SYNERGY
ENVIRONMENTAL, LLC

November 26, 2014

Scott Green, R.G.
Manager, Remedial Projects Unit
ARIZONA DEPARTMENT OF ENVIROMENTAL QUALITY
1110 West Washington Street
Phoenix, AZ 85007

Re: **RESPONSE TO ADEQ COMMENTS**
ADMINISTRATIVE COMPLETENESS REVIEW OF
RID DRAFT FEASIBILITY STUDY REPORT

Dear Mr. Green:

Synergy Environmental is providing this letter on behalf of Roosevelt Irrigation District (RID) to respond to Arizona Department of Environmental Quality's (ADEQ) analysis of the "administrative completeness" of the RID draft Feasibility Study Report (FS Report) dated July 2014. ADEQ communicated their findings of an internal review of this report for administrative completeness in a letter and accompanying checklist that was issued on October 24, 2104.

Four attachments to this letter provide clarification and expanded information to address the administrative deficiencies identified by RID and ADEQ and how the FS Report text has been revised to address the ADEQ comments. As requested, two copies of each written document are included.

- **Attachment A: Response to Comments** – provides a detailed response to each specific comment that ADEQ listed under the headings of "Required Information" and "Recommendations" in the October 24 letter. The information provided in the responses explains how the draft RID FS Report has been revised to address ADEQ comments. Specifically, revisions have been made to the following sections of the July 2014 Draft FS Report:
    - Section 2.2 (under *Profiles of Target COCs* discussion)
    - Section 8.1.4
    - Section 8.1.5
    - Section 8.4.1 (under *Risk* criterion discussion)
    - Section 8.4.2 (under *Risk* criterion discussion)
    - Section 8.4.3 (under *Risk* criterion discussion)
    - Section 8.4.4 (under *Risk* criterion discussion)
    - Section 9.1.4
- **Attachment B**: **Proposal for Public Notice** – completes compliance with AAC R18-16-413.A.7 required elements for "any person who seeks approval of a remedial action at a site or a portion of a site." RID had previously included the "list of the names and addresses of persons whom the applicant believes to be responsible

parties under A.R.S. § 49-283 and a summary of the basis for that belief," which is required for ADEQ approval.

- **Attachment C: Hard Copy of Revised July 2014 Draft FS Report Text –** provides a hard copy of the complete text of the July 2014 Draft FS Report including proposed changes to Sections 2, 8, and 9 of this report that were made in response to the ADEQ comments. The revisions to the text in these sections are shown in redline/strikeout format so ADEQ will be clear on the changes we propose to make to the July 2014 draft FS Report to assure the report is administratively complete.

- **Attachment D**: **PDF Version of Revised July 2014 Draft FS Report –** provides a complete copy of Draft FS Report text in PDF format on compact disk, with the redlined text provided in Attachment C incorporated into this version. There have been no changes to any tables, figures, or appendices in the July 2014 Draft FS Report.

As discussed in RID's October 31, 2014 letter to ADEQ and the November 19, 2014 meeting between RID and ADEQ, RID had failed in part to include all of the information in its written request submitted to ADEQ for approval of the FS Report as required in AAC R18-16-413.A. Pursuant to AAC R18-16-413.A.7, "any person who seeks approval of a remedial action at a site or a portion of a site" shall include a "proposal for public notice and an opportunity for public comment on the application for approval under this Section. The proposal shall include a list of the names and addresses of persons whom the applicant believes to be responsible parties under A.R.S. § 49-283 and a summary of the basis for that belief." As noted in RID's October 31, 2014 letter, RID's failure to include a proposal for public notice was inadvertent. RID previously had complied with the second required element of AAC R18-16-413.A.7 to "include a list of the names and addresses of persons <u>*whom the applicant believes*</u> to be responsible parties under A.R.S. § 49-283 and a summary of the basis for that belief." Therefore, with the attached proposal for public comment, RID's written request for ADEQ approval contains <u>*all*</u> of the information as required under R18-16-413.A. RID expects that ADEQ will require a similar proposal from the Working Group, that is seeking ADEQ's approval of its FS Report pursuant to AAC R18-16-413 consistent with its Agreement to Conduct Work with ADEQ, dated January 15, 2013. Similarly, RID expects that ADEQ will require the Working Group, pursuant to the mandatory elements of R18-16-413.A, to "include a list of the names and addresses of persons <u>*whom the applicant believes*</u> to be responsible parties under A.R.S. § 49-283 and a summary of the basis for that belief."

RID appreciates that ADEQ has asked for more explicit information regarding the evaluation of the "risk" criterion specified in A.A.C. R18-16-407(H)(3)(b), that came from the ADEQ administrative completeness review. RID clearly believes this is one of the more essential comparison criteria that distinguishes the remedial action developed by RID versus that of the Working Group. Specifically, all remedial alternatives formulated by RID directly and systematically address the overall protectiveness of public health and the environment as required by the WQARF program by employing groundwater extraction and treatment as a principal element of the remedy to significantly and permanently reduce the toxicity, mobility, concentration, and volume of hazardous substances in all routes of exposure to environmental receptors. The Working Group's proposed remedial action, on the other hand, does very little to mitigate the uncontrolled releases of hazardous substances into the environment or prevent the spread of groundwater contamination beyond the existing extent of the WVBA plume.

In consideration of the diametrically opposing views that exist regarding "risk" and what this means regarding the overall protectiveness of public health, welfare, and the environment, RID fully anticipates that ADEQ will select a groundwater remedy in the same legal, technical, and policy context that has been established at all other CERCLA/WQARF sites in Arizona. In this regard, ADEQ has consistently taken the position that it is:

- unacceptable to transfer VOC contaminants from groundwater to air,
- VOCs in groundwater should be removed from the environment and treated or disposed of appropriately, and
- groundwater remedial actions require a high degree of public protection against potential exposure to VOCs in air.

Moreover, based on ADEQ's position and strong feelings expressed by the public, EPA has affirmed their position that air emission controls are necessary, even in situations where risk assessment may conclude otherwise.

In sum, RID is glad for the opportunity to have a more substantive evaluation of "risk" and to urge consistency in applying this metric to the remedy selection.

Best Regards,

SYNERGY Environmental, LLC

Dennis H. Shirley, PG

cc: Cover Letter only

Laura Malone, ADEQ Director Waste Programs
Tina LePage, ADEQ Manager Remedial Projects Section
Danielle Taber, ADEQ Project Manager
Donovan Neese, Roosevelt Irrigation District
David Kimball, Gallagher & Kennedy
Tim Leo, Montgomery & Associates

ATTACHMENT A

RID Response to ADEQ Comments
Administrative Completeness Review of the
July 2014 RID Draft Feasibility Study Report

Required Information: (Not identified in letter dated October 24, 2014)

As discussed in RID's October 31, 2014 letter to ADEQ and the November 19, 2014 meeting between RID and ADEQ, RID had failed in part to include all of the information in its written request submitted to ADEQ for approval of the FS Report as required in AAC R18-16-413.A. Pursuant to AAC R18-16-413.A.7, "any person who seeks approval of a remedial action at a site or a portion of a site" shall include a "proposal for public notice and an opportunity for public comment on the application for approval under this Section. The proposal shall include a list of the names and addresses of persons whom the applicant believes to be responsible parties under A.R.S. § 49-283 and a summary of the basis for that belief." As noted in RID's October 31, 2014 letter, RID's failure to include a proposal for public notice was inadvertent. RID previously had complied with the second required element of AAC R18-16-413.A.7 to "include a list of the names and addresses of persons *whom the applicant believes* to be responsible parties under A.R.S. § 49-283 and a summary of the basis for that belief." Therefore, with the attached proposal for public comment, RID's written request for ADEQ approval contains *all* of the information as required under R18-16-413.A.

Required Information: (As identified in ADEQ letter dated October 24, 2014)

1. *In accordance with A.A.C. R18-16-407(H), an FS Report shall include an evaluation of several topics regarding each alternative remedy. ADEQ was unable to locate the evaluation of:*

   a. *A.A.C. R18-16-407(H)(3)(b)(iii): Exposure pathways, duration of exposure and changes in risk over the life of the remediation*

   In response to ADEQ comments, RID has revised the findings included in the evaluation of "Risk" for each remedial alternative in Section 8.4 of the RID FS Report to clearly indicate that all groundwater alternative remedies address and reduce the primary exposure pathways for contaminants of concern (COCs) in groundwater, surface water, and air at the WVBA Site. Given that groundwater pumpage is the major outflow from the groundwater system, the remedial strategies and measures included in each groundwater alternative remedy substantially reduce the potential for exposed populations and environmental receptors to come in contact with COCs by the following mechanisms:

   - Operational controls will be implemented to optimize pumping of RID wells in the WVBA Site to increase COC mass removal and enhance plume containment. Priority pumping of RID wells in the center of the plume will prevent contaminant migration to other threatened water provider wells (including RID, SRP, and City of Tolleson water supply wells) and the direct use of this water supply at wells that are peripheral to and downgradient of the current plume boundary.

- Granular activated carbon (GAC) treatment systems will be installed at the mostly highly contaminated RID wells within the plume and engineering (or operational?) controls for blending with groundwater extracted at certain other less contaminated RID wells within the plume will be implemented to remove and reduce COCs from extracted groundwater to prevent the release of volatile chemicals into the environment above any applicable environmental or public health standards and therefore reduce the risk of imminent and substantial endangerment to public health and welfare from exposure to hazardous air pollutants by inhalation.

- Engineering controls will be implemented to restrict point source and fugitive emissions of COCs at well discharge structures and in open water conveyance laterals within the WVBA Site to eliminate incidental exposure risk to nearby residents and (unauthorized) public use of the RID water systems for swimming, bathing, and drinking.

There will be no “duration of exposure” or “changes in risk over the life of the remediation” associated with RID’s proposed groundwater alternative remedies since all alternatives substantially limit the exposure route for contaminant impacts to environmental receptors from COC releases to groundwater, surface water, and air. As a result, there is no continuing endangerment to the public health and welfare and the environment or unacceptable impact on water use once the remedy is implemented. Priority pumping to contain the plume will protect additional groundwater supplies outside the plume from being polluted and will assure peripheral and downgradient wells that are threatened by the contaminant plume will remain available for unrestricted use for the long-term future. Installed GAC treatment systems at the most highly contaminated RID wells and blending of certain less contaminated RID wells will capture, remove and reduce target COCs to assure the wells and water supply are available for all beneficial uses and prevent these contaminants from discharging into local surface waters and the air above any applicable environmental or public health standards.

