present optimal operational cost and flexibility.

The treatment processes recommended for the surface water treatment plant include pre-treatment with coagulation, flocculation and DAF followed by microfiltration and GAC for taste and odor and DBP precursor control. Salinity control will be achieved by blending with groundwater; this will also decrease Cr6 levels in groundwater. Cost estimates were developed for the following technologies:

- Coagulation
- Flocculation and DAF



- Microfiltration
- Granular activated carbon
- Free chlorine disinfection

The basis for cost estimates are provided in this section. Costs were aggregated in several scenarios with groundwater treatment at remaining wells to enable comparison of complete cost effective solutions (Section 9). Key assumptions and cost are provided in Appendix G. Surface water treatment cost estimates were developed based on a plant with a treatment capacity of 20 MGD selected by CVWD as a representative plant size.

7.6 CONCLUSIONS

Analysis of surface water treatment options included identification of a recommended treatment train and potential site locations. Blending of surface water and groundwater, similar to the blending at CVWD recharge sites only aboveground rather than below, was identified as a cost-saving approach to avoid RO for TDS reduction and maximize use of water supplies including high Cr6 wells. Two potential surface water treatment sites were carried forward into the scenario analysis – Mid Valley and East Valley – for further analysis of costs and system impacts, although the East Valley option has more advantages.

This study provided a recommended approach for surface water treatment and potential sites to serve the Mid Valley and East Valley, which was brought forward into the Scenario Analysis.



8. POINT-OF-USE/ POINT-OF-ENTRY

This section evaluates POU systems as a means of complying with the Cr6 MCL. A POU system is a small treatment unit attached directly to a water faucet used specifically for drinking or cooking. A familiar example of POU in many homes is an RO unit under a kitchen sink treating the cold water. In schools or other public facilities, POU treatment units can be installed at every drinking fountain as well as at cold water taps in food preparation areas. The USEPA estimates that only 1 – 3% of household water is used for drinking and cooking, thus making POU a targeted and efficient system that does not treat water used for bathing, cleaning and outdoor irrigation. A photo of a typical commercially available RO unit is shown in in the schematic below with the pre filter, membrane cartridge, post filter, storage tank, and faucet.

By comparison with POU, POE systems would treat the water before it enters the home. This was viewed as a more expensive alternative because it treats all of the household water. POE systems may also require additional plumbing to separate household water from irrigation water. Focus in this analysis was placed on a POU approach.



Schematic of a Reverse Osmosis Point of Use System

This section covers the regulatory/legislative requirements of POU implementation, an analysis of the implementation approach, and cost estimate basis.

8.1 REGULATORY AND LEGISLATIVE REQUIREMENTS

POU systems are regulated under California Code of Regulations Title 22 Social Security, Division 4 Environmental Health Chapter 15 Domestic Water Quality and Monitoring Regulations, and Article 2.5 Point-of-Use Treatment. The California Department of Public Health, Division of Drinking Water and



Environmental Management – Point of Use Compliance March 2013 document also provides guidelines and requirements for obtaining a POU permit.

8.1.1. PERMITTING

The application of POU is subject to the following requirements:

1. POU may not be used for microbial contaminants, VOCs, or radon compliance
2. The water system serve fewer than 200 service connections
3. Centralized treatment for the constituents of concern is not feasible within three years of the POU application date
4. Centralized treatment costs are greater than 1.0% of median household income (MHI), or centralized treatment in addition to current water bills is more than 1.5% of MHI if community is below the state MHI, or centralized treatment is more than 2% if community MHI is above the state M
5. POE systems are not economically feasible, or are not as protective of public health
6. A public hearing and review period finds no substantial community opposition
7. POU systems can be permitted for a three year period

8.1.2. IMPLEMENTATION

The implementation, procurement, and construction of POU are subject to the following requirements:

1. Submittal of a POU Treatment Strategy, Operations and Maintenance Program, and Monitoring Program for DDW review and approval
2. At least 50% of the community must have POU at start up, and 100% must have it within the implementation period
3. POU must be American National Standards Institute (ANSI) certified or approved by DDW
4. Installation must be on the drinking and cooking water supply, i.e. kitchen sink cold water
5. Pilot testing is required unless the POU has been demonstrated under equivalent conditions
6. Unit must contain a mechanical warning system or automatic shut-off mechanism
7. Unit must contain a totalizing flow meter
8. POU must be owned, controlled, operated and maintained by the water system, or its contractor, not by the property owner or resident

8.1.3. OPERATION

The operation, control, and maintenance of a community-wide POU system would require the following:

1. Staff to monitor and maintain POU, which would include regular purchase and replacement of cartridges and other components
2. Records of location, type, monitoring results, maintenance and repairs, customer complaints
3. Monthly treated water monitoring



4. Quarterly source water monitoring, maintenance, investigations and corrective actions to ensure compliance
5. POU effluent sample collection and testing on day of installation
6. POU effluent sample collection and testing done annually, with the addition of one twelfth of all units sampled monthly on a rotating basis
7. After two years of monitoring, CVWD can apply for reduced on-going monitoring if results from ongoing monitoring do not exceed 75 percent of contaminant MCL

8.1.4. COMPLIANCE

The regulations define violation as the following:

1. More than 5% of effluent monitoring exceeds the MCL in a 12-month interval for all POU's combined
2. For any single POU, the effluent fails to meet compliance determination requirements
3. A customer (residential, industrial or other) does not have a POU

8.2 ANALYSIS OF POTENTIAL POINT-OF-USE APPROACH

8.2.1. LEGISLATIVE AND REGULATORY AMENDMENTS

While POU systems can remove Cr6 and other relevant constituents of concern, significant regulatory and legislative issues would be associated with this approach. California Code of Regulations Title 22, Division 4, Chapter 15, Article 2.5 § 64418 (a) limits the implementation of POU treatment to only water systems that serve fewer than 200 service connections. In order to implement the use of POU treatment units for all customers in the CVWD system, this regulation would have to be amended to allow the use of POU systems for all service connections in the district.

Title 22, Division 4, Chapter 15, Article 2.5 § 64418.8 (8) allows for a POU permit for only a 3 year period before a water system must reapply. An amendment to this regulation for a longer period of time (perhaps 20 years) would be necessary for implementation of district wide POU systems.

In accordance with Title 22, Division 4, Chapter 15, Article 2.5 § 64418.3 (c) the water system must exhibit proper authority that requires customers to accept POU treatment for drinking and cooking water only and additionally allows for a discontinuation of service in the event that a customer fails to accept the treatment system. California DDW, through its POU Compliance guidelines, also mandates 100% participation of service connections by the end of a certain implementation period. An amendment to CVWD's Ordinance No. 1399.5 Regulations Governing Domestic Water Service would likely be necessary to require the installation of POU treatment systems.

In the event that a customer (homeowner, business, etc.) already uses a POU treatment unit, the code of regulations requires that the water district be able to demonstrate the authority to ensure accreditation of



the device, replace the device if it does not meet treatment standards, and obtain legal ownership of the unit after providing appropriate compensation to the customer.

While changes to these regulations require a petition to the controlling agency (in this case, DDW), legislative and regulatory action may be necessary to expedite amendments to allow the CVWD's use of POU for treatment.

8.2.2. SYSTEM CONFIGURATION

The treatment system considered for this alternative consists of an under sink RO unit installed for every customer for drinking and cooking water use. Commercially available RO models with individual faucets can be used for nearly all customers, most notably residential homes. Commercial, business, and hotel/motel customers may require varying capacity RO units depending on drinking water consumption.

The following assumptions were made in consideration of this treatment alternative:

1. Existing pipes have at least a minimum of 40 psi water pressure for the use of RO systems so as to avoid the need for booster pumps in the household
2. The selected RO unit is deemed sufficient for Cr6 treatment to below the MCL and certified for use as a POU treatment system
3. RO brine generated will recombine with sewage flows for no net change in salt loading to the sewer

8.2.3. LAND

The only land requirement is for a warehouse to store the RO units, replacement filters, and membranes. This facility should also include a sizeable parking lot to accommodate the vehicles used for installation and service visits. The size of the facility need only be large enough for a small administrative staff and to hold inventory for approximately two weeks' worth of service visits. Supplies can be restocked regularly on a two-week basis without requiring a larger warehouse. Given CVWD's availability of existing land and facilities for use, the space for administration, storage, and vehicle parking is not expected to require significant additional resources.

8.2.4. COMMUNITY OUTREACH

Pursuant to regulations regarding POU, community outreach must include giving notification of and conducting a public hearing. The hearing must provide a description of the POU treatment strategy, adverse health effects associated with Cr6, and operations, maintenance, and monitoring that necessitates customer involvement.

As a consequence of POU RO treatment, the removal of chlorine, TDS, and other minerals/constituents may play a significant factor in customers' perceived taste in water. In some cases, customers may negatively react to the change in taste. Additional education may be necessary to inform customers of the quality and effects of RO water in order to promote acceptance of the new POU treated water.



RO systems require approximately 4 gallons of water to produce 1 gallon of drinking water. Customers may not be aware of this. While drinking water use is small in comparison to overall domestic water use (1-3% of household water use), this increase in water use (and bill) should be communicated through community outreach.

Following the public hearing, customers must be surveyed and given the option to support or oppose the POU implementation. This customer survey is a requirement for the DDW application for a POU implementation permit, and would only be granted in the absence of substantial customer opposition. Having no substantial customer opposition is defined by the following formula:

$$\frac{(Number\ of\ customers\ voting\ against\ POUs) + (Number\ of\ non - respondents)}{Total\ number\ of\ customers} < 0.5$$

Achieving greater than 50% approval, given non-respondents are considered "no votes", could be challenging.

8.2.5. SYSTEM PERFORMANCE

RO units have the capability to consistently remove many constituents, including Cr6, nitrate, and TDS, to very low concentrations. Despite the corrosive nature of RO filtered water, the risk of corrosion is negligible since the treated water is conveyed only through the system's dedicated faucet. The inclusion of a pre filter provides a reduction in sediments and other constituents that may otherwise contribute to the fouling of the RO membrane. It is also assumed that with routine maintenance, under sink RO units may have a service life of up to 20 years.

Pilot testing to determine how effective RO is in treating Cr6 is not required, as this technology is considered a BAT. However, pilot testing could help confirm operations factors such as membrane and filter replacement requirements (instead of relying on manufacturers' recommendations). As an alternative to running a full pilot test, CVWD could enlist volunteer homeowners who already use POU RO systems and perform monitoring and evaluation on those units for an extended period of time. The results of that monitoring could provide an indication of both water quality and maintenance requirements of POU RO units.

8.2.6. SYSTEM INSTALLATION

In this analysis, the materials and labor were estimated for POU installation in the CVWD system as follows:

1. RO units
 - a. 142,365 units
 - b. 2 installations/day/technician
 - c. Additional totalizing flow meters for each unit



2. An administrative staff for record keeping, reporting, and scheduling
 - a. 2 environmental services specialists to administer the program
 - b. 10 customer service/administrative assistants
3. A training staff of 4 instructors
4. An installation team consisting of:
 - a. 66 installation technicians
5. Transportation vehicles for each technician
6. Plumbing toolsets for each technician

An installation team would be dedicated to visiting each customer and providing a POU treatment system within an assumed 5-year compliance schedule. The installed RO treatment units would be connected to the household water distribution system and placed underneath the kitchen sink with its own separate faucet (or to a drinking fountain for public facilities). A waste water pipe would also be connected to the existing sewage/septic system. An additional cost of installation may include sink replacements in the cases where existing sinks or counters require either significant modification or replacement to accommodate the addition of the RO units. The total number of units broken down by customer class can be found in **Table 8-1**.

The number of RO units for the hotel/motel customer class was obtained from the estimate of hotel rooms in the area by the Greater Palm Springs Convention and Visitors Bureau. While it is acknowledged that this approximation includes rooms that are not CVWD customers, this figure provided a reasonable approximation.

POU units would be installed for 100% of CVWD's customers, including those whose water is currently below the Cr6 MCL. Installing POU units at all homes ensures that all customers are adequately protected and provided with a uniform level of treated water.

After the installation period begins, inspections should be made on a representative subset of units to ensure quality control. Training staff may also need to be maintained through the training period for new hires or for installation quality control and re-training of the installation team. Under California Plumbing Code from Title 24, Part 5, Chapter 6, all RO systems installed are required to discharge the waste stream through an air gap drain. Commercial RO units have the capability to be installed for this configuration and would require the installation team to install the units as such. The installation of POU treatment systems for commercial, business, and hotel/motel customers may require different processes depending on site-specific conditions.

8.2.7. OPERATIONS AND MAINTENANCE

Operation and maintenance of POU RO units was estimated to require:

1. A maintenance staff of 57 technicians, in addition to the initial installation team, to serve a higher frequency of household/customer visits each year
2. Administrative staff for record keeping and continued scheduling (retained from installation period) including:



- a. 2 environmental services specialists to administer the program
- b. 10 customer service/administrative assistants
3. Transportation vehicles for each technician
4. Lab analysis and water quality testing
5. Filter and indicator light battery replacement (including pre/post filters and membranes)
 - a. 142,365 replacements each year

During annual operation and maintenance, an administrative staff would be necessary to continue reporting and scheduling with customers for service visits. DDW mandates that records be kept for at least 10 years. In order to meet this requirement, it would be necessary to retain an administrative staff to maintain all records associated with POU RO installation and maintenance.

All maintenance would be performed by trained installation/maintenance staff as required by the California Code of Regulations for POU systems. Maintenance visits would be performed once a year (or as needed) to replace pre/post filters, membranes, flow meters (every five years) and batteries to ensure the proper and continued function of the treatment systems.

Routine water sample collecting would also occur during service visits each year; the samples would be tested in a lab to ensure water quality and compliance. The high volume of water sample tests may also require an increase in laboratory capabilities. Due to more frequent visits for maintenance (as opposed to the 5 year compliance schedule for installation), a larger maintenance team, in addition to the initial installation team, would be required to service all POU units each year.

8.2.8. OTHER CONSIDERATIONS

The selection of a suitable RO unit should take into consideration required cost and frequency of maintenance. A lower maintenance/replacement frequency could save CVWD in operations and maintenance cost, but may incur a higher capital cost for the unit. Preliminary cost estimates are provided in **Table 8-2**. Analysis showed that a unit that only requires a once per year service visit (despite the higher unit price for the system) would be more cost efficient.

8.2.8.1. USE OF A CONTRACTOR FOR INSTALLATION AND O&M

A potential consideration for implementation may include the utilization of a contract with a privately operated company. Companies that provide leased or owned water conditioning units to households and businesses could potentially place competitive bids for a franchise service. In addition to the potential for more favorable costs, this alternative could help avoid the logistical challenges of operations and maintenance.

8.2.8.2. INCREASE IN WASTEWATER FLOW AND DOMESTIC WATER DEMAND

It is recognized that RO systems require a higher volume of water for use and consequently disposal of a waste brine stream where the reject contaminants and dissolved solids are concentrated. Due to increases in water usage from the RO brine and back flushing, CVWD wastewater treatment facilities may



expect an increase in sewer flow. Daily district demand for drinking water averages 103 million gallons of water. Taking into account that 1-3% of domestic water is used for drinking and cooking (CDPH Point of Use Compliance Advisory Policy Document, March 2013) and the 3 fold increase in water usage from RO units (low end commercially available RO units typically have a product to waste brine ratio of 1 to 4), CVWD's wastewater treatment facilities can expect an increase of 3 to 9 MGD of brine. However, the concentration of TDS and Cr6 in the waste stream is not expected to have a net increase after the implementation of POU systems. With regard to water supply, the increase in water demand would be 3 to 9 MGD.

8.2.8.3. RECYCLING OF USED CARTRIDGES

In light of the large quantity of POU systems to be installed, a larger quantity of filters and membranes would require replacement each year. The disposal of used cartridges could be done through a partnership with a local waste recycling company to extract and reuse the aluminum and polypropylene from the exhausted cartridges. This is common practice with privately owned companies that serve water conditioning units.

8.2.8.4. GUIDELINES FOR FILTER AND MEMBRANE CARTRIDGE REPLACEMENT

The rate at which filters and membranes foul is dependent on the quality of faucet water including TOC, pH, calcium carbonate, and other constituents. Various manufacturers suggest different replacement frequencies for filters and membranes. Commercially available models typically require a replacement every 6 months to a year. Running a pilot could help provide a more accurate estimate of replacement frequency.

8.3 COST ESTIMATE BASIS

A cost estimate was prepared for the implementation of POU treatment, broken down by customer class and presented to show both annualized cost of implementation and monthly cost to customers. The POU cost estimate, with assumptions, is detailed in Appendix G.

8.4 CONCLUSIONS

POU devices would be beneficial in that they would remove multiple constituents of current and potential regulatory concern. Although implementation of POU devices are technically feasible, their use would be challenging due to required regulatory/legislative changes, implementation complexity, and continuing operation and maintenance requirements. Costs were developed in the scenario analysis for POU to determine if the challenges would be worth overcoming to implement this approach.



9. SYSTEM-WIDE SCENARIO ANALYSIS

The Project Team developed and vetted multiple alternative water supply/treatment scenarios to comply with the Cr6 MCL. To facilitate decision-making of the CVWD Cr6 compliance approach, six scenarios were compared including:

- Scenario 1 – Groundwater treatment at clusters of wells
- Scenario 2 – Groundwater treatment at individual wells and a central resin regeneration facility
- Scenario 3 – Surface Water Treatment Plant in Mid-Valley with the balance of groundwater treatment at individual wells and a central resin regeneration facility
- Scenario 4 – Surface Water Treatment Plant in East Valley with the balance of groundwater treatment at individual wells and a central resin regeneration facility
- Scenario 5 – Point-of-use treatment
- Scenario 6 – Surface Water Treatment Plants in Mid-Valley and East Valley with the balance of groundwater treatment at individual wells and a central resin regeneration facility

All of these scenarios are able to meet CVWD's domestic water peak daily demand. However, each of the scenarios has a different balance of water sources and treatment approaches.

For Scenario 1, the system would rely on 100% groundwater. Wells that are affected by the Cr6 MCL would be primarily treated in clusters of multiple wells.

In Scenario 2, the system would rely on 100% groundwater. Wells that are affected by the Cr6 MCL would be primarily treated at individual well sites, with two clustered locations.

In Scenarios 3, 4 and 6, treated surface water would be added to the domestic water supply. The difference between Scenarios 3 and 4 is the location of the surface water treatment plant (in Mid-Valley versus East Valley), which also affects the number of groundwater wells in service. The Mid-Valley location was selected primarily to address the current deficiency and subsidence in the Valley zone. The East Valley location was selected primarily to provide for expected future growth in the East Valley. Scenario 6 includes surface water treatment plants in both Mid-Valley and East Valley locations, which would provide the most significant resource diversification.

Scenario 5 included the use of POU devices at homes and businesses for achieving Cr6 compliance.

The six scenarios were evaluated utilizing the following criteria; (1) annualized cost, (2) operational complexity, (3) diversity of supply, (4) public acceptance/environmental impacts, (5) implementation complexity, (6) operational flexibility and (7) water quality benefits. Major components, advantages and disadvantages of the scenarios are summarized in **Table 9-1**.



Figures 9-1 and 9-2 portray the capital and annualized costs for the six scenarios. Conceptual cost estimates for Tier 1 wells (red dots) and Tier 1 + 2 wells (yellow dots) are depicted, with bars reflecting the level of accuracy for this conceptual analysis (-30%, +50%). Assumptions and costs underlying the analysis were presented in Sections 4, 5, 6, 7, and 8, and Appendix G.

9.1 APPROACH

Advantages and disadvantages for each of the scenarios were weighed. The approach for evaluating the options included development of a spreadsheet model that allowed the Project Team (staff and consultants) to weigh the qualitative and quantitative aspects of each alternative based on a variety of selection criteria. The selection criteria were weighted to reflect CVWD priorities (e.g. scenarios that create added water resource flexibility might be more favored/higher weighted than scenarios that are less operationally complex). The model generated a “score” that reflected the overall performance of the scenario across the weighted selection criteria. The weighting was adjusted to perform a sensitivity analysis of the effect of prioritizing different criteria on the selection outcome.

9.2 CRITERIA SELECTION

The selection criteria were reviewed, refined and selected with CVWD in a workshop. The qualitative and quantitative criteria include:

9.2.1. ANNUALIZED COST

The cost criterion is an annualized value that includes both capital and operations and maintenance costs over the life the project (assumed 20 years).

9.2.2. OPERATIONAL COMPLEXITY

Operational complexity reflects the staffing burden that the scenario creates (number of staff) and the level of sophistication of the treatment process (level of operator certification required to implement the scenario above that currently present in the district). The California DDW treatment certification rating system was used to define the certification levels required by the scenario. DDW uses a five level classification system, for distribution systems, treatment facilities and operators. Distribution systems are classified into categories D1 through D5 according to population served and the complexity of the system. Treatment facilities are classified into categories T1 through T5 based on points assigned according to source water characteristics, maximum capacity, and treatment processes used. Operators are required to be certified for the specific classification of distribution system or treatment facility for which they are employed.



9.2.3. DIVERSIFICATION

Diversification relates to both supply and treatment. Multiple sources of water supply reduce the risk of any individual supply source being unavailable. New supply sources help meet future water demands as well as manage groundwater basin overdraft. Treatment diversification can be beneficial by limiting the risk due to a particular treatment technology not performing properly or being affected by future regulation that increase the cost or reduce the effectiveness of the treatment.

9.2.4. PUBLIC ACCEPTANCE / ENVIRONMENTAL IMPACTS

This criterion relates to the potential for the scenario to engender public opposition due to factors such as chemical handling risks, disposal of treatment residuals, truck traffic, noise, or other concerns. Additionally, the criterion considers the level of confidence the public will likely have in the solution as well as potential changes in the aesthetic quality of the water produced through the scenario.

9.2.5. IMPLEMENTATION COMPLEXITY

This criterion encompasses the relative complexity of the physical solution including the amount of pipeline construction required, the impact of tight schedules, and permitting issues.

9.2.6. OPERATIONAL FLEXIBILITY

Operational flexibility is the degree to which the scenario provides added physical system flexibility should CVWD lose a water supply source for any reason.

9.2.7. WATER QUALITY BENEFIT

The criterion for water quality benefit relates to the degree to which the scenario provides added water quality management benefits, treats multiple constituents in water or provides robustness against future regulations. It also includes the potential for water quality aesthetics impacts (positive or negative).

9.3 WEIGHTING

A numeric rating scale, shown in **Table 9-2**, was developed to rate each of the seven criteria for the scenarios. The rating scale is linked to a color-coding scheme from red (a rating of 1) to green (a rating of 3). This color-coding allowed the Project Team to rapidly rank the Scenarios both numerically and visually.

The Project Team adopted a weighting of the criteria as shown in **Table 9-3**. The model allows various weightings to determine the sensitivity of the analysis to different criteria. The team opined that annualized cost, diversification, public acceptance/environmental impacts and water quality benefits were especially important selection criteria. These were given triple the “importance/weight” (20% each) when compared to operational complexity, implementation complexity and operational flexibility (which were weighted at approximately 6.7% each). The total sum of the weightings for the seven criteria is 100%.



9.4 OUTCOME OF WORKSHOP

Each of the criteria were thoroughly discussed in a workshop with CVWD. The group used a consensus process to set the value of the criteria for each of the Scenarios. The outcome of that group process (and the weightings described earlier) is depicted in **Figure 9-3**.

The color-coding/numeric evaluation shows lower relative ratings for Scenarios 1 and 5. Scenarios 3, 4 and 6 had slightly higher ratings than Scenario 2 as they incorporate new sources of water supply, which improve supply diversification and accommodate a future WMP goal of meeting growth-related demands with treated Colorado River Water.

Higher cost, operational complexity, no added supply diversification, regulatory and customer acceptability, and implementation complexity associated with Scenario 5 were significant enough to rule out POU implementation as a preferred method of compliance.

A closer evaluation of Colorado River supply and demand was conducted by a CVWD Strategic Planning Initiative team. This evaluation concluded that domestic water demands have not grown to the point where existing supply needs to be supplemented by treated Colorado River Water. Therefore, this discounts the slight advantage for Scenarios 3, 4 and 6.

Another consideration is that the U.S. Geological Survey (USGS) has linked subsidence in the Valley and La Quinta pressure zone areas with declines in groundwater levels, as discussed in Section 2. Diversification of water supply through the use of surface water either for domestic consumption or recharge may help to relieve the stress on the aquifer and mitigate further subsidence. This was one factor in rating Scenarios 3, 4, and 6 higher for diversification of water supply.

CVWD also coordinated with IWA, MDWC, and Coachella Water Authority (CWA) to evaluate the potential of a regional surface water treatment plant. A facility in the vicinity of Burr Street/I-10 could serve CVWD, IWA and Myoma but there was little support for a regional plant at this time. This site will continued to be considered in the future. A conceptual design for a surface water treatment plant is included in Appendix H for future reference.

Scenario 2 is recommended as the preferred project due to its lower cost and the fact that a surface water treatment plant is not required at this time to fulfill additional domestic water supply demands. In addition, groundwater treatment at individual sites was viewed favorably due to less operational and implementation complexity, and flexibility for incorporating future treatment for additional constituents of concern.



10. CONCEPTUAL DESIGN OF TREATMENT

This section presents conceptual designs for the recommended treatment facilities for CVWD compliance with the Cr6 MCL. These include two different types of groundwater treatment (SBA and WBA) and a Central Resin Regeneration Facility.

Common elements that will be provided at each well treatment site include:

- Electrical Rooms – Sites with new pumps or other equipment with high electrical demand will need additional electrical facilities. For sites which already have electrical rooms the additional facilities will be housed in these rooms if space is available. For sites where the existing electrical facilities are outdoors, a new electrical room can be constructed to enclose both the existing and new facilities.
- Pre-filters – All ion exchange treatment sites will have pre-filters to keep silt and sand out of the resin vessels. All pre-filters will be standardized on a single brand and a single type of filter. All filters may not be the same size since filter size is dependent on to flow rate.
- Resin Vessels – All resin vessels will be standardized on a single size and rated at a nominal 1,000 gpm. The standard resin vessel size is based on 600 cubic feet of resin; this is the maximum amount of resin that can be transported to the CRRF without exceeding highway weight restrictions, and that can be accommodated in a standard 12-foot diameter vessel.
- Valves
- Controls

10.1 STRONG-BASE ANION EXCHANGE TREATMENT

10.1.1. PROCESS FLOW DIAGRAM

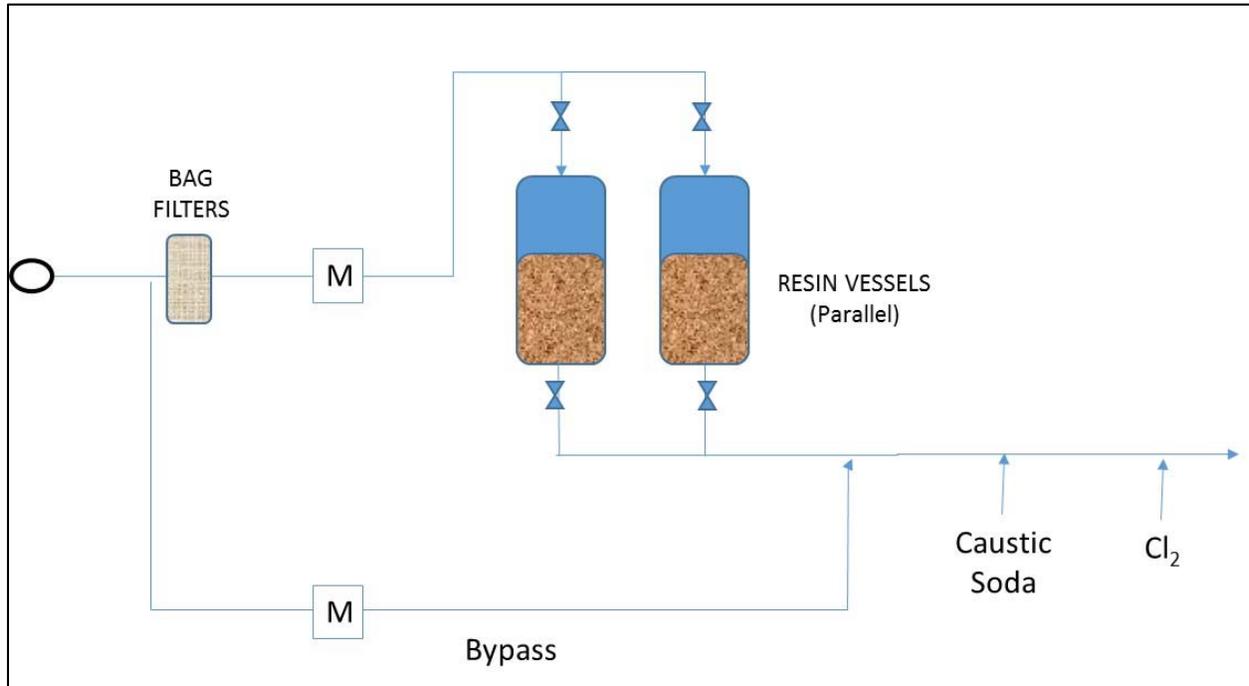
The treatment process includes a treatment stream and a bypass stream. The basic equipment required at the SBA sites includes pre-filters, followed by ion exchange pressure vessels, then calcium hypochlorite for disinfection and caustic soda for final pH adjustment (if needed), as shown in the schematic.

SBA resin vessels will be designed to operate in parallel. A pair of vessels, each sized to treat up to 1,000 gpm, will be provided at treatment sites with design flows of 2,000 gpm or less. A small number of wells have design flows greater than 2,000 gpm; three vessels are anticipated for these sites. Actual treated flows may be less than design flows, depending on the amount of flow bypassed.

The new treatment facilities will add significant headloss to the system. Modification of the pumping system will be necessary to overcome this pressure loss and maintain the existing capacity of the well. This could be done by installing a booster pump or by modifying the existing well pump. Alternately, the CVWD system may be able to accommodate slightly lower pumping capacities, which will be evaluated



in preliminary design. The booster pump configuration would increase operational complexity and was eliminated.



Schematic of the Conceptual Process Flow Diagram for SBA at CVWD

Caustic dosing facilities may be needed at the SBA sites to control the corrosivity of the treated water. The caustic dosing system would consist of a metering pump, storage tank and delivery piping. Caustic dosing facilities will be housed inside a small building.

Sites that have existing gas chlorine feed will be converted to tablet feeders to address CVWD's safety concerns and for consistency of disinfection strategy in the system. The tablet feeders will be enclosed in a small building. Where site constraints allow, this will be combined with caustic dosing facilities.

Electrical facilities at individual well sites will be assessed and updated on a case-by-case basis. In most cases, the additional loads will be small and the existing facilities may not require updating. Some sites already have electrical rooms and these typically have sufficient free space to allow the additional electrical components to be installed. For sites where the existing electrical facilities are outdoors, an electrical room will be constructed around the existing electrical facilities.



10.1.2. LAYOUT

Figure 10-1 shows a sample layout for an SBA system. This layout is based on Well 6728-1, which is located on Desert Shadows Drive in La Quinta. The sample layout has been configured to fit within the available space at Well Site 6728-1. This site is typical of a medium size site. The existing well house is near the center of the site and new facilities have been located so as not to obstruct access to existing facilities. The site includes an existing standby generator, which is recessed to minimize visual impact.

Removal of resin will require entry to the site by a tractor-trailer type vehicle. In some cases, modifications to the existing site entrance may be required to facilitate this. A paved and drained area will be provided for trucks to park when changing resin.

10.1.3. HYDRAULIC PROFILE

Figure 10-2 shows the hydraulic profile for a SBA wellhead treatment facility with a capacity of 2,000 gpm. The well pump will be used to pump the flow through the pre-filters. After the pre-filters the flow will be split between a treated leg and a bypass leg. Downstream of the ion exchange vessels the treated flow will combine with the bypass flow.

10.2 CENTRAL RESIN REGENERATION FACILITY

A CRRF will be used for regeneration of SBA resin from all of the operating SBA wells. The CRRF will provide regeneration of spent resin, in addition to waste management of residuals. Specifically, the facility will deliver the following functions:

- Brine regeneration of spent SBA resin
- Brine treatment to remove Cr6 and other hazardous constituents before brine disposal
- Treated brine evaporation
- Waste solids dewatering and disposal

In addition to the requirements of CVWD resin regeneration, consideration has also been given to the incorporation of resin regeneration and/or the handling of brine waste from the CVWD arsenic treatment plant facilities as well as the ion exchange facilities planned for nearby Indio Water Authority and Coachella Water Authority.

10.2.1. CAPACITY

The CRRF has been conceptually designed around the regeneration of 600 cubic foot (cf) volumes of resin, since this is the standard vessel size that will be used for the SBA facilities, and is consistent with standard vessel sizes used by private operators such as Evoqua. To provide both redundancy and also allow storage of resin at the facility, two 600 cf regeneration vessels have been included in the design. The



CRRF equipment, including pumps, piping and tanks, has been sized on the basis of one regeneration occurring at a time.

The frequency of regeneration will determine the costs of energy and chemical consumption. In order to determine the anticipated frequency of regeneration, an assessment of all wells was conducted. The assessment included an estimate of bed volumes between regenerations and the anticipated production from each well.

To provide a sensitivity analysis of the regeneration frequency, three different scenarios were considered for the CVWD wells:

- 2012 historical operational production data
- 30% well use (average for the system)
- 100% well use

Although 100% well utility is an unlikely scenario operationally, it was included as an upper bound to determine the absolute maximum possible requirement. IWA and CWA estimates of potential regenerations were also included if all of the impacted wells are serviced at CVWD's CRRF. From the combination of this information, average and peak regeneration frequency was assessed and the capacity of the CRRF to handle this regeneration frequency was determined (**Figure 10-3**).