The selected groundwater remedy will be operated until the contaminant concentrations in groundwater have been reduced to applicable aquifer water quality standards that are protective of human health and the environment. As further discussed in RID’s concluding comment, RID does not believe it is possible to meaningfully estimate the time it will take to achieve aquifer restoration. Instead, it was pointed out in the discussion of “risk” that contaminant concentrations will decline, but the rate of decline is uncertain and will vary depending on the location within the aquifer and proximity to continuing sources, either local or regional. Further, the duration of the groundwater remedy will depend on other factors that are presently uncertain, including the presence of DNAPLs, changes in MCLs, and changes in aquifer conditions.

Although it is not possible to quantify the duration of cleanup, the RID FS Report provided an estimate of the relative amount of COC mass that would be addressed and removed annually by wells with designated treatment systems. Accordingly, the estimated COC mass removal associated with each groundwater alternative remedy is:

- Reference Remedy – 83%
- Less Aggressive – 77%
- More Aggressive – 77%
- Most Aggressive – 91 %

As evident, all alternatives would substantially and permanently reduce the mass of hazardous substances released and reduce public and environmental exposures and the associated health risk while the remedy is ongoing.

b. *A.A.C. R18-16-407(H)(3)(b)(iv): Protection of public health and aquatic and terrestrial biota while implementing the remedial action and after the remedial action.*

The characterization of risk associated with the proposed groundwater alternative remedies in the RID FS Report was dominantly focused on potential public health impacts. As indicated in the preceding comment response, there was substantial analysis regarding how and the extent to which installation of GAC treatment systems would prevent uncontrolled releases of hazardous substances into the environment and reduce the risk of imminent and substantial endangerment to public health and welfare for all groundwater alternative remedies.

In focusing the risk evaluation on public health, the RID FS Report did not document potential impacts to and protection of aquatic and terrestrial biota. This oversight has been addressed by revising the following text in the RID FS Report:

Section 2.2 - Contaminants of Concern:

- In the subsection, <u>Profiles of Target COCs</u>, an additional bullet point is provided to summarize the potential ecological impacts for each of the target COCs. For example, for TCE it is noted:
  - According to the June 2014 Toxic Substances Control Act Work Plan Chemical Risk Assessment, TCE poses a negligible ecological risk to aquatic and terrestrial biota due to its moderate persistence, low bioaccumulation potential, and low aquatic toxicity.

- The promulgation of significantly higher (less stringent) water quality standards for TCE applied to aquatic and wildlife designated uses under the Clean Water Act corroborates the overall low concern for potential ecological impacts related to TCE releases.
- As a volatile chemical, TCE concentrations are reduced substantially through volatilization when entering surface waters or terrestrial habitats.

Similar explanations will be provided for PCE and 1,1-DCE.

- In the subsection, Routes of Potential Exposure, the following language has been added to the first paragraph:
    - As identified in the previous discussion, the exposure pathway and potential for target COC releases to impact aquatic and terrestrial biota is of low concern. Consequently, further discussion of routes of potential exposure to target COCs and associated risks in this FS will focus on the substantially more significant concern for potential hazards to human health.

Section 8.4 – Detailed Evaluation of Remedies: Comparison Criteria:

- The following sentence has been added to the last paragraph of the discussion of Risk criterion for each proposed groundwater alternative remedy:
    - Reductions in contaminant releases to the environment would also be more protective of aquatic and terrestrial biota even though, as indicated in Section 2.2, the overall ecological risk associated with the target COCs is generally of low concern.

c. A.A.C. R18-16-407(H)(3)(b)(v): Residual risk in the aquifer at the end of remediation

RID believes an evaluation of the residual risk in the aquifer is adequately addressed in the discussion of the Risk criterion for each groundwater alternative remedy in Section 8.4. However, to be more explicit, the following paragraph has been added at the end of this Risk criterion for each groundwater alternative remedy:

- The residual risk in the aquifer is addressed by employing groundwater extraction and treatment as a principal element of the groundwater alternative remedies to permanently and significantly reduce the toxicity, mobility, concentration and volume of the hazardous substances. Consistent with RID requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until aquifer water quality standards are attained and the groundwater supply is available for unrestricted use. Preferentially pumping of RID wells in the center of the plume will also prevent further contaminant migration in the aquifer from polluting additional groundwater supplies outside of the plume. Treatment through GAC captures essentially all the contaminants in extracted groundwater and prevents uncontrolled releases of hazardous substances into surface waters and the air while implementing the remedy. The treatment systems are modular and can be relocated or replaced as needed to provide continued protection from residual contamination. Spent GAC media from the groundwater treatment process is sent to a permitted regeneration facility for permanent destruction of any residual contaminants.

d. *A.A.C. R18-16-407(H)(3)(c): Transactional costs necessary to implement the remedial alternative, including the transactional costs of establishing long-term financial mechanisms, such as trust funds, for funding an alternative remedy*

As indicated throughout Section 8.4, RID's cost estimates for each groundwater alternative remedy were strictly for design, construction, operation and maintenance (O&M) of the wellhead treatment systems and other remedial measures included in each alternative. The O&M costs included three transactional cost components:

1) an annualized three percent assessment based on the total capital equipment cost to provide contingency funds to cover periodic costs needed for equipment maintenance, repair, and replacement;
2) an annualized six percent assessment of the estimated O&M cost for project administration and reporting; and,
3) an annual $10,000 per skid charge for the additional power requirements for pumping at higher discharge pressures through the wellhead treatment units.

RID believes accounting for these specific design, construction, and O&M costs offers the most precise and objective basis for comparative evaluation of life-cycle costs of the proposed groundwater alternative remedies, as required by the FS process. Therefore, for the purposes of this FS, only these direct capital and O&M costs are included in the FS costing.

As mentioned in the RID FS Report, RID has incurred notable transactional costs that meet the definition of "remedial actions" in ARS § 49-281.12, including costs that have gone into development of the work that RID is committed to perform at the WVBA Site, which is to implement an Early Response Action and conduct the FS. Specifically, RID has incurred at least $9.5 million in remedial action transaction costs over the past six years in conducting this work. These costs span a wide range of required project support, including evaluating the scope and impact of groundwater contamination, developing and implementing response action work plans, conducting required actions, and responding to extensive stakeholder input. Although indirectly needed to support RID's initiatives, particularly given the potentially responsible parties (PRPs) protracted opposition to the cleanup efforts, these costs are not included as part of the FS capital costs because they are not "necessary to implement the remedial alternative" as specified in AAC R18-16-407.H.3.c. Further, these costs are in addition to the approximate $6.2 million of direct costs expended to date for design, construction and O&M of wellhead treatment systems at four RID wells, and do not include debt services or legal costs in support of litigation.

RID did not include other transactional costs in the cost estimate, such as costs to establish long-term funding mechanisms for payment of recurring O&M costs for two reasons. First, these transactional costs are not "necessary to implement the remedial alternative" as specified in AAC R18-16-407.H.3.c. In a separate and unrelated matter, RID is pursuing a federal cost recovery action against the PRPs legally responsible for the groundwater contamination impacting RID's wells within the WVBA WQARF Site. Although the FS Report or the implementation of the final remedy is not included in the current RID federal cost recovery action, a similar action would constitute a long-term financial mechanism for funding the selected remedy. Any recoverable monies in such an action would cover in perpetuity the funds necessary to implement the selected remedy and ensure that the State of Arizona and the Arizona taxpayers would not be burdened for the response costs that should be borne by the identified polluters. It is not yet determined how or under what arrangements the PRPs will pay these costs. Second, if an account is established with funds available for payment of long-term response costs then there should be no real transactional costs associated with administering this funding mechanism. Rather, the funds deposited to cover these costs will generate some level of investment return and this return will help offset future costs. For this reason, the RID FS Report used a discounted basis to forecast the net present value of long-term recurring O&M costs.

Recommendations

Although the United States Environmental Protection Agency has employed an informal policy of capping Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedial action costs at 30 or 50 years, ADEQ strongly recommends that RID perform a cost evaluation that is based upon the amount of time needed to reach numeric water quality standards as opposed to the subjective 30 or 50 year timeframe.

RID agrees with ADEQ's stated position that capping the estimated remedial action costs at either 30 or 50 years is subjective. However, RID believes that defining costs based upon the estimated amount of time needed to reach numeric water quality standards[1] is also subjective and more arbitrary[2] than using fixed timeframes. The RID FS Report did not estimate the timeframe for plume remediation within the WVBA Site because RID believes and has consistently stated that it is not possible to predict the duration of time it will take to achieve aquifer restoration with any confidence. For example, in the first document RID submitted to conceptually evaluate RID groundwater response actions at the WVBA Site[3], it was stated:

> *Any objective analysis of aquifer restoration can only be conducted in relative terms. Moreover, at a site like the WVBA Site, with such pervasive and widespread groundwater contamination, the timeframe to restore groundwater cannot be estimated with a high degree of certainty. The groundwater restoration time is highly uncertain due to the presence of multiple continuing sources of groundwater contamination from undocumented COC releases and threatened releases to the subsurface, the potential presence of dense non-aqueous phase liquids in soil and groundwater, and diffusion-limited COC migration from recalcitrant fine-grained sediments throughout the site. In practical terms, it is likely that all remedial actions will require a long and indeterminate time to achieve aquifer restoration, which may be 50 to 100 years or longer.*

Given the uncertainty in deriving any meaningful estimate of the aquifer restoration timeframe, RID followed EPA guidance[4] for documenting FS life-cycle cost estimates of the proposed groundwater alternative remedies in terms of the commonly-used

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[1] In fact, it is reasonable to assume that the current numeric water quality standards for TCE and PCE will change over the next 30 or 50+ years. After more than 20 years of scientific studies and debate, EPA has completed its health risk assessments for TCE and PCE and published new toxicity data for these chemicals in the EPA Integrated Risk Information System (IRIS). As explained in footnote 29 of RID's FS Report, TCE is now considered a more potent carcinogen while PCE is believed to be less so. For example, the revised toxicity data have led EPA to establish new risk-based exposure levels, termed Regional Screening Levels, for TCE and PCE in drinking water, that correspond to 0.44 µg/l and 9.7 µg/l, respectively. According to the EPA, the MCL standards set by the Office of Water have not changed but will be undergoing review as a result of the new IRIS assessment of TCE and PCE.

[2] Numeric water quality standards are not the only applicable water quality standards. Pursuant to state law, the applicable water quality standards include the narrative aquifer water quality standards that prohibit "a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health … [or] impairs existing or reasonably foreseeable uses of water in an aquifer." *See* ARS § 49-221.D and AAC R18-11-405.

[3] *Draft Implementation Plan, Roosevelt Irrigation District Groundwater Response Action*, West *Van Buren Water Quality Assurance Revolving Fund Site*, prepared by Montgomery & Associates, September 25, 2009.

[4] *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, prepared by the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency, July 2000.

30-year period for project duration. The RID FS Report also provided an estimate of the 50-year present worth to reflect longer project duration, anticipating this to be more representative of conditions in the WVBA Site. Calculations of any longer duration response costs are not included because future costs that may be incurred beyond 50 years are increasingly immaterial in terms of their present value. RID continues to believe the use of 30- and 50-year present value analysis is appropriate for the purposes of this FS, which is to generate cost estimates for comparative analysis and not budgeting purposes. Nevertheless, in light of the aforementioned technical uncertainties and the reasonable probability of a lower drinking water MCL for TCE in the future, RID believes that a 50- to 100-year horizon to achieve aquifer restoration is not unreasonable.

NOTICE OF 30 DAY PUBLIC COMMENT PERIOD ON REQUEST OF APPROVAL OF FEASIBILITY STUDY REPORT FOR THE WEST VAN BUREN AREA (WVBA) WATER QUALITY ASSURANCE REVOLVING FUND (WQARF) REGISTRY SITE

PLEASE TAKE NOTICE that the Roosevelt Irrigation District (RID), a political subdivision of the State of Arizona, has submitted and seeks approval of a Feasibility Study Report for the WVBA WQARF Site pursuant to A.A.C. R18-16-407 and 413. The Roosevelt Irrigation District conducted the Feasibility Study pursuant to a Working Agreement with ADEQ and an ADEQ-approved Feasibility Study Work Plan to identify a remedy and alternative remedies capable of achieving the remedial objectives established by ADEQ for the WVBA WQARF Site.

The WVBA WQARF Site is located in Phoenix and is bounded approximately by W. McDowell Road to the north, 7th Avenue to the east, W. Buckeye Road to the south and 75th Avenue to the west. In addition, a finger shaped plume exists between 7th Avenue and 27th Avenue between Buckeye Road and Lower Buckeye Road.

A copy of the Feasibility Study Report is available for review at the Harmon Public Library, 1325 S. 5th Ave., Phoenix, AZ 85003. A copy is also available on the ADEQ web site, http://www.azdeq.gov/environ/waste/sps/wvb.html or at ADEQ Records Center, 1110 W. Washington Street, Phoenix, AZ 85007. In Phoenix, please call (602) 771-4380 or email recordscenter@azdeq.gov 24-hours in advance to schedule an appointment to review the document. For further information on the WVBA WQARF site, please visit: http://azdeq.gov/environ/waste/sps/siteinfo.html.

ADEQ will hold a Community Advisory Board meeting on December 1, 2014 starting at 6:00 pm, at ADEQ's office located at 1110 W. Washington Street, Phoenix, AZ 85007.

PARTIES WISHING TO MAKE COMMENTS regarding the request of approval may make such comments in writing to ADEQ, Attention: Danielle Taber, Waste Programs Division, Arizona Department of Environmental Quality, 1110 W. Washington Street, Phoenix, AZ 85007. Written comments will be accepted by ADEQ during the thirty day comment period that starts on December 2, 2014.

Questions regarding this notice should be directed to Wendy Flood, (602) 771-4410 or via e-mail flood.wendy@azdeq.gov.

Dated this 26th of November 2014

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APPENDICES

LIST OF ACRONYMS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
AAC	Arizona Administrative Code
AAR	Arizona Administrative Register
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AF	acre-feet
AFY	acre-feet per year
ALASG	Air Liquide America Specialty Gases
ALSCo	American Linen Supply Company
APS	Arizona Public Service
ARS	Arizona Revised Statutes
A/S	air stripping
AS	air sparging
ASR	Aquifer Storage and Recovery
ATSDR	Agency for Toxic Substances and Disease Registry
AWQS	aquifer water quality standard
BE&K	Bolvig, Edmonds, & Kennedy
bls	below land surface
C	Celsius
CAB	Community Advisory Board
CAP	Central Arizona Project
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CGTF	Central Groundwater Treatment Facility
CIP	Community Involvement Plan
COC	contaminant of concern
COP	City of Phoenix
COT	City of Tolleson
CPPM	Central Phoenix Plume Model
CSM	conceptual site model
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid

LIST OF ACRONYMS (Continued)

EPA	Environmental Protection Agency
ERA	Early Response Action
ERM	Environmental Resource Management
ESD	Explanation of Significant Difference
EWA	East Washington Area
FS	Feasibility Study
ft/d	feet per day
GAC	granular activated carbon
GEC	Geotechnical and Environmental Consultants, Inc.
GPL	Groundwater Protection Level
gpd/ft	gallons per day per foot
gpm	gallons per minute
GTI	[Fluor Daniel] Groundwater Technology Inc.
HBGL	Health Based Guidance Level
HVOCs	halogenated volatile organic compounds
LAU	lower alluvial unit
LGAC	liquid-phase granular activated carbon
LSGS	lower sand and gravel subunit
LTOAR	Long-Term Operational Assessment Report
M&A	Montgomery & Associates
M&I	municipal & industrial
M52	Motorola 52nd Street Federal Superfund Site
MAU	middle alluvial unit
MCESD	Maricopa County Environmental Services Department
MCL	maximum contaminant level
MCMM	Maricopa County Materials Management
MFGU	middle fine grained unit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
NAPL	non-aqueous phase liquid
NIBW	North Indian Bend Wash
NFA	No Further Action
NOI	Notice of Intent
NPL	National Priorities List
NRC	National Research Council
O&M	Operation and Maintenance

LIST OF ACRONYMS (Continued)

OU	Operable Unit
P&T	pump and treat
PCE	tetrachloroethene
PGA	Phoenix Goodyear Airport
POS	Prudential Overall Supply
PQGWP	Poor Quality Groundwater Withdrawal Permit
PRAP	proposed remedial action plan
PRP	potentially responsible party
PSA	Pacific Southwest Airlines
RAO	remedial action objectives
RCRA	Resources Conservation and Recovery Act
RFQ	Request for Qualifications
RI	remedial investigation
RID	Roosevelt Irrigation District
RO	remedial objectives
ROD	Record of Decision
RSL	Regional Screening Level
SGWS	shallow groundwater system
SHA	Sky Harbor International Airport
SP	stress period
SRL	Soil Remediation Level
SRP	Salt River Project
SRPMIC	Salt River Pima-Maricopa Indian Community
SRV	Salt River Valley
SRVWUA	Salt River Valley Water Users Association
SVE	soil vapor extraction
SWQS	surface water quality standards
TCA	trichloroethane
TCE	trichloroethene
TIAA	Tucson International Airport Area
UAU	upper alluvial unit
UF	ultra-filtration
UIC	United Industrial Corporation
UNOCAL	Union Oil Company of California
USC	United States Code
USDOE	United States Department of Energy
UV/Ox	ultraviolet oxidation

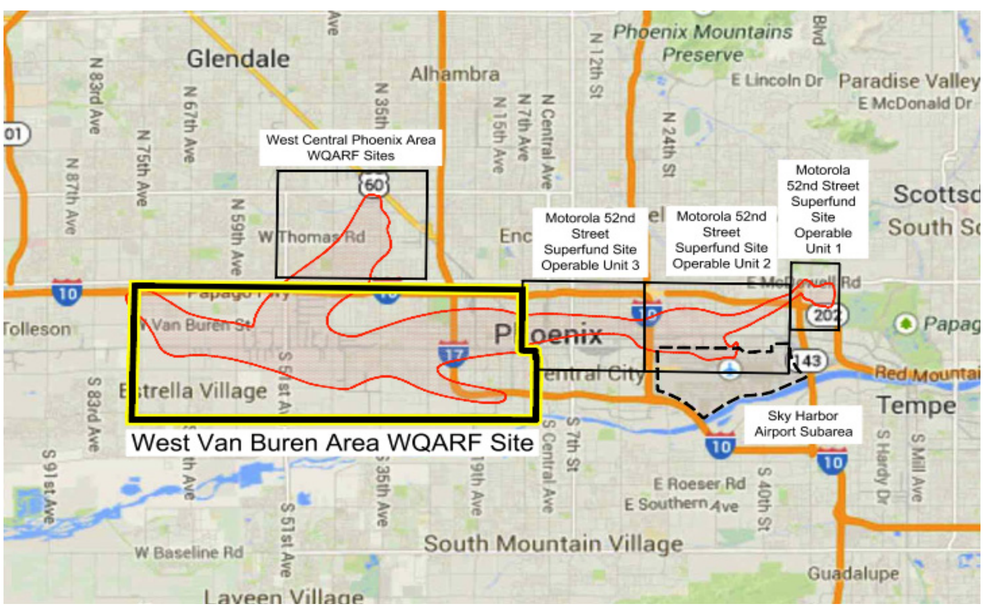
LIST OF ACRONYMS (Continued)

VBTF	Van Buren Tank Farm
VGAC	vapor-phase GAC
VOC	volatile organic compound
WAPA	Western Area Power Administration
WCP	West Central Phoenix
WOC	West Osborn Complex
WQARF	Water Quality Assurance Revolving Fund
WVBA	West Van Buren Area
WVBG	West Van Buren Group
WVBSA	West Van Buren Study Area
WWTP	Waste Water Treatment Plant
VGAC	vapor-phase granular activated carbon
VW&R	Van Waters & Rogers

EXECUTIVE SUMMARY

Groundwater in the West Van Buren Area (WVBA) Water Quality Assurance Revolving Fund (WQARF) Site contains significant concentrations of hazardous chlorinated volatile organic compounds (VOCs) that are commingled and widely distributed throughout the WVBA Site. Site investigations conducted over the past 25 years at over 50 industrial and commercial facilities in the WVBA Site have identified numerous source areas that released and contributed VOCs that are the contaminants of concern (COCs) in groundwater within the WVBA Site.

Groundwater contamination in the WVBA Site also is part of a larger commingled plume of VOC contamination that encompasses the adjacent Motorola 52nd Street federal Superfund Site (M52 Site) to the east, the Sky Harbor International Airport (SHA) Site to the southeast, and the West Central Phoenix Area WQARF sites (WCP sites) to the north, as shown below. The commingled plumes of VOC-contaminated groundwater from these adjacent sites flow toward and enter the WVBA Site in response to large-scale pumping of Roosevelt Irrigation District (RID) water supply wells within the WVBA and notable pumping centers in the vicinity of the Luke Air Force Base. Collectively, the commingled VOC groundwater plume extends nearly 15 miles throughout central Phoenix from 52nd Street to beyond 75th Avenue and is the largest groundwater contaminant plume site in Arizona and one of the single largest plumes in the country.