The duration of each regeneration sequence is estimated to be ninety (90) minutes from the time the resin is inside the regeneration vessel. With two regeneration vessels at the site, resin transfer from or to the second vessel can occur without impacting a regeneration sequence in progress. As shown in **Figure 10-3**, with an average regeneration frequency of just over 1 per day for CVWD (for Tier 1 and 2 wells) and just over 2 for CVWD plus IWA and CWA, the CRRF will easily accommodate average requirements (reflected by 2012 and 30% capacity use rates). At peak conditions (in warmer months during higher demand periods), as much as double that capacity is achievable. Note that this assumes operation of the CRRF seven days per week; it may be preferable to perform regenerations Monday through Fridays only, which will be evaluated in the preliminary design. Further, multiple operations shifts could be utilized.

10.2.2. REGENERATION SEQUENCE

The anticipated regeneration process is described as follows. Resin would be delivered to the CRRF by tanker truck. Using a combination of dechlorinated water and compressed air or pumping, resin will be sluiced into one of the 600 cf regeneration vessels. Details of vessel handling requirements and resin sluicing for each option will be developed as part of the detailed design.

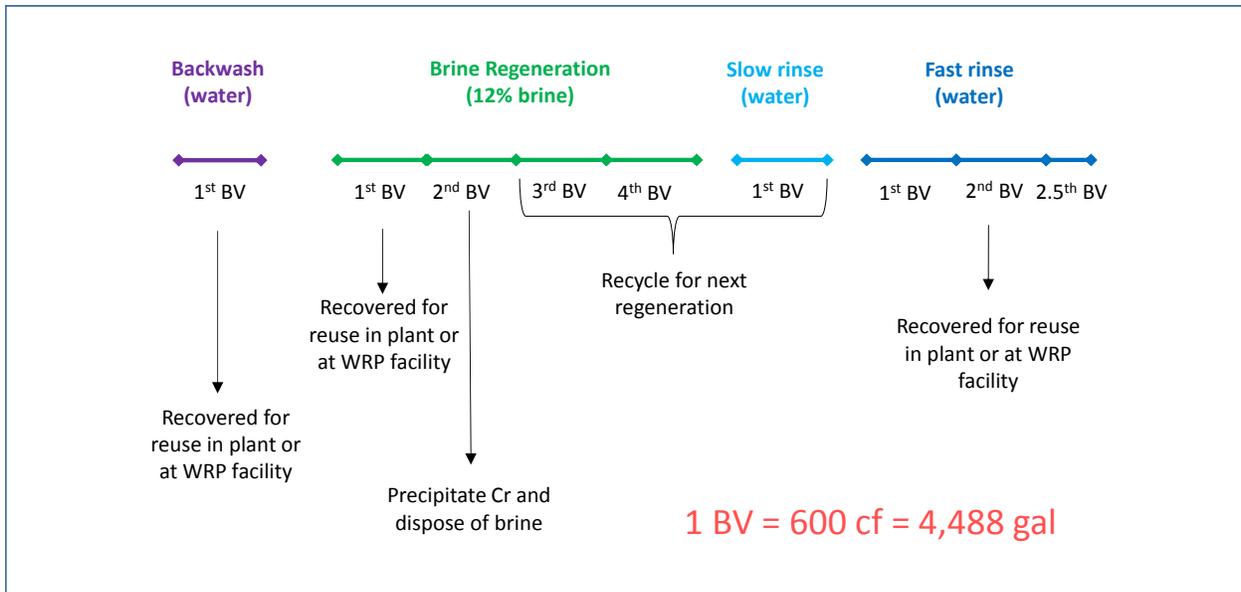
The regeneration sequence consists of four steps:

- A resin backwash, to lift and redistribute resin within the regeneration vessel
- Resin regeneration, in which the resin is contacted with 12% sodium chloride solution to displace Cr6, sulfate and other anions from the resin and replace them with chloride



- A slow rinse of clean water to displace brine solution
- A fast rinse for final resin cleaning

The CRRF conceptual process flow diagram is shown in **Figure 10-4**. CVWD’s preferred approach is to use any excess backwash and fast rinse water at the WRP 4 facility as an additional waste minimization strategy. Opportunities to achieve this strategy will be further evaluated in the preliminary design.



Schematic of the Waste Minimization Strategy

A conceptual design for the regeneration sequence follows:

10.2.2.1. BACKWASH

Water is flushed in the countercurrent direction (from bottom of vessel to top) to fluidize the bed and backwash any particulate matter from the resin. The backwash water could be recycled from spent fast rinse as a means of optimizing water use at the site.

10.2.2.2. RESIN REGENERATION

The brine regeneration step is the heart of the regeneration sequence. A solution of 12% brine (sodium chloride, or common table salt) is pumped through the resin. The high ionic strength of the solution displaces the Cr₆, sulfate, and other anions from the resin and replaces them with chloride ions. The brine is produced by dilution of a 26% saturated brine solution that is stored on site, along with feed water.

A key feature of the design is that a portion of the 12% brine solution can be recycled. This provides significant savings both in terms of brine (salt) consumption, as well as a substantial reduction in the amount of waste volume that must be treated. Pilot testing suggests that up to 75% of the brine may be



recycled without negatively impacting subsequent regeneration cycles. The 25% of brine that contains higher Cr6 is disposed as spent brine.

Pilot testing conducted at CVWD has shown that Cr6 levels in the spent brine peak for approximately one bed volume of the regeneration step (**Figure 10-5**). The conceptual design is to capture the peak chromium levels for disposal, and recycle the brine with lower chromium concentrations. The level of Cr6 in the recycled brine will reach an equilibrium, as seen in **Figure 10-6**, calculated for average and maximum levels of Cr6 observed in the brine.

The brine recycle tank is made up at the end of each regeneration sequence to replace the volume of spent brine disposal. This could be prepared from a combination of 26% saturated brine and the slow rinse.

10.2.2.3. SLOW RINSE

The slow rinse uses feed water to displace brine at the end of the brine regeneration step. The slow rinse would be captured for reuse in the next regeneration.

10.2.2.4. FAST RINSE

The fast rinse is the final step in the overall regeneration sequence, with 2.5 BVs of feed water utilized as a final rinse through the resin as recommended by a supplier.

10.2.3. SPENT BRINE DISPOSAL

Several options are available for spent brine disposal. Brine could be disposed as a liquid hazardous waste, or could be treated to remove hazardous constituents and either disposed off-site as non-hazardous brine or minimized in evaporation ponds.

Pilot testing has determined that Cr6 can be precipitated from the solution by dosing with a solution of ferrous sulfate or chloride. Based on benchmarking at other facilities, the ferrous iron dose used in the conceptual design estimates was a 7:1 molar ratio of iron to Cr6 (for removal of Cr6). All constituents of concern were decreased significantly below hazardous waste classification limits using this ferrous iron dose in CVWD pilot testing; this formed the basis for the cost evaluation of technologies. Additional evaluation of solids characteristics is underway

The occurrence of selenium at concentrations slightly higher than the STLC limit has been recently identified in optimization testing on two CVWD wells, despite selenium being non-detect in the tested groundwater. Preliminary evidence from testing underway shows that several strategies are possible to decrease the selenium concentrations to render the brine non-hazardous. The recommended approach for spent brine disposal will be further analyzed in the preliminary design.



One option for the minimization of treated brine waste that was considered in this conceptual analysis is the use of evaporation ponds, which can be cost-effective in a desert environment like the Coachella Valley. The conceptual design for spent brine disposal assumed that the salt would be thickened to a moist consistency in evaporation ponds and transported from site as a non-hazardous waste. This assumption requires additional testing and cost evaluation to determine the preferred approach for brine disposal, which will be developed in the preliminary design.

10.2.4. LAYOUT

For conceptual land evaluation purposes, an example conceptual layout of the CRRF including evaporation ponds is shown in **Figure 10-7**. The sizing of the evaporation ponds is impacted by the amount of brine waste that is produced. **Figure 10-8** shows the impact of different brine recycle rates for the CVWD brine (Tier 1 and Tier 2 wells), and potential regional partners (IWA and CWA used for conceptual purposes). As can be seen from the graphs, the amount of brine recycle that can be achieved has a significant impact on evaporation pond sizing. As a result, additional opportunities for maximizing brine recycle and reuse of slow and fast rinses in the CRRF could be considered.

10.3 WEAK-BASE ANION EXCHANGE TREATMENT

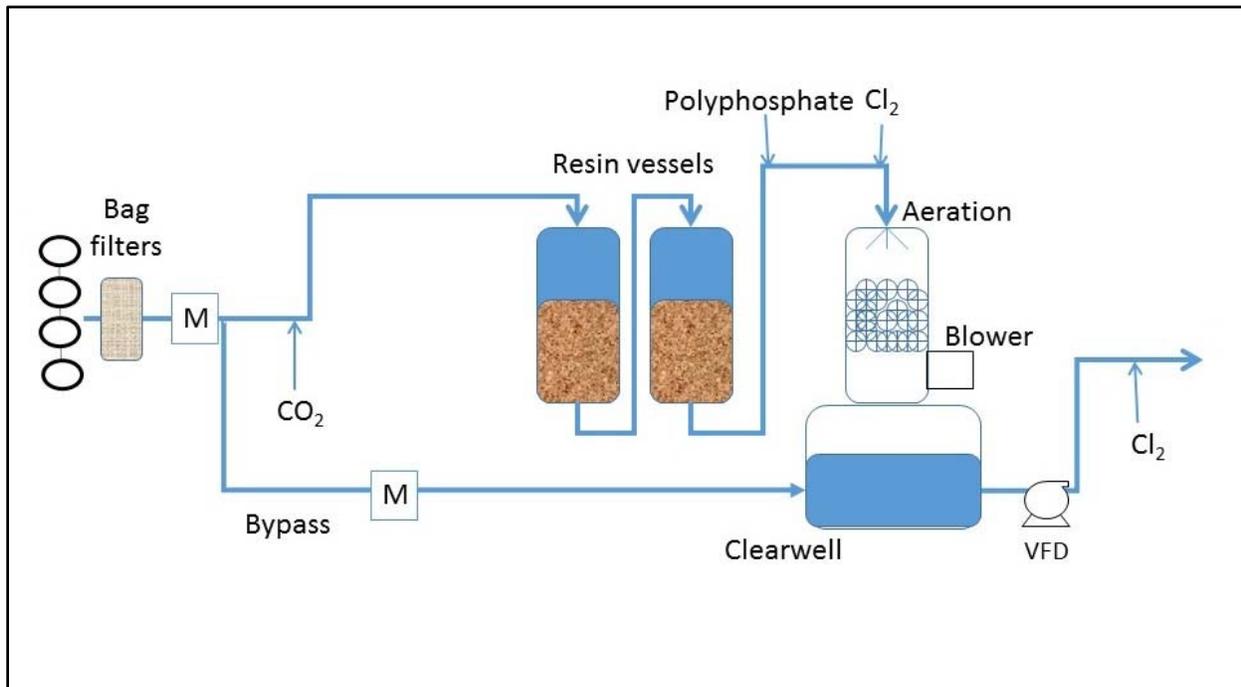
10.3.1. PROCESS FLOW DIAGRAM

The WBA systems will include a treatment stream and a bypass stream. The basic equipment required at the WBA sites are pre-filters, pre-pH adjustment, ion exchange vessels, post-pH adjustment, storage, and chemical feeds. WBA vessels will be designed to operate as pairs in series. Multiple pairs of vessels will be required at each treatment site. Each pair of vessels will be sized to treat up to 1,000 gpm.

The WBA system is capable of removing Cr6 to concentrations substantially below the MCL. To take advantage of this, a portion of the flow will be bypassed around the treatment system and then blended to achieve a final target level of Cr6.

The WBA process requires the pH of the water to be decreased prior to treatment. Carbon dioxide dosing will be used to achieve pH suppression. The carbon dioxide system includes a storage tank, vaporization equipment, carrier water system, and pressure solution feed system.

Following treatment, it will be necessary to raise the pH to a level suitable for distribution. Aeration towers can be used to strip carbon dioxide from the treated water and raise the pH to an acceptable level. Polyphosphate and chlorine are added to prevent scaling and biofouling of the aeration system. After aeration, the treated flow will be blended with the bypass flow in a clearwell and boosted to the discharge pressure.



Schematic of the Conceptual Process Flow for WBA at CVWD

10.3.2. LAYOUT

Figure 10-9 shows a sample layout for a WBA system. This layout is based on treatment of the four wells in the Sky Valley pressure zone. Additional space is shown in for future treatment for supplemental wells planned by CVWD in this area.

10.3.3. HYDRAULIC PROFILE

Figure 10-10 shows the hydraulic profile for a WBA wellhead treatment facility with a capacity of 4,200 gpm. The flow will be split to a treated stream and a bypass stream. The well pump will be used to pump the flow through both legs. Valves will be used to proportion flow between treatment and bypass. Both the treated flow and the bypass will discharge into the clearwell. Booster pumps will pump the flow from the clearwell to the distribution system.

Upgrading of the well pumps in lieu of booster pumps is not an option for the WBA system since it is necessary to break head as part of the WBA treatment process.



10.4 ENVIRONMENTAL CONSTRAINTS

This section discusses potential environmental constraints associated with the construction of water treatment facilities to comply with the Cr6 MCL based on the Study and conceptual designs. A general overview of environmental considerations is included, followed by a discussion of specific issues associated with each compliance approach.

10.4.1. OVERVIEW

Environmental constraints associated with implementing Cr6 treatment at locations across the Coachella Valley study area were identified in accordance with California Environmental Quality Act (CEQA) guidance (i.e., the CEQA Checklist) and CEQA-Plus guidelines (required for projects funded in part from the State Revolving Fund). Areas were identified where potential adverse impacts could occur as a result of project activities; these impacts may require evaluation and/or mitigation. This preliminary analysis is intended to provide an initial understanding of environmental issues; it is not an environmental review document under CEQA. That documentation will be performed after the project is further along in the design process.

Specific topics in the constraints analysis included: aesthetics, biological resources, land use planning, population/housing, transportation/traffic, cultural resources, hazards and hazardous materials, air quality, geology/soils, hydrology/water quality and noise. As understood at this stage in the conceptual design, impacts to recreation, public services, utilities/service systems, mineral resources, and agriculture and forestry are not anticipated, so potential impacts to these parameters are not discussed herein. However, the impact categories that apply may change depending on specifics of the final design.

10.4.1.1. AESTHETICS

Treatment facilities have the potential to change the existing visual or urban design context of sites. To avoid a significant impact to existing sites, landscaping and fencing may be needed as part of the proposed project. However, it is anticipated that facilities would be sited within preexisting CVWD locations. Therefore, the proposed design would be consistent with current conditions, as well as with the accepted CVWD design guidelines.

10.4.1.2. AIR QUALITY

Any potential emissions from both construction activities and project operations would need to be analyzed to evaluate the potential effects to sensitive receptors. Air quality emissions would also need to comply with the California Air Resources Board (CARB) and South Coast Air Quality Management District (SCAQMD) policies for regulated emissions such as carbon monoxide, sulfur dioxide, nitrogen oxides, particulate matter, lead compounds and VOCs. If applicable, CEQA-Plus requirements may include a Clean Air Act general conformity analysis, depending on the level and type of emissions.



10.4.1.3. BIOLOGICAL RESOURCES

The evaluation of biological resources, such as natural communities, federally protected species and conservation plans, typically require coordination with several agencies, institutions, and regulatory reports to ensure local biological resources are not compromised. As a permittee to the Coachella Valley Multi Species Habitat Conservation Plan (CVMSHCP), CVWD is not restricted from developing properties outside of designated conservation areas, which are covered by the Permit for the Take of Covered Species to the Permittees.²⁹ For projects within Non-Conserved Permittee Owned Lands (refer to Table 4-6 of the CVMSHCP) that would result in disturbance, a Joint Project Review Process shall be instituted by Coachella Valley Conservation Commission (CVCC) to evaluate the potential impacts from the project in order to allow CVCC to facilitate and monitor implementation of the CVMSHCP.³⁰ For areas inside existing permittee conservation areas, “New Development on Local Permittee Land, except as specifically authorized in Section 7 of this Plan, may be permitted only through a Plan amendment and must be consistent with the Conservation Objectives of the relevant Conservation Area.”³¹ If applicable, CEQA-Plus requirements include providing species lists, biological assessments, and other documents that disclose information on the project’s effect on sensitive species.

10.4.1.4. CULTURAL RESOURCES

Any treatment facilities that are not sited in previously or regularly disturbed areas will likely require consultation with California Historical Resources Information System, University of California Riverside Eastern Information Center, and research with local City planning departments and historical organizations. Additionally, facilities siting should take into consideration areas where known historic or archeological resources exist. Since project facilities are likely to be sited on locations that have been previously disturbed, the project is not anticipated to significantly affect historic or archeologic resources pursuant to §15064.5. If applicable, CEQA-Plus further requires the project comply with Section 106 of the National Historic Preservation Act.

10.4.1.5. GEOLOGY/SOILS

According to the State of California Department of Conservation, the South Branch of the San Andreas Fault runs through Coachella Valley. This fault has a classification of Holocene Fault Displacement (during past 11,700 years) with no recent historic record. Additionally, low angle faults run through the Santa Rosa-San Jacinto Mountains southwest of the valley. The California Geologic Survey has not delineated potential slope stability problems in Coachella Valley. With the likelihood of facilities being sited in

²⁹ Refer to Section 7.1 of the CVMSHCP, Covered Activities outside Conservation Areas

³⁰ The Joint Project Review Process “shall in no way limit the Local Permittees’ land use authority.” CVCC does not have the authority through the Joint Project Review Process to prevent permittee development. Refer to Section 6.6.1.1 *Joint Project Review Process within Conservation Areas* of the CVMSHCP for a full description of the process.

³¹ Refer to Section 4.1 of the CVMSHCP, Existing Conservation Lands within Conservation Areas



previously disturbed locations, it is anticipated that the proposed project would not expose a population to erosion, earthquake or landslide hazards.

10.4.1.6. GREENHOUSE GAS EMISSIONS

Potential greenhouse gas emissions resulting from the proposed project would be evaluated depending on the type of water treatment technology implemented and any other equipment (e.g. backup generators) installed onsite. As part of the CalUSEPA California Global Warming Solutions Act of 2006, (AB 32; Stats. 2006, chapter 488) CARB was tasked with collecting data on greenhouse gas emissions. Potential treatment options would potentially be impacted under this program.

10.4.1.7. HAZARDS/ HAZARDOUS MATERIALS

Phase I investigations and a review of environmental databases may need to be conducted for selected project sites, as applicable. Furthermore, depending on the type of treatment method proposed at a particular site, the generation of potentially hazardous materials during operations will be evaluated. For example, in the case of ion exchange technology, spent resin would require transportation and disposal per applicable regulations. Further, direct and secondary effects of potential facilities, such as risk to waterfowl from hazardous materials in evaporation ponds, would need evaluation upon final design.

10.4.1.8. HYDROLOGY/ WATER QUALITY

The water treatment facilities being evaluated will achieve compliance with the Cr6 MCL for existing water resources and are not anticipated to significantly increase the rate of groundwater withdrawal. Impacts associated with withdrawals for a surface water treatment plant would be assessed in a project-level CEQA document, as described in the Subsequent Program Environmental Impact Report (SPEIR) for the 2010 WMP update.

Hydrology or water quality may be impacted from localized changes to stormwater drainage, installation of evaporation ponds, or any required wastewater discharge. In these instances, the project design would consider potential impacts in order to reduce effects on local waterbodies and to apply with all applicable regulations.

10.4.1.9. LAND USE/ PLANNING

Purchase of land for treatment facilities or ancillary infrastructure (e.g. pipelines) may cause a change in the current land uses. While the current status of CVWD-owned land is known, land acquired would need further evaluation for potential environmental constraints (e.g. biological resources, cultural resources, etc.). The project design should consider avoiding impacts on areas of concern including tribal lands, sensitive wildlife habitats, or sensitive populations. In addition, any sites chosen for water treatment facilities would comply with permitted local land uses and zoning ordinances. If water treatment sites do not comply with surrounding land uses, coordination with local planning bodies would be required, as well as mitigation measures where necessary.



10.4.1.10. NOISE

Any new water treatment facilities could emit noise from ongoing operations. Noise levels would be evaluated with respect to the proximity of any sensitive receptors (e.g. parks and schools) based upon local plans, noise ordinances and other applicable standards. Noise buffering technologies could be implemented as necessary.

10.4.1.11. POPULATION/ HOUSING

The project would improve the quality of potable water supplied to the Coachella Valley. These actions are therefore not anticipated to induce physical growth in the region. There is a likelihood that treatment facilities would be located in close proximity to residential areas; however, no housing or population would be displaced. With the potential for facilities to be located near residential areas, there may be environmental justice concerns. In order to identify these potential issues, OEHHA, on behalf of the California USEPA, has developed the California Communities Environmental Health Screening Tool. This screening methodology can be used to help identify California communities that are disproportionately burdened by multiple sources of pollution, and would be useful in determining the project's impact in a given community.

10.4.1.12. TRAFFIC/ TRANSPORTATION

Pipelines required as part of the proposed project may be installed beneath existing roadways. This would temporarily impact the use of these roadways for vehicle or pedestrian traffic. Local, state, and federal coordination may be required as part of construction activities. In addition, coordination with local utilities would be required to prevent any issues with other municipal services. If future maintenance were required for any potential pipelines, the roadway would be temporarily disturbed to make repairs.

In addition to temporary construction impacts, as part of the proposed project's ongoing operations, deliveries would be made to the site(s) on a regular basis, causing additional traffic effects. Truck traffic for replacement of resin is expected to occur annually for WBA treatment and every few weeks for SBA treatment. However, frequency at specific sites will depend on the Cr6 concentration, flow rates, water quality, and ion exchange tank size. Therefore, truck traffic estimates at each location will depend on the final design.

10.4.2. SPECIFIC CONSIDERATIONS

Below are specific environmental considerations for the wellhead treatment facilities and the CRRF. These considerations are based on the Study, current conceptual designs, and site options. Upon finalization of facility locations and designs, an appropriate environmental analysis would be required for CEQA compliance.



10.4.2.1. SBA AND WBA TREATMENT FACILITIES

Construction activities would include the installation of treatment process equipment and on-site piping. For SBA facilities, equipment would include ion exchange tanks, booster pumps, and a sodium hydroxide (NaOH) storage building. For WBA facilities, equipment would include ion exchange tanks, booster pumps, CO₂ storage tank and feed pumps, and aerators. Because upgrades would occur on previously-disturbed sites located in developed areas, the potential for significant adverse impacts to aesthetics, biological resources, cultural resources, geology/soils, hazards/hazardous materials, hydrology/water quality and land use are generally low.

However, individual well sites may require specific consideration of adjacent or nearby land uses. For example, areas toward the edge of the Valley abut conservation areas, while sites in more developed areas are adjacent to residential areas and near parks, schools, and other potentially sensitive receptors. None of the site-specific issues are anticipated to preclude improvements to CVWD facilities; these issues may require additional analysis of potential impacts and potentially mitigation in compliance with CEQA. The following is a list of potential site-specific environmental considerations at individual well locations.

- Site 3408-1 is located within the Upper Mission Creek/Big Morongo Canyon Conservation area (**Figure 10-11**). As per section 6.6.1.1 of the CVMSHCP, a Joint Project Review Process is required in addition to environmental documents prepared pursuant to CEQA. The Joint Project Review Process may potentially delay the project, and may not allow for installation of treatment facilities at this location within the time frame of the compliance plan for CVWD.
- Site 3409-2 is located approximately 350 feet to the north of the Willow Hole Conservation Area (**Figure 10-11**).
- Sites 3408-1 and 3409-2 fall under the jurisdiction of the Riverside County Economic Development Agency Mid-County Project Area (**Figure 10-11**).
- The proposed Desert Hot Springs Well Field Development is located within the Willow Hole Conservation Area. Similar to Site 3408-1, a Joint Permit Review Process is required in addition to environmental documents prepared pursuant to CEQA. However, due to previously undeveloped site conditions, review time may be substantially longer under the CVMSHCP. The potential well field is currently undeveloped, and would require the construction of a road to the site. In addition, the site may require additional disturbance due to construction and staging. However, disturbed areas outside of well footprints would be restored to pre-existing conditions.
- Sites 6728-1, 6808-1, and 6805-1 are located in the Riverside County Economic Development Agency Desert Communities Project Area.
- Sites 5713-1, 5714-1, 5716-1, 5717-1, and 5718-1 are situated in a highly developed area (**Figure 10-12**).
- Site 5718-1 on Fred Waring Drive is located directly adjacent to Monticello Park in the City of La Quinta.
- Site 5714-1 is located approximately ¼ mile from Earhart Elementary School and approximately 0.4 mile from La Quinta Park.



- Site 5716-1 is located approximately ¼ mile from Earhart Elementary School, approximately ¼ mile from La Quinta Park, and approximately ¼ mile from La Quinta High School.
- WBA treatment processes could result in the release of radon gas and will need additional evaluation with respect to sensitive receptors.
- WBA treatment processes could result in the release of CO₂ and will need additional evaluation with respect to greenhouse gas emissions.

10.4.2.2. CENTRAL RESIN REGENERATION FACILITY

Options considered for a Central Resin Regeneration Facility location include co-locating with an existing CVWD facility located at Avenue 64 and Fillmore Street or an undeveloped property owned by the US Bureau of Reclamation located at Avenue 52 at Coachella Canal (**Figures 10-13 and 10-14**). No additional site-specific constraints are anticipated for the CRRF at either site beyond those described in Section 10.4.1 of this report. However, some additional considerations for the two sites are described below.

Adjacent land uses for the Bureau of Reclamation property include a Riverside County designated Coachella Valley Agricultural Preserve and the Canal Regional Park. Adjacent land uses for the CVWD property include a Riverside County designated Coachella Valley Agricultural Preserve and Torres-Martinez Tribal Lands. Development of either site should take these existing land uses into account to prevent potential impacts to neighboring parcels.

Evaporation ponds will require Waste Discharge Requirements (WDR) from the California Regional Water Quality Control Board and the design of the ponds must conform to Title 27 of the CA regulations (<http://www.calrecycle.ca.gov/laws/Regulations/title27/default.htm>). The process for obtaining WDRs for the project will require public comment and a hearing. A common concern for evaporation ponds is wildlife mortality, particularly if the brine has the potential to be toxic. Bird activity at or near the evaporation ponds may also be a concern for any local airports. Typical mitigation measures are fencing and netting to prevent wildlife and birds from entering the ponds.

Solid wastes and wastewater generated at the facility would need to be disposed of properly, which may lead to indirect impacts depending on the location and method of ultimate disposal. Additionally, truck traffic in the vicinity of the regeneration facility will be greater than that around the individual wellhead treatment facilities. Traffic will include initial construction traffic, personnel vehicles, and vehicles for regular operations. Both proposed locations have suitable access by road and are not located in areas with a large residential population. However, the US Bureau of Reclamation site is located near the Canal Regional Park, which is a sensitive receptor.

Development of the CRRF on US Bureau of Reclamation property may also require an environmental assessment prepared per federal National Environmental Policy Act (USEPA) regulations. If a USEPA assessment is applicable, the project would require coordination between federal and state agencies to ensure the requirements of both USEPA and CEQA are met. Fundamental aspects of the two policies are



similar; however, there may be procedural differences (e.g. schedules, involved parties, structure of assessment reports, etc.) that would require consideration.

10.4.3. CEQA COMPLIANCE AND SCHEDULE

The wellhead treatment facilities and central regeneration facility were not included in the 2010 WMP and are, therefore, not covered by the SPEIR SCH No. 2007091099. CVWD could elect to update their WMP and hence their SPEIR based on the treatment projects required to comply with the Cr6 MCL. This update would be followed by site-specific environmental documents prepared to analyze issues specific to the elements of the projects being implemented. This option is not recommended based on the compliance schedule for the Cr6 MCL.

As part of the engineering design phase for the Cr6 facilities, CVWD will need to determine the appropriate environmental review method for the project. The environmental review process will be determined based on the project definition, i.e., the number and location/type of facilities, construction schedule, and similar factors. The process will also be determined based on whether there is a nexus to federal involvement, either through use of federally-owned property, funding e.g., State Revolving Fund program), or regulatory permitting requirements. After the project description is finalized through the design process, then CVWD can proceed with developing the CEQA (and potentially USEPA) scope of work and schedule, and then initiate the environmental review process.

10.4.4. SUMMARY

Planned development of SBA & WBA treatment facilities and the CRRF at sites identified in this study will require additional analyses and potentially mitigation to address project impacts, but are not expected to be precluded for development or site improvements. It does not appear from the constraints analysis that there are any “fatal flaws” for environmental impacts related to construction and operation of the project as currently defined.

The results of this constraints review identified two project sites that are subject to a Joint Project Review Process as per the CVMSHCP. This review is in addition to required CEQA documentation and may slow down project implementation at these sites, or result in recommendations for mitigation measures or design modifications in order to maintain consistency with the conservation area’s conservation objectives. The review process flow chart for the Joint Project Review Process from the CVMSHCP is presented in **Figure 10-15**.



11. IMPLEMENTATION OF COMPLIANCE PROJECTS

This section presents an implementation plan for achieving Cr6 compliance, including:

- An early start to accelerate design and construction where feasible
- A program schedule to lay out the necessary steps
- A procurement strategy to decrease time to bring facilities online

Facilities to achieve Cr6 compliance include those listed below. The facilities include 23 SBA treatment plants at well sites, two WBA treatment plants including pipelines from nearby wells to cluster treatment for 4 wells in Sky Valley and 2 wells in Lake Cahuilla, 1 well blended with distribution system water in an on-site tank, and a Central Resin Regeneration Facility.

Note that one well, 4728-1, was eliminated from treatment in preliminary design when the site evaluation showed the well site was not conducive to upgrades and the well was at the end of its useful life.

Treatment Technologies Planned for Cr6 Compliance

Facility Number	CVWD Well Number	Well Treatment Design Capacity (gpm)	Technology
1	4510-1	2,000	SBA
2	4610-1	2,000	SBA
3	4720-1	2,000	SBA
4	4721-1	2,000	SBA
5	4722-1	2,000	SBA
6	5632-2	2,000	SBA
7	5657-2	2,000	SBA
8	5664-1	2,000	SBA
9	5676-2	2,000	SBA
10	5677-1	2,000	SBA
11	5678-1	2,000	SBA
12	5679-1	2,000	SBA
13	5711-1	2,000	SBA
14	5717-1	2,000	SBA
15	5718-1	2,000	SBA
16	5719-1	2,000	SBA



Facility Number	CVWD Well Number	Well Treatment Design Capacity (gpm)	Technology
17	5720-1	2,000	SBA
18	6701-1	2,000	SBA
19	6805-1	2,000	SBA
20	6808-1	2,000	SBA
21	6726-1	2,000	SBA
22	6728-1	2,000	SBA
23	6734-1	2,000	SBA
24	3405-1	-	Transfer to WBA cluster at 3408-1
25	3408-1	5,000	WBA cluster
26	3409-1	-	Transfer to WBA cluster at 3408-1
27	3410-1	-	Transfer to WBA cluster at 3408-1
28	6723-1	-	Blending with lower Cr6 water
29	6724-1	4,000	Transfer to WBA cluster at new site
30	6725-1	-	Transfer to WBA cluster at new site
31	-	-	Central resin regeneration facility for SBA resin

Key steps in the implementation at the conceptual level include the following, with the end goal of treatment operational by July 2019 as depicted below:

- Conceptual design – December 2014 to April 2015
- Preliminary design – February to August 2015
- CEQA certification – February 2015 to May 2016
- Detailed design – July 2015 to May 2016
- Preconstruction – September 2015 to May 2016
- Construction – June 2016 to June 2019

Adherence to this schedule will allow CVWD to install and bring treatment online within 5 years of Cr6 rule promulgation, while achieving compliance with environmental regulations (e.g., CEQA).



12. FUTURE PROJECTS

As described in this report, Tier 1 wells require immediate treatment to achieve compliance with the Cr6 MCL. Tier 2 wells have concentrations between 8 and 10.4 µg/L and are below the MCL. However, it is recommended that CVWD continue to monitor these wells and implement wellhead treatment if they become out of compliance in the future. The capacity to handle future treatment at Tier 2 sites using the central resin regeneration facility was included in the conceptual design.

Other constituents of concern identified in CVWD groundwater that have current regulatory limits and may be susceptible to lower regulatory limits or rising groundwater concentrations in the future include nitrate, arsenic, VOCs, and perchlorate. In general, treatment of Cr6 using SBA is advantageous over treatment of nitrate and arsenic. Lower brine volumes are generated when treating Cr6, which is an important factor for CVWD due to the large number of well sites, small footprint available at most sites, and locations in residential areas where truck traffic minimization is desirable. Should perchlorate treatment become necessary in the future, removal with single-pass perchlorate-selective resins would be preferable to regenerable SBA due to difficulty in removing perchlorate from waste brine. VOCs in wells would require processes such as aeration and/or granular activated carbon, in addition to the nitrate treatment required for many of the VOC impacted wells, making treatment costly.

Nitrate concentrations were observed to be rising in several wells and may require replacement with new wells in the future. Two wells were identified that could be modified to draw from a lower nitrate concentration depth in the aquifer. Replacement of other nitrate impacted wells would avoid costly treatment in challenging residential areas. Areas in the Date Palm zone and three locations in the Valley and Lake Cahuilla zones that are at lower risk for constituents of concern including nitrate and Cr6 were identified based on cross-section analysis in different areas of the Coachella Valley.