VOC contaminants in groundwater from these adjacent sites, along with VOC releases within the WVBA Site, contribute to widespread groundwater contamination observed in wells within the WVBA Site. Based on recent Arizona Department of Environmental Quality (ADEQ) monitoring of RID's water supply wells within the WVBA Site, 24 RID wells have detectable concentrations of one or more hazardous VOCs, while 13 of these wells exceed applicable VOC aquifer water quality standards (AWQSs) and maximum contaminant levels (MCLs). Other water providers such as Arizona Public Service (APS), Salt River Project (SRP), and the cities of Phoenix and Tolleson have water supply wells in the WVBA vicinity; however, these other existing water supply wells, although threatened, presently are not impacted by VOCs in concentrations that would restrict their use, including as a drinking water supply. RID currently is the only WVBA water provider whose existing water supply wells and reasonably foreseeable water end uses are adversely impacted or immediately threatened by the widespread VOC groundwater plume in the WVBA Site. Nonetheless, state law requires that the final groundwater remedy selected by ADEQ for the WVBA Site must address, at a minimum, all existing wells of all the current water providers in and adjacent to the WVBA Site that "would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end use without treatment," including as a drinking water supply as established by RID, City of Phoenix (COP), SRP and City of Tolleson (COT).[1]

The extensive pumping of RID wells in the WVBA Site is highly significant to groundwater flow and contaminant transport within the regional commingled VOC groundwater plume. Specifically, in recent years the 33 RID wells in the WVBA vicinity have pumped an average of 83,500 acre-feet of groundwater, and extracted an estimated 2,900 pounds of VOCs annually. Without treatment, the contaminated groundwater pumped by RID discharges to a surface conveyance system where VOCs in the water are known to volatilize and transfer hazardous VOC air pollutants[2] from groundwater to air.

Model simulations of groundwater flow illustrate the critical significance of RID pumping in managing the overall impact of VOC groundwater contamination in the entire region. The results demonstrate that groundwater pumping of RID water supply wells in the WVBA Site physically contains, for the most part, the regional commingled VOC groundwater contamination in central Phoenix. Without RID pumping, the VOC groundwater plume in the WVBA Site (with contributions from the M52 Site, SHA Site and WCP sites) would migrate westward[3] and impact widespread areas not currently affected by VOC groundwater contamination and impact and threaten a substantial number of uncontaminated SRP, COP, and COT water supply wells.

[1] *See* Arizona Revised Statute (ARS) §§ 49-282.06.A and 49-282.06.B.4.b.
[2] See 42 United States Code (USC) § 7412.b.
[3] *See* Figure 20.

Synergy Environmental has prepared this Feasibility Study (FS) Report to evaluate possible groundwater alternative remedies and determine a proposed final groundwater remedy for the WVBA Site. Because the focus is on a groundwater remedy, response actions conducted by private parties or ADEQ to address facility-specific source areas of VOC releases within the WVBA Site, including past and future source control actions, are not included in the scope of this FS. This FS Report is submitted on behalf of RID to ADEQ pursuant to WQARF requirements[4] and in accordance with the *Agreement to Conduct Work* between ADEQ and RID, dated October 8, 2009.

Remedial strategies and measures were developed to meet the applicable remedial action criteria in ARS § 49-282.06 and Arizona Administrative Code (AAC) R18-16-407 and formulated into possible groundwater alternative remedies that are capable of achieving the Remedial Objectives (ROs) for water use within the WVBA Site and are consistent with general water management plans. As determined on the basis of the screening analysis in this FS, all groundwater alternative remedies integrate strategies of plume remediation, plume containment, controlled migration and groundwater monitoring. Remedial measures adopted in all of the groundwater alternative remedies consist of wellhead treatment by liquid-phase granular activated carbon (LGAC), well replacement, well modification, and engineering controls.

Four (4) groundwater alternative remedies were evaluated as a potential final groundwater remedy for the WVBA Site, and in simplest terms, the main elements consist of:

> **Reference Remedy** – Installing wellhead treatment at nine (9) impacted wells and blending of four (4) other impacted wells that would be operated to achieve both applicable AWQSs and MCL water quality for all current and reasonably foreseeable water end uses at all wells of the existing water providers within or adjacent to the WVBA Site. Two (2) replacement wells would be drilled to enhance hydraulic capture in critical areas of plume containment and to restore any reduction in the available supply of water caused by addressing impacted wells.
>
> **Less Aggressive Groundwater Alternative Remedy** – Reducing the scale of the Reference Remedy by installing wellhead treatment at six (6) impacted wells and blending of six (6) other impacted wells to achieve both applicable AWQSs and MCL water quality for all current and reasonably foreseeable water end uses at all wells of the existing water providers within or adjacent to the WVBA Site. Only one (1) replacement well would be drilled to address and achieve both applicable AWQSs and MCL water quality for all current and reasonably foreseeable water end uses at one (1) other impacted well, as well as to enhance hydraulic capture in critical areas of plume

[4] *See* AAC R18-16-407

containment and to restore any reduction in the available supply of water caused by addressing impacted wells.

More Aggressive Groundwater Alternative Remedy – All elements of the Less Aggressive groundwater alternative remedy plus proposed modifications at five (5) wells in peripheral areas most threatened by the WVBA Site plume to reconfigure the wells for injection of underutilized effluent that is available during low irrigation demand periods.

Most Aggressive Groundwater Alternative Remedy – Installing wellhead treatment at all 13 impacted wells that exceed AWQSs and MCLs for the VOC groundwater contaminants.

All of these groundwater alternative remedies incorporate engineering controls for mitigation of volatilization and for prioritized pumping of impacted wells with treatment, as feasible, as well as on-going groundwater monitoring to verify plume remediation and containment.

Each of the groundwater alternative remedies presented in this FS Report was evaluated according to the WQARF comparison criteria of practicability, cost, risk and benefit/value to assess the advantages and disadvantages of each groundwater alternative remedy relative to one another. In terms of practicability and cost, the Less Aggressive groundwater alternative remedy clearly is distinguished as the preferred alternative based on its ease of implementation and lower cost. In terms of risk and benefit/value factors, the Most Aggressive groundwater alternative remedy is slightly more advantageous based on a somewhat greater removal of VOC mass in extracted groundwater.

Based on the results of detailed analysis that is set forth in this FS Report, the Less Aggressive groundwater alternative remedy is the proposed final groundwater remedy for the WVBA Site. This groundwater alternative remedy is reasonable, necessary, cost-effective and technically feasible and decisively considered the most readily implementable and cost beneficial approach that satisfies all of the applicable remedial action criteria in ARS § 49-282.06.A. and ARS § 49-282.06.B.4.b., including cleaning up waters of the state for their "maximum beneficial use" and addressing all existing wells within and adjacent to the WVBA Site that may not be fit for their "current or reasonably foreseeable end uses" without treatment. This groundwater remedy also meets the groundwater ROs for the WVBA Site, including the restoration of the impacted groundwater for its current or reasonably foreseeable end use as a source of drinking water, while reducing the risk of hazardous VOCs being transferred to surrounding communities.

The Less Aggressive groundwater alternative remedy would require implementation of the following remedial measures, in addition to the four (4) existing wellhead treatment systems that were installed to address certain highly impacted wells within the WVBA Site as part of a wellhead treatment system pilot initiative which was approved by ADEQ as being necessary, reasonable and cost-effective in the Modified Early Response Action:

- Wellhead treatment using LGAC at two (2) additional impacted water supply wells;
- Installation of a higher capacity replacement well, completed solely in the contaminated aquifer, to address and achieve both applicable AWQSs and MCLs for the target COCs at one (1) other impacted well, as well as to enhance hydraulic capture at the leading edge of the plume and to restore any reduction in the available supply of water caused by addressing impacted wells;
- Priority pumping of all impacted wells equipped with treatment to enhance mass removal and plume containment to achieve applicable AWQSs for the target COCs and to enable blending of other impacted wells to achieve necessary MCL water quality for all current and reasonably foreseeable end uses of the groundwater as a source of drinking water by all existing water providers at all wells within and adjacent to the WVBA Site;
- Engineering controls to limit potential routes of public exposure to COCs within the RID water delivery system; and
- Groundwater monitoring to verify plume containment and assess the progress towards groundwater remediation.

The estimated capital cost of the Less Aggressive groundwater alternative remedy is $9.4 million for all remedial measures (including those already implemented), and annual operation and maintenance costs are projected to be $2.0 million. Pursuant to AAC R18-16-411.G, RID is fully committed to implement and operate the selected groundwater remedy proposed in this FS Report, in working partnership with ADEQ, to address VOC groundwater contamination to achieve applicable AWQSs for the target COCs, to achieve MCL water quality to protect the current and reasonably foreseeable water end uses of all existing well owners at all wells within and adjacent to the WVBA Site (including RID, SRP, COP, APS and COT wells) and to mitigate environmental concerns at the largest groundwater contaminant plume in Arizona.

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1.0 INTRODUCTION

Synergy Environmental (Synergy) has prepared this Feasibility Study Report (FS Report) for the contaminated groundwater remedy evaluation of the West Van Buren Area (WVBA) Water Quality Assurance Revolving Fund (WQARF) Site (WVBA Site). As shown in **Figure 1**, the WVBA site is located in the western portion of Phoenix, Arizona. The site is bounded approximately by Interstate 10 to the north, 7th Avenue to the east, Buckeye Road to the south and beyond 75th Avenue to the west. In addition, a finger shaped plume exists between 7th Avenue and 27th Avenue between Buckeye Road and Lower Buckeye Road. Groundwater contamination within the WVBA Site is part of a larger regional commingled plume[5] of contaminated groundwater that extends to the north and east of the WVBA Site, as shown on **Figure 2**.

This FS Report is submitted on behalf of Roosevelt Irrigation District (RID) to the Arizona Department of Environmental Quality (ADEQ) and pursuant to Arizona Revised Statutes (ARS) §§ 49-282.06 and 49-287.03, and in accordance with the terms of the *Agreement to Conduct Work* between ADEQ and RID dated October 8, 2009 (ADEQ, 2009), as Amended February 27, 2014 (ADEQ, 2014a). This FS Report follows the *Feasibility Study Work Plan for Regional Groundwater Remedy Evaluation* (FS Work Plan) dated June 21, 2013 (Synergy, 2013a) and approved by ADEQ on July 16, 2013. This section provides information regarding the purpose, scope and organization of this FS Report.

The WQARF program was established by the Arizona legislature in 1986 as Arizona's version of the federal "superfund" program[6] under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) to address sites that pose actual or potential risks to public health, welfare or the environment due to historical soil or water contamination. Comprehensive reforms to the WQARF program were enacted in 1997 and incorporated in regulations promulgated in the Arizona Administrative Code (AAC) R18-16-401 through 416 that became effective in 2002.[7]

The WQARF process consists of sequential steps to evaluate and subsequently remediate a site contaminated with hazardous substances. Accordingly, after a preliminary investigation

[5] Composite representation of the estimated extent of trichloroethene and tetrachloroethene contamination in upper alluvial unit groundwater, where concentrations exceed the U.S. Environmental Protection Agency (EPA) primary MCLs under the federal Safe Drinking Water Act of five (5) micrograms per liter, which have been adopted as applicable Arizona drinking water quality MCLs and numeric aquifer water quality standards (AWQSs). *See* 40 Code of Federal Regulations (CFR) 141.61, AAC R18-11-406 and ARSs §§ 49-223.A. and 49-224.B. Given that there are multiple COCs in groundwater originating from various, widespread sources identified in four (4) different areas under different agency oversight, the depiction of a regional plume throughout this area is, by its very nature, a generalized representation.

[6] 8 Arizona Administrative Register (AAR) 1492, effective March 4, 2002 (Supp. 02-1).

[7] *See* 8 AAR 1493.

indicates a site poses an actual or potential risk to the public health, welfare or the environment, and pending the opportunity for public comment, it is designated as a WQARF Registry site. The WVBA Site, originally called the Van Buren Tank Farm Study Area, was placed on the WQARF Registry as a priority site in November 1987. Since 1988, ADEQ and various parties have conducted investigations of contaminated soil and groundwater within the WVBA Site through a protracted, 20-year Remedial Investigation (RI) process.

Pursuant to AAC R18-16-406.A, the purpose of the RI is to:

1. Establish the nature and extent of the contamination and the sources thereof,
2. Identify current and potential impacts to public health, welfare, and the environment,
3. Identify current and reasonably foreseeable uses of land and waters of the state, and
4. Obtain and evaluate any other information necessary for identification and comparison of alternative remedial actions.

The 20-year RI process culminated in the *Draft Remedial Investigation Report* (Terranext, 2008) (Draft RI Report) released in October 2008 and a final *Remedial Investigation Report* (Final RI Report) issued in August 2012 (Terranext, 2012)[8] for the WVBA Site. As required by WQARF rules, the Final RI Report established Remedial Objectives (ROs) for land uses in accordance with requirements of local land use jurisdictions and water uses consistent with water management plans of all water providers whose water supplies may be impaired by the contamination.[9]

At any time during the WQARF process, an Early Response Action (ERA) may be deemed necessary and implemented per AAC R18-16-405 (Terranext, 2012). ERAs are certain remedial actions initiated by ADEQ or any person prior to selection of a remedy at a site. In many instances, ERAs may involve "spending a penny today to save a dollar tomorrow." ERAs may prevent spreading or exacerbation of contamination by containing or removing the source of contamination or may prevent the loss of water supply. In other instances, ERAs may address a current risk to human health, welfare and the environment that cannot or should not go unaddressed until a final remedy is developed. ERAs may be relatively inexpensive short-term actions, such as fencing or providing bottled water, or they may involve an expensive large-scale groundwater treatment system.[10]

[8] Hereafter, further reference to the WVBA Site RI Report will be cited without attribution to Terranext.
[9] *See* AAC R18-16-406; see also 8 AAR 1501-1503.
[10] *See* 8 AAR 1496.

1.1 PURPOSE AND SCOPE OF THE FEASIBILITY STUDY REPORT

This FS Report has been prepared in accordance with AAC R18-16-407 based upon the data and findings presented in the Final RI Report and the *Final Remedial Objectives Report* [RO Report] prepared by ADEQ (2012b).

The purpose of the FS is described by the following objectives:[11]

1. Identify a reference and groundwater alternative remedies capable of achieving the ROs.
2. Evaluate each of the identified remedies and recommend the best alternative that will meet the ROs and comply with the requirements of ARS § 49-282.06.

Based on the above objectives, the FS Report presents a proposed groundwater remedy for the WVBA Site, consistent with the statutory requirements in ARS § 49-282.06, which:

1. assures protection of public health, welfare and the environment;
2. to the extent practicable, provides for control, management, or cleanup of hazardous substances so as to allow for the maximum beneficial use of waters of the state, to the extent practicable;
3. is reasonable, necessary, cost-effective and technically feasible;[12] and,
4. addresses any well that either supplies water for municipal, domestic, industrial, irrigation or agricultural uses or is part of a public water system, if the well would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end use without treatment. The specific measures to address any such well shall not reduce the supply of water available to the owner of the well.[13]

The scope of this FS is primarily focused on addressing contaminants of concern (COCs) in groundwater[14] within the WVBA Site. However, as noted in the *FS Work Plan* (Synergy, 2013a),

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[11] *See* AAC R18-16-407.A.
[12] *See* ARS § 49-282.06.A.; 8 AAR 1503.
[13] *See* ARS § 49-282.06.B.4.b.; 8 AAR 1503.
[14] The scope of this FS will not include source control actions for surface and subsurface soils in consideration of remedial alternatives for the groundwater remedy. As noted in the FS Work Plan, it is assumed that these source control actions will be addressed by the West Van Buren Working Group in its FS Report. Should any further information arise that identifies the need to address a presently unknown source of hazardous substances or loss or impairment of land use caused by contamination of surface and subsurface soils, it is further assumed that ADEQ will, independent of the groundwater remedy, assure that necessary actions are taken to remediate or control the hazardous substances causing the impairment or restriction to the land and/or groundwater use.

the WVBA Site also is part of a larger region of groundwater contamination that encompasses the adjacent Motorola 52nd Street federal Superfund[15] site (M52 Site) to the east, the Sky Harbor Area Site (SHA Site) to the southeast, and the West Central Phoenix Area WQARF sites (WCP sites) to the north, as shown in **Figure 2**. To date, the regional extent of groundwater contamination has not been mapped and addressed in an integrated manner. The depicted regional groundwater contaminant plume in **Figure 2** is an extrapolation of commingled groundwater contaminant plumes from multiple sources throughout the four (4) regional sites.[16] As noted in stakeholder comments on the Draft RI Report, "*the concept of the 'WVBA groundwater plume' is a simplification of the distribution of contaminants in groundwater in the WVSA* [sic]. *In reality, the WVBSA has a combination of many, commingled plumes with different sources, different timing, different VOCs and differing fate and transport parameters. In addition, a significant portion of the groundwater contamination of the WVBA appears to be related to contamination entering the Site from the east.*"[17]

Information provided in the Final RI Report indicates that groundwater contamination from the M52 Site[18] and from the WCP sites migrates into and impacts the WVBA Site. Although the WVBA, WCP, SHA and M52 sites are contiguous, they have been subdivided for the purpose of administrating and implementing groundwater remedial actions. This FS will integrate available information from these adjacent regional sites, where appropriate, to provide regional context for the evaluation of WVBA Site groundwater remedial actions.

1.2 REPORT ORGANIZATION

This FS Report has been organized into the following sections, which is adjusted slightly from the organization presented in the FS Work Plan.

Section 1.0 - Introduction
Section 2.0 - Site Background
Section 3.0 - Site Characterization
Section 4.0 - Feasibility Study Scoping

[15] The Federal Superfund program was promulgated under CERCLA and is administered by the Environmental Protection Agency.
[16] In this and subsequent maps, the SHA Site is not shown. Rather, as will be discussed in section 3.3.2, the SHA subarea will be treated as part of Operable Unit 2 (OU2) of the M52 Site.
[17] Letter from Univar to ADEQ regarding *Univar USA Inc.'s Comments, Draft Remedial Investigation Report, West Van Buren Area WQARF Site, Phoenix, AZ,* dated December 29, 2008 (Univar, 2008).
[18] ADEQ previously had determined that "the contaminant plumes from the sources in each site [East Washington WQARF Site, SHA Site and M52 Site] have merged into one large plume." In fact, the initial purpose of SHA Site activities was "toward confirmation of involvement, or not, in the M52 site," which ADEQ's *"hydrology support staff believe this has already been confirmed."* Memorandum from Jeff Kulon, ADEQ Project Manager, to Al Brown, ADEQ Manager, re: "Sky Harbor/East Washington WQARF Sites", August 18, 1994. (ADEQ, 1994b)

Section 5.0 - Screening of Remedial Strategies and Measures
Section 6.0 - Identification and Screening of Remediation Technologies
Section 7.0 - Development of Reference and Groundwater Alternative Remedies
Section 8.0 - Detailed Analysis of Proposed Remedies
Section 9.0 - Proposed Groundwater Remedy

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2.0 SITE BACKGROUND

This section presents a summary description of the WVBA Site, the volatile organic compounds (VOCs) that are COCs at the Site, Site registry and remedial investigation activities conducted, chronology of Site activities by ADEQ, and the early response actions conducted to date.

2.1 SITE DESCRIPTION AND PHYSICAL SETTING

According to the Final RI Report, the WVBA Site extends from approximately 7th Avenue west to beyond 75th Avenue, and from Buckeye Road north to Interstate 10. This corresponds to an area approximately eight miles in length and 1.5 miles in width (i.e., approximately 12 square miles), see **Figure 1**. In addition, a finger shaped plume exists approximately between 7th and 27th Avenues between Buckeye and Lower Buckeye Roads (see **Figure 2**).

The entire WVBA Site is located within the City of Phoenix (COP), although the western margin along 75th Avenue abuts the City of Tolleson (COT). Land within the WVBA Site is used for a combination of residential, commercial, industrial and agricultural purposes. According to the Final RO Report (ADEQ, 2012b), the Estrella Village, which is referenced as one (1) of 15 "urban villages" that comprise the COP and one (1) of two (2) "urban villages" within the WVBA Site, is a targeted growth area that is expected to experience significant increases in both employment and residential growth. Further information concerning site demography is available in the Final RI Report and Final RO Report.

As established by ADEQ's industrial surveys, within the WVBA Site are industrial facilities that have used VOCs in former, and in some cases, current operations. Based on observations made during performance of RI field activities, typical industrial businesses within the WVBA Site include automobile repair, automobile painting, chemical mixing and distribution, dry cleaning operations, foundry operations, manufacturing operations, metal fabrication and plating, plastic manufacturing, printing operations, and vulcanizing operations.