Unregulated constituents of reasonably anticipated regulatory significance in CVWD groundwater include chlorate, strontium, and vanadium. Among Cr6 treatment options, the ability to address strontium and vanadium is most compatible with the use of regenerable ion exchange (SBA), particularly with a central resin regeneration approach for brine treatment and disposal. Additional vessels and on-site regeneration equipment may be needed to address these constituents, depending on the potential future regulatory levels. Chlorate is a disinfection by-product and susceptibility to this constituent of concern can be minimized by continued use of calcium hypochlorite disinfection, which was recommended in this Study.

Surface water treatment is also anticipated to be necessary in the future to address projected growth outlined in the 2014 Water Management Plan Update. Several potential projects, including treatment processes and potential locations in the Mid-Valley and East Valley, were identified, including recommended testing prior to implementation.



FIGURES

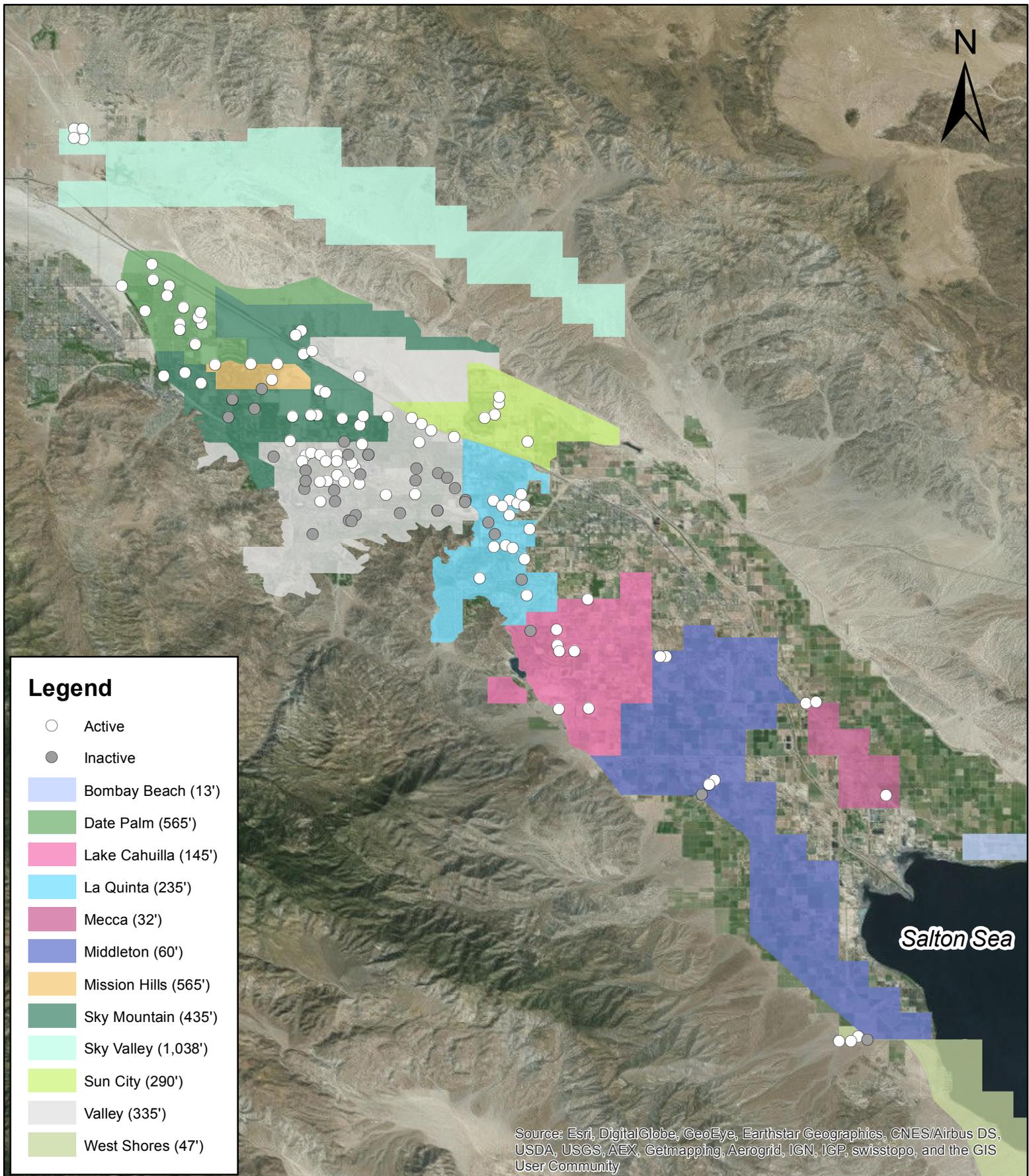


Figure 2-1
Pressure Zones with Active and Inactive CVWD Production Wells

Coachella Valley Groundwater Chromium-6 Occurrence March 17th 2015

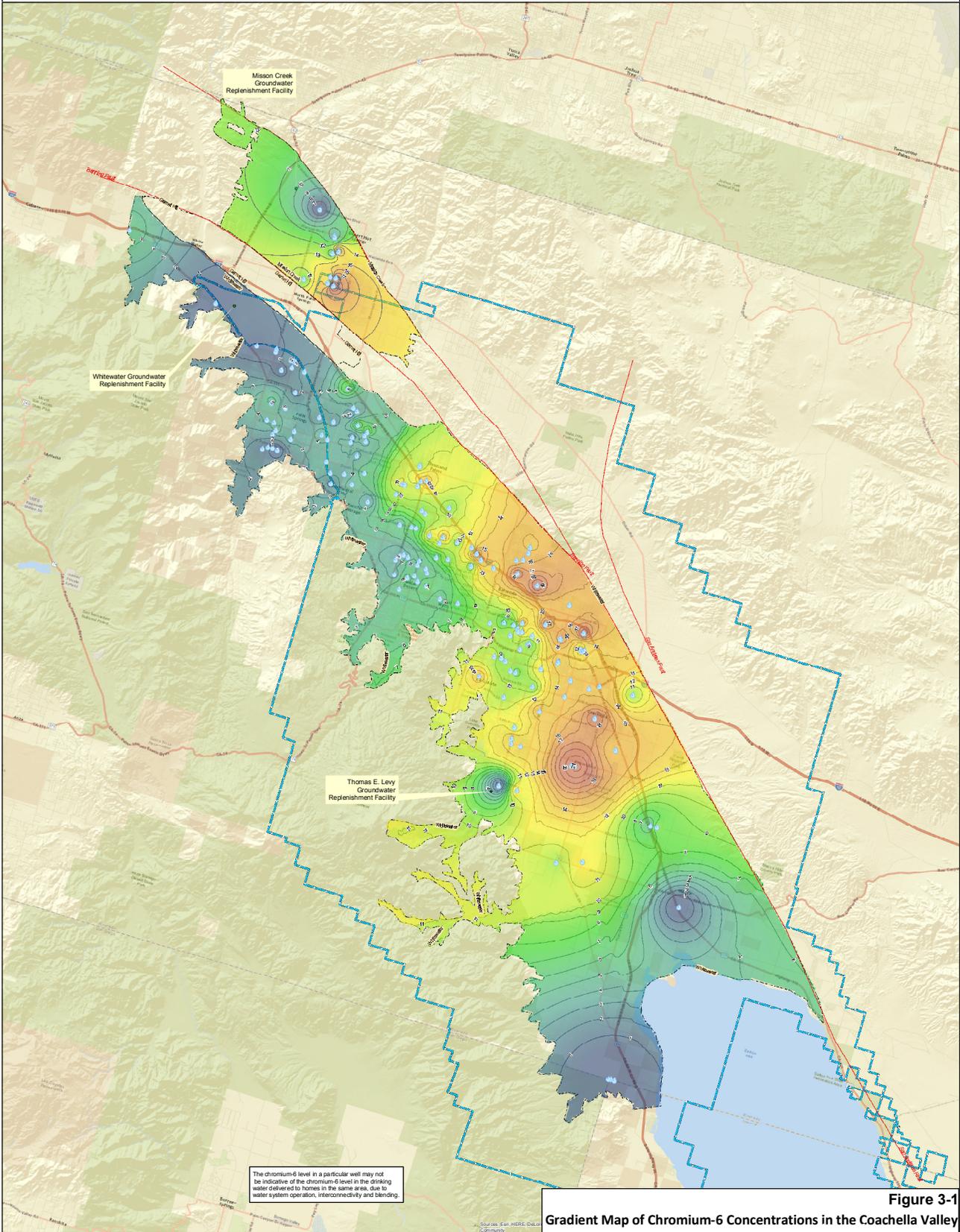


Figure 3-1
Gradient Map of Chromium-6 Concentrations in the Coachella Valley



Legend

Chromium-6 Levels

Value

High : 23.6675

Low : 0.0003776

Domestic Water Well

Contours (Parts per Billion)

Fault Lines

CVWD Boundary

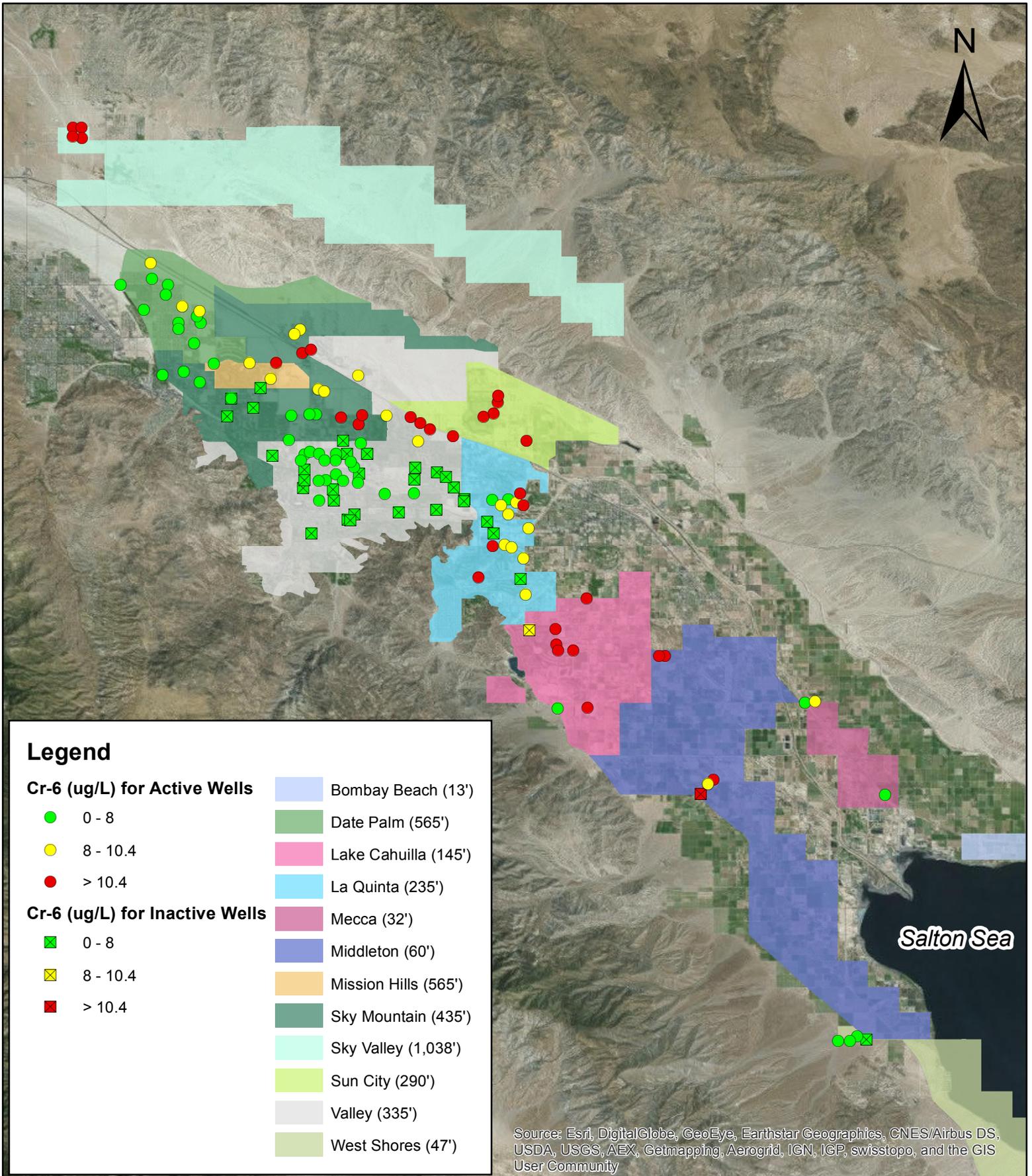
Subbasin Boundary

Coachella Valley Water District

75515 Hovley Lane East
 Palm Desert, CA 92221
 www.cvwd.org
 Ph. (760) 398-2662
 Fx. (760) 568-1789

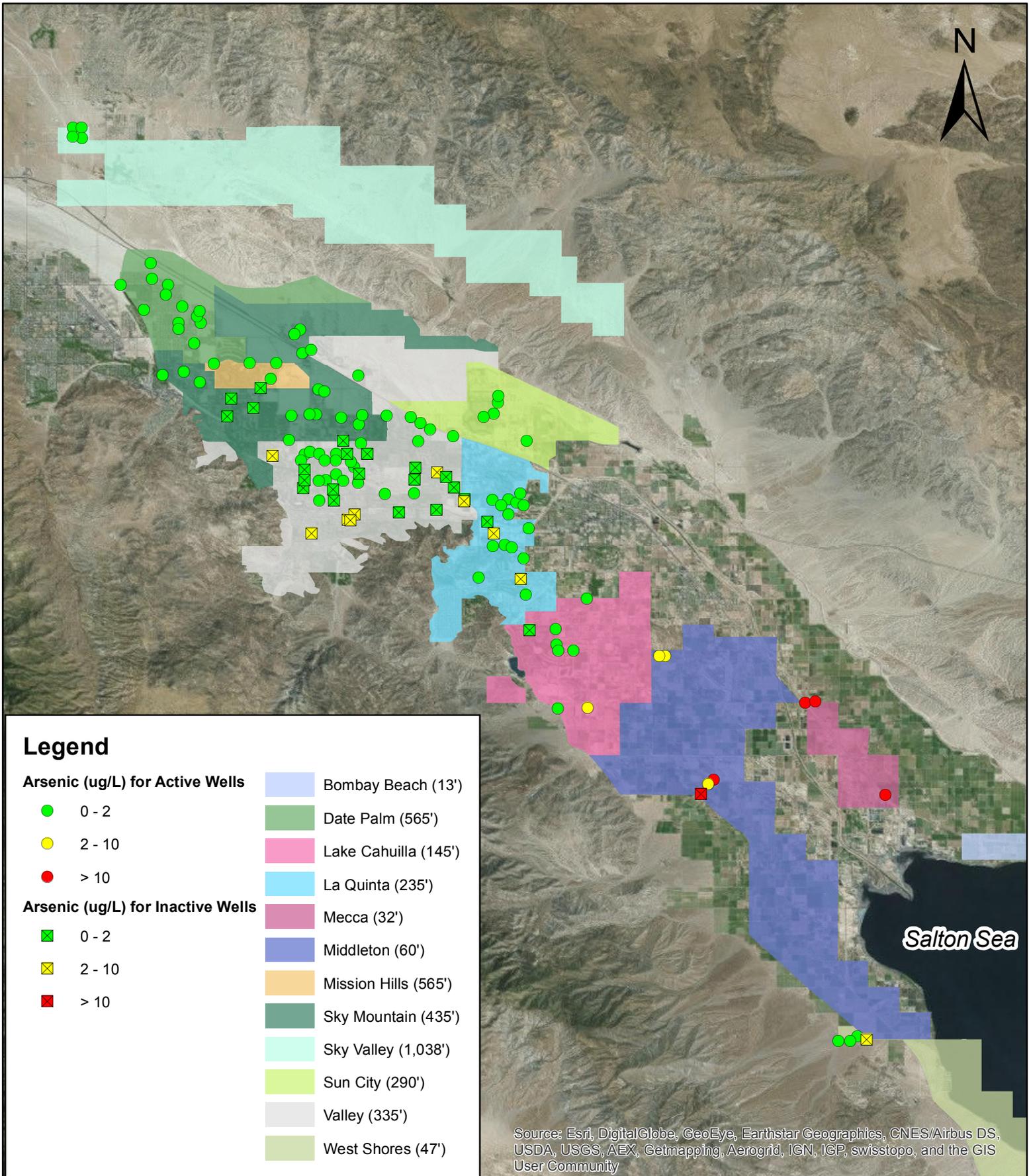
Miles

0 0.75 1.5 3 4.5 6 7.5 9



SCALE
0 12,000 24,000 48,000
Feet

Figure 3-2
Chromium 6 in Active and Inactive CVWD Production Wells



SCALE
0 12,000 24,000 48,000
Feet

Figure 3-4
Arsenic in Active and Inactive CVWD Production Wells

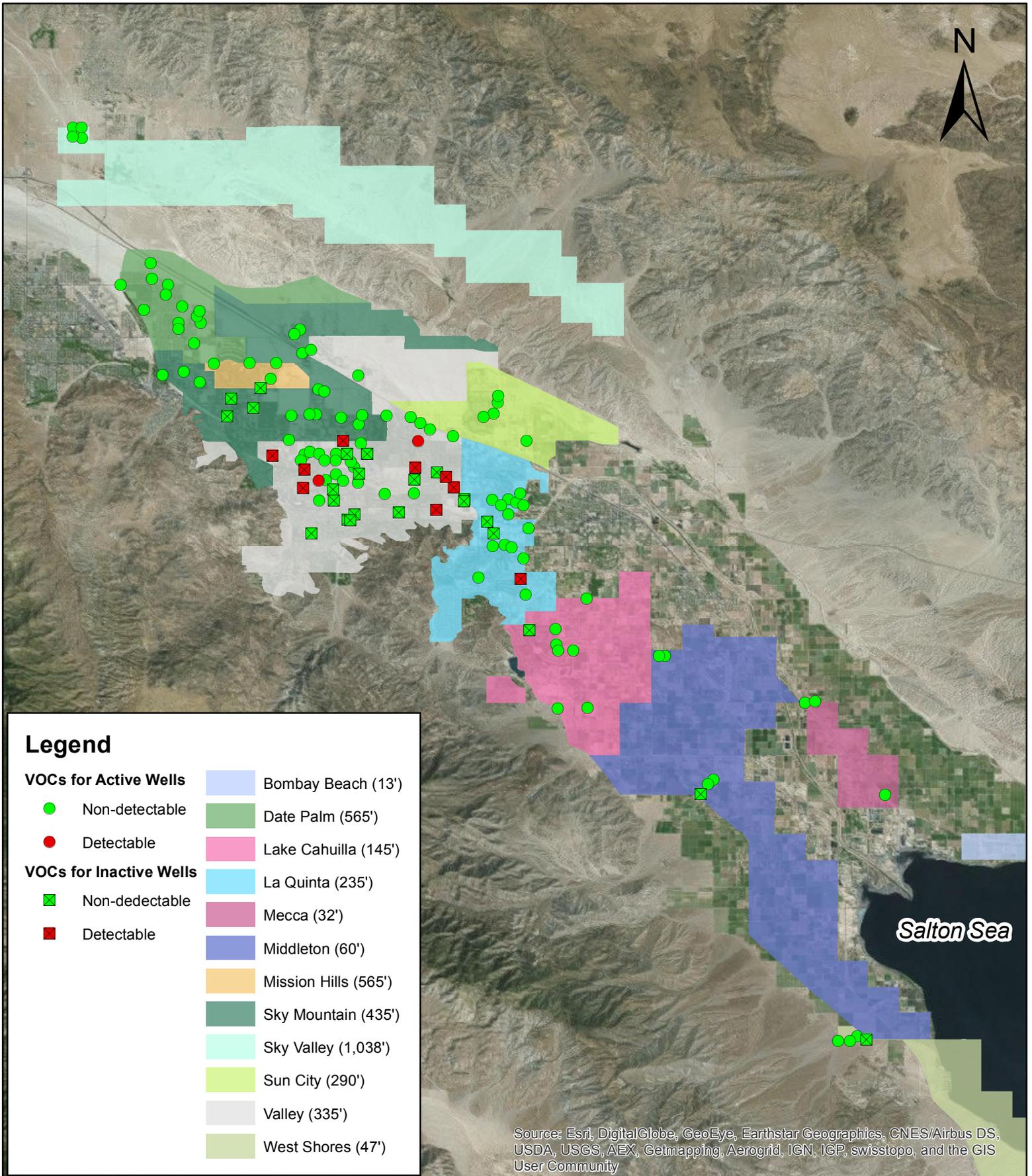
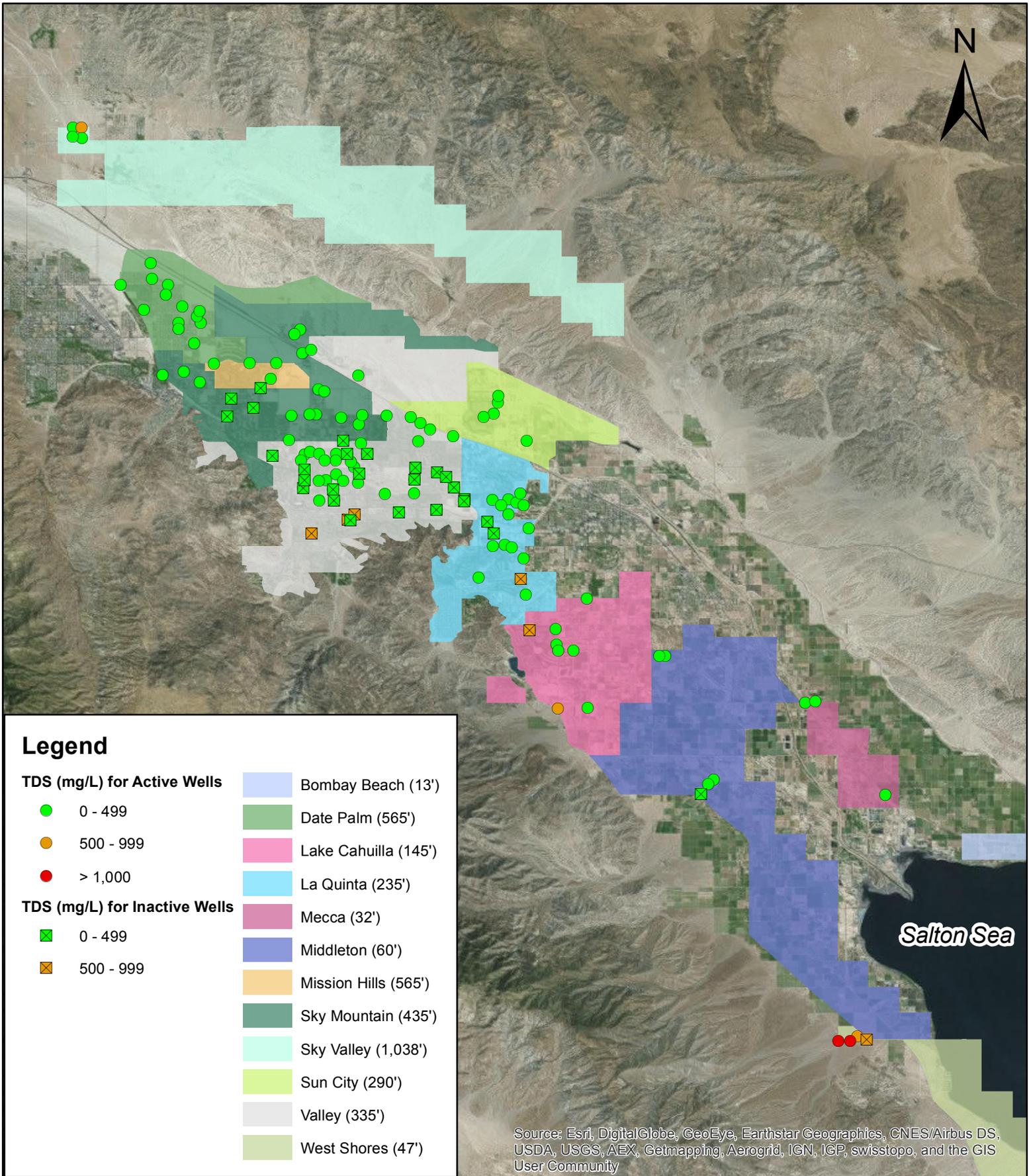


Figure 3-5
VOCs in Active and Inactive CVWD Production Wells



Salton Sea

SCALE



Figure 3-6
TDS in Active and Inactive CVWD Production Wells

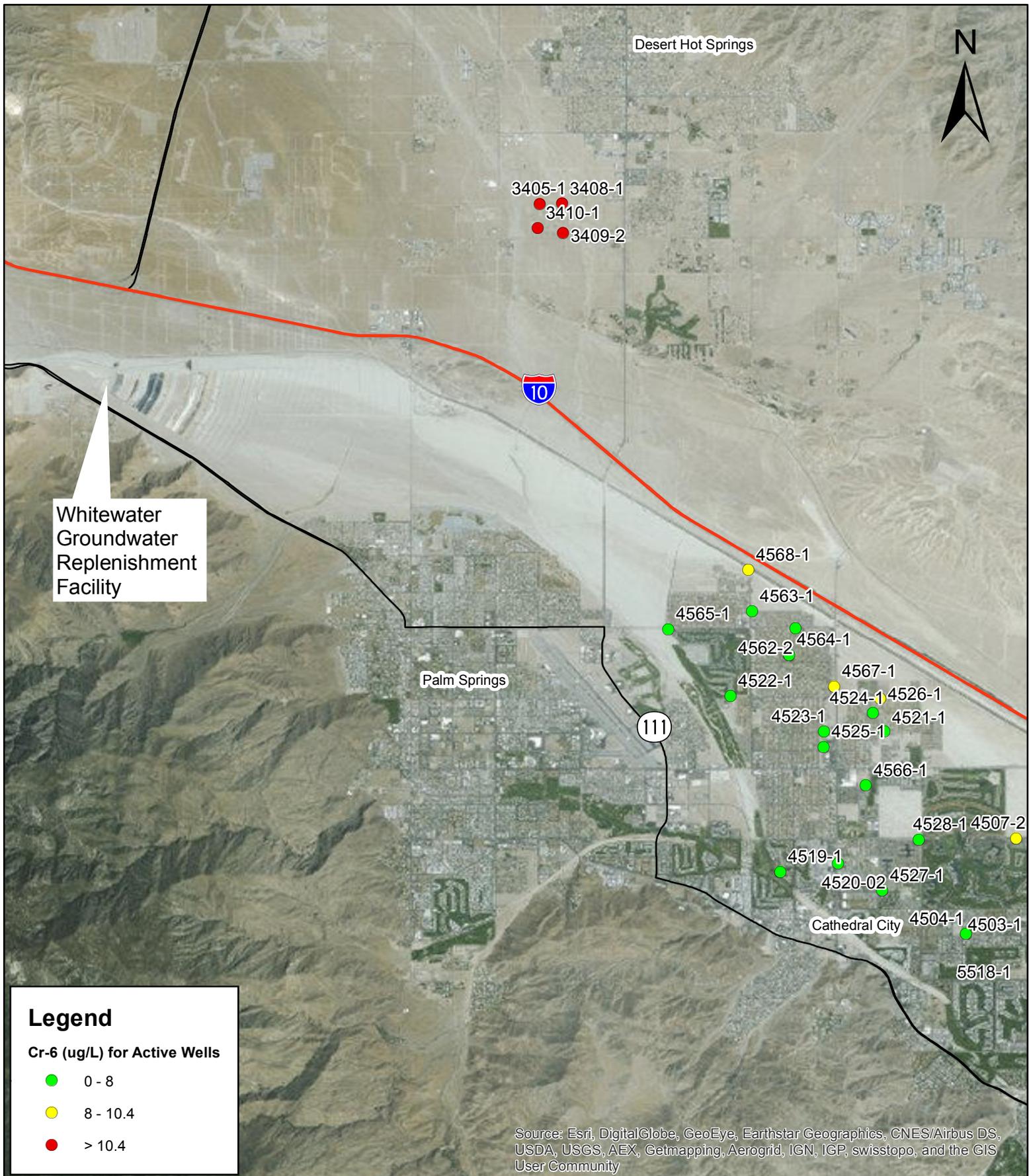


Figure 3-7
Groundwater Wells near the
Whitewater Groundwater Replenishment Facility

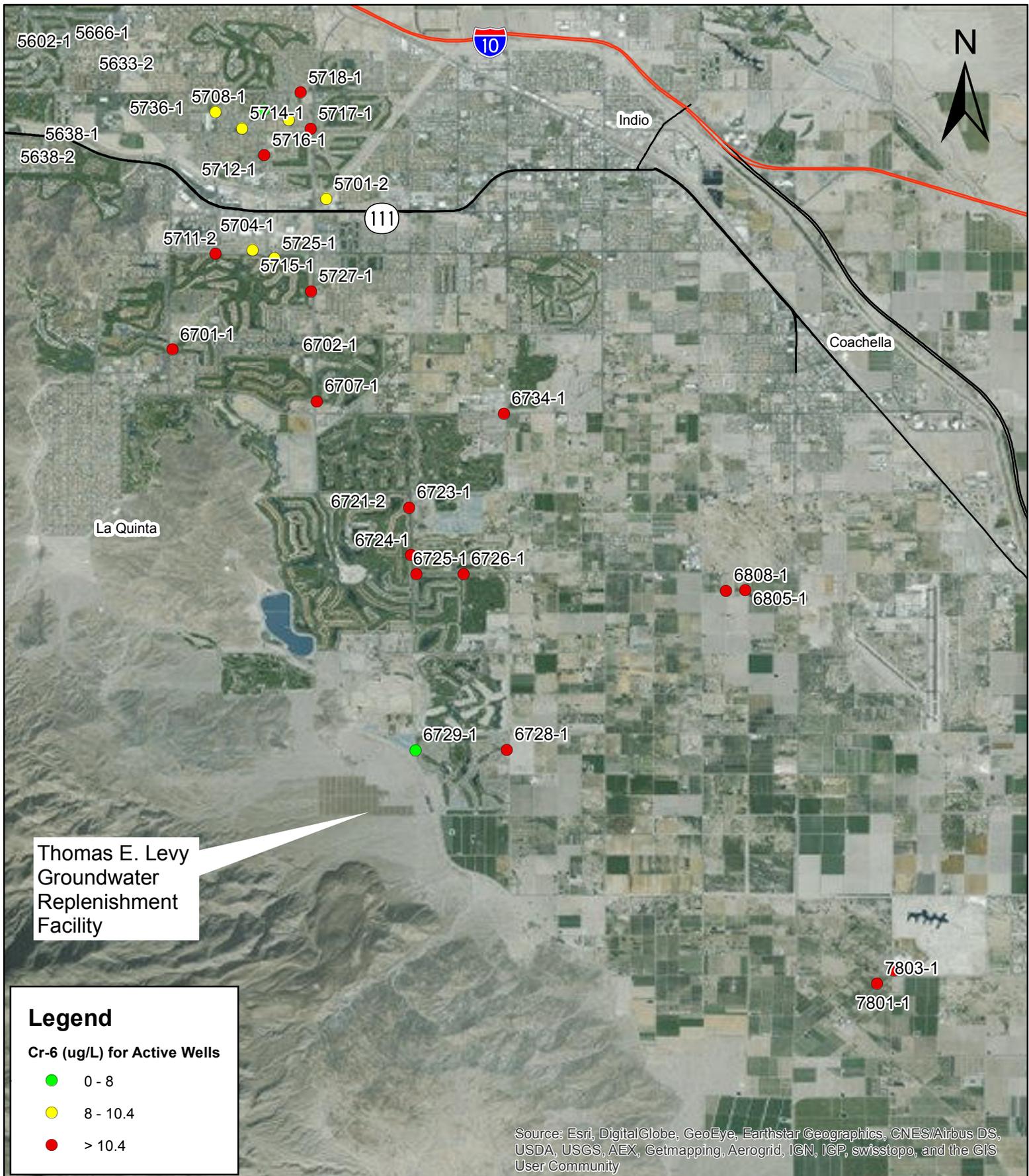


Figure 3-8
Groundwater Wells near the Thomas E. Levy
Groundwater Replenishment Facility



Figure 3-9. Water Quality Influence of Recharge near the Thomas E. Levy Groundwater Replenishment Facility

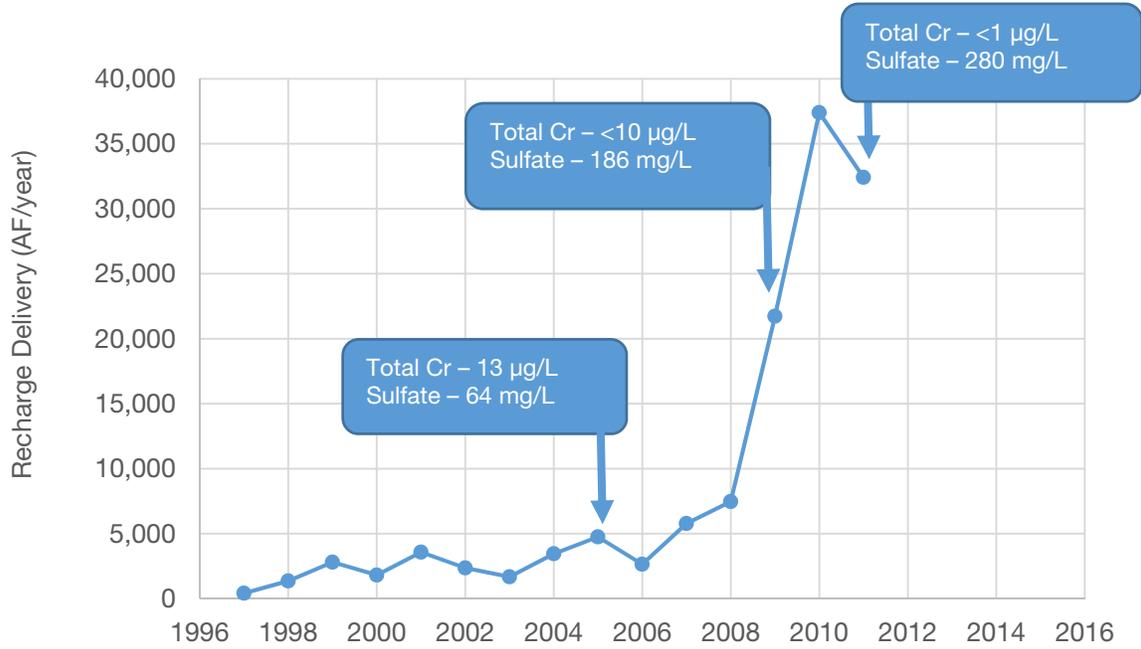




Figure 4-1. Schematic of New Pipelines to Distribute Water from Replacement Wells Located in Date Palm