The scope of commercial and industrial operations that may have contributed to soil and groundwater contamination within the WVBA Site is extensive and, for all practical purposes, indeterminate.[19] For example, in a single industrial survey commissioned by ADEQ (HydroGeoLogic, 2002), the following businesses where COCs are known to have been used

[19] According to the Air Liquide comments to ADEQ (Basin & Range Hydrogeologists, 2010) on RID's original ERA, *"relative to the number of current and former facilities that exist, and the population of people residing in the Area ... only small numbers of groundwater contamination sources have been identified in the Site. This suggests that many sources of groundwater contamination have yet to be identified or evaluated in any meaningful way."*

during the period 1935 to 2000 were identified within only two (2) quarter sections of land on the very eastern boundary of the WVBA Site:

- 33 auto body repair shops;
- 21 auto repair shops;
- 27 dry cleaner operations;
- 33 metal fabrication and plating operations;
- 24 printing operations; and,
- 10 chemical manufacturing and distribution facilities.

More details regarding the WVBA Site facilities are provided in Section 3.3.1.

2.2 CONTAMINANTS OF CONCERN

Volatile Organic Compounds

The VOCs that are COCs at the WVBA Site have been identified based on historical and present data obtained from samples collected by ADEQ. These COCs comprise the commingled WVBA Site plume and are listed as follows, including the chemical name and the Chemical Abstract Service (CAS) number:

- 1,1-Dichloroethene (1,1-DCE) CAS number 75-53-4
- Tetrachloroethene (PCE) CAS number 127-18-4
- Trichloroethene (TCE) CAS number 79-01-6
- 1,1,1-Trichloroethane (TCA) CAS number 71-55-6
- cis-1,2-Dichloroethene (cis-1,2-DCE) CAS number 156-59-2
- 1,1-Dichloroethane (1,1-DCA) CAS number 75-34-3

Table 1 presents a summary of analytical results for groundwater samples collected at WVBA Site monitor wells by ADEQ during March 2013 (Terranext, 2013). **Table 2** presents a summary of analytical results for PCE, TCE, and 1,1-DCE found in groundwater samples collected at RID water supply wells by ADEQ during 2003 through 2014. These three (3) COCs are the principal VOC contaminants in WVBA groundwater and are referred to as "target COCs" throughout this report.[20]

[20] Although all three (3) target COCs occur in concentrations exceeding AWQSs and MCLs, this FS Report primarily focuses on PCE and TCE since these compounds are more prevalent, have higher concentrations, and are considered a greater health risk than 1,1-DCE.

Chromium

Chromium, to a limited extent, also is considered a COC that occurs locally within the WVBA Site boundaries. During the March 2013 sampling round (Terranext, 2013), analytical results for 11 out of 50 WVBA monitor wells indicated concentrations of total chromium greater than the applicable numeric AWQS and MCL of 0.1 milligrams per liter (mg/L)[21] with the highest concentration detected at 5.74 mg/L and the lowest concentration detected at 0.11 mg/L (**Table 1**). During March 2014, ADEQ sampled 28 of the 33 RID water supply wells located within the WVBA Site for chromium, and analytical results provided in **Table 3** indicate that the highest total chromium concentration detected was less than half of the applicable numeric AWQS and MCL.[22]

The Final RI Report indicated that chromium is limited in occurrence and can only be clearly attributed to one known source area in the southeast portion of the WVBA Site. Additionally, the Final RI Report noted that ADEQ believes the detected chromium in monitor wells may be due to deterioration of stainless steel well casing, where present, or naturally occurring in subsurface soils. Due to the limited and localized occurrence of chromium, the uncertainty regarding sources of chromium in groundwater within the WVBA Site and the fact that there are no existing wells within or adjacent to the WVBA Site (including RID, SRP, COP, APS and COT wells) that exceed the applicable numeric AWQS or MCL, chromium will not be further evaluated or addressed in this regional groundwater FS.[23]

Extent of Volatile Organic Compounds in Groundwater

Recent water quality data obtained at WVBA Site monitor wells, RID water supply wells, and shallow groundwater monitor wells in the WCP sites (principally the West Osborn Complex (WOC) WQARF Site) are shown on the plume map depicted in **Figure 2**. This map represents the estimated regional extent of TCE and PCE contamination in UAU groundwater that is greater than the applicable numeric AWQS of 5.0 µg/L in the commingled plume.[24] Additionally, this figure identifies the extent of groundwater contamination in the M52 Site based on mapping of the plume by ADEQ.

[21] *See* 40 CFR 141.62 and AAC R18-11-406.
[22] The current numeric AWQS and primary MCL drinking water standard are for total chromium. These samples also were analyzed for hexavalent chromium with the understanding that EPA likely will develop a primary drinking water standard applicable to this species of chromium. Of the 28 RID wells tested for hexavalent chromium, 10 RID wells had concentrations above the method reporting limit of 5 µg/L. The observed hexavalent chromium concentrations are all below 15 µg/L, with the exception of well RID-99 at 43 µg/L.
[23] Although this FS does not address chromium contamination as part of the regional groundwater remedy, it may be necessary to reevaluate requirements for remedial actions in the WVBA Site if EPA and/or ADEQ should adopt a MCL or AWQS for hexavalent chromium at or below 10 µg/L. Also, it is assumed that the Working Group will focus on the limited chromium occurrences according to their FS Work Plan.
[24] *See* footnote 5.

Given that there are multiple COCs in groundwater originating from various, widespread sources identified in four (4) different regional areas under different agency oversight, the depiction of a regional plume throughout this area is, by its very nature, a generalized representation. Furthermore, the data available to characterize the extent of groundwater contamination derives from diverse well completions ranging from monitoring wells having limited, depth discrete sampling intervals to large capacity RID water supply wells that may yield groundwater from perforated casing over many hundreds of feet within the aquifer(s). Consequently, well data do not always appear consistent and are interpreted with greater significance attached to water supply well data, since this provides more representative characterization of bulk conditions of the producing aquifer.

Regional Extent of Volatile Organic Compounds in Groundwater

Three (3) target COCs (TCE, PCE and 1,1-DCE) are present in groundwater within the WVBA Site at concentrations that exceed the applicable numeric and narrative AWQS[25] and MCLs.[26] The numeric AWQSs, MCLs and MCL Goals[27] for the target COCs are:

- TCE = 5.0 micrograms per liter (μg/L) (AWQS/MCL) and 0 μg/L (MCL Goal)
- PCE = 5.0 μg/L (AWQS/MCL) and 0 μg/L (MCL Goal)
- 1,1-DCE = 7.0 μg/L (AWQS/MCL) and 7.0 μg/L (MCL Goal)

Aside from the primary MCL drinking water standards, which were applicable prior to the WQARF Program, various other regulatory standards and thresholds are listed for the target COCs in the Final RI Report, including: human Health-Based Guidance Levels (HBGLs) implemented by ADEQ in 1992, Soil Remediation Levels (SRLs) implemented by ADEQ in December 1997 and revised in May 2007, Groundwater Protection Levels (GPLs) implemented by ADEQ in September 1996, EPA MCLs promulgated in 1987, and Arizona numeric and narrative AWQSs implemented by ADEQ in January 1990.

More recently, EPA developed risk-based screening levels applicable to CERCLA hazardous substances, including WVBA Site target COCs, for potential public exposure to these

[25] Arizona has established enforceable numeric AWQSs based upon EPA's primary drinking water MCL standards because all aquifers in Arizona are classified for drinking water protected use. *See* ARS § 49-224.B., ARS § 49-223.A., and AAC R18-11-406. In addition to the enforceable numeric AWQSs, Arizona has established the following enforceable narrative AWQSs: a discharge shall not cause a pollutant to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health; a discharge shall not cause or contribute to a violation of a water quality standard established for a navigable water of the state; and a discharge shall not cause a pollutant to be present in an aquifer which impairs existing or reasonably foreseeable uses of water in an aquifer. *See* ARS § 49-221.D. and AAC R18-11-405.

[26] EPA has established primary MCLs as enforceable drinking water standards determined by balancing the adverse health effects of a particular chemical against the feasibility and cost of treating contaminated water. Arizona has adopted EPA's primary MCLs as enforceable state drinking water standards. *See* AAC R18-4-104.

[27] EPA has established a MCL Goal as non-enforceable health-based guidelines, which have been traditionally set to zero (0) for potential human carcinogens.

contaminants in water, soil, and air. In 2009, EPA harmonized the screening levels from Regions 3, 6, and 9 into a single table: *Regional Screening Levels* (RSLs) *for Chemical Contaminants at Superfund Sites*. The RSLs[28] were developed, and are periodically updated, using risk assessment guidance from the EPA Superfund program. RSLs are derived from standardized equations combining exposure information assumptions with current EPA toxicity data.[29] A summary of the RSLs[30] for the WVBA Site target COCs is included in the following table:

Regional Screening Level Summary Table

Contaminant		Screening Levels					
Analyte	CAS No.	Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Residential Air (μg/m^3)	Industrial Air (μg/m^3)	Tapwater (μg/L)	MCL (μg/L)
1,1-DCE	75-35-4	240	1,100	210	880	260	7.0
PCE	127-18-4	22	110	9.4	47	9.7	5.0
TCE	79-01-6	0.91	6.4	0.43	3.0	0.44	5.0

Explanation:
mg/kg = milligrams per kilogram
μg/m^3 = micrograms per cubic meter
μg/L = micrograms per liter

Profiles of Target COCs

Brief summaries regarding the hazardous properties for each of the target COCs, obtained from the EPA and Agency for Toxic Substances and Disease Registry (ATSDR), are included as follows.

[28] *See* EPA user guide: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

[29] On February 10, 2012, EPA issued new toxicity information for PCE. This publication followed the release of new toxicity factors on September 28, 2011 for TCE. EPA's recent review lowered the carcinogenic values previously used as screening levels for TCE (i.e., TCE is now considered a more potent carcinogen). The new toxicity criteria led EPA to adjust the RSLs it uses for evaluating environmental data for TCE in November 2011. However, unlike TCE, the cancer RSLs for PCE have actually increased (are less conservative) by about 20 times. *See* EPA updates located online at http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/whatsnew.htm (last visited on 5/13/2014) and http://www.epa.gov/region9/superfund/prg/rsl-table.html (last visited 5/4/2012). From a drinking water perspective, the new toxicity data are impacting EPA's review of its MCLs for both chemicals. The MCL for TCE is expected to decrease, perhaps by a factor of up to 10, because it is considered to be carcinogenic by all routes of exposure (EPA's highest carcinogenicity classification), while the MCL for PCE is expected to increase. EPA proposed MCL revisions for both chemicals could be revised in the next five (5) years. This new toxicity information for PCE and TCE also may become relevant under ADEQ's narrative AWQSs, which prohibit pollutants to be present in an aquifer classified for a drinking water protected use in a concentration which endangers human health or which impairs existing or reasonably foreseeable uses of water in an aquifer. *See* AAC R18-11-405 and ARS § 49-221.