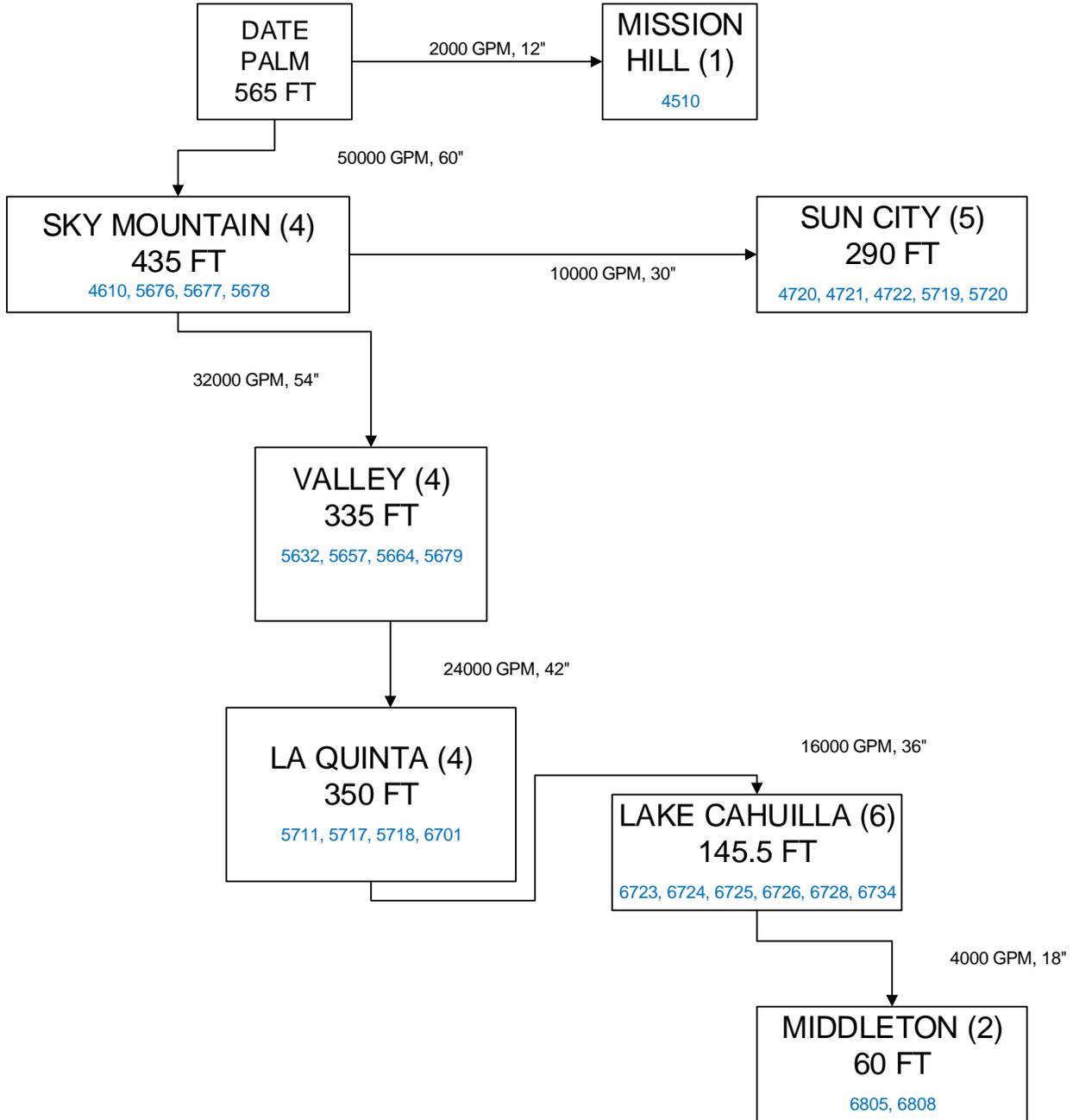
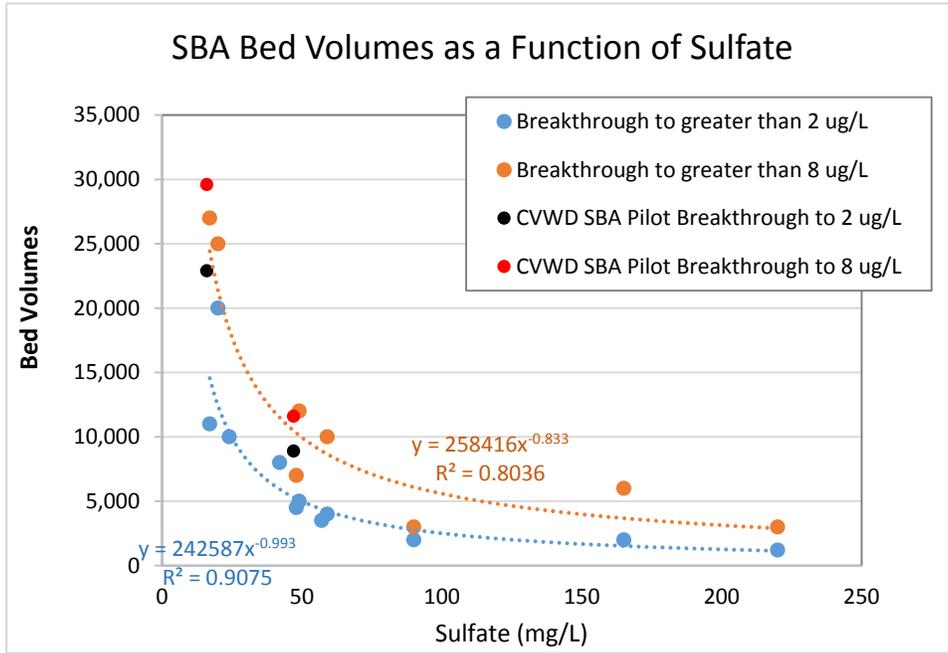




Figure 5-1. Correlation of SBA Bed Volumes with Sulfate Concentration



Data Sources: CVWD pilot testing WRF 4449, Glendale pilot testing WRF 4423, Bench testing at 8 utilities - WRF 4450



Figure 6-1. Economies of Scale for Clustered Treatment Compared with Individual WBA Treatment (Sky Valley)

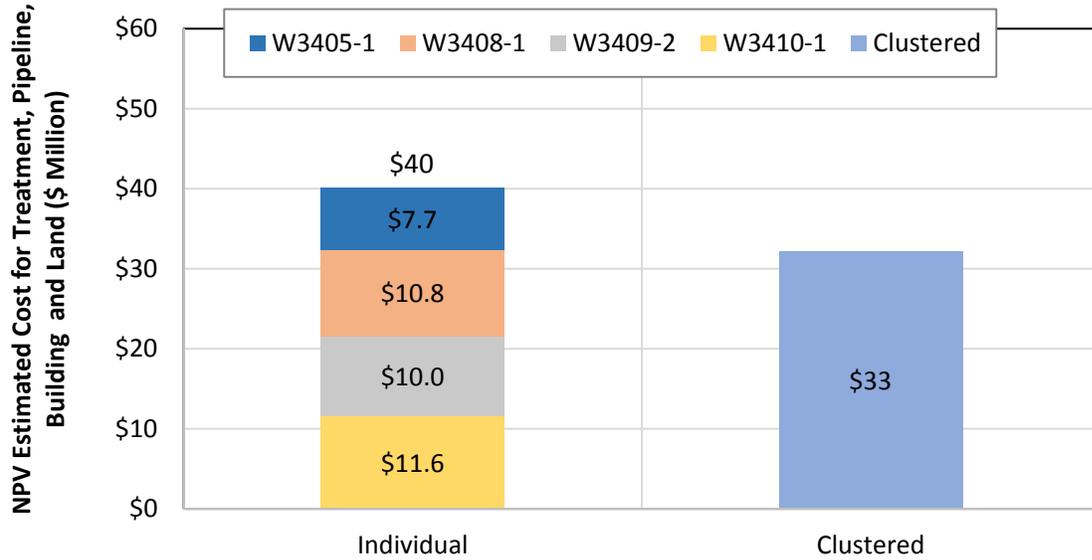
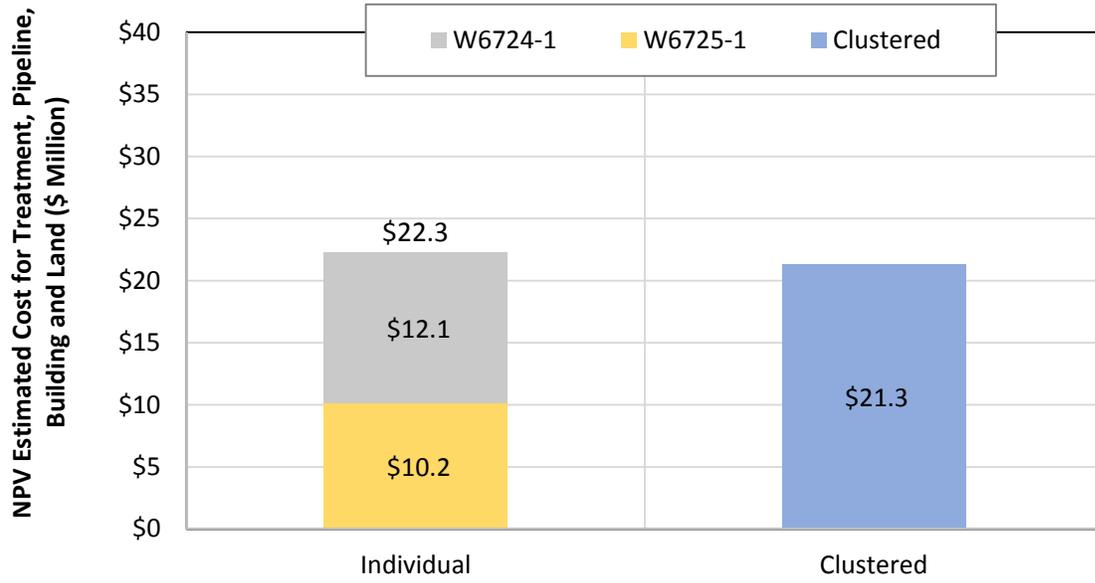




Figure 6-2. Economies of Scale for Clustered Treatment Compared with Individual WBA Treatment (La Quinta)



/



Figure 6-3. Site Layout for a SBA Facility (with Offsite Central Regeneration) at 4510-1

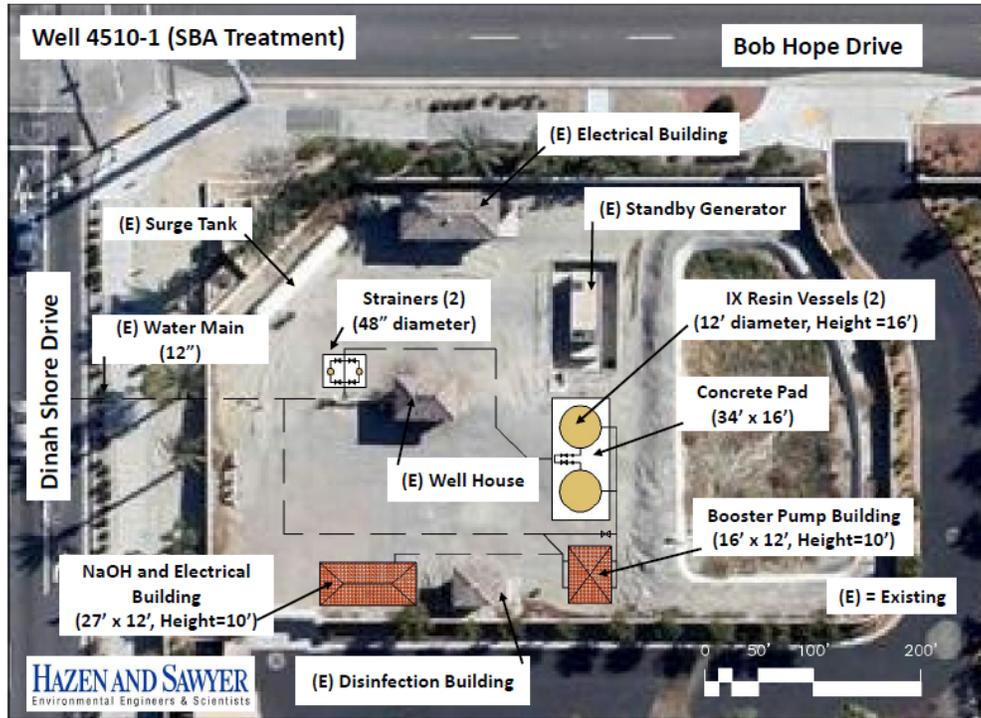




Figure 6-4. Site Layout for a WBA Facility at 4510-1

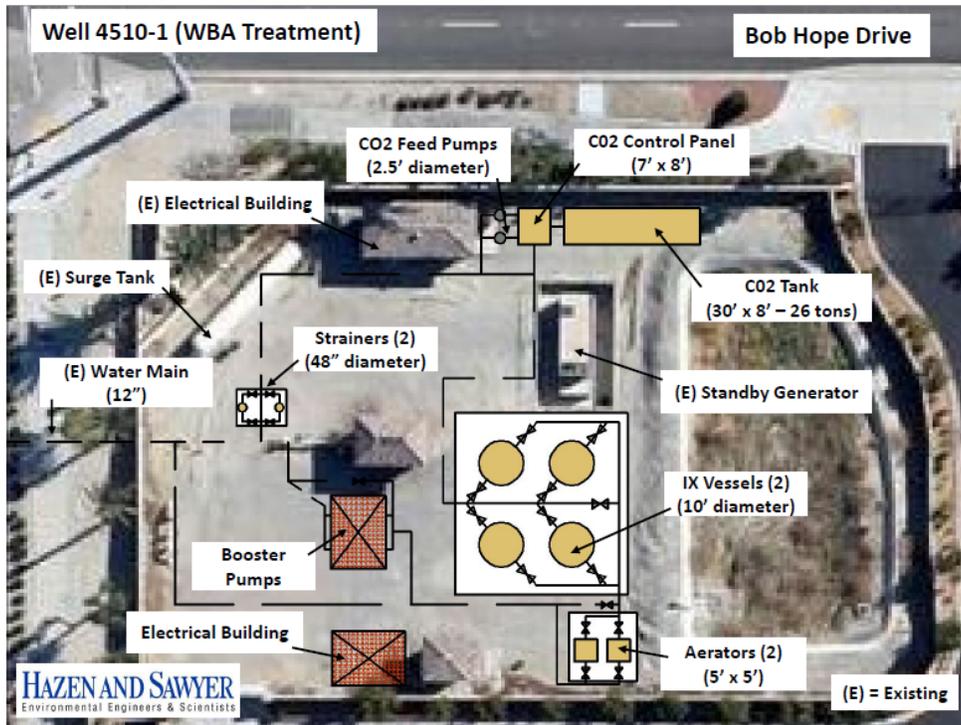




Figure 6-5. Site Layout for a RCF Facility at 4510-1

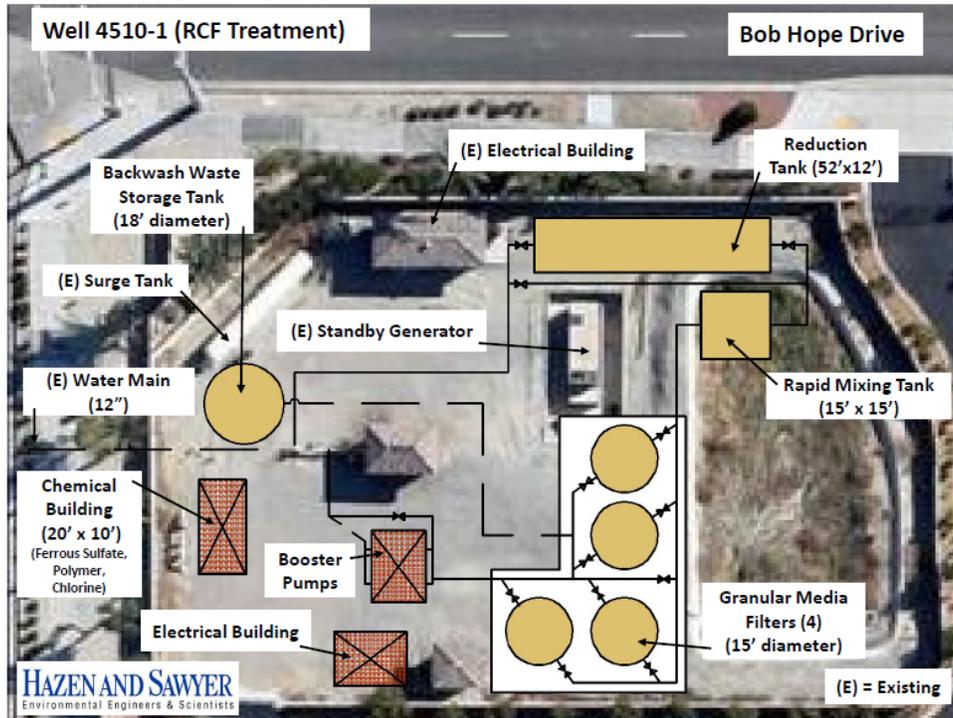
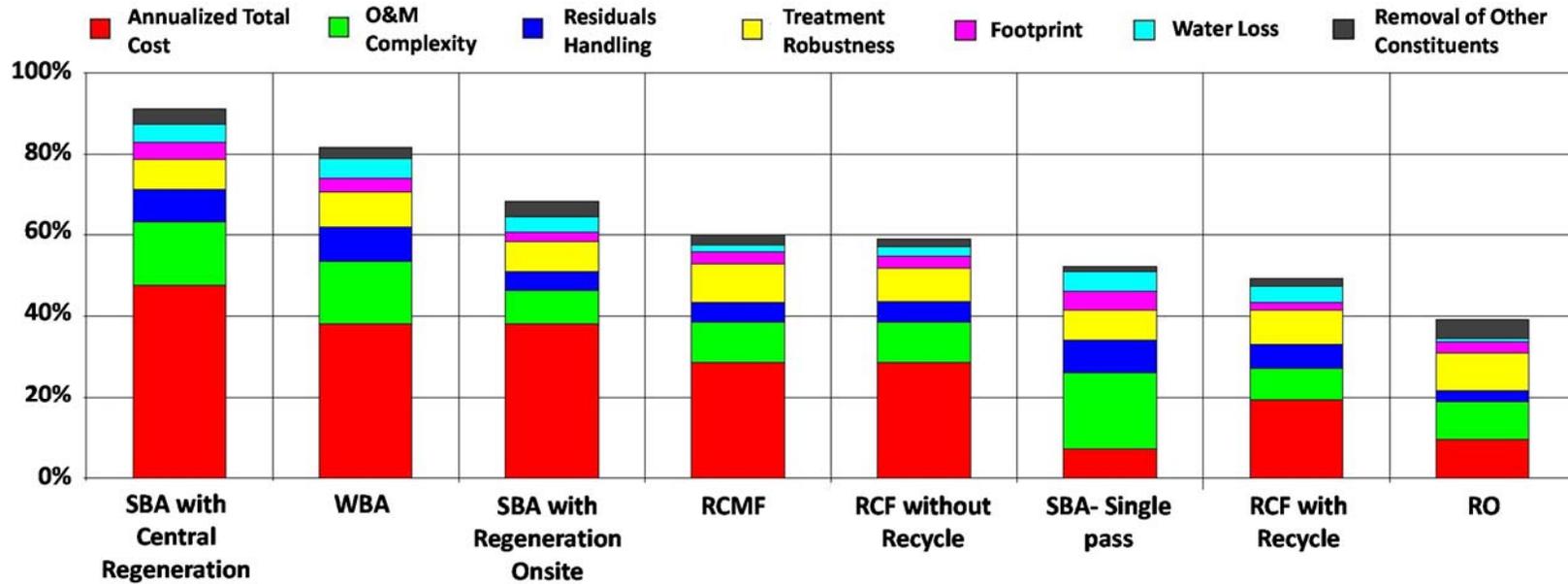




Figure 6-6. Weighting of Technologies for CVWD



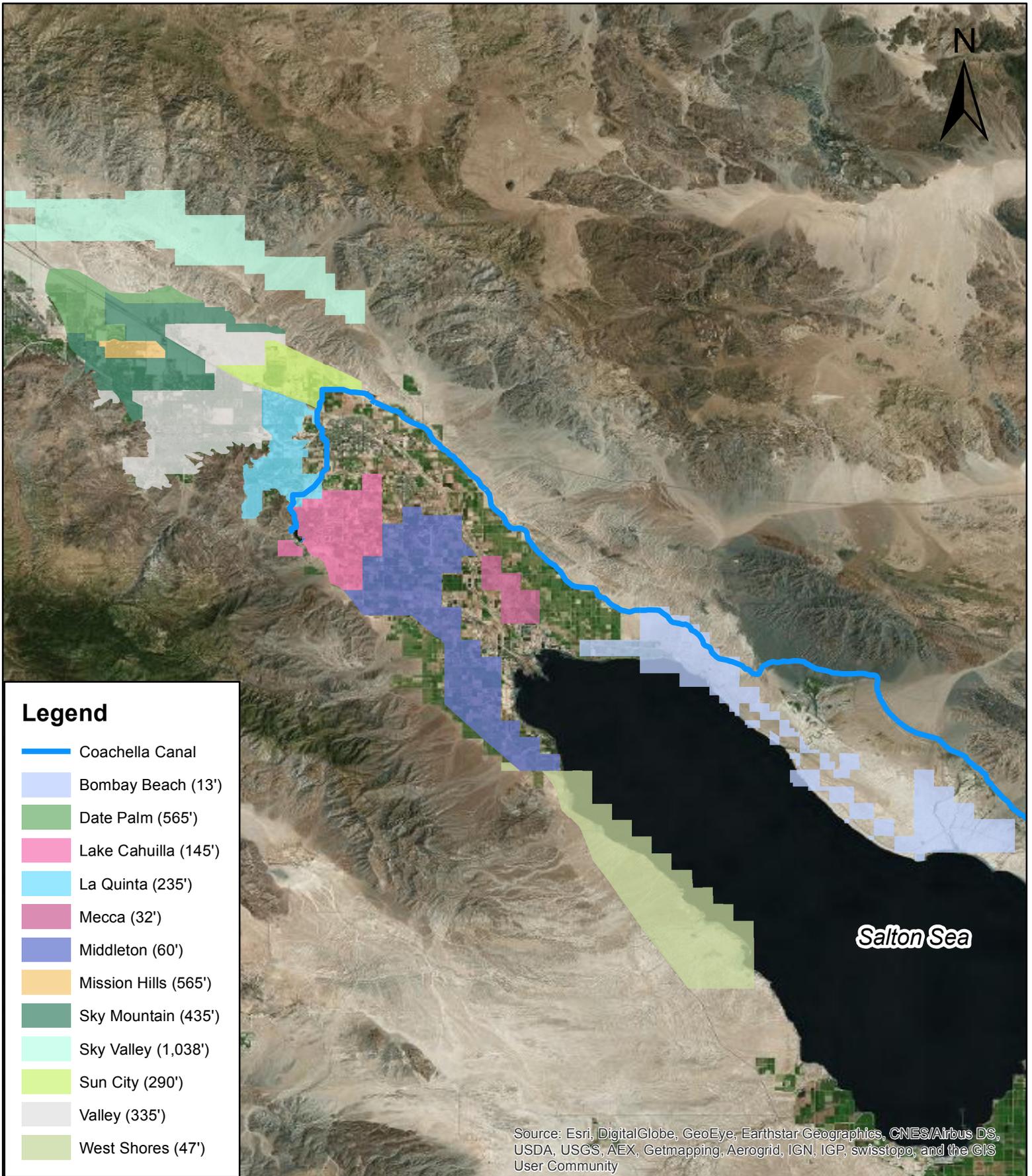


Figure 7-1
Map Showing the Coachella Canal and the CVWD Boundary



Figure 7-2. Clarification Selection Guidelines Based on Average Raw Water Turbidity and TOC Values

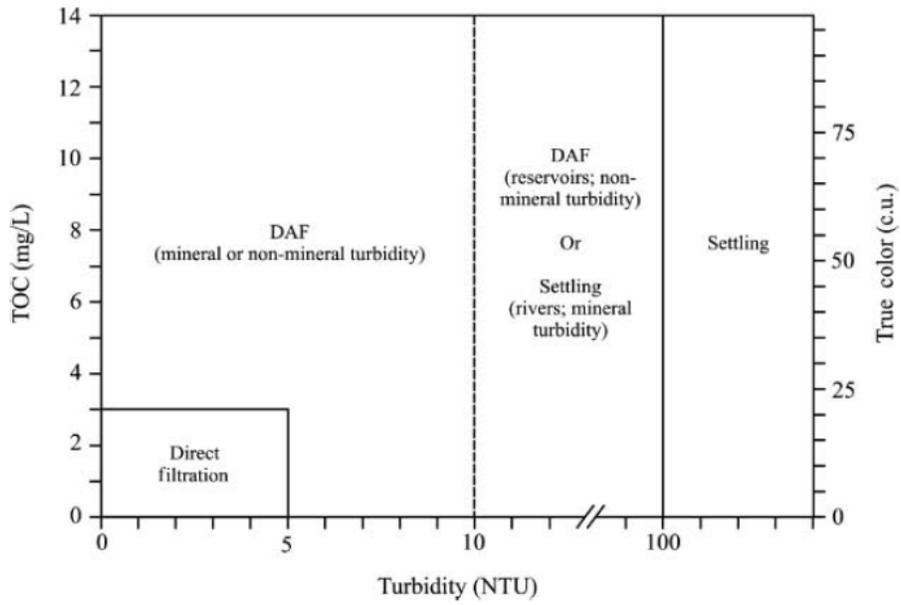




Figure 7-3. Clarification Selection Guidelines Based on Average Maximum Water Turbidity and TOC Values

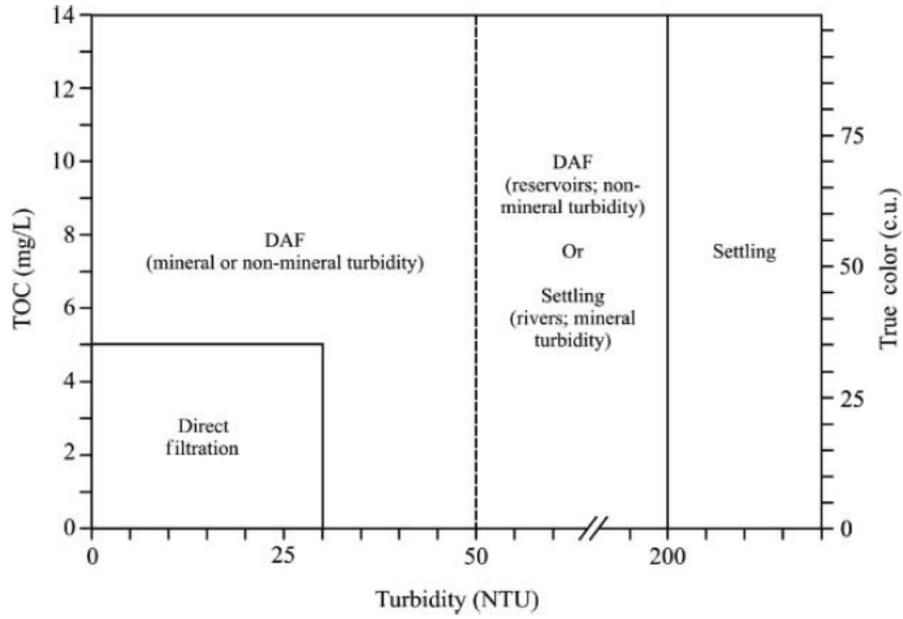




Figure 7-4. Potential Surface Water Treatment Plant at the Sun City Site





Figure 7-5. Potential Surface Water Treatment Plant at the Burr Street Site





Figure 7-6. Pipeline Requirements for the Burr Street Site

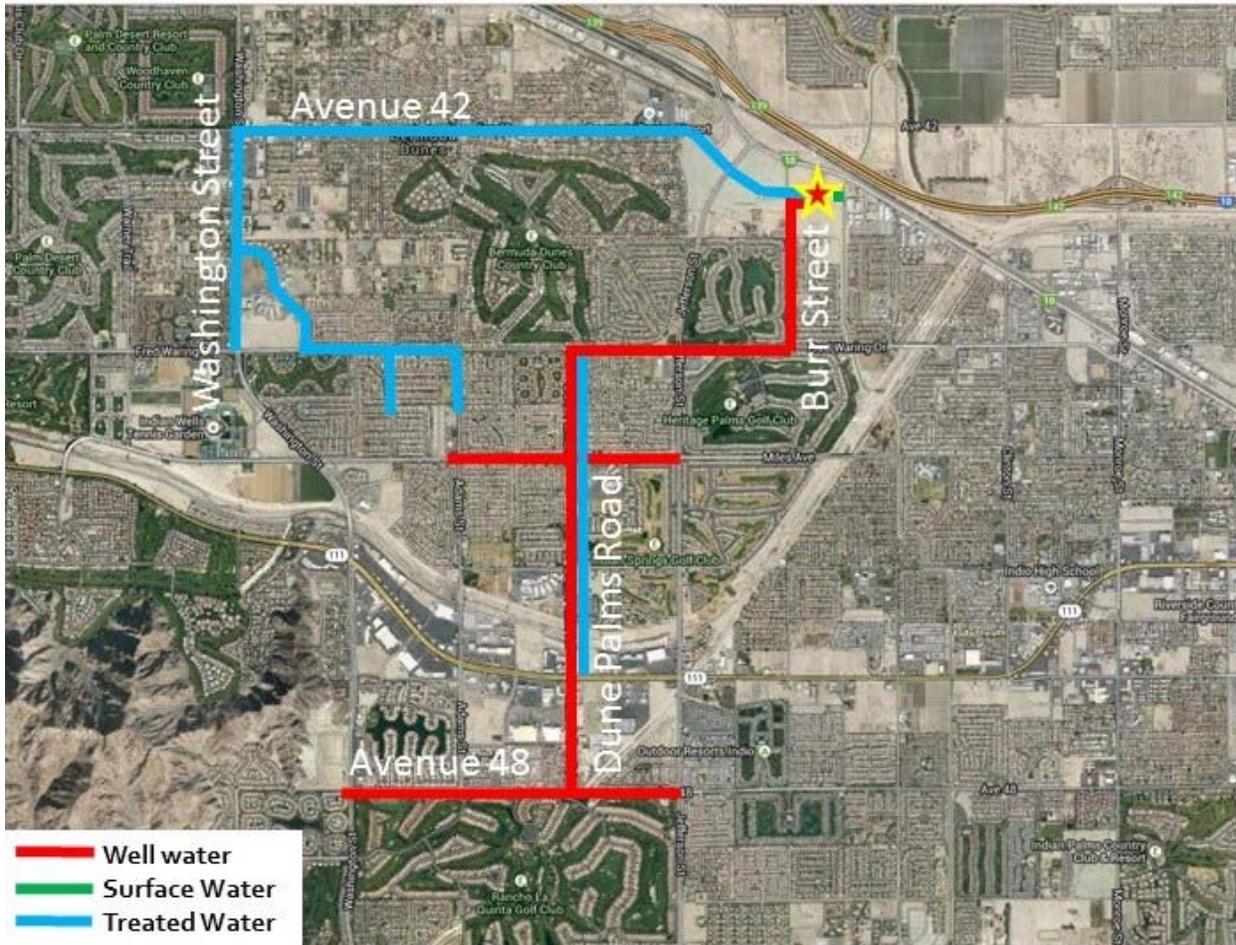




Figure 7-7. Potential Surface Water Treatment Plant at the Mid-Valley Site





Figure 7-8. Pipeline Requirements for the Mid-Valley Site

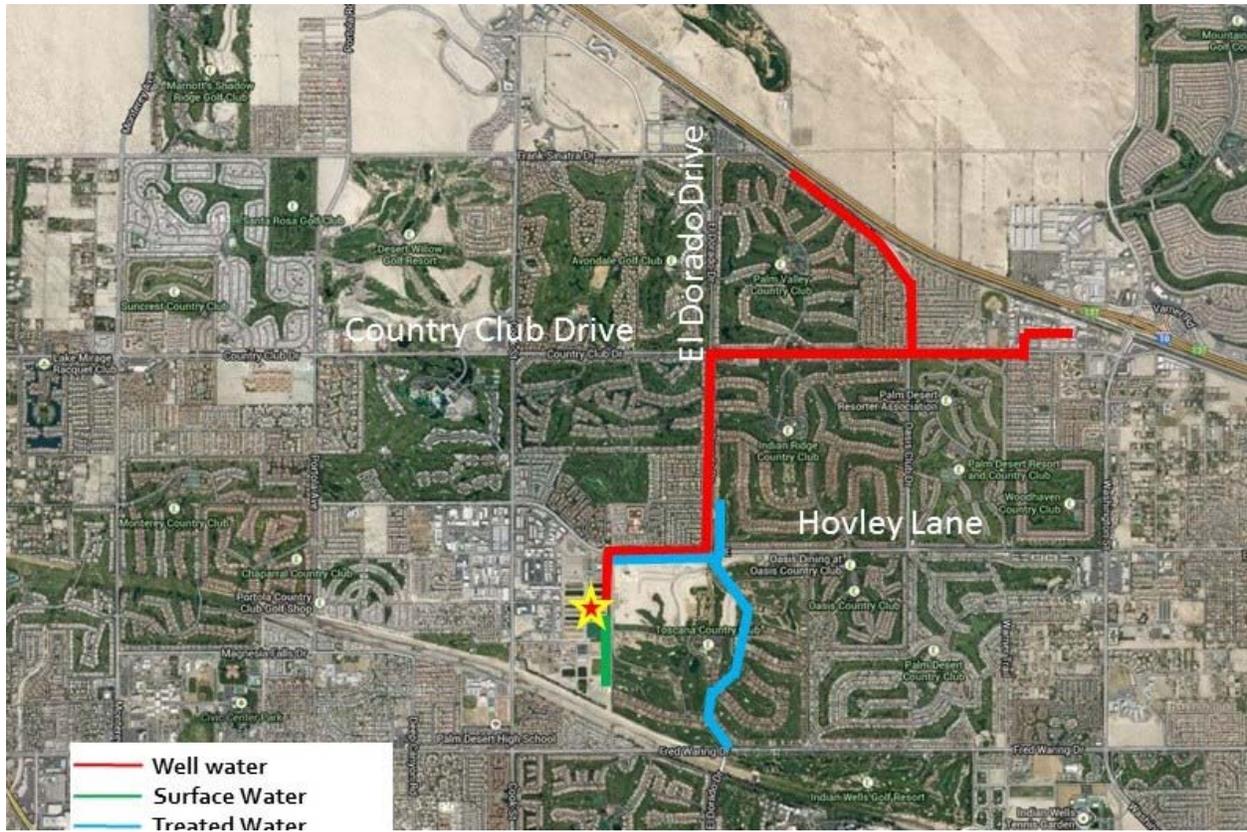




Figure 7-9. Potential Plant Location at the East Valley Site (Jefferson Location)