[30] Current soil data are not indicative of potential prior contamination to the groundwater. *See* Memorandum from Michael Leach, ADEQ Hydrologist, to Tom Curry, ADEQ WQARF Coordination Unit, re: "Van Buren Tank Farm – Final Summary Site Assessment Report" (ADEQ, 1990), (noting that contaminants from facilities could also reach the water table by way of surface conduits [such as drywells] with very little detectable contamination of the vadose zone.")

TCE:

- Chemical Classification: volatile organic compound
- Summary and Uses: TCE is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it also is an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. TCE is not found naturally in the environment. However, it has been found in underground water sources and many surface waters as a result of the manufacture, use, and disposal of the chemical.
- Cancer Effects:[31] carcinogenic in humans[32] by all routes of exposure; strong evidence of causal association with TCE exposure in humans and kidney cancer and non-Hodgkin lymphoma; less well defined association of TCE exposure to other types of cancer, including liver, biliary tract, bladder, esophageal, prostrate, cervical, breast and childhood leukemia.
- Non-Cancer Effects:[33] potential human health hazard for non-cancer toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus.
- Ecological Impacts: according to background analysis of TCE environmental toxicity contained in the June 2014 *TSCA Work Plan Chemical Risk Assessment* (EPA, 2014), TCE poses a negligible ecological risk to aquatic and terrestrial biota due to its moderate persistence, low bioaccumulation potential, and low aquatic toxicity. The promulgation of significantly higher (less stringent) water quality standards for TCE applied to aquatic and wildlife designated uses under the Clean Water Act corroborates the overall low concern for potential ecological impacts related to TCE releases.

PCE:

- Chemical Classification: volatile organic compound
- Summary and Uses: PCE is a manufactured chemical, not found naturally in the environment, that is widely used for dry cleaning of fabrics and for metal degreasing. It also is used to make other chemicals and is used in some consumer products.

[31] Toxicology Review of Trichloroethylene, In Support of Summary Information on the Integrated Risk Information System, EPA/635/R-09/011F, US EPA, Washington, DC, September 2011. (EPA, 2011)
[32] The National Toxicology Program announced that TCE should be reclassified as a "known human carcinogen" from "reasonably anticipated to be a human carcinogen," in a draft report released June 27, 2014. The report indicated there is sufficient evidence based on studies in humans that exposure to TCE causes kidney cancer in humans. The draft report further states there is only limited evidence in human studies that TCE exposure causes non-Hodgkin lymphoma and there is insufficient evidence to evaluate the relationship between TCE exposure and liver cancer. The draft report is undergoing peer review. (National Toxicology Program, 2014)
[33] *Ibid.*

- Cancer Effects:[34] likely to be carcinogenic to humans by all routes of exposure based on epidemiologic evidence associating PCE exposure in humans with several types of cancer, including bladder, non-Hodgkin lymphoma, and multiple myeloma and animal studies of increased incidence of liver, kidney, and testicular tumors.
- Non-Cancer Effects:[35] potential human health hazard for non-cancer toxicity to the central nervous system, kidney, liver, immune and hematologic system, and on development and reproduction.
- Ecological Impacts: PCE has similar physical and chemical properties to that of TCE and is anticipated to behave similarly in having overall limited ecological impacts on aquatic and terrestrial biota due to its moderate persistence, low bioaccumulation potential, and low aquatic toxicity (EPA, 2014). The promulgation of significantly higher (less stringent) water quality standards for PCE applied to aquatic and wildlife designated uses under the Clean Water Act corroborates the overall low concern for potential ecological impacts related to PCE releases.

1,1-DCE:

- Chemical Classification: volatile organic compound
- Summary and Uses: 1,1-DCE is an industrial chemical that is not found naturally in the environment. It is a colorless liquid with a mild, sweet smell. It also is called vinylidene chloride. 1,1-DCE is used to make certain plastics, such as flexible films like food wrap, and in packaging materials. It also is used to make flame retardant coatings for fiber and carpet backings, and in piping, coating for steel pipes, and in adhesive applications. 1,1-DCE may be found in the environment from the biotic or abiotic breakdown of PCE, 1,1,1-TCA, 1,1,2-TCA, and 1,1-DCA.[36]

[34] Toxicology Review of Tetrachloroethylene, In Support of Summary Information on the Integrated Risk Information System, EPA/635/R-08/011F, US EPA, Washington, DC, February 2012. (EPA, 2012)
[35] *Ibid.*
[36] Researchers have identified the following compounds as daughter compounds of TCE, TCA, and PCE degradation: (1) 1,1-dichloroethene (DCE); (2) 1,2-DCE; (3) 1,1-DCA; (4) chloroethane; (5) chloroethene; (6) ethanol; (7) acetic acid; and, (8) carbon dioxide. Suzanne Lesage, Richard E. Jackson, Mark W. Priddle, & Peter G. Riemann, *Occurrence and Fate of Organic Solvent Residues in Anoxic Groundwater at the Gloucester Landfill, Canada*, 24 Environmental Science and Technology, 559, 564 (1990) (providing a flowchart of parent compounds degrading into daughter compounds). Researchers and EPA have taken the position that abundant sources of organic carbon, including fuel hydrocarbons, are a driving force behind the chemical reactions, which create chlorinated daughter compounds inside VOC-contaminated groundwater. *See* EPA, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*, 3, 23-26 (1998) (explaining that the chemical reaction facilitated by organic carbon is "reductive dechlorination") (EPA, 1998). In fact, ADEQ reviewed leaking underground storage tanks as potential sources for VOC-contaminated groundwater *"because of the potential for petroleum hydrocarbon contamination to facilitate natural biodegradation of VOCs."* ADEQ, *Final Remedial Investigation Report, WCP East Grand Avenue WQARF Site, Phoenix, Arizona, 2-15* (June 2006). (ADEQ, 2006b). As noted in Honeywell's Additional Site Characterization Work Plan (April 2003), "an important aspect of the presence of fuel hydrocarbons is the chlorinated solvent biodegradation (anaerobic dechlorination)

- Cancer Effects[37]: EPA considers 1,1-DCE to be a possible human carcinogen based on animal studies; there are limited and inconclusive data for assessment of human carcinogenic potential.
- Non-Cancer Effects:[38] no information is available on the non-cancer health effects associated with human exposure to 1,1-DCE. In animal studies, the target organs associated with 1,1-DCE exposure are the liver, kidney, and lungs.
- Ecological Impacts: 1,1-DCE has similar physical and chemical properties to that of TCE and is anticipated to behave similarly in having overall limited ecological impacts on aquatic and terrestrial biota due to its moderate persistence, low bioaccumulation potential, and low aquatic toxicity (EPA, 2014). The promulgation of significantly higher (less stringent) water quality standards for PCE applied to aquatic and wildlife designated uses under the Clean Water Act corroborates the overall low concern for potential ecological impacts related to 1,1-DCE releases.

Routes of Potential Exposure

According to the *Final RI Report*, groundwater pumpage is the major outflow from the groundwater system and is therefore the main exposure pathway for COCs that have been released to surface and subsurface soils and entered groundwater to come in contact with environmental receptors. The exposure point occurs when the contaminated groundwater is withdrawn from the aquifer and enters the outfall to the water provider's water distribution system.

The primary water supply wells within the WVBA Site are those operated by RID. RID wells pump and discharge of contaminated groundwater into a system of discharge boxes, water transmission lines (mostly buried), and conveyance canals. As identified in the previous discussion, the exposure pathway and potential for target COC releases to impact aquatic and terrestrial biota is of low concern. Consequently, further discussion of routes of potential exposure to target COCs and associated risks in this FS will focus on the substantially more significant concern for potential hazards to human health.

Public exposure routes to COCs discharged into the RID water system include inhalation (air), ingestion (water), and dermal absorption. Public exposure is controlled at RID well sites by

Deleted: ¶
Exposure pathways for target COCs at the WVBA Site resulting from the current

Deleted: the RID water system include potential p

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stimulated by the fuel hydrocarbons. … Therefore, the areas at the Site where anaerobic biodegradation of chlorinated solvents is enhanced coincide with the areas of free-phase and dissolved-phase fuel hydrocarbons. … In summary, detection of the chlorinated solvent byproducts of TCE and 111TCA in groundwater samples collected from groundwater monitor wells indicates that reductive dechlorination occurs within and downgradient of the Honeywell Site."

[37] Toxicology Review of 1,1-Dichloroethylene, In Support of Summary Information on the Integrated Risk Information System, EPA/635/R02/002, US EPA, Washington, DC, June 2002. (EPA, 2002)

[38] *Ibid.*

security fencing that precludes general public access, but is uncontrolled outside of the RID well sites at open segments along canals/laterals (ingestion and dermal absorption) and where volatilization/engineering controls have not been installed at the discharge structure for each well (inhalation).[39] Engineering controls have only been installed at RID-89, RID-92, RID-95 and RID-114 where wellhead treatment systems were voluntarily constructed pursuant to the *RID-95 Wellhead Treatment Systems Proposal* as agreed to by ADEQ (ADEQ, 2011e). Further discussion of the extent of contamination impacts and environmental fate of COCs in groundwater, surface water, and air in the WVBA Site is given in Section 3.4.

With respect to impacts to other water provider wells, Arizona Department of Health Services (ADHS) completed a health risk assessment in October 1992 addressing the potential threat to drinking water wells. The study was conducted in anticipation of potential COT groundwater contamination of wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in ADEQ monitor wells located near 67th Avenue and West Van Buren Street.

Finally, as stated in the Final RI Report, vapor intrusion is a potential exposure pathway. *"Once released to the unsaturated zone, VOCs can volatilize into soil gas, which can migrate upwards to the ground surface. Depending on the land use/surface cover, soil gas can either be released directly to the atmosphere, become trapped beneath impermeable structures, or migrate into structures either beneath or at the ground surface. Typically, vapor intrusion will occur at or near the contaminant (in this case VOC) source area, but can also occur via off-gassing from the groundwater. The likelihood of vapor intrusion via this pathway decreases with increasing depth to groundwater."*[40] This FS does not address vapor intrusion issues due to the observed depth to groundwater in the WVBA Site, which minimizes the potential for vapor migration to land surface.

Section 3.4.5 contains further information regarding the extent and migration routes of target COCs.

2.3 CHRONOLOGY OF SITE ACTIVITIES

Following is a brief summary of the chronology of WVBA Site activities. For a more substantive summary, please refer to the Final RI Report.