Figure 7-10. Potential Surface Water Treatment Plant at the East Valley Site (Lake Cahulla Location)





Figure 7-11. Pipeline Requirements for the East Valley Site (Jefferson Location)

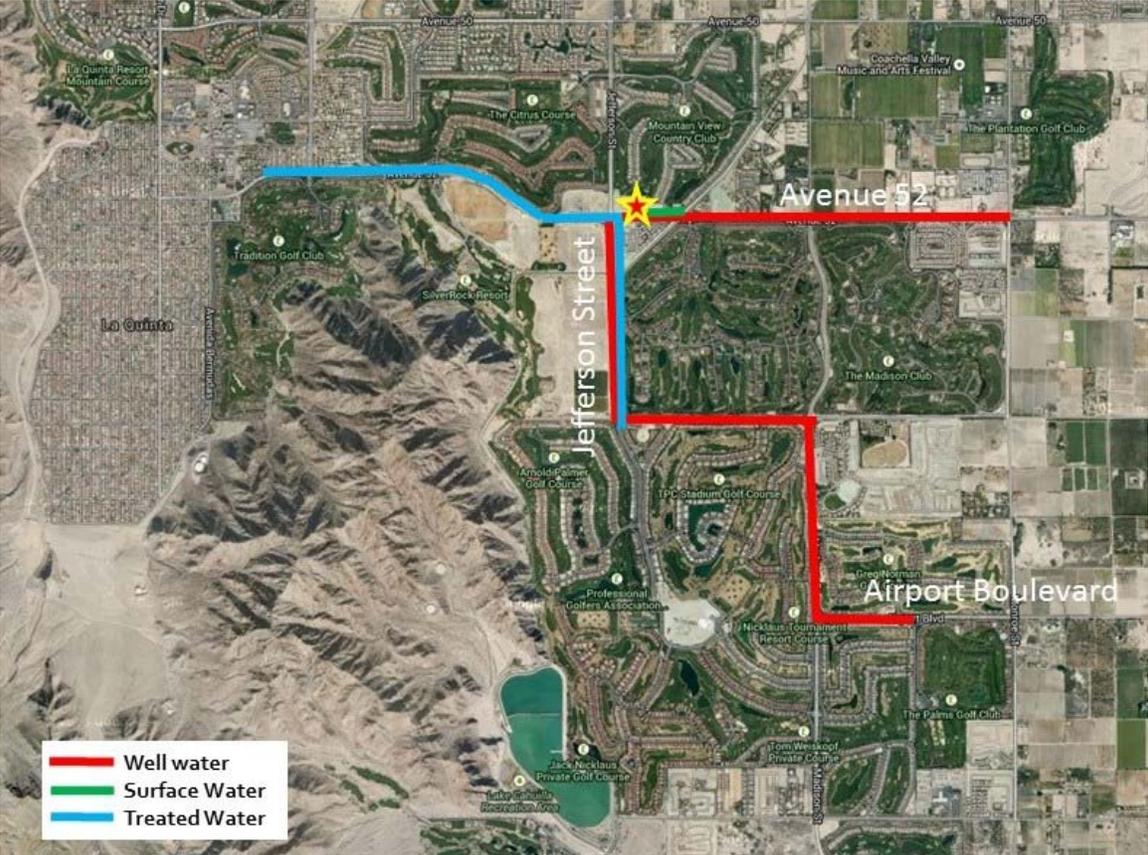




Figure 7-12. Pipeline Requirements for the East Valley Site (Lake Cahulla Location)

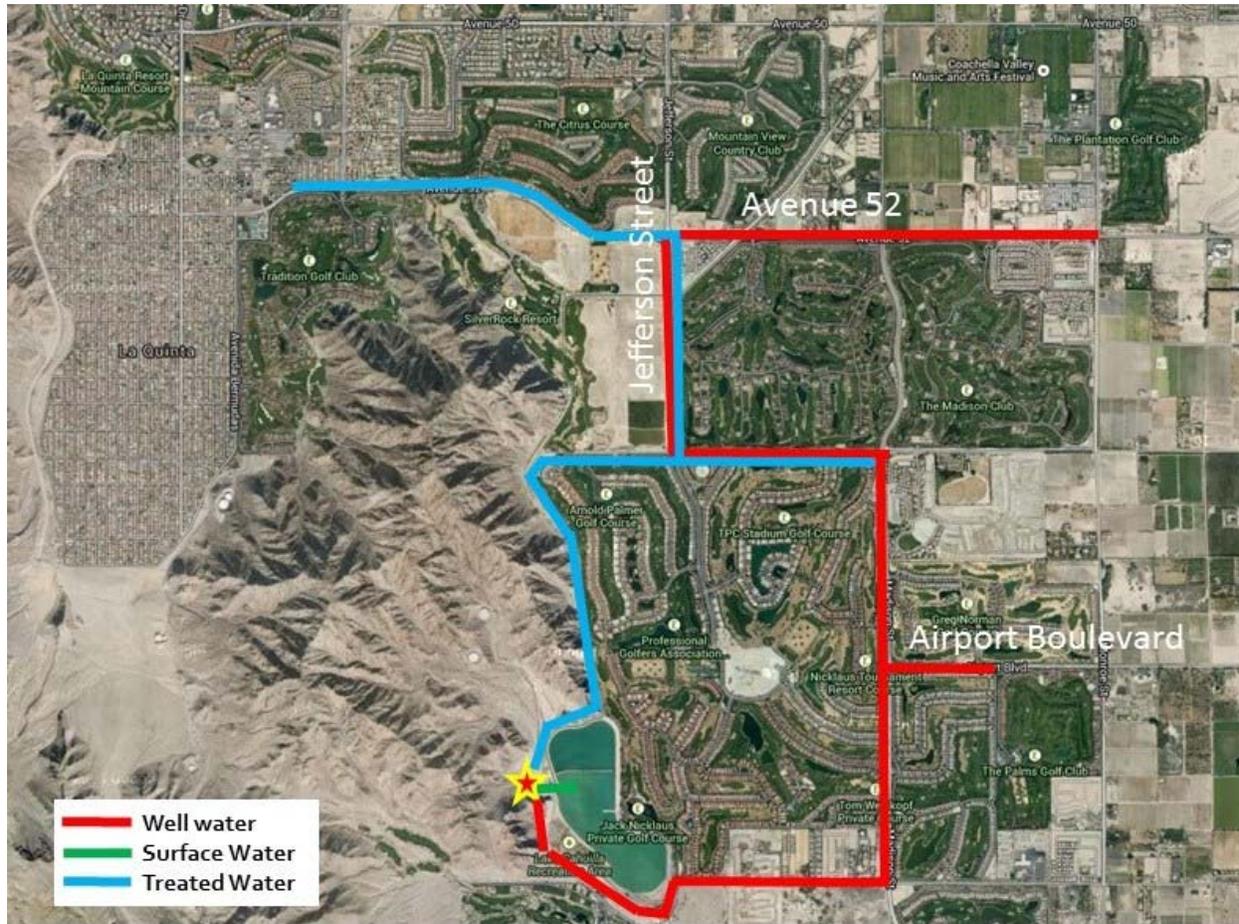




Figure 9-1. Capital Cost Estimates of Treatment for Each Scenario

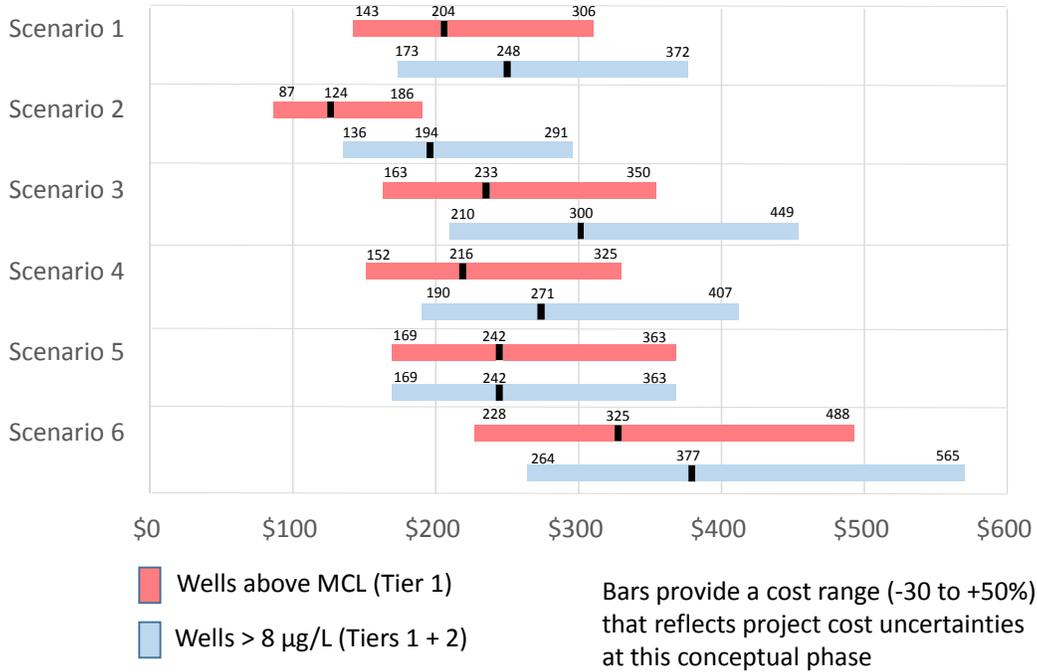


Figure 9-2. Annualized Cost Estimates of Treatment for Each Scenario (Capital + O&M)

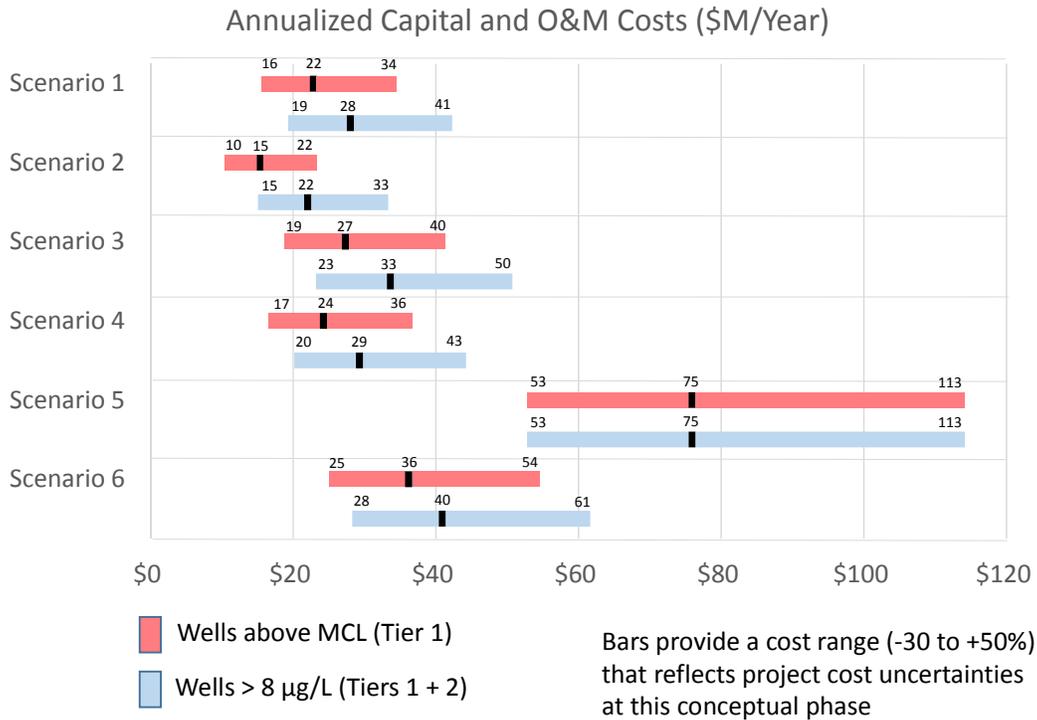




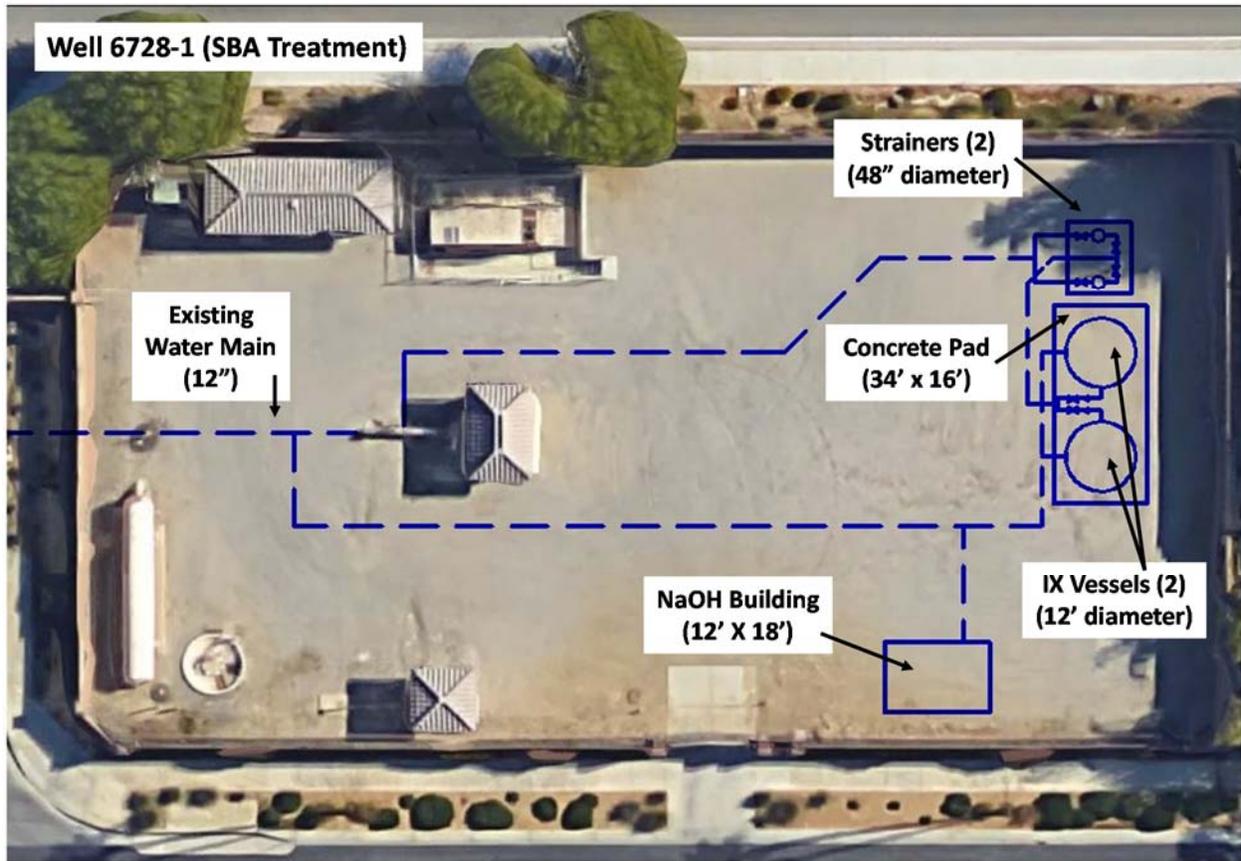
Figure 9-3. Evaluation Matrix of Alternatives Considered and Project Team Scoring

Selection Criteria	Weighting Factor	Alternative					
		Scenario 1 – Ground water treatment at mostly clusters	Scenario 2 – Ground-water treatment at mostly indiv. wells	Scenario 3 – Mid Valley SWTP and mostly indiv. Wells	Scenario 4 – East Valley SWTP and mostly indiv. wells	Scenario 5 – POU	Scenario 6 – Mid Valley and East Valley SWTPs and mostly indiv. wells
Annualized Cost	0.20	2	3	2	2	1	1.5
Operational Complexity	0.067	2.5	3	2	2	1	2
Diversification (supply & treatment)	0.20	1	1	2	2.5	1	3
Public Acceptance / Environmental	0.20	2	1.5	2.5	2.5	1	2.5
Implementation Complexity	0.067	2	2.5	2	2	1	1.5
Operational Flexibility	0.067	1.5	2	2.5	2.5	2	3
Water Quality Benefits	0.20	2	2	2	2	3	2
Score	1.00	1.8	2.0	2.1	2.2	1.5	2.2





Figure 10-1. Typical Layout for the SBA System



EL 526.0

EL 497.0

EL 491.0

EL 441.0

EL 435.0

WELL PUMP

BAG FILTER

RESIN VESSELS
(PARALLEL)

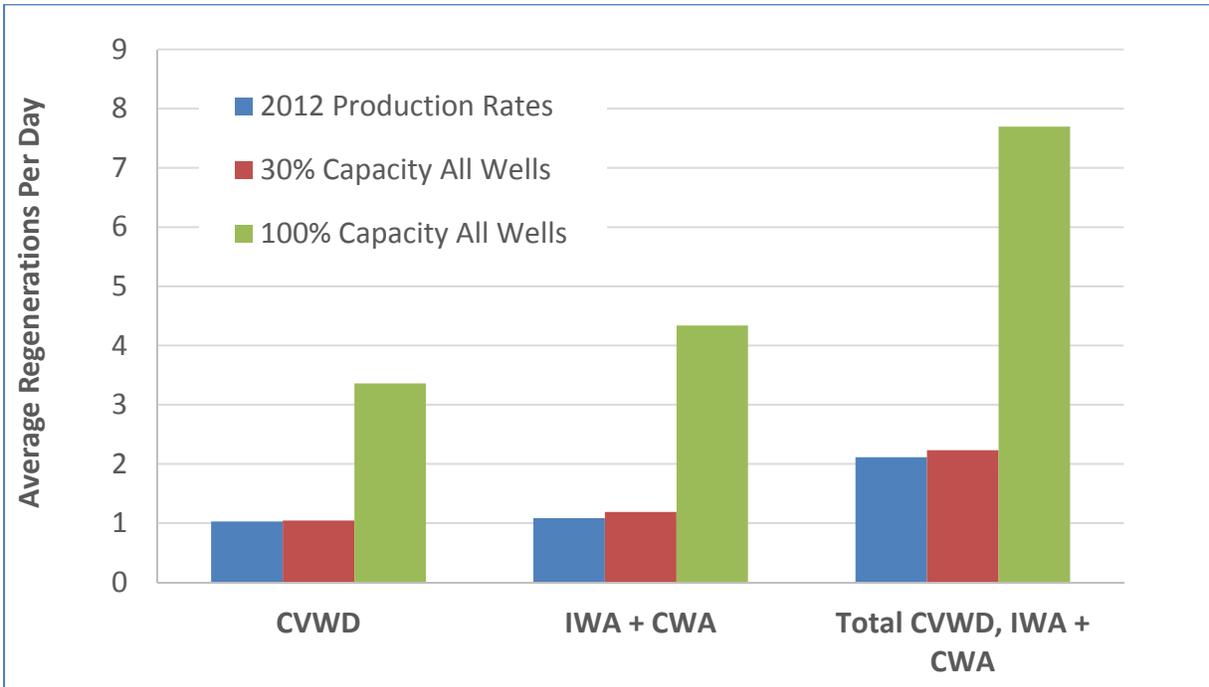
TO DISTRIBUTION
SYSTEM

HAZEN AND SAWYER
Environmental Engineers & Scientists

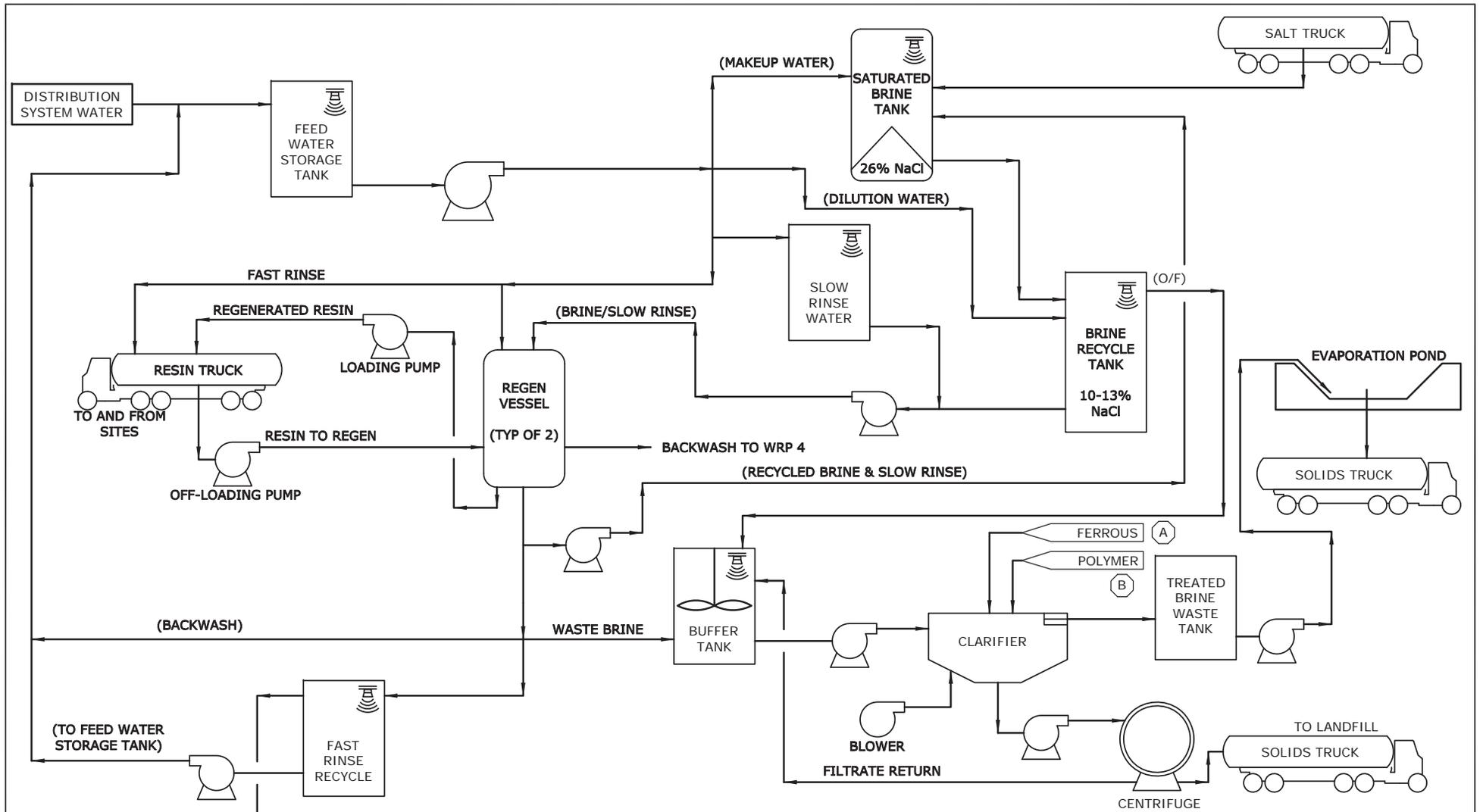
COACHELLA VALLEY WATER DISTRICT
SBA TREATMENT PLANT HYDRAULIC PROFILE – FIGURE 10-2



Figure 10-3. Estimated Number of Regenerations per Day Based on Estimated Resin Bed Volumes to Exhaustion and Well Utility



* IWA and CWA used in the analysis to represent potential capacity of regional partners.



**Figure 10-4. Conceptual Process Flow Diagram for CRRF
COACHELLA VALLEY WATER DISTRICT**

**CENTRAL RESIN REGENERATION FACILITY
PROCESS FLOW DIAGRAM
TRADITIONAL**



Figure 10-5. Pilot Testing Results Illustrating Spent Brine Cr6 Peak (Well 6701-1)

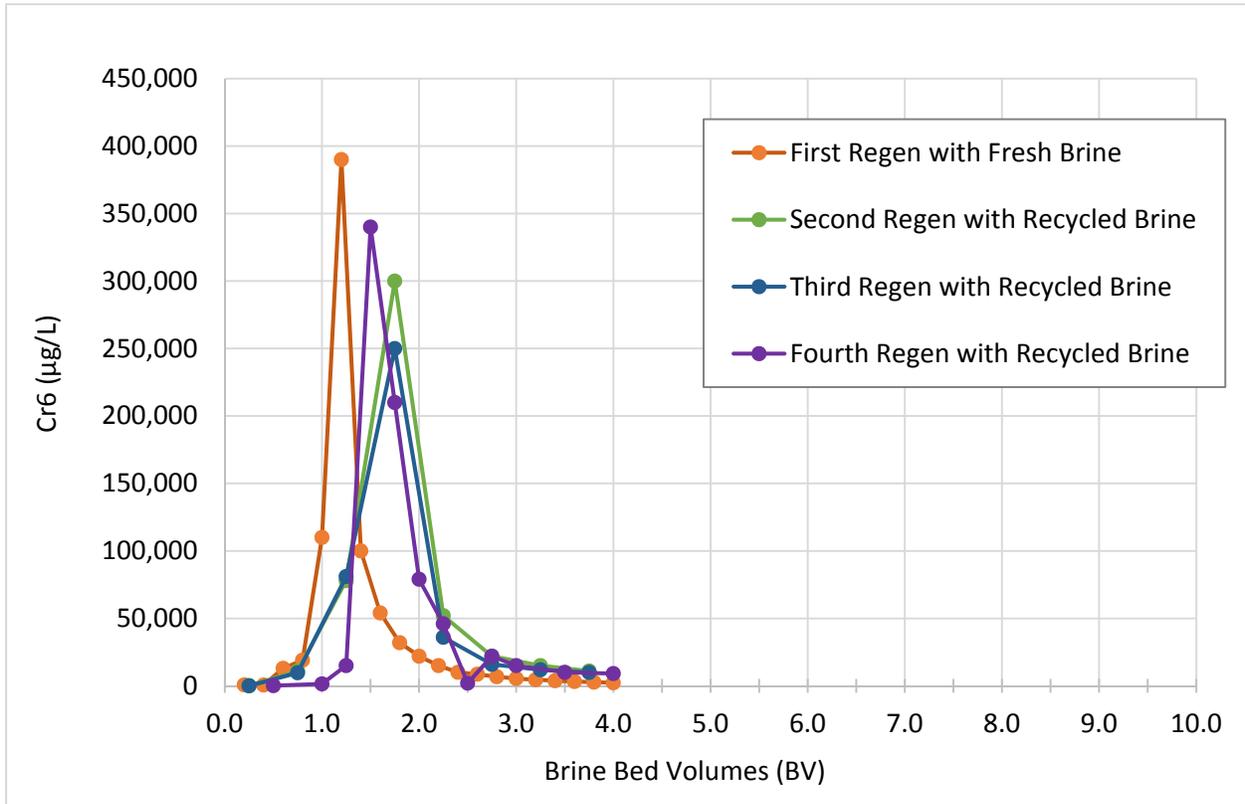




Figure 10-6. Anticipated Cr6 Concentrations in Recycled Brine

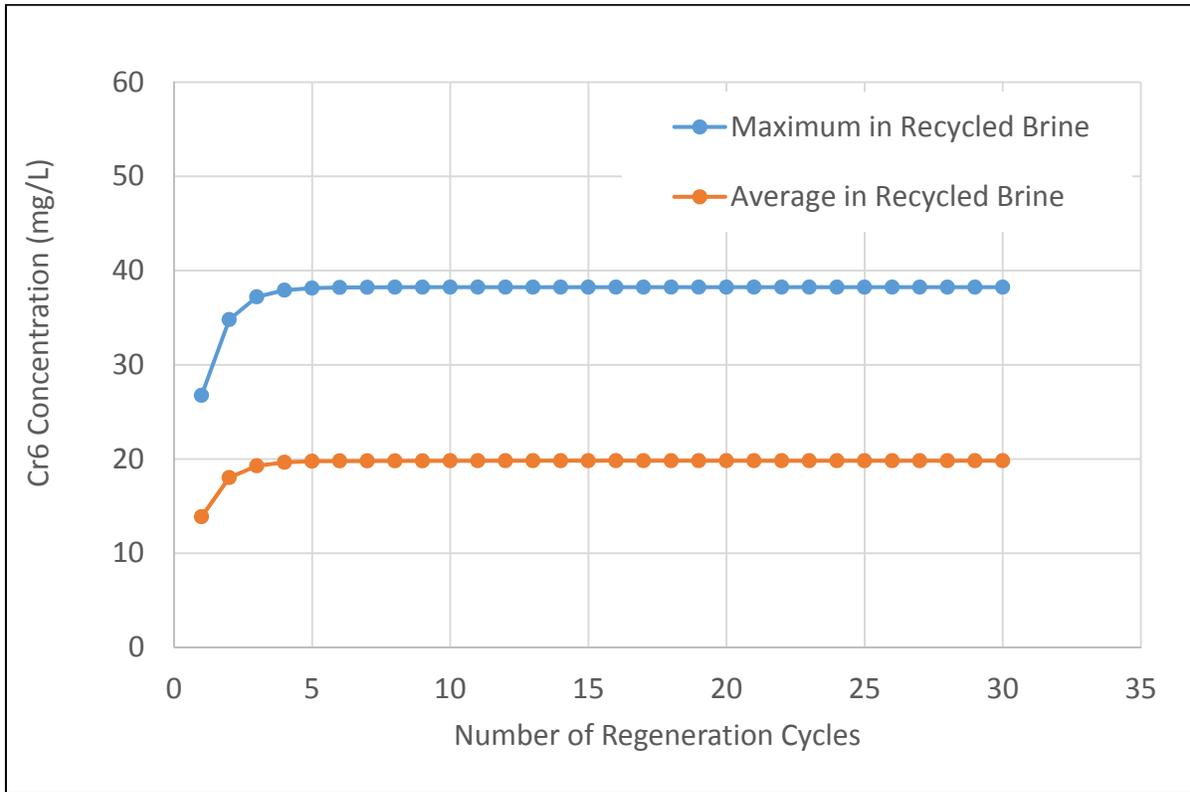




Figure 10-7. Conceptual Design Layout of the Central Regeneration Facility

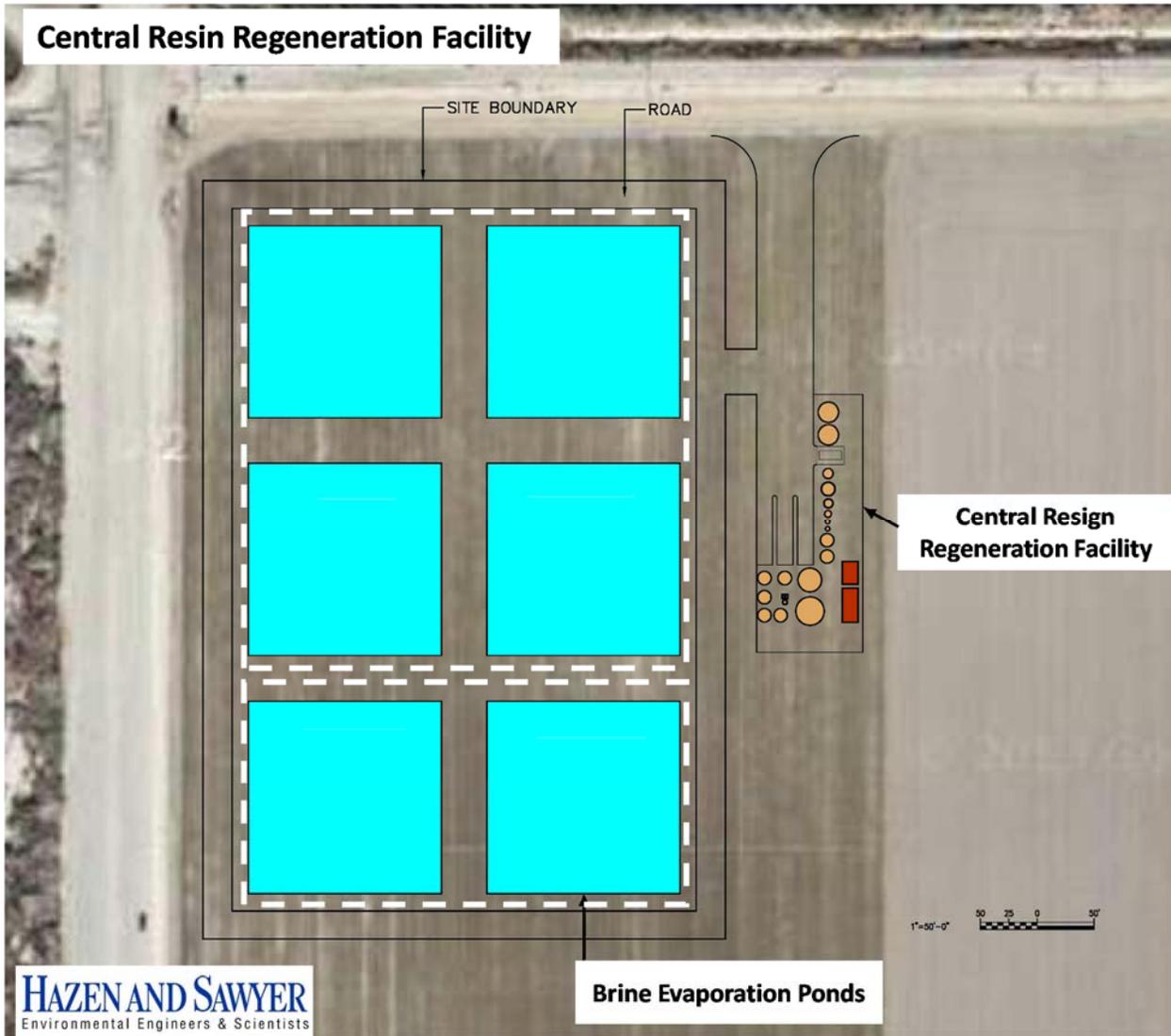
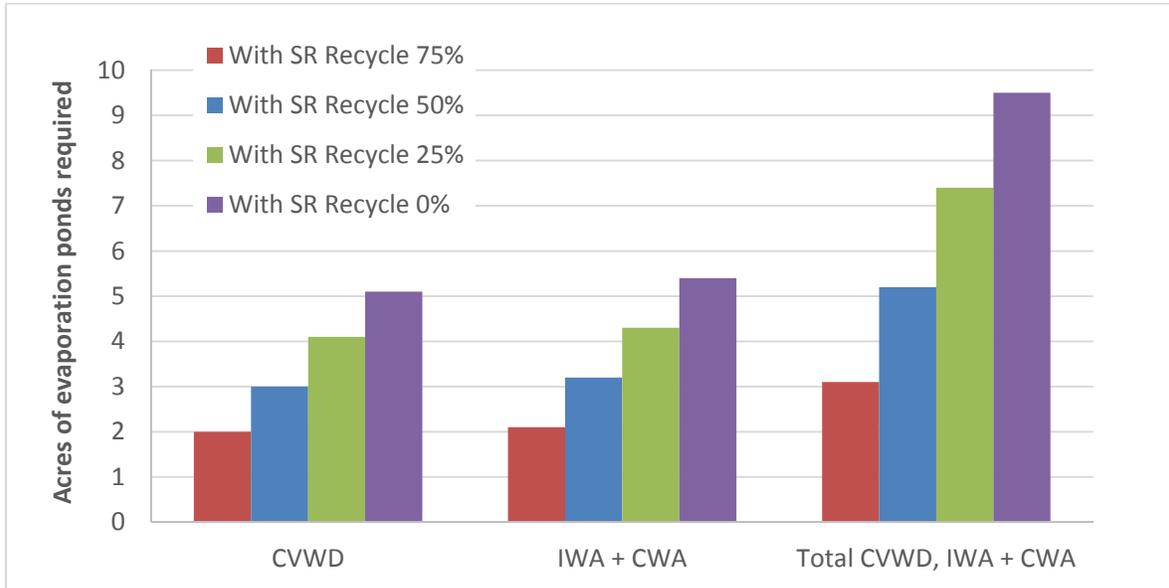




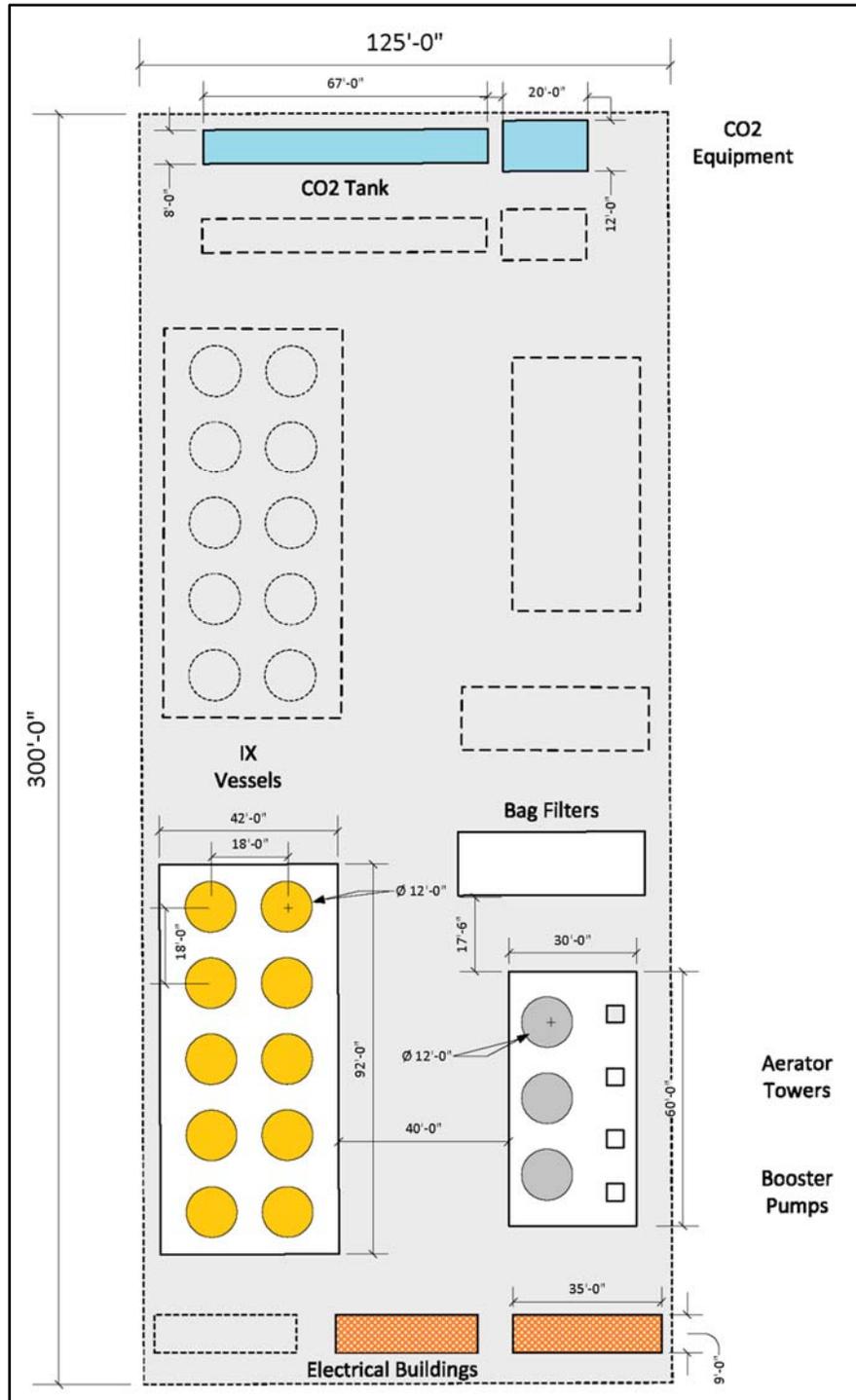
Figure 10-8. Estimated Acreage of Evaporation Ponds Required at Different Brine Recycle Percentages (including Full Recycle of Slow Rinse)



* IWA and CWA used in the analysis to represent potential capacity of regional partners.



Figure 10-9. Example Layout for the WBA System at Sky Valley



EL 916.0
EL 912.0
EL 910.0

EL 1100.0

EL 887.0

EL 862.0

EL 830.0

EL 810.0



BAG FILTER

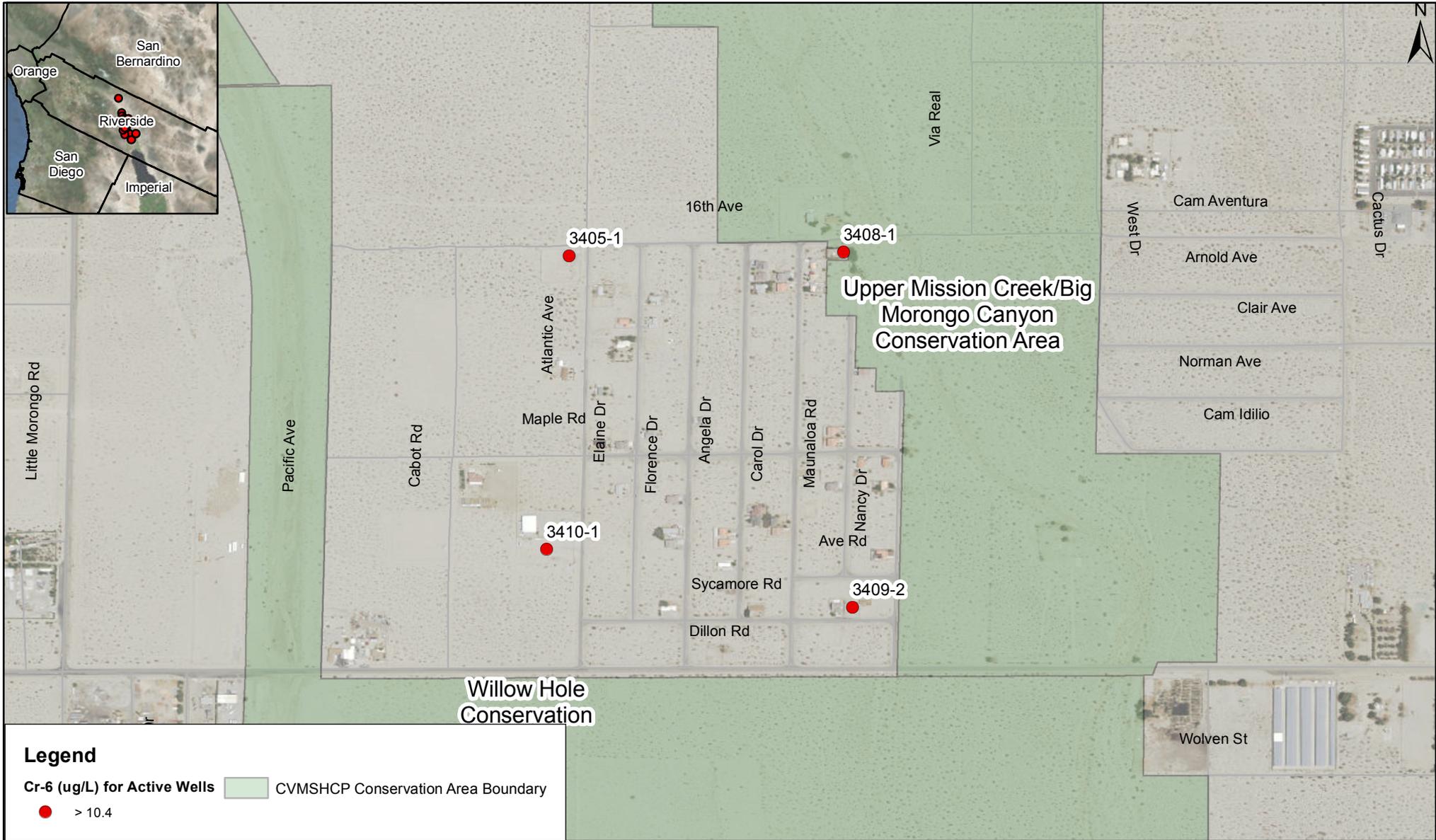
RESIN VESSELS
(SERIES)

AERATION
BLOWER

CLEARWELL

BOOSTER
PUMP

TO DISTRIBUTION
SYSTEM



Legend

Cr-6 (ug/L) for Active Wells CVMSHCP Conservation Area Boundary

● > 10.4



Figure 10-11
Potential Environmental Constraints in Sky Valley



Figure 10-12
Potential Environmental Constraints near Fred Waring Drive

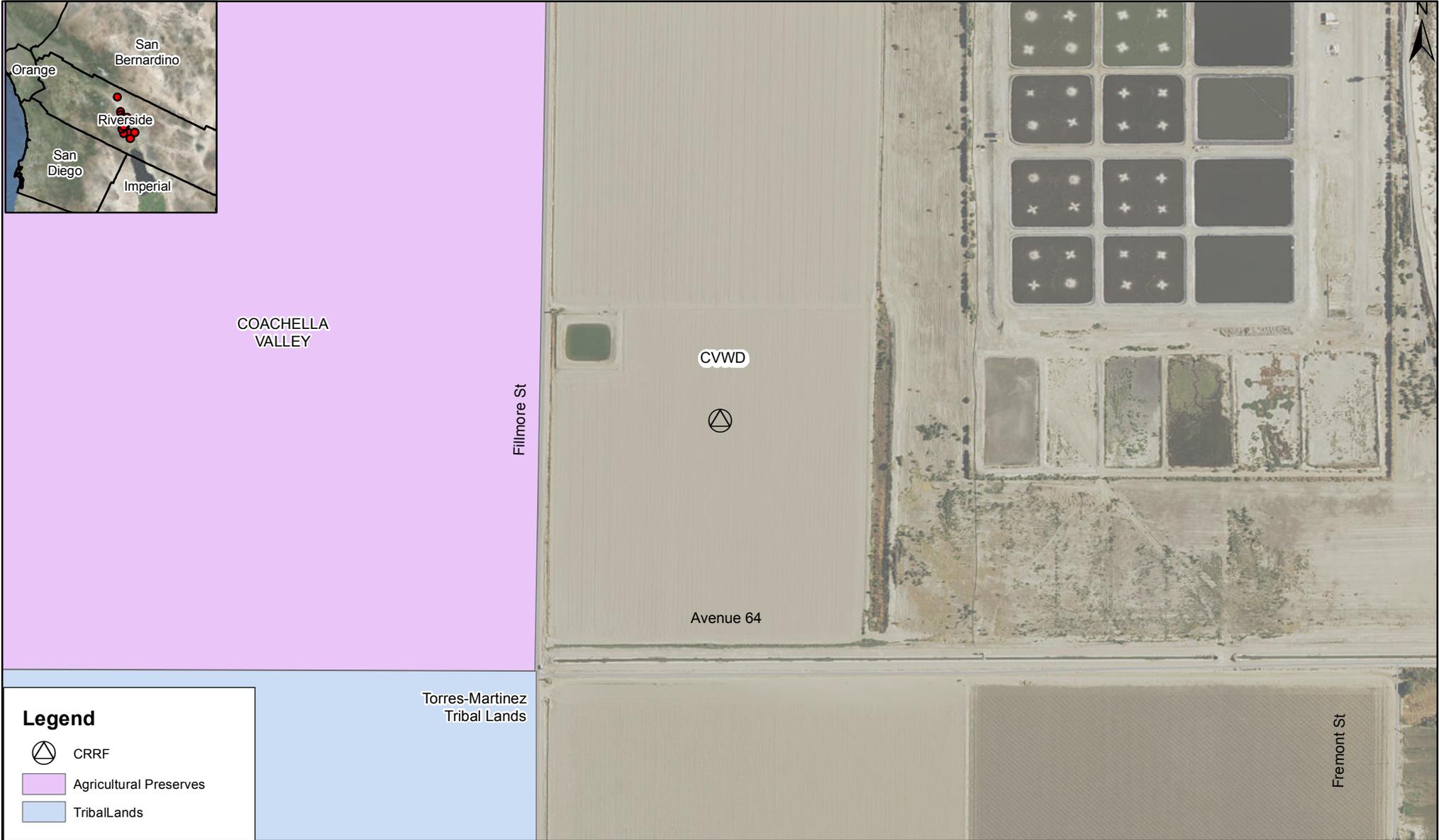


Figure 10-13
Potential Environmental Constraints at Avenue 64 and Fillmore

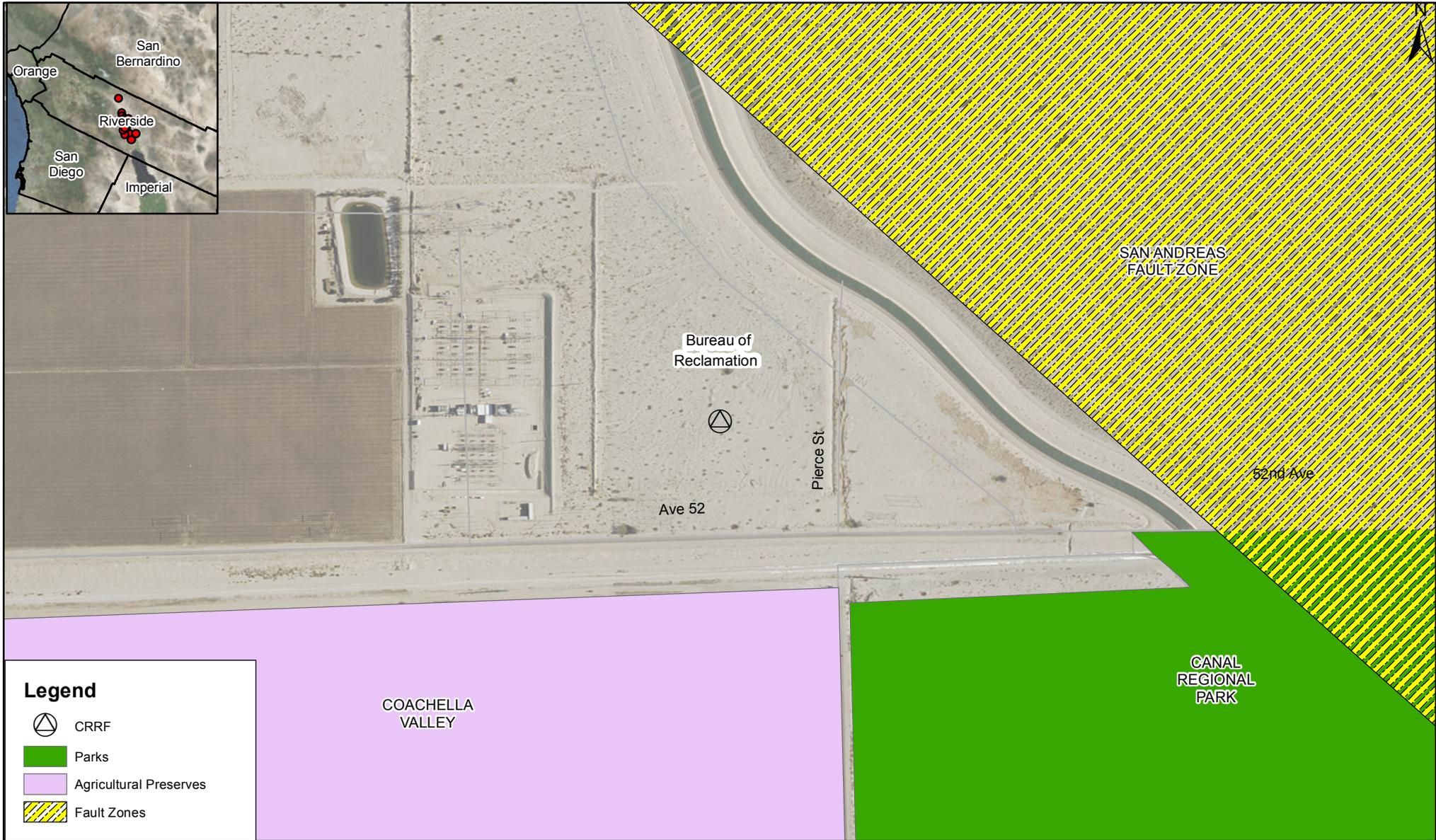
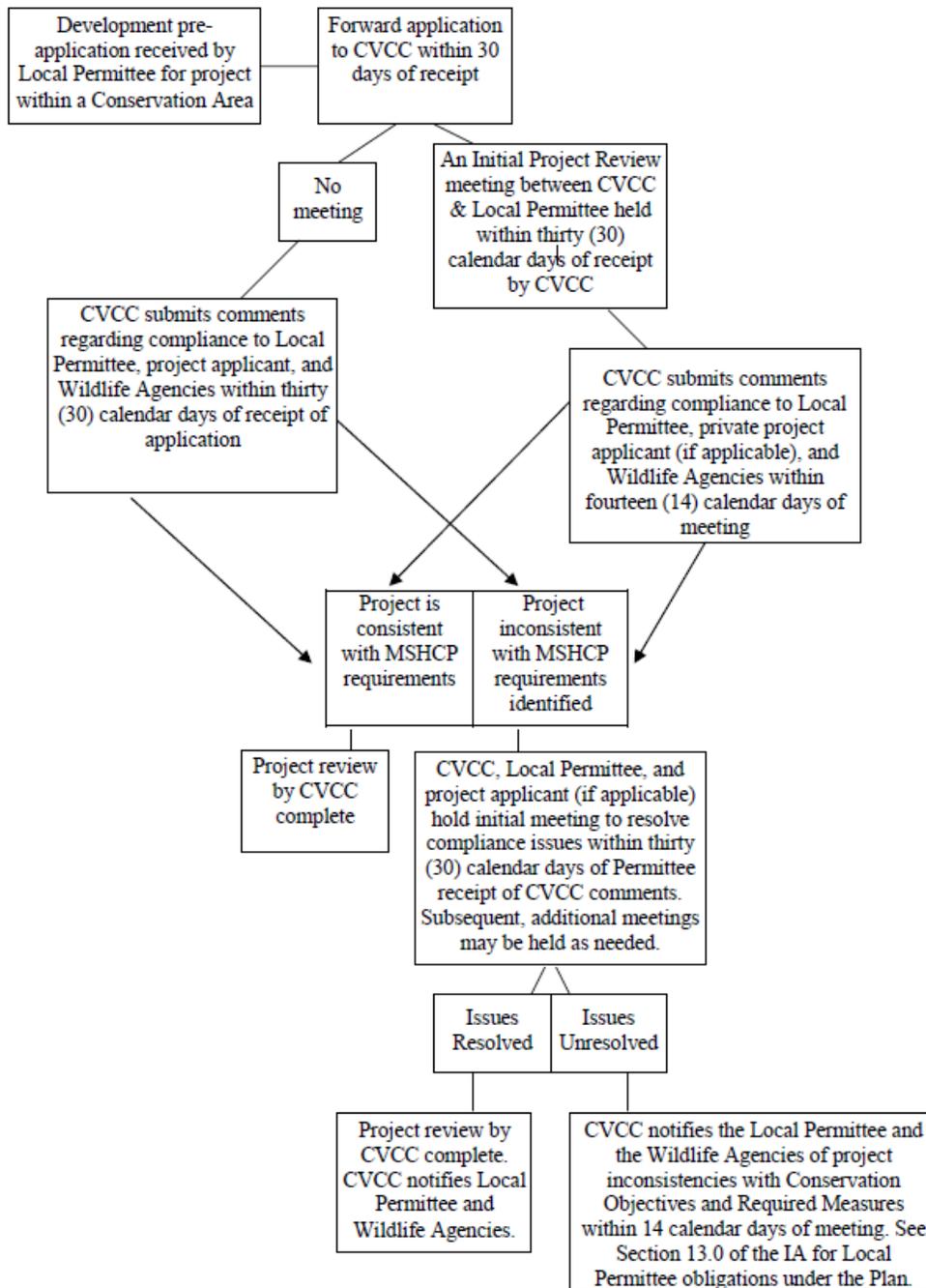


Figure 10-14
 Potential Environmental Constraints at Avenue 52 and the Coachella Canal



Figure 10-15. Joint Project Review Process from the CVMSHCP





TABLES



Table 2-1. Current Sources of Supply (Akel Engineering, 2015)

Pressure Zone	HGL	Total Wells	ADD (gpm)	PDD (1) (gpm)	Capacity (2) (gpm)	Existing Surplus/Deficit (-) (gpm)
Sky Valley	1,038	4	1,844	3,688	4,293	605
Date Palm	565	15	8,846	17,693	24,622	6,929
Mission Hills	500	3	3,436	6,872	5,527	- 1,345
Sky Mountain	435	17	11,929	23,857	26,385	2,528
Valley	335	25	24,888	49,777	44,503	- 5,274
Sun City	290	5	2,927	5,855	9,614	3,759
La Quinta	235	14	10,667	21,333	25,647	4,314
Lake Cahuilla	145	7	3,829	7,678	10,416	2,738
Middleton Road	60	4	354	709	8,346	7,637
Mecca	2	2	816	1,631	3,400	1,769
Bombay Beach	13	1	740	1,481	880	- 601
West Shores	47	3	763	1,526	2,020	494
Totals		100	71,039	142,100	165,653	23,553

Notes:

(1) PDD=ADD x 2.0

(2) Total Capacity less Standby



Table 3-1. Tier Categorization According to Cr6 Concentrations

Tier	Cr6 Concentration Range	Number of Active Wells
1	Greater than 10.4 µg/L	31 wells
2	Between 8 and 10.4 µg/L	25 wells
3	Less than 8 µg/L	42 wells
N/A	New wells not yet classified	2 wells
		100 wells total



Table 3-2. Regulated Constituents of Concern

Constituent	CA MCL (mg/L)	CA PHG (mg/L)	USEPA MCL (mg/L)
Chromium-6	0.010	0.00002	NA
Nitrate (as NO ₃)	45	NA	45
Arsenic	0.010	0.000004	0.010
VOCs	Variable	Variable	Variable
Perchlorate	0.006	0.001	NA
TDS	Recommended range <500 – 1,000 (secondary)	NA	500 (secondary)
Antimony	0.006	0.0007 (draft)	0.006
Selenium	0.05	0.03	0.05
Fluoride*	2	1	4 (primary) 2 (secondary)
Uranium	20 pCi/L	0.43 pCi/L	0.030

NA = not available.

CA = California.

MCL = Maximum contaminant level. NL = Notification level. PHG = Public health goal.

References:

CDPH, 2014. MCLs, DLRs, and PHGs for Regulated Drinking Water Contaminants

* U.S. Department of Health and Human Services Agency (HHS) is recommending 0.7 mg/L for systems practicing fluoridation.



Table 3-3. Groundwater Wells with Elevated Nitrate Concentrations (> 22.5 mg/L as NO₃)

Pressure Zone	Well ID	Cr6 Tier	Nitrate (mg/L as NO ₃)
Sky Mountain	5630-1	3	24
Valley	5639-1	3	40
	5656-1	3	37
	5662-1	3	33
	5667-1	3	28
	5670-1	3	36
	5673-1	3	27
La Quinta	5708-1	2	30
	5709-1	3	23
	5711-2	1	26



Table 3-4. Inactive Wells with Elevated Nitrate Concentrations (> 22.5 mg/L as NO₃)

Pressure Zone	Well ID	Reason for Inactive Status
Sky	4502-1	Elevated nitrate (39 mg/L)
Mountain	4508-1	Elevated nitrate (43 mg/L)
	5518-1	Elevated nitrate (40 mg/L)
Valley	5609-1M	Elevated nitrate (40 mg/L); PCE detected
	5619-1	High nitrate (115 mg/L)
	5620-1	Elevated nitrate (40 mg/L)
	5621-1	High nitrate (65 mg/L)
	5623-1	Elevated nitrate; PCE detected (42 mg/L)
	5627-1	Elevated nitrate (40 mg/L)
	5628-2	Elevated nitrate (44 mg/L)
	5633-2	High nitrate (55 mg/L); DBCP detected
	5637-1	High nitrate (116 mg/L)
	5638-2	High nitrate (52 mg/L); DBCP detected
	5660-1	Elevated nitrate (40 mg/L); DCPA detected
	5661-1	Elevated nitrate (43 mg/L)
	5663-1	Elevated nitrate (40 mg/L); PCE and TCP detected
	5665-1	High nitrate (63 mg/L); DBCP detected
	5666-1	High nitrate (60 mg/L); DBCP detected
5674-1	High nitrate (112 mg/L)	
PD Hwy	5604-1	High nitrate (127 mg/L)
	5644-1	High nitrate (98 mg/L)
La Quinta	5704-1	Elevated nitrate (38 mg/L)
	5710-1	Elevated nitrate (39 mg/L)
	5712-1	High nitrate (63 mg/L)
	5736-1	High nitrate (59 mg/L)

Elevated nitrate = concentrations approaching the MCL.

High nitrate = concentrations exceeding the MCL.



Table 3-5. Active Wells with Detectable Arsenic Concentrations (> 2 µg/L)

Pressure Zone	Well ID	Cr6 Tier	Arsenic (µg/L)
Lake Cahuilla	6728-1	1	3.9
Middleton Road	7802-1	3	12*
	7803-1	3	7.4*
	6805-1	1	2.5
	6808-1	1	2.8
Mecca	6806-1	3	13*
	6807-1	3	20*
Bombay Beach	7991-1	3	32*

* Ion Exchange Treatment Plants remove arsenic to achieve compliance with the 10 µg/L arsenic MCL.



Table 3-6. Inactive Wells with Detectable Arsenic Concentrations

Pressure Zone	Well ID	Reason for Inactive Status
Middleton Road	7801-1	High arsenic concentration (25 mg/L)



Table 3-7. Groundwater Wells with Detectable VOC Concentrations

Pressure Zone	Well ID	Cr6 Tier	VOC Concentration
Valley	5669-1	2	0.03 µg/L DBCP



Table 3-8. Inactive Wells with Detectable VOC Concentrations

Pressure Zone	Well ID	Reason for Inactive Status
Valley	5516-1	PCE detected (0.5 µg/L); nitrate concentration of 20 mg/L
	5609-1M	PCE detected (1.5 µg/L); elevated nitrate
	5623-1	PCE detected (0.5 µg/L); elevated nitrate
	5633-2	DBCP detected (0.033 µg/L); high nitrate
	5638-2	DBCP detected (0.037 µg/L); high nitrate
	5660-1	DCEP detected (1.0 µg/L); elevated nitrate
	5663-1	PCE (0.84 µg/L) and TCP (0.006 µg/L) detected; elevated nitrate
	5665-1	DBCP detected (0.06 µg/L); high nitrate
	5666-1	DBCP detected (0.03 µg/L); high nitrate
	6702-1	DBCP detected (0.07 µg/L)



Table 3-9. Groundwater Wells with Higher TDS Concentrations near the Salton Sea

Pressure Zone	Well ID	Cr6 Tier	TDS (mg/L)
West Shores	8993-2	3	900
	8995-1	3	1,425
	8995-2	3	1,100



Table 3-10. TDS Concentrations in Active Wells near Whitewater GRF

Pressure Zone	Well ID	Cr6 Tier	TDS (mg/L)	Approximate Distance and Direction from Recharge Facility
Date Palm	4521-1	3	360	8.6 miles south/southeast
	4522-1	3	460	6.9 miles south/southeast
	4523-1	3	450	8.1 miles south/southeast
	4524-1	3	380	8.4 miles south/southeast
	4525-1	3	280	8.1 miles south/southeast
	4526-1	2	220	8.3 miles south/southeast
	4528-1	3	160	9.9 miles south/southeast
	4562-2	3	360	7.0 miles south/southeast
	4563-1	3	400	6.4 miles south/southeast
	4564-1	3	490	7.1 miles south/southeast
	4565-1	3	480	5.8 miles south/southeast
	4566-1	3	290	8.9 miles south/southeast
	4567-1	2	220	7.9 miles east/southeast
	4568-1	2	210	6.2 miles east/southeast
Sky	4504-1	3	240	11 miles south/southeast
Mountain	4519-1	3	240	8.8 miles south/southeast
	4527-1	3	160	9.8 miles south/southeast



Table 3-11. TDS Concentrations in Active Wells near the TEL Recharge Facility

Pressure Zone	Well ID	Cr6 Tier	TDS (mg/L)	Approximate Distance and Direction from Recharge Facility
Lake Cahuilla	6729-1	3	700	0.3 miles to north/northeast
	6728-1	1	160	1.2 miles to east
	6725-1	1	360	2.8 miles to north/northeast
	6726-1	1	170	2.8 miles to north/northeast
	6724-1	1	290	2.8 miles to north/northeast
	6723-1	1	280	3.1 miles to north
Middleton Road	6808-1	1	170	4.1 miles to northeast
	6805-1	1	210	4.1 miles to northeast
	7802-1	3	140	5.7 miles to the southeast
	7803-1	3	180	5.7 miles to the southeast
La Quinta	6707-1	1	210	4.4 miles to north
	5727-1	1	160	5.7 miles to north
	5725-1	1	170	6.5 miles to north
	5715-1	1	180	6.8 miles to north
	5701-2	1	160	7 miles to north



Table 3-12. Active Wells with Detectable Perchlorate Concentrations

Pressure Zone	Well ID	Cr6 Tier	Perchlorate (µg/L)
Date Palm	4523-1	2	1.5
Date Palm	4563-1	2	1.1



Table 3-13. Inactive Wells with Detectable Perchlorate Concentrations

Pressure Zone	Well ID	Reason for Inactive Status
Lake Cahuilla	6721-2	High TDS; perchlorate detected (5.4 µg/L)



Table 3-14. Active Wells with Fluoride Concentrations above 1.2 mg/L

Pressure Zone	Well ID	Cr6 Tier	Fluoride (mg/L)
Middleton Road	7803-1	3	1.2
West Shores	8993-2	3	1.5
	8995-1	3	1.3



Table 3-15. Active Wells with Elevated Uranium Concentrations (>11 µg/L)

Pressure Zone	Well ID	Cr6 Tier	Uranium (µg/L)
Date Palm	4521-1	3	11.5
	4562-2	3	14.5
	4563-1	3	13.3
	4564-1	3	12.2



Table 3-16. Constituents of Concern with Reasonably Anticipated Future Regulatory Significance

Contaminant	CA MCL (mg/L)	CA NL (mg/L)	CA PHG (mg/L)	EPA MCL (mg/L)	EPA HAL (mg/L)
1,4-Dioxane	-	0.001	-	-	-
Cobalt	-	-	-	-	-
Chlorate	-	0.8	-	-	-
Manganese	0.050 (secondary)	-	-	0.050 (secondary)	0.3
Molybdenum	-	-	-	-	0.04
Nitrosamines	-	0.000010*	0.000003^	-	-
Strontium	-	-	-	-	1.5
Vanadium	-	0.050	-	-	-
Dimethyl tetrachloro-terephthalate (DCPA)	-	-	-	-	0.070
1,2,3-Trichloropropane (TCP)	-	0.000005	0.0000007	-	-

*NDEA, NDMA and NDPA. ^NDMA.

ND = non-detect. NA = not available.

CA = California. MCL = Maximum contaminant level. NL = Notification level. PHG = Public health goal.

HAL = Health advisory level. RL = Reference level.

References:

CDPH, 2010. Drinking Water Notification Levels and Response Levels: An Overview.

CDPH, 2014. MCLs, DLRs, and PHGs for Regulated Drinking Water Contaminants

#<http://www.drinktap.org/home/water-information/water-quality/ucmr3/vanadium.aspx>



Table 3-17. Comparison of Secondary Disinfection Strategies for the CVWD System

	Calcium Hypochlorite Tablets	Sodium Hypochlorite Liquid	Gaseous Chlorine
Advantages	<ul style="list-style-type: none"> • Less formation of disinfection by-products (chlorate and perchlorate) compared with sodium hypochlorite • More stability in desert environment • Climate control is not necessary • Simpler operations and maintenance 	<ul style="list-style-type: none"> • Less variability in dosing expected 	<ul style="list-style-type: none"> • Less formation of disinfection by-products (chlorate and perchlorate) compared with sodium hypochlorite • Less variability in dosing expected • Climate control is not necessary • Simpler operations and maintenance
Disadvantages	<ul style="list-style-type: none"> • More variability in dosing expected 	<ul style="list-style-type: none"> • Greater formation of disinfection by-products (chlorate and perchlorate) compared with sodium hypochlorite • Climate control and minimization of solution age would be necessary to minimize by-product formation and degradation, which would require additional infrastructure and is less compatible with intermittent use of wells 	<ul style="list-style-type: none"> • Risks to neighbors in case of a chlorine gas leak



Table 4-1. Impact of Cr6 Rule on Water Supply by Pressure Zone

	Current Surplus or Deficiency (gpm)	Surplus or Deficiency with wells above 10.4 µg/L Cr6 offline	Surplus or Deficiency with wells above 8 µg/L Cr6 offline
Sky Valley	+ 600	-2,700	-3,700
Date Palm	+ 6,900	+ 6,900	+1,300
Sky Mountain	+2,500	-4,300	-13,900
Mission Hills	-1,300	-3,100	-6,900
Valley	-5,300	-13,900	-20,100
Bombay Beach (Area 23)	-600	-600	-600
La Quinta	+4,300	-8,500	-20,000
Cahuilla	+2,700	-7,700	-7,700
Sun City	+3,700	-5,900	-5,900
Middleton Road	+7,600	+3,000	+3,000
Mecca	+1,700	+1,700	-100
West Shores (ID11)	+500	+500	+500
System-Wide*	+23,500	-34,500	-74,000

* System-wide numbers do not exactly equal the total of individual zones due to rounding

Source: Akel Engineering, 2015.



Table 4-2. Approximate Cost of New Distribution System Pipelines to Distribute Water from Replacement Wells Located in Date Palm

Pressure Zone	Pipe Diameter (inches)	Pipe Length (miles)	Total Cost
Date Palm to Sky Mountain	60	11.2	\$93,000,000
Sky Mountain to Valley	54	5.9	\$45,000,000
Valley to La Quinta	42	7.0	\$45,000,000
La Quinta to Lake Cahuilla	36	6.0	\$31,000,000
Lake Cahuilla to Middleton	18	5.0	\$13,000,000
Date Palm to Mission Hills	12	2.0	\$4,000,000
Sky Mountain to Sun City	30	4.5	\$21,000,000
Pipeline Total		41.6	\$252,000,000*
17 New Wells and Land			\$34,000,000
Total Estimated Cost			\$286,000,000

* Pipeline costs include 30% contingency.



Table 5-1. Cr6 Concentrations in Active Wells

Zone	Well ID	Cr6 Tier	Average Cr6 (2000-2014)	90th Percentile Cr6 (2000-2014)	Cr6 Range (2000-2014)	First Cr6 Compliance Conc. or Grand-fathered Conc.	Design Cr6 Conc. Used for Cost Evaluation
			µg/L	µg/L	µg/L	µg/L	µg/L
Sky Valley (ID8) 4 wells	3405-1	>10.4	9.6	10.0	9.1 - 10	13	13.0
	3408-1	>10.4	19.0	19.0	18 - 22	19	22.0
	3409-2	>10.4	17.0	17.0	17 - 17	22	22.0
	3410-1	>10.4	15.0	15.0	15 - 15	14	15.0
Date Palm 14 wells	4521-1	<8	4.0	4.7	2.0 - 4.7	3.4	4.7
	4522-1	<8	2.9	3.0	2.2 - 3.0	2.2	-
	4523-1	<8	2.3	2.4	1.4 - 2.4	1.4	-
	4524-1	<8	4.0	4.1	3.1 - 4.1	3.1	4.1
	4525-1	<8	5.5	5.8	5.1 - 6.0	5.1	-
	4526-1	8 - 10.4	9.8	9.9	9.3 - 10	9.8	10.0
	4528-1	<8	6.2	6.2	6.1 - 6.2	6.1	-
	4562-2	<8	4.2	4.2	4.2 - 4.2	4.2	-
	4563-1	<8	4.1	4.1	2.8 - 4.1	2.8	4.1
	4564-1	<8	2.9	3.0	1.5 - 3.0	1.5	-
	4565-1	<8	2.6	2.9	1.7 - 3.0	1.7	-
	4566-1	<8	4.9	4.9	3.8 - 5.0	3.8	-
	4567-1	8 - 10.4	8.9	9.0	8.7 - 9.1	8.9	9.1
	4568-1	8 - 10.4	8.0	8.2	7.5 - 8.3	8.3	8.3
Sky Mountain 18 wells	4504-1	<8	3.5	3.8	3.1 - 4.0	3.1	-
	4519-1	<8	2.7	3.0	2.4 - 3.1	3.1	-
	4520-02	(NEW)					
	4527-1	<8	5.4	5.8	4.8 - 6.1	4.8	-
	4610-1	>10.4	13.3	15.5	12 - 17	14	17.0
	4611-1	8 - 10.4	8.9	9.4	7.1 - 9.8	7.1	9.8
	4612-1	<8	6.6	6.7	6.5 - 6.9	6.6	6.9
	4613-1	8 - 10.4	12.5	12.9	9.2 - 13	9.2	13.0
	4614-2	8 - 10.4	8.7	9.8	2.9 - 9.9	9.8	9.9
	4615-1	(NEW)					
	5630-1	<8	5.4	5.8	5.0 - 6.0	5.0	6.0
	5640-2	<8	-	-	5.8	5.8	5.8
	5658-1	8 - 10.4	9.4	9.5	9.0 - 9.5	9.4	9.5
	5676-2	>10.4	12.0	12.0	12 - 13	12	13.0
	5677-1	>10.4	12.3	12.7	12 - 13	11	13.0
	5678-1	>10.4	15.0	15.0	15 - 15	14	15.0
4630-1	8 - 10.4	11.0	11.0	10 - 11	10	11.0	
4631-2	8 - 10.4	9.4	10.3	8.1 - 10.4	10	10.4	
Mission Hills	4509-1	8 - 10.4	9.8	10.0	8.9 - 10	9.8	10.0
	4510-1	>10.4	13.0	13.0	13 - 13	12	13.0



Zone	Well ID	Cr6 Tier	Average Cr6 (2000-2014)	90th Percentile Cr6 (2000-2014)	Cr6 Range (2000-2014)	First Cr6 Compliance Conc. or Grandfathered Conc.	Design Cr6 Conc. Used for Cost Evaluation
3 wells	4507-2	8 - 10.4	10.1	10.3	9.6 - 10.4	10	10.4
Valley	5603-2	8 - 10.4	7.6	8.2	7.3 - 8.8	7.5	8.8
25 wells	5624-1	<8	5.2	5.5	2.7 - 5.5	2.7	-
	5625-2	<8	6.1	6.6	5.5 - 6.7	6.7	-
	5631-1	<8	5.2	5.3	5.0 - 5.5	5.5	-
	5632-2	>10.4	18.0	18.0	18 - 18	Under repair	18.0
	5639-1	<8	6.2	6.2	5.4 - 6.2	5.4	6.2
	5656-1	<8	4.7	5.0	4.4 - 5.0	4.9	-
	5657-2 (NEW)	>10.4			15 - 16	Under constr.	16.0
	5659-1	<8	5.8	6.0	5.5 - 6.0	5.5	-
	5662-1	<8	4.2	5.0	3.6 - 5.9	5.9	-
	5664-1	>10.4	12.5	13.4	12 - 14	12	14.0
	5667-1	<8	4.9	5.0	3.3 - 5.0	3.3	-
	5668-1	<8	5.2	6.0	4.3 - 6.0	5.7	-
	5669-1	8 - 10.4	9.1	9.5	8.8 - 9.6	8.9	9.6
	5670-1	<8	4.7	5.0	4.4 - 5.2	5.2	5.2
	5671-1	<8	4.3	4.4	4.0 - 4.4	4.7	-
	5672-1	<8	4.4	4.8	4.0 - 5.0	4.0	-
	5673-1	<8	4.7	4.9	2.9 - 5.0	2.9	-
	5675-1	<8	5.7	7.4	3.6 - 7.4	3.6	-
	5679-1	>10.4	16.1	16.0	16 - 20	16	20.0
	5680-1	<8	7.2	7.2	6.6 - 7.2	6.6	-
	5681-1	<8	7.4	7.9	6.0 - 7.9	7.4	-
	5682-1	8 - 10.4	7.6	9.0	6.8 - 9.4	7.2	9.4
	4628-2	>10.4	13.2	14.0	11 - 14	14	14.0
4629-1	8 - 10.4	9.4	9.7	9.0 - 9.7	9.5	9.7	
La Quinta	5701-2	8 - 10.4	10.0	10.2	9.2 - 10.3	10	10.3
14 wells	5708-1	8 - 10.4	7.8	8.5	7.0 - 8.5	7.5	8.5
	5709-1	<8	7.2	7.3	6.9 - 7.3	6.9	-
	5711-2	>10.4	11.8	13.1	11 - 14	11	14.0
	5713-1	8 - 10.4	9.5	10.0	8.3 - 10.1	8.7	10.1
	5714-1	8 - 10.4	9.5	9.7	8.0 - 9.7	9.4	9.7
	5715-1	8 - 10.4	8.4	10.0	4.0 - 10	8.2	10.0
	5716-1	8 - 10.4	10.7	11.0	9.6 - 11	9.6	11.0
	5717-1	>10.4	12.0	12.0	12 - 12	14	14.0
	5718-1	>10.4	14.5	15.0	13 - 15	16	16.0
	5725-1	8 - 10.4	10.2	10.9	9.1 - 12	10	10.3 ^s
	5727-1	8 - 10.4	10.2	10.9	9.6 - 11	10	11.0
	6701-1	>10.4	14.0	14.0	14 - 14	14	14.0
	6707-1	8 - 10.4	12.5	13.7	11 - 14	10	14.0



Zone	Well ID	Cr6 Tier	Average Cr6 (2000-2014)	90th Percentile Cr6 (2000-2014)	Cr6 Range (2000-2014)	First Cr6 Compliance Conc. or Grand-fathered Conc.	Design Cr6 Conc. Used for Cost Evaluation
Lake Cahuilla 7 wells	6723-1	>10.4	11.0	11.0	11 - 11	11	11.0
	6724-1	>10.4	12.6	13.8	12 - 14.5	14	14.5
	6725-1	>10.4	10.8	11.0	10 - 11	13	13.0
	6726-1	>10.4	12.0	12.8	11 - 13	14	14.0
	6728-1	>10.4	16.2	17.0	15 - 17	12	17.0
	6729-1	<8	0.2	0.4	0 - 0.4	<1.0	-
	6734-1	>10.4	12.5	13.7	11 - 14	15	14.0
Sun City 5 wells	4720-1	>10.4	15.1	16.5	14 - 17.5	16	17.5
	4721-1	>10.4	14.5	15.0	13 - 15	16	16.0
	4722-1	>10.4	15.8	16.0	15 - 16	14	16.0
	5719-1	>10.4	18.0	19.6	16 - 20	20	20.0
	5720-1	>10.4	13.8	14.0	13 - 14	15	15.0
Middleton Road 4 wells	7802-1*	<8	11.7	13.0	7.6 - 13	12	-
	7803-1*	<8	8.9	10.4	7.6 - 11	10	-
	6805-1	>10.4	22.1	23.4	21 - 23.5	22	23.5
	6808-1	>10.4	17.0	17.0	17 - 17	20	20.0
Mecca 2 wells	6806-1*	<8	6.8	6.9	5.6 - 7.0	5.6	-
	6807-1*	8 - 10.4	3.5	6.3	<1 - 9.1	9.1	9.1
West Shores 3 wells	8993-2	<8	<1.0	<1.0	<1.0	<1.0	-
	8995-1	<8	<1.0	<1.0	<1.0 - 3.6	<1.0	-
	8995-2	<8	<1.0	<1.0	<1.0 - 2.3	<1.0	-
Bombay Beach	7991-1	<8	<1.0	<1.0	<1.0	<1.0	-

* Cr6 is removed from these wells at the arsenic IXTPs.

§ Additional sampling in 2014 found Cr6 concentrations consistently below the MCL, so the maximum of 2014 data was used as the design Cr6 concentration.

Concentration is decreasing, suspected to be due to infiltration at the Thomas E. Levy Recharge facility. The latest total chromium concentration was 12 µg/L (September 2014).

Shading: red = Tier 1, yellow = Tier 2, green = Tier 3.



Table 5-2. Summary of SBA Case Studies for Cr6 Removal

Tested Conditions						Technology Effectiveness				Waste Products				Addressing Variability	
No.	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate Cr6 removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	CVWD pilot at Well 5679	Drinking water	Single pass columns (without regeneration); 2 min EBCT per column; Purolite A600E/9149	0.32 gpm	5 months	None	Influent Cr6 and total Cr = 16 µg/L. Effluent Cr6 and Total Cr were 5.6 and 6.6 µg/L at 23,843 BVs	Sulfate in raw water (20 mg/L)	< 16,000 BV (breakthrough by next sample collected after 1,200 BV sample)	Not investigated	Not investigated	Not investigated	Not investigated	SBA can handle changes in Cr6 concentration without significantly reducing resin life. However, increases in sulfate are expected to significantly reduce resin life.	For a system designed for a certain flow rate, a lower flow rate can be accommodated without problems and a higher flow rate may be acceptable to a level at which the minimum EBCT is achieved. The lowest EBCT tested and found to be effective was 45 seconds at Soquel Creek.
2	CVWD pilot Well 3408	Drinking water	Single pass columns (without regeneration); 2 min EBCT per column; Purolite A600E/9149	0.32 gpm	3 months	None	Influent Cr6 and total Cr = 18 µg/L. Effluent Cr6 was equal to the influent Cr6 level at 6,149 BVs	Sulfate in raw water (220 mg/L)	< 1,200 BV	Not investigated	Not investigated	Not investigated	Not investigated	Same as above	Same as above
3	CVWD full scale IXTPs	Drinking water	One SBA vessel with 3-min EBCT. Regeneration facilities available at the treatment plant. ResinTech SGB-1.	150 gpm	4 months with intermittent shutdowns	None	Influent Cr6 = 6.7 to 12 µg/L. Influent total Cr = 12 µg/L. Effluent Cr6 achieved 50% breakthrough at 3,500 BVs	Sulfate in raw water (32 mg/L)	Arsenic	Spent brine was non-RCRA hazardous waste in California. Spent brine was treated onsite to remove Cr before disposal, rendering it non-hazardous. Precipitated waste is non-RCRA hazardous waste.	Depending on regeneration frequency	Treated brine trucked to a wastewater facility. Sludge sent to a hazardous waste landfill.	Bench-scale testing of brine reuse (too low of a brine strength used - 5%)	Same as above	Same as above
4	CVWD pilot at Well 5676-2	Drinking water	Single SBA columns, 2-min EBCT, Purolite A600E/9149 and Dow PWA15	0.32 gpm per column	Started in July 2014 and planned to end in March 2015	None	Influent Cr6 = 12 µg/L. Influent total Cr = 12 µg/L. Effluent Cr6 reached 8 µg/L at 29,600 BVs for Purolite A600E/9149 and at 15,100 BVs for Dow PWA15. Effluent total Cr results are similar to Cr6	Sulfate in raw water (16 mg/L); resin product	Molybdenum and vanadium were removed but broke through before Cr6	To be determined	To be determined	To be determined	To be determined	Same as above	Same as above



Tested Conditions						Technology Effectiveness				Waste Products				Addressing Variability	
No.	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate Cr6 removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
5	CVWD pilot at Well 6701-1	Drinking water	Single SBA columns, 2-min EBCT, Purolite A600E/9149 and Dow PWA15	0.32 gpm per column	Started in July 2014 and planned to end in December 2014	None	Influent Cr6 = 12 µg/L. Influent total Cr = 12 µg/L. Effluent Cr6 reached 10 ppb at 11,600 BVs for Purolite A600E/9149 and 13 µg/L at 6,900 BVs for Dow PWA15. Effluent total Cr results are similar to Cr6	Sulfate in raw water (47 mg/L); resin product	Molybdenum and vanadium were removed but broke through before Cr6	To be determined	To be determined	To be determined	Most of the used brine is recycled while a segment containing high Cr6 concentration is disposed of as waste	Same as above	Same as above
6	Glendale pilot	Drinking water	SBA columns in lead/lag configuration; 3.7 min EBCT per column; Amberlite PWA 410 CI	2 gpm	3 weeks	None	Influent Cr6 = 100 µg/L. Cr6 in lead effluent reached 5 µg/L at approx. 1,900 BVs	Sulfate in raw water (90 mg/L). Resin regeneration efficiency	Nitrate and phosphate were removed but broke through before Cr6. Nitrate and phosphate chromatographic peaking were observed	Spent brine that contains chromium and high TDS levels	5 BVs of brine, 2 BVs of slow rinse and 24 BVs of fast rinse per regeneration	Not investigated	Brine recycle and/or treatment	Same as above	Same as above
7	Soquel Creek pilot	Drinking water	Single SBA column; 45 seconds EBCT; Purolite A600E/9149	2.1 gpm	4 months	None	Influent Cr6 = 15 - 17 µg/L. Effluent Cr6 reached 6 µg/L at approx. 25,000 BVs	Resin regen efficiency	Not investigated	Spent brine that contains chromium and high TDS levels	3.5 BVs of brine; 2 BVs of slow rinse	Not investigated	Brine recycle and/or treatment using RCF or adsorptive media	Same as above	Same as above
8	Cal Water and Glendale pilot	Drinking water	Single column; 2 min EBCT; Purolite A600E/9149, Dow SAR, Envirogen HyperSorb A3-2-1	0.32 gpm	3 weeks (approx. one week for each resin with full breakthrough)	None	Glendale site: Influent Cr6 = 24 - 20 µg/L. Effluent Cr6 reached 6 µg/L at approx. 3,000 BVs (best performer) Livermore site: Influent Cr6 = 9 - 10 µg/L. Effluent Cr6 reached 6 µg/L at approx. 6,000 BVs (best performer)	Influent sulfate and possibly Cr6 concentrations. Glendale site: sulfate = 110 mg/L. Livermore site: sulfate = 55 mg/L	Nitrate, sulfate, and phosphate were removed but with faster breakthrough than Cr6. Uranium was completely removed by the end of testing.	Spent resin as non-hazardous and uranium below the LLRW limit (0.05%)	0.09 cubic feet of resin per column	Not investigated	None	Same as above	Same as above
9	WQTS (WaterRF 4450); bench scale test	Drinking water	Single column; 3 min EBCT; Purolite A600E/9149 and Dow SAR	5.9 mL/min (i.e. 0.0016 gpm)	2 months	None	Influent Cr6 = 4.8 to 62 µg/L. Effluent Cr6 was non-detect at approx. 12,000 BVs (best performer) for influent Cr6 of 19 µg/L	Influent nitrate and sulfate concentrations; no significant effect by influent Cr6 level	Nitrate, perchlorate and arsenic were removed but with faster breakthrough than Cr6. Uranium was effectively removed throughout testing period	Spent brine as non-RCRA hazardous waste	1.5 BVs of 14% brine, 3 BVs of slow rinse and 5 BVs of fast rinse per regeneration	Trucking off as hazardous or treatment on-site then discharge to the sewer or off-site disposal	Not investigated	Same as above	Same as above



Tested Conditions						Technology Effectiveness				Waste Products				Addressing Variability	
No.	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate Cr6 removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
									(up to 12,000 BVs).						
10	Glendale pilot; MIEX technology*	Drinking water	Continuously-stirred mixing tanks with 20 min contact time; resin settler; resin regeneration system; post filtration may be needed for turbidity control	2 gpm	2 weeks	None	Influent Cr6 = 100 µg/L. Effluent Cr6 below 5 µg/L in 16 out of 28 samples (Cr6 removal efficiency of 92 - 97%), suggesting non-reliable removal of Cr6 removal to < 5 µg/L	Resin dose was critical for performance. High sulfate level (87 mg/L) was suspected to negatively affect Cr6 removal	Nitrate and sulfate were removed by 43% and 80%, respectively. No chromatographic peaking was observed for nitrate	Spent brine as non-RCRA hazardous waste	Not specified	Not investigated	Not investigated	Contact time, resin dose and resin regeneration rate	For a system designed for a certain flow rate, it can handle a lower flow rate without problems and a higher flow rate to a level at which the minimum contact time is achieved

*SBA resin with a magnetic component in its structure to allow rapid agglomeration and settling of resin from the treated water. 5% of the resin (adjustable) was continuously regenerated with brine in a separate system and reintroduced into the mixing tanks.
 EBCT = Empty bed contact time. IXTP = Ion exchange treatment plant.



Table 5-3. Summary of WBA Case Studies for Cr6 Removal

No.	Tested Conditions					Technology Effectiveness				Waste Products				Addressing Variability	
	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	CVWD pilot at Well 5679	Drinking water	pH reduction using sulfuric acid, 2-min EBCT for Dow PWA7 and ResinTech SIR-700, 3.75 min EBCT for Purolite S106	0.14 gpm (0.17 gpm for Purolite S106)	1.5 years (ongoing)	pH reduction to 6.0	Influent Cr6 = 17 µg/L. Influent total Cr = 18 µg/L. Effluent Cr6 reached approx. 0.5 µg/L at 250,000 BVs for PWA7 and SIR-700. Effluent total Cr ~5 µg/L at 210,000 BVs for PWA7 and SIR-700, approx. 1.5 ppb at 120,000 BVs for S106.	pH	Uranium and vanadium were effectively removed	Not investigated	Not investigated	Not investigated	Not investigated	WBA can handle changes in Cr6 concentration. Increased Cr6 concentrations may result in a shorter resin life. Changes in other water quality parameters (except pH) are not expected to significantly affect WBA performance.	For a system designed for a certain flow rate, a lower flow rate can be accommodated without problems and a higher flow rate is possible to a level at which the minimum EBCT is achieved. The lowest EBCT tested and found to be effective was 2 minutes.
2	CVWD pilot Well 3408	Drinking water	pH reduction using sulfuric acid, 2-min EBCT for Dow PWA7 and ResinTech SIR-700, 3.75 min EBCT for Purolite S106	0.14 gpm (0.17 gpm for Purolite S106)	1.5 years and ongoing	pH reduction to 6.0	Influent Cr6 = 19 µg/L. Influent total Cr = 19 µg/L. Effluent Cr6 reached 4.5 µg/L at 250,000 BVs for PWA7 and SIR-700, approx. 0.5 µg/L at 120,000 BVs for S106. Effluent total Cr reached approx. 7 µg/L at 250,000 BVs for PWA7 and approx. 5 µg/L for SIR-700, approx. 1.5 µg/L at 120,000 BVs for Purolite S106. Cr6 leaching was observed for S106 and SIR-700.	pH	Uranium and vanadium were effectively removed	Resin is non-RCRA hazardous waste, and TENORM	Resin volume	Resin trucked to a non-RCRA hazardous waste landfill	Not investigated	Same as above	Same as above
3	Glendale demonstration	Drinking water	pH reduction using CO ₂ , IX vessels in lead/lag configuration, 3-min EBCT per vessel; Dow PWA7	425 gpm	3 years (ongoing)	pH reduction to 6.0	Influent Cr6 = 20 to 40 µg/L. Effluent Cr6 in lag bed effluent reached 5 µg/L when the lead bed resin treated approx. 364,000 BVs of water.	pH	Uranium was effectively removed	Spent resin as non-RCRA hazardous waste, TENORM and LLRW (uranium above 0.05% by weight) Backwash and forward flush water at resin startup due to formaldehyde leaching	185 cf per resin changeout (once a year)	US Ecology landfill in Idaho	Resin preconditioning to minimize wastewater from resin changeout	WBA can handle varying influent Cr6 concentrations. Higher Cr6 is expected to result in shorter resin life.	For a WBA system designed for a certain flow rate, a higher flow may be possible but would result in a shorter EBCT and possibly less effective Cr6 removal.



		Tested Conditions				Technology Effectiveness				Waste Products			Addressing Variability		
No.	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
4	Glendale pilot	Drinking water	pH reduction using CO ₂ , single resin column, 2-min EBCT for ResinTech SIR-700, 3.75-min EBCT for Purolite S106	0.14 gpm - ResinTech SIR-700; 0.17 gpm - Purolite S106	9 months	pH reduction to 6.0	Average influent Cr6 = 28 µg/L. Effluent Cr6 reached 1.8 µg/L at approx. 105,000 BVs for Purolite S106 (end of testing) and 6 µg/L at approx. 200,000 BVs for ResinTech SIR-700. Initial Cr6 leakage up to 10 µg/L for both resins for approximately two months following startup.	pH and influent Cr6 concentration	Nitrate, sulfate and phosphate were removed but with fast breakthrough. Uranium was effectively removed through the end of testing	Spent resin as non-RCRA hazardous waste, TENORM and LLRW (uranium above 0.05% by weight); Minimal wastewater at resin startup. No formaldehyde leaching was observed for either resin	0.09 cf for Purolite S106; 0.04 cf for ResinTech SIR-700	Not investigated	Not investigated	Same as above	Same as above
5	Cal Water pilot at Livermore	Drinking water	pH reduction using HCl acid, single resin column, 2-min EBCT for Dow PWA7	0.14 gpm	4 months	pH reduction to 6.0	Influent Cr6 = 9 to 10 µg/L. Effluent Cr6 reached 0.22 µg/L at approx. 83,300 BVs (end of testing)	pH and influent Cr6 concentration	Not investigated	Not investigated	0.04 cf	Not investigated	Not investigated	Same as above	Same as above
6	WRF 4450; bench scale	Drinking water	pH reduction using HCl acid, single resin column (two segments), 3-min EBCT for Dow PWA7 and Purolite S106	8.8 mL/min (i.e. 0.002 gpm)	6 months	pH reduction to 6.0 and 5.5	Influent Cr6 ranged from 4.8 to 62 µg/L for various water sources. Effluent Cr6 varied for the resins and water qualities. Effective Cr6 removal was achieved.	EBCT and influent Cr6 concentration Possible small effect by sulfate	Uranium was effectively removed. Nitrate chromatographic peaking was observed.	Spent resin as non-RCRA hazardous waste, TENORM and LLRW (about half of water qualities tested)	0.0009 cf per column.	Not investigated	Not investigated	Same as above	Same as above
7	Hanford remediation; bench scale	Groundwater remediation	pH reduction using sulfuric acid. 1-inch diameter columns. EBCT unknown. ResinTech SIR-700	Unknown	9 months	pH reduction to 5	DR-5 site: Influent Cr6 increased from 700 µg/L to 1,800 µg/L. Effluent Cr6 target was 10 µg/L. Estimated resin capacity was >65,000 BVs. KX site: Influent Cr6 = 60 µg/L. No Cr6 breakthrough at 80,000 BVs.	pH	Unknown	Spent resin was RCRA hazardous waste	Unknown	Spent resin needs to be stabilized using Portland cement (or similar material) before disposal to Environmental Restoration Disposal Facility	Unknown	Same as above	Same as above



Table 5-4. Summary of RCF and RCMF Case Studies for Cr6 Removal

No.	Tested Conditions					Technology Effectiveness				Waste Products				Addressing Variability	
	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	CVWD bench-scale test (RCF)	Drinking water	Ferrous iron addition, coagulation and filtration	Jar testing; not applicable	Approximately one month	None	Influent Cr6 and total Cr were between 3.3 and 20 µg/L. Effluent Cr6 was between 0.47 and 3 µg/L. Effluent total Cr was between 0.63 and 4.8 µg/L.	Ferrous iron dose and reduction time. pH and silica have slight effects on Cr removal	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	RCF can be adjusted to treat various Cr6 concentrations by adjusting chemical doses	RCF cannot be easily adjusted to handle flow beyond the design flow rate
2	Glendale demonstration (RCF)	Drinking water	Ferrous iron injection, reduction tanks, aeration or chlorination, polymer injection and granular media filtration	100 gpm	3 years	None	Influent Cr6 and total Cr approximately ~100 µg/L most of the time and occasionally 5 - 15 µg/L. Effluent Cr6 mostly below 1 µg/L. Effluent total Cr mostly below 5 µg/L.	Ferrous iron dose, reduction time, filtration effectiveness	None	Spent filter backwash water was non-hazardous, which was treated by settling and dewatering. Dewatered solids were non-RCRA hazardous waste.	Approximately 1,400 lb/month of dewatered solids	Non-RCRA hazardous landfill	Treated spent backwash water recycle back to the process to minimize liquid waste	Same as above	Same as above
3	WQTS (WaterRF 4450); pilot-scale test (RCF)	Drinking water	Coagulants injection (alum and polymer), rapid mix, ferrous sulfate injection (2 mg/L as Fe), flocculation, sedimentation, chlorine and filter aid injection, granular media filtration	3 gpm	2 months	None	Influent Cr6 spiked to 25 µg/L. Effluent Cr6 < 1 µg/L. Effluent total Cr < 1 µg/L.	Not investigated. Ferrous iron dose and detention times were fixed. Alum and filter aid doses have slight impacts on Cr removal	None	Not investigated	Not investigated	Not investigated	Not investigated	Same as above	Same as above
4	CVWD pilot at Well 5679 (RCMF)	Drinking water	Ferrous iron injection, reduction tank, chlorine injection, chlorine contact tank and microfiltration	Approx. 15 gpm	2 months	None	Influent Cr6 and total Cr = 16 µg/L. Effluent Cr6 < 1 µg/L and total Cr < 2 µg/L under well controlled conditions.	Ferrous iron dose	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	RCMF can be adjusted to treat various Cr6 concentrations by adjusting chemical doses	RCMF cannot be easily adjusted to handle flow beyond the design flow rate
5	Glendale pilot (WaterRF 4365) (RCMF)	Drinking water	Ferrous iron injection, reduction tanks, aeration, chlorination, microfiltration	11 to 34 gpm	5 months	None	Influent Cr6 and total Cr were 4 to 15 µg/L most of the time. Effluent Cr6 and total Cr below 1 µg/L.	Ferrous iron dose	Not investigated	Membrane backwash wastewater was non-hazardous. Membrane chemical cleaning wastewater had low pH and high TOC levels	3 to 5% of treatment flow rate	Not investigated	Not investigated. Backwash wastewater can be possibly treated to remove solids and recycled back to the treatment process	Same as above	Same as above



Table 5-5. Summary of RO Case Histories for Cr6 Removal

No.	Tested Conditions					Technology Effectiveness				Waste Products				Addressing Variability	
	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	Hinkley Point-of-Entry Whole House Treatment	Drinking water	Carbon pre-filter, softener, RO membrane (thin-film composite membrane), chlorination and calcite contactor. Two-stage RO was used to reduce water loss	1,344 gpd (operated 8 hours a day)	4 months	None	Influent Cr6 = 4.1 to 5.3 µg/L. Effluent Cr6 < 0.02 µg/L. Effluent total Cr < 0.1 µg/L.	Not investigated	TDS, sulfate, nitrate, arsenic, uranium and chloride	RO brine is non-hazardous and a TENORM due to presence of radionuclides and uranium	Softener brine was 15% of the whole treatment flow. RO brine was 24% of the whole treatment flow	Disposal to a landfill that accepts TENORM	Not investigated	RO can remove many constituents simultaneously, thus can address water variability	RO can address temporary changes in flow rate with more frequent membrane cleaning
2	Glendale bench-scale test	Drinking water	RO membrane in a stirred cell	Not applicable (batch mode)	Not applicable	None	Influent Cr6 = 70 - 120 µg/L for three waters. Cr6 removal by 74 - 86% (loose RO membrane) and 95-99% (tight RO membrane).	Membrane type	TDS, DOC	Not investigated	Not investigated	Not investigated	Not investigated	Same as above	Same as above



Table 5-6. Summary of Adsorptive Media Case Histories for Cr6 Removal

No.	Name of technology	How the technology works	Tested Conditions					Technology Effectiveness				Waste Products			Addressing Variability		
			Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	Zeolite (Z-33)	Adsorption	Glendale pilot	Drinking water	One de-aeration column, six media columns in series (5-min EBCT per column and a total of 30-min EBCT)	2 gpm	One month	De-aeration to decrease oxygen in groundwater	Influent Cr6 = 60 to 110 µg/L. Final effluent Cr6 reached 5 µg/L at 620 BVs. Total Cr results were similar to Cr6	EBCT	No significant removal of arsenic, iron, nitrate, phosphate or sulfate. Silica and alkalinity were likely removed but with a fast breakthrough (<300 BVs and <200 BVs, respectively)	Spent media was a non-RCRA hazardous waste	7 cf	Landfill that accepts non-RCRA wastes	Not investigated	Not investigated	Not investigated
2	Iron adsorptive media (SMI®)	Surface reduction and adsorption	Glendale bench testing	Drinking water	Single 1/2-inch column with upflow; 2-min EBCT	10 mL/min	Unknown (likely a few months)	pH adjustment for some test conditions	Influent Cr6 = 1,000 to 2,670 µg/L. For influent Cr6 of 1,000 µg/L and pH 8.3, effluent Cr6 reached 50% breakthrough at 17,300 BVs. For influent Cr6 of 1,000 µg/L and pH 7.0, effluent Cr6 did not achieve breakthrough by the end of testing (46,000 BVs).	pH (improved performance at pH 7 compared to pH 8.3) and influent Cr6 (improved performance with lower influent Cr6 levels)	Not investigated	Likely would pass TCLP but not CA WET	Unknown	Not investigated	Not investigated	Performance is not likely affected by nitrate, sulfate, chloride, arsenic or perchlorate	Not investigated
3	Iron adsorptive media (Cleanit®)	Surface reduction and adsorption	Glendale pilot	Drinking water	Pre-filter, polyphosphate addition to minimize calcification, two columns in series with upflow (1-ft diameter, 1.5 to 3-ft media depth per column, 15-min EBCT per column), chlorination and post filtration	0.55 to 0.85 gpm	1.5 years	None	Influent Cr6 = 64 to 130 µg/L. Influent total Cr = 58 to 130 µg/L. Effluent Cr6 in lead effluent was non-detect at 1,814 BVs, 10 ppb at 2,446 BVs and reached full breakthrough at 3,096 BVs. Effluent total Cr breakthrough followed the same trend as Cr6	EBCT	Nitrate and sulfate were removed with quick breakthrough (approximately 1,100 BVs or less). Uranium was removed and reached 9 µg/L at 3,600 BVs (compared to influent level of 13 µg/L)	Media backwash wastewater is likely non-hazardous. Spent media was a non-RCRA hazardous waste and TENORM	1.2 cf per column	Landfill that accepts non-RCRA and TENORM wastes.	Not investigated	Likely flexible for various influent Cr6 levels	Expected to be able to absorb changes in flow rate for a short time of period within constraints of maximum EBCT



No.	Name of technology	How the technology works	Location of testing	Tested Conditions				Technology Effectiveness				Waste Products				Addressing Variability	
				Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
4	GAC	Adsorption	Glendale pilot	Drinking water	Two GAC products were tested: Filtrasorb 600 and Filtrashorb 200 PHA. Each GAC was tested using a single column with 5-min EBCT and 0.35 cf media.	0.5 gpm per column	One month	None	Influent Cr6 = 100 µg/L. Influent total Cr = 100 µg/L. Effluent Cr6 reached 5 µg/L at approximately 600 BVs.	Unknown	Iron was removed as of 600 BVs (end of monitoring). Sulfate, nitrate, arsenic, silica, and phosphate were not removed	Not investigated	0.35 cf	Not investigated	Not investigated	Not investigated	Not investigated
5	Modified Activated Carbon (Toxsorb's NP2 media)	Adsorption and catalyzed reduction of Cr6 to Cr3	Indio pilot	Drinking water	HCl acid addition, hypochlorite addition, media contactor (down flow, 3-min EBCT), NaOH addition as post-pH adjustment. In addition, regeneration using HCl and NaOH and a backwash storage tank.	100 gpm	Approx. 5 months	pH adjustment to 4.5 – 5.5 and hypochlorite addition to adjust oxidation reduction potential (ORP)	Cr6 data not available. Influent total Cr = 15 to 19 µg/L. Effluent total Cr reached 2.4 µg/L at 4,800 BVs during Phase 3(1). Effluent total Cr fluctuated between 1.9 and 28 µg/L during Phase 3(2) and between 4 and 10 µg/L during Phase 4. No typical breakthrough curves observed for Phases 3(2) and 4. High effluent Cr concentrations >200 µg/L observed in a few occasions, which are suspected to be caused by the auto-sampler capturing media.	Currently unknown	Not investigated	Currently unknown	Backwash waste-water, waste brine and dewatered solids containing Cr3. Quantities currently unknown	Currently unknown	ToxSorb intends to test feeding waste brine back to the head of the process	Currently unknown	Currently unknown



Table 5-7. Summary of Biological Treatment Media Case Studies for Cr6 Removal

No.	Tested Conditions					Technology Effectiveness				Waste Products				Addressing Variability	
	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	APT water MBR pilot at Burbank	Drinking water	Hydrogen gas, carbon dioxide and nutrient additions, ARO reactor (consists of membrane modules for biofilm). No aeration or post filtration tested for this pilot.	4 to 5 gpm	1.5 years	None	Influent Cr6 and total Cr spiked to 40 to 50 µg/L. Biological reactor effluent Cr6 was non-detect; total Cr was between 15 and 20 µg/L.	Unknown	Nitrate was removed from 8-9 mg/L as N to <0.3 mg/L as N. Perchlorate was removed by similar processes at other pilots (not tested in this pilot).	According to APT water, preliminary results of biomass indicate it is likely not a hazardous in California.	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated
2	Davis CA pilot	Drinking water	Pilot process consist of pH adjustment, acetic acid and phosphoric acid addition, biological fluidized bed reactor. Conceptual design also included aeration, coagulant and polymer addition, clarification, post filtration and disinfection.	20 to 40 mL/min (0.005 go 0.01 gpm)	4 months	None	Influent Cr6 = 40 to 50 µg/L. Influent total Cr = 44 to 50 µg/L. After a one-month acclimation period, FBR effluent Cr6 < 5 µg/L and total Cr between 8 and 22 µg/L. Jar testing suggests total Cr can be removed by coagulation (using FeCl3) and filtration to < 4 µg/L.	Potentially acetic acid dose (carbon source for microorganisms)	Nitrate was effectively removed by 72 - 100%. Limited data indicated selenium was removed by 70%.	Clarified backwash wastewater	Unknown	"Discharge of clarified backwash water to WRP headworks & about 1% solids discharged directly to the sewer. Further analysis of residuals necessary to determine if any waste classification applies."	Not investigated	Not investigated	Not investigated
3	Hanford full scale	Remediation	Carbon substrate, nutrients, micronutrients, sulfuric acid addition, fluidized bed reactor, followed by aerated splitter tank and membrane biological reactor to remove carbon substrate and biomass.	600 to 900 gpm	9 months as of April 2013	None	Influent Cr6 = 30.2 µg/L. FBR effluent Cr6 = 3 µg/L as of April 2013. Total Cr or Cr3 data not reported.	Unknown	Nitrate was removed from 23 - 28 to 4 - 8 mg/L as N.	Biomass waste	Expected to be 3% of the total flow	Waste biomass was aerated and dewatered. Biomass solids was planned for offsite disposal.	Treated waste flow was planned to be recycled to the head of the plant.	Not investigated	Not investigated
4	LA County Department of Public Works, Water Works Districts, District 37 pilot	Drinking water	Acetic acid, phosphoric acid addition, anoxic biological contactor (10 min EBCT), aeration, coagulation, filtration and disinfection	Unknown	Unknown	None	Influent Cr6 = 20 to 30 µg/L. Biological contactor effluent Cr6 below 3 µg/L.	Unknown	Nitrate was removed from approximately 9 to 2 mg/L as N.	Biological contactor and post filtration backwash wastewater	12% of total flow without recycle; 1% of total flow with recycle	Settled waste can go to the sewer, septic system or off-site disposal	Clarified wastewater was designed to be recycled to the head of the plant.	Not investigated	Not investigated



Table 5-8. Summary of ED/EDR Case Histories for Cr6 Removal

No.	Tested Conditions					Technology Effectiveness				Waste Products				Addressing Variability	
	Location of testing	Application (Drinking water, wastewater, remediation)	System components	Flow rate of testing	Length of testing	Adjustments to accommodate chromium removal	Cr6 and Total Cr influent and treated water concentrations	Primary factors impacting performance	Removal of other constituents	Waste classification	Volume	Disposal	Opportunities for waste minimization	Possible adjustments to address water variability	Possible adjustments to address changes in flow rate
1	India, bench-scale test	Simulated industrial wastewater	ED	0.4 to 1.2 mL/min	Unknown	None	Influent Cr6 = 10 mg/L. Effluent Cr6 = 100 µg/L. Total Cr results not reported.	More electricity and/or more time improves C6 removal	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated
2	Italy, bench-scale test	Simulated lab water with 25 mg/L Cr6	EDR	190 mL/min	150 min	Cathode material: carbon felt vs. compact graphite. Initial pH 2	Compacted Graphite Cathode (faster reduction): Influent Cr6 = 25 mg/L. Effluent Cr6 = 1 mg/L in 35 min, <0.01 mg/L in 130 min. Carbon Felt Cathode (less expensive material): Influent Cr6 = 25 mg/L, Effluent Cr6 = 1 mg/L in 17 min, <0.01 mg/L in 35 min	At carbon felt cathode: higher current & power densities	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated	Not investigated



Table 5-9. Active Wells with Cr6 above 8 µg/L and Nitrate Concentrations above 10 mg/L as NO₃⁻

Pressure Zone	Well ID	Cr6 Tier	Reported Nitrate Concentration (mg/L as NO₃)
Valley	5682-1	2	13
La Quinta	5708-1	2	30
	5711-2	1	26
	5715-1	2	11



Table 5-10. Summary of Technology Evaluation for Removal of Regulated Constituents of Concern

	SBA	WBA	RCF	RO	Biological treatment	Adsorptive media	ED/EDR	GAC	Aeration
Chromium 6	●	●	●	●	●	●	●	●	●
Nitrate	●	●	●	●	●	●	●	●	●
Arsenic ¹	●	●	●	●	●	●	●	●	●
Perchlorate	●	●	●	●	●	●	●	●	●
VOCs	●	●	●	●	●	●	●	●	●

- Best available technology, proven effective in full scale applications
- Bench- and/or pilot- scale testing or full-scale industrial applications suggest that this process will be effective; however, full scale applications for drinking water treatment are not operational
- Not effective based on literature search or technology mechanism or not tested

* Arsenic also includes other technologies not broadly applicable to the other constituents of concern, including activated alumina, lime softening, and oxidation/filtration.



Table 5-11. Relative Comparison of SBA Resin Regeneration Frequency for Constituents of Concern

	Approx. Number of Bed Volumes of Treatment before Regeneration	Approx. Traffic at Well Sites (assuming 30% utilization of a 2,000 gpm treatment system)
Chromium 6	2,000 - 15,000 BV (all but 2 wells are >5,000 BV)	1 tanker truck every other week to 1 tanker truck per quarter (hazardous brine)
Nitrate	200 – 400 BV (standard SBA resin)	7 to 14 tanker trucks per week (non-hazardous brine)
Arsenic	1,000 BV	1 tanker truck per week (hazardous brine)
Perchlorate	>100,000 BV (perchlorate-selective resin)	1 resin bed disposal every quarter

* Based on an assumption of 4,500 gallons per tanker truck for offsite disposal.



Table 5-12. Comparison of Applicability of Biological Treatment vs. Ion Exchange

	Favored Technology
Intermittent service demand	Ion Exchange
Targeted/ selective compound removal	Ion Exchange
Installation area (footprint) / height limitations	Ion Exchange
High contaminant/ TDS loading	Biological Treatment
High waste disposal costs	Biological Treatment
Green technology classification	Biological Treatment

Reference: Schwartz, W. and T. Webster. 2013. Technical Evaluation of Ion Exchange and Biological treatment of Oxyanions for Potable Water Production: System Selection Considerations. International Water Conference, Orlando, Florida.



Table 6-1. Blending Non-Treatment Option for Cr6 Impacted Wells (with Active Wells)

Pressure Zone	Well IDs	Miles of Pipelines
Date Palm	4524-1, 4526-1 , 4567-1 , 4521-1	1.7
	4568-1 , 4563-1	0.6
Sky Mountain	4611-1 , 4612-1, 5630-1	0.8
Valley	5603-2 , 5639-1	1.0
	5682-1 , 5670-1	1.4
La Quinta	5708-1 , 5712	1.0
	6723-1	On-site blending in tank

Note: Bold wells are Tier 2 wells; non-bold wells are Tier 3.



Table 6-2. Capital Cost Factors Assumptions

Item	Percentage applied to installed equipment costs	Description
General Requirements	7.5%	“Division 1” requirements including labor supervision, field offices, temporary utilities, health and safety, office supplies, clean up, photographs, survey, erosion control, coordination, testing services, and record documents
Earthwork	5%	Excavation, backfill, and fill required to construct the project
Site Work	5%	Roadways, curb and gutter, sidewalk, and landscaping
Valves, piping, and appurtenances	15%	Major system piping and valves
Electrical, Instrumentation and Control	15%	Motor control center (MCC), conduit and wire, programmable logic controller (PLC) and supervisory control and data acquisition (SCADA) equipment



Table 6-3. Engineering Factors Assumptions

Item	Percentage applied to total direct costs	Description
Contractor's Overhead and Profit	20%	Includes bonds, mobilization and demobilization, insurance, overhead and profit, and management reserves
Engineering, Legal and Administrative	20%	Includes permits, legal fees, and engineering fees for design and construction.
Project Level Allowance	30%	Budget item to cover change orders due to unforeseen conditions



Table 6-4. O&M Cost Assumptions

Item (Unit)	Unit Price	Source
Electricity (\$/kWh)	\$0.11	Cost reviewed and agreed by CVWD
CO ₂ unit price (\$/lb)	\$0.07	Average cost at City of Glendale for WBA
Spent WBA resin disposal (\$/cf)	\$342	Average cost at City of Glendale for WBA
Sewer discharge (\$/hcf)	\$0.67	CVWD charge for business starting July 2015
Sewer quarterly fee (\$/EDU/month)	\$38	CVWD charge for business starting July 2015. One EDU is 121 hcf/year.
Labor annual salary (\$/yr)	\$105,000	Cost reviewed and agreed by CVWD
Salt (\$/ton, including shipping)	\$136	Cost provided by CVWD
Ferrous Sulfate (\$/gal)	\$2.50	Brenntag quote
Ferric Chloride and Ferrous Sulfate Blend (\$/gal)	\$9.93	Cost provided by CVWD
Polymer (\$/gal)	\$30	Cost provided by CVWD
Clarified brine disposal for SBA with on-site regen (\$/kgal)	\$300	Cost provided by CVWD
Non-RCRA hazardous solids disposal (\$/lb)	\$1.61	Cost at City of Glendale for non-RCRA hazardous waste
SBA resin unit price (\$/cf)	\$188	Purolite's quote for A600E/9149, with extra 15% for tax and freight and \$15/cf for resin installation. Evoqua's quote for Dow SAR resin is \$150.
SBA spent resin disposal (\$/cf)	\$15	Evoqua's quote for non-hazardous, including disposal for incineration and transportation.
WBA resin unit price (\$/cf)	\$329	Evoqua's quote for SIR700, including resin rinsing and installation. Purolite's budgetary quote for S106 was \$265/cf plus \$10K for turnkey installation.



Table 6-5. Criteria Used in the Technology Weighting Evaluation

	Criteria/Sub-criteria	Definition	Weight (%)
1	Treatment Robustness		10
	Reliability to Meet Cr(VI) Goal of 6 ppb	Ability to achieve or exceed water quality goals	40
	System Resilience to Change	Ability to handle fluctuations in water quality or changes in the treatment goal without significant operational changes	30
	Impact from Competing Constituents	Interfering constituents (i.e. sulfate, silica, iron, manganese)	20
	Concern of Chromatographic Peaking	Co-occurring constituents exceed half the MCL and have the potential for release at higher than influent concentrations (e.g., nitrate from SBA resins)	10
2	O&M Complexity		20
	Equipment Complexity	Chemical feed system requirements and the need for constant monitoring. Multiple components requiring frequent maintenance.	40
	Chemical Deliveries	Frequency of chemical deliveries	40
	Operations Certification	Level of operations staff required for the system	10
	Number of Full-time Employees (FTEs)	Number of staff required to maintain operation of process and the need for operator attention.	10
3	Water Loss	Water loss associated from process	5
4	Residuals Handling		10
	Disposal of Liquid Waste	Is liquid waste generated? Is there access to a sewer?	80
	Offsite Disposal of Solid Waste	How frequent are truck trips to dispose of waste offsite?	20
5	Removal of Other Constituents	Technology removal of co-occurring constituents requiring treatment	5
6	Footprint	Treatment plant footprint and land requirements	5
7	Annualized Cost	Construction, equipment, engineering, and O&M	50



Table 7-1. Historical Raw Water Quality Data for Colorado River and Coachella Canal

Parameter	Average	Range
Turbidity (NTU)	4.4	0.4-38
TOC (mg/L)	3.1	2.6-3.4
pH	8.1	6.8 – 8.9
Alkalinity (mg CaCO ₃ /L)	146	101 – 189
Hardness (mg CaCO ₃ /L)	343	135 – 433
Iron (mg/L)	0.35 (historical) 0.04 for total Fe, 0.01 for dissolved Fe (2008 pilot testing)	0.01 – 1.3 (historical) 0.02 – 0.08 for total Fe, 0.00 – 0.02 for dissolved Fe (2008 pilot testing)
Manganese (mg/L)	0.013 (historical) 0.048 for total Mn, 0.024 for dissolved Mn (2008 pilot testing)	<0.001 – 0.040 (historical) 0.025 – 0.121 for total Mn, 0.000 – 0.080 for dissolved Mn
TDS (mg/L)	780	585 – 1,077

Reference: Average values from data presented in the Malcom Pirnie report and range includes data from the Black and Veatch report.



Table 7-2. Hydraulic Loading Rates for Clarification Basins

Type	Hydraulic loading ¹ (gpm/ft ²)	Flocculation time (min)
Conventional	0.2 – 0.5 (t_d 2-4 hours)	30
Tube settler	1 – 3	30
Plate settler	2 – 4	30
Superpulsator ²	1 – 3	0 (included)
Contact adsorption clarifier ²	8 – 10	0 (included)
Microsand ballasted clarifier ²	12 – 30	10 (termed maturation period)
Dissolved air flotation (DAF) ³	6 – 16	5 – 10

¹ Based on footprint area (for plate and tube sedimentation processes, the equivalent Hazen overflow rates will be roughly 0.2 to 0.4 gpm/ft²).

² Note that a separate flocculation step is not required.

³ Flocculation time for DAF is only 5-10 minutes total.



Table 7-3. Comparison of Conventional Sedimentation, Plate Settlers, and DAF – Advantages and Disadvantages

Process	Advantages	Disadvantages
Conventional Sedimentation	<ul style="list-style-type: none"> • Handles high solids loading to plant • No building needed • Relatively low operating cost • Nonproprietary 	<ul style="list-style-type: none"> • Largest plant footprint (30 minute flocculation time and low surface loading rate on sedimentation basin (0.5 gpm/ ft²)) • Long process response time • Solids can go anoxic if not frequently removed • Poor performance for high algae loading • Algae can grow in sedimentation basins • Large temperature changes can result in convection currents and interfere with settling • Polymer needed
Inclined Plate Settlers	<ul style="list-style-type: none"> • Handles high solids loading to plant • No building needed • Relatively low operating cost • Compact/high rate (0.3 gpm/ ft² effective plate area, ~ 3-4 gpm/ft² surface loading rate) • Can be nonproprietary 	<ul style="list-style-type: none"> • Long flocculation time (30 minutes) • Need to control algal growth on plates – chlorine addition or covers are sometimes needed • Rapid response time requires careful operator attention • Polymer needed
Dissolved Air Flotation	<ul style="list-style-type: none"> • Compact/high rate (6-12 gpm/ft²) • Short flocculation time (5-10 minutes) • Considered BAT for algae • 2% residuals – thickener not required • Rapid response to changing raw WQ • No polymer required • Can be nonproprietary 	<ul style="list-style-type: none"> • Higher energy costs (6 HP/MGD output) • Performance issue with high silt/clay turbidity • Needs a roof or a canopy over the basins • More moving parts than conventional sedimentation or plates



Table 7-4. Comparison of Conventional Sedimentation, Plate Settlers, and DAF – Relative Comparison Metrics

	Conventional Sedimentation	Plate Settlers	DAF
High turbidity loading	●	●	●
Low turbidity periods	●	●	●
Algae removal	●	●	●
Residuals production and handling	●	●	●
Moving parts (ease of maintenance)	●	●	●
Footprint	●	●	●
Capital cost	●	●	●
Operational cost	●	●	●

● Most advantageous ● Moderate ● Least advantageous



Table 7-5. Comparison of Granular Media and Microfiltration – Advantages and Disadvantages

Process	Advantages	Disadvantages
Granular media filters	<ul style="list-style-type: none"> • Effective • Long history of performance • Well understood process • Manganese removal is possible directly on filters 	<ul style="list-style-type: none"> • Reliant on effective coagulation • Subject to filter ripening • Need effective backwashing to prevent mudballs and other filter maintenance issues • Less effective removal of Cr-associated particles compared to MF (proven to < 5 µg/L for total Cr)
Membrane microfiltration	<ul style="list-style-type: none"> • Effective • Absolute verifiable barrier to particles and pathogenic cysts • Not as reliant on pre-treatment coagulation • Better removal of Cr-associated particles (proven to < 1 µg/L for total Cr) 	<ul style="list-style-type: none"> • Higher waste backwash volume • Greater dependence on high level controls and automation • Higher amount of mechanical and electrical assets for routine maintenance. • More cleaning chemicals • Higher capital cost when directly compared to granular media filters



**Table 7-6. WRP 10 Effluent Limits and Projected Increases from
Mid-Valley Surface Water Treatment**

	WRP 10 Effluent Limits (Annual Average)	WRP 10 Effluent (2013)	Projected WRP 10 Effluent with a 8 MGD of SWT	Projected WRP 10 Effluent with a 14 MGD of SWT
TDS (mg/L)	500	428	510	601
Sulfate (mg/L)	70	69	106	147
Chloride (mg/L)	70	62	77	94

Assumptions provided by CVWD:

- Canal water – 750 mg/L TDS, 273 mg/L sulfate, 113 mg/L chloride
- Drinking water – 240 mg/L TDS, 44 mg/L sulfate, 19 mg/L chloride
- Salt addition is additive on 2013 current concentrations (no additional)



Table 7-7. Potential Surface Water Treatment Sites Evaluated

Location	Proximity to surface water supply	Proximity to groundwater wells for blending	Proximity to service area with significant demand	CVWD owned land	Selected for more detailed evaluation
Avenue 52	Adjacent	No	No	No (USBR)	No
Avenue 44	Adjacent	No	No	No (USBR)	No
Airport Blvd	Adjacent	No	No	No (USBR)	No
Sun City	Within 0.5 miles	Yes	Would require transfer to Valley	No	No
Burr Street	Adjacent	Yes	Yes	No	Yes
Mid-Valley	Requires allocation form Mid Valley Pipeline	Yes	Yes	Yes	Yes
East Valley (Jefferson)	Yes	Yes	Yes	No	Yes
East Valley (Lake Cahuilla)	Yes	Yes	Yes	Yes	Yes



Table 7-8. Flows for Treatment Plant Options Considered

Location	Flow Scenario	GW Sent to SW Plant (mgd)	GW Treated at SW Plant (mgd)	SW Treated (mgd)	Total Treated (mgd)	Total Plant Production (mgd)	Product Water Cr6 (µg/L)	Product Water TDS (mg/L)
Burr Street	Peak	14	3	10	13	25	6.0	491
	Average	8	2	6	8	14	5.9	499
Mid Valley	Peak	14	5	11	16	24	5.7	481
	Average	8	2	5	7	13	5.9	452
East Valley	Peak	19	6	11	17	30	5.7	457
	Average	8	2	5	7	13	5.7	488

GW = Groundwater. SW = Surface Water.



Table 7-9. Capital Cost Factors Assumptions

Item	Percentage of installed equipment costs	Description
General Requirements	7.5%	“Division 1” requirements including labor supervision, field offices, temporary utilities, health and safety, office supplies, clean up, photographs, survey, erosion control, coordination, testing services, and record documents
Earthwork	5%	Excavation, backfill, and fill required to construct the project
Site Work	5%	Roadways, curb and gutter, sidewalk, and landscaping
Valves, piping, and appurtenances	15%	Major system piping and valves
Electrical, Instrumentation and Control	15%	Motor control center (MCC), conduit and wire, programmable logic controller (PLC) and supervisory control and data acquisition (SCADA) equipment



Table 7-10. Engineering Factors Assumptions

Item	Percentage of total direct costs	Description
Contractor's Overhead and Profit	20%	Includes bonds, mobilization and demobilization, insurance, overhead and profit, and management reserves
Engineering, Legal and Administrative	20%	Includes permits, legal fees, and engineering fees for design and construction.
Project Level Allowance	30%	Budget item to cover change orders due to unforeseen conditions



Table 7-11. O&M Cost Factors Assumptions

Item (Unit)	Unit Price	Source
Electricity (\$/kWh)	\$0.11	Cost reviewed and agreed by CVWD
Labor annual salary (\$/yr)	\$105,000	Cost reviewed and agreed by CVWD
GAC replacement (\$/lb, including shipping)	\$1.30	Scottsdale GAC regen cost
GMF Media – Sand (\$/lb)	\$0.19	Costmac
GMF Media – Anthracite (\$/lb)	\$0.31	Costmac
Sodium Hypochlorite (membrane cleaning) (\$/gal)	\$1.05	Typical costs in Southern California
Citric Acid (membrane cleaning) (\$/lb)	\$0.58	Typical costs in Southern California
Sodium Bisulfite (neutralize membrane cleaning waste) (\$/lb)	\$3.30	Typical costs in Southern California
Sodium Hydroxide neutralize membrane cleaning waste) (\$/gal)	\$1.00	Cost provided by CVWD
Non-RCRA hazardous solids disposal (\$/lb)	\$1.61	Cost at City of Glendale for non-RCRA hazardous waste



Table 8-1. Estimates of POU Quantities by Residential and Commercial Categories

Residential	No. of Connections	No. of RO Units	
Single Family Residence	91,832	91,832	
Duplex Triplex	2,753	2,753	
Multi Dwelling	5,723	5,723	
Apartments	10,148	10,148	
Mobile Home	9,758	9,758	
Total	120,214	120,214	
Commercial and Public Agency	No. of Connections	No. of Water Units	No. of RO Units
Public Agency	447	608	1,216
Business	3,322	3,651	3,651
Hotel/Motel	1,349	1,862	15,200
Commercial	1,424	2,084	2,084
Total	6,542	8,205	22,151



Table 8-2. POU Model Comparisons

Brand	Pre Filter Replacement Frequency	Post Filter Replacement Frequency	Membrane Replacement Frequency	Unit Price
EcoPure ECOP309	6 months	6 months	6 months	\$170
Watts Premier ZRO-4	6 months	1 year	3 years	\$289
Kinetico Aquakinetic A200	1 year	1 year	5 years	\$636



Table 9-1. Comparison of Scenario Components and Advantages and Disadvantages

Scenario	Components to Treat Tier 1 Wells	Components to Treat Tier 1 and Tier 2 Wells	Major Advantages	Major Disadvantages
Scenario 1 - Groundwater treatment at mostly clusters of wells	<ul style="list-style-type: none"> • 8 clusters – 2 WBA, 4 SBA, 1 blend • 7 individuals – SBA • 38 miles pipelines 	<ul style="list-style-type: none"> • 19 clusters – 2 WBA, 10 SBA, 7 blends • 4 individuals – 4 SBA • 47 miles pipelines 	<ul style="list-style-type: none"> • Less operational complexity than surface water • Consolidation of treatment facilities 	<ul style="list-style-type: none"> • On-site SBA regeneration • No added supply diversification • More pipelines resulting in complex implementation • Less flexibility for adding new treatment
Scenario 2 - Groundwater treatment at mostly individual wells	<ul style="list-style-type: none"> • 3 clusters – 2 WBA, 1 blend • 24 individuals –SBA • CRRF • 3 miles pipelines 	<ul style="list-style-type: none"> • 8 clusters – 2 WBA, 6 blends • 43 individuals – 43 SBA • CRRF • 11 miles pipelines 	<ul style="list-style-type: none"> • Less onsite operational complexity than surface water and clusters • Fewer pipelines • Less complex implementation 	<ul style="list-style-type: none"> • More treatment sites • No added supply diversification
Scenario 3 - SWTP in Mid Valley with the balance of mostly individual groundwater treatment sites	<ul style="list-style-type: none"> • 4 wells used for SWTP blending • 3 clusters – 2 WBA, 1 blend • 20 individuals – SBA • CRRF • 12 miles pipelines 	<ul style="list-style-type: none"> • 5 wells used for SWTP blending • 8 clusters – 2 WBA, 6 blends • 38 individuals –SBA • CRRF • 19 miles pipelines 	<ul style="list-style-type: none"> • Fills deficiency in Mid Valley zone and addresses subsidence • Supply diversification • Added resilience to changing regulations 	<ul style="list-style-type: none"> • More operationally complex than groundwater treatment • Does not provide for future growth
Scenario 4 - SWTP in East Valley with the balance of mostly individual groundwater treatment sites	<ul style="list-style-type: none"> • 4 wells used for SWTP blending • 1 clusters – WBA • 18 individual treatment –SBA • CRRF • 15 miles pipelines 	<ul style="list-style-type: none"> • 7 wells used for SWTP blending • 6 clusters – 1 WBA, 5 blends • 32 individual treatment – SBA • CRRF • 20 miles pipelines 	<ul style="list-style-type: none"> • Supply diversification • Provides for future growth • Operational flexibility in using surface water or groundwater 	<ul style="list-style-type: none"> • More operationally complex than groundwater treatment
Scenario 5 – POU	<ul style="list-style-type: none"> • 142,365 RO units • Warehouse 	<ul style="list-style-type: none"> • 142,365 RO units • Warehouse 	<ul style="list-style-type: none"> • Added resilience to changing regulations 	<ul style="list-style-type: none"> • Not currently legal option • More operationally complex than groundwater treatment • Does not provide for future growth • No added supply diversification
Scenario 6 – SWTPs in Mid Valley and East Valley with the balance of mostly individual groundwater treatment sites	<ul style="list-style-type: none"> • 4 Valley wells used for SWTP blending • 4 La Quinta and Cahuilla wells used for SWTP blending • 1 cluster - WBA • 14 individual treatment – SBA • 20 miles pipelines 	<ul style="list-style-type: none"> • 5 Valley wells used for SWTP blending • 7 La Quinta and Cahuilla wells used for SWTP blending • 5 clusters – 1 WBA, 5 blends • 23 individual treatment - SBA • CRRF • 27 miles pipelines 	<ul style="list-style-type: none"> • Most significant supply resource diversification • Provides for future growth • Operational flexibility in using surface water or groundwater 	<ul style="list-style-type: none"> • More operationally complex than groundwater treatment



Table 9-2. Rating Scale Used for Weighing Scenario Criteria

Rating	Category	Description
1.0	Significant disadvantages	The Scenario contains one or more serious disadvantages. While the disadvantages may not be “fatal”, they are of such magnitude that they represent serious hurdles to successful completion of the Scenario.
1.5	Some disadvantages	The Scenario has one or more disadvantages that represent technical or institutional hurdles that will require significant effort to overcome.
2.0	Issues but manageable	The Scenario has one or more issues that are familiar and manageable.
2.5	Some advantages	The Scenario has one or more advantages that will speed the acceptance and implementation of the solution.
3.0	Significant advantages	The Scenario has one or more advantages that cause the alternative scenario to stand out from the others and significantly improve the acceptance and implementation of the solution.



Table 9-3. Initial Weighting of Screening Criteria

Criterion	Weighting
Annualized cost	20.0%
Operational complexity	6.7%
Diversification	20.0%
Public acceptance / Environmental	20.0%
Implementation complexity	6.7%
Operational flexibility	6.7%
Water quality benefit	20.0%
Total	100%