[39] *See* ADEQ's Approval of RID's Modified Early Response Action Work Plan (February 1, 2013) (requiring that measures be implemented to limit exposures that might cause long-term effects based on data that significant volatilization and transfer of contaminants, from water into the air, is occurring and ongoing.) (ADEQ, 2013a)
[40] Terranext, 2012

1986 Groundwater contamination was first detected in the WVBA Site, originally called the Van Buren Tank Farm Study Area, during groundwater sampling conducted by Chevron USA Inc. (Chevron) at its facility in the Phoenix Terminal located south of Van Buren Street, and between 51st and 55th Avenues. Because Chevron reportedly had never used the solvents detected,[41] the Arizona Department of Water Resources (ADWR) conducted an area-wide groundwater investigation in conjunction with the ADHS.

1987 The WVBA Site was placed on the WQARF Registry as a priority site in November.

1988 ADEQ contracted with Kleinfelder, Inc. (Kleinfelder) to conduct the preliminary site investigation. Since 1988, ADEQ and several companies within the WVBA Site have conducted investigations of contaminated soil and groundwater. Initial field work included groundwater monitoring, soil sampling, examining area land uses, reviewing past and current disposal practices of industrial operations, and analyzing the potential health risks of identified COCs.

1989 A Phase I report was finalized for ADEQ in July. The report concluded that five (5) of the COCs were found to be present in groundwater at levels above EPA MCLs.

1991-1998 A Phase II groundwater investigation was conducted in 1991 and sampling report issued in 1992.

In October 1992, ADHS completed a health risk assessment addressing the potential threat to COT drinking water wells. The study was conducted in anticipation of potential groundwater contamination of wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in ADEQ monitor wells located near 67th Avenue and West Van Buren Street. COT's most easterly well is located at approximately 83rd Avenue and

[41] See Memorandum from Michael Leach, ADEQ Hydrologist, to Tom Curry, ADEQ WQARF Coordination Unit, re: "Van Buren Tank Farm (VBTF) – Final Summary Site Assessment Report" (Feb. 26, 1990) noting that despite claims that "VBTF facilities could not be responsible for the halogenated [HVOC] contamination found in the groundwater underlying the site because the site operations don't use or store any HVOCs … [and] no HVOCs were detected as a result of soil sampling of the vadose zone," that "evidence developed by [VBTF facilities] indicates that HVOCs have been stored or used, and have subsequently been detected in soil samples collected from UNOCAL, one of the VBTF facilities. In addition, as explained in my 3-16-89 memo, contaminants from the other VBTF facilities could also reach the water table by way of surface conduits (such as drywells) with very little detectable contamination of the vadose zone." (ADEQ, 1990)

Harrison Street. In response, COT removed potentially affected wells from service. As indicated in the Final RI Report, COT currently receives most of its water from the COP through an Intergovernmental Agreement. The four (4) operating COT wells are used mainly during summer months for backup supply purposes. Two (2) ADEQ monitor wells have been installed at 79th Avenue, north and south of the RID canal, between the leading edge of the plume and the COT municipal well field to monitor groundwater quality in the area of concern.[42]

ADEQ conducted a soil investigation at the Maricopa County Materials Management (MCMM) facility in 1992 as a result of groundwater contamination detected in an ADEQ monitor well located downgradient of the MCMM facility. ADEQ also installed three (3) groundwater monitor wells at the MCMM facility. Maricopa County then conducted a site characterization of its facility and installed and operated a soil vapor extraction (SVE) system to remove the hazardous substances.

In November 1992, ADEQ encouraged approximately 50 parties to form a steering committee to address groundwater contamination issues in the WVBA Site. Participants of the steering committee formed the West Van Buren Group (WVBG). The WVBG was a key component of the steering committee. The makeup and formal membership of the WVBG varied during the mid-1990s, and originally consisted of: Reynolds Metals Co. (Reynolds Metals), Van Waters & Rogers Inc. (VW&R), Maricopa County, Dolphin, Inc. (Dolphin), American Linen Supply Company (ALSCo, formerly Maroney's Cleaners), and ChemResearch Company, Inc. (ChemResearch). ChemResearch, ALSCo, and Maricopa County withdrew from the WVBG by 1995. The WVBG suspended further negotiations with ADEQ for a site-wide consent agreement in June 1996 in anticipation of Arizona legislative changes that were enacted to the WQARF program in 1997.

In August, a federal court approved a Consent Decree between ADEQ and ALSCo. ALSCo settled with ADEQ in May for $2 million. No settlement agreement was negotiated between ADEQ and Maroney's Cleaners & Laundry, Inc.

[42] Although ADEQ monitor wells located east of 79th Avenue do not have detectable PCE or TCE concentrations, this does not delineate the extent of the WVBA Site groundwater contamination. Recent sampling in March 2014 of well RID-82 located at 83rd Avenue and McDowell Road indicate PCE and TCE have been detected at concentrations of 3.53 µg/L and 1.22 µg/L, respectively. As shown in **Figure 2**, RID-82 had 2.95 µg/L of PCE and 1.00 µg/L of TCE when sampled in September 2013.

By the end of 1998, site characterization activities included installation of 35 monitor wells by Kleinfelder (8), Weston (14), Fluor Daniel GTI (6) and GEC (7).

Two well inventories were conducted by Kleinfelder and Weston to identify groundwater wells located within/adjacent to the WVBA Site. Information obtained from the surveys was used to identify wells for collecting groundwater samples and preparing lithologic descriptions. Concurrent with the well inventory, Weston developed a Phase I database followed by a conceptual model. Weston developed a five-layer model with seasonal stress periods as a final end product (i.e., Central Phoenix Plume Model).

1999 ADEQ retained Terranext (previously known as BE&K/Terranext) to perform RI activities. Terranext developed project plans and initiated on-going site characterization activities including: a well inventory; monitor well installations; water level measurements; groundwater sampling; preparation of water level and COC concentration contour maps; and monitor well abandonments.

2000 Reynolds Metals received a No Further Action (NFA) letter for soils within 14 specific areas at its facility by ADEQ.

A Resources Conservation and Recovery Act (RCRA) Consent Decree was issued to Dolphin by ADEQ in January.

2001 Pursuant to AAC R18-16-406(D), a Land and Water Use Study was prepared. Terranext gathered information on current and foreseeable land and water usage through interviews, COP General Plan maps, ADWR well database, aerial photographs, and facility reports submitted to ADEQ and zoning maps from the COP, COT, and Maricopa County. Updates since 2001 were obtained through researching current information and issuing a questionnaire to stakeholders within the WVBA Site. Two (2) different questionnaires were developed for stakeholders. One focused on property owners within the WVBA Site and one focused on municipalities/utilities. A final *Land and Water Use Study* can be found in Appendix K of the Final RI Report along with sample questionnaires.

Upon completion of site characterization and soil remediation, Maricopa County and Union Pacific Railroad, one of the previous owners of the MCMM property, negotiated a settlement with ADEQ. In October, Maricopa County and Union Pacific Railroad settled with ADEQ for $450,000 for ADEQ's response and oversight costs. ADEQ continues to investigate the ownership and tenant history of the facility to evaluate whether other entities may also be responsible for contamination detected at the MCMM facility.

In January, the WQARF Program collected $410,000 from Dolphin to be used in remedial action on the WVBA Site plume's threat to COT drinking water wells.

2002 Reynolds Metals entered into a Consent Decree with the State of Arizona in September. The Consent Decree resolved the alleged liability and potential liability of Reynolds Metals by seeking recovery of costs, recovery for natural resource damages, injunctive relief, and declaratory judgment. Reynolds Metals settled with ADEQ for $1,956,474 in October.

ADEQ issued a NFA letter to VW&R for soils, which terminated a 1996 Consent Decree. VW&R paid ADEQ $7,711 for oversight costs incurred.

2005 ADWR conducted a review of its database, ADEQ files, and conducted field surveys to identify monitor wells within and adjacent to the WVBA Site. Information from this survey was used to identify duplicates in the ADEQ database and identify private wells for sampling. The data was submitted to ADEQ in database format for incorporation into the ADEQ database (September). Twenty-nine domestic wells were identified in or adjacent to the WVBA Site; of these, five (5) are located within the Site and provide groundwater for domestic use. In order to gain access to domestic wells, ADEQ attempted to contact domestic well owners through certified letters and residential visits. ADEQ was able to gain access to four (4) of the five (5) domestic wells for sampling. No VOCs (analyzed by EPA Method 8260B) were detected in any of the groundwater samples collected from the four domestic wells. No VOCs were detected with the reporting limit ranging from <0.50 μg/L to <20 μg/L.

2006 Dolphin received closure of the 2000 RCRA Consent Decree in June.

2008 ADEQ granted ALSCo an NFA determination for soil in March.
Terranext issued the Draft RI Report during October.

RID submitted comments to ADEQ on the Draft RI Report in December, requesting immediate action to mitigate groundwater contamination impact on RID wells and water operations.

2009	In early 2009, RID initiated voluntary remedial actions to address the groundwater contamination impacting and threatening its wells within the WVBA Site.
	In September, RID met with the Potentially Responsible Party (PRP) Group to discuss response actions and settlement opportunities.
	In October, RID submitted the Draft ERA Work Plan[43] to ADEQ and entered into an agreement with ADEQ to conduct an ERA and FS.
2010	In early 2010, RID responded to public comments on the Draft ERA Work Plan.
	In June, ADEQ approved the Draft ERA Work Plan with conditions.
2011	In May, ADEQ issued the Proposed RO Report for public comment.
	In August, RID submitted the RID-95 Wellhead Treatment Systems Proposal.
	In September, ADEQ agrees to the RID-95 Wellhead Treatment Systems Proposal and Working Group submits Draft Feasibility Study Work Plan.
2012	In February, RID initiated treatment at well RID-95.
	ADEQ issued the Final RO Report and Terranext issued the Final RI Report in August.
	RID submitted a Modified ERA Work Plan in October.
2013	In February, ADEQ approves the Modified ERA Work Plan, and RID submitted Draft Feasibility Study Work Plan.
	RID submitted a Final Feasibility Study Work Plan in June.
	In July, ADEQ approved the RID Feasibility Study Work Plan, and Working Group submitted its Final Feasibility Study Work Plan.
	In August, ADEQ approves the Working Group's Feasibility Study Work Plan.

[43] Further explanation of RID response actions following submittal of the Draft ERA Work Plan are included in Section 2.4.2.

2.4 EARLY RESPONSE ACTIONS

Pursuant to AAC R18-16-405, an ERA is authorized to address current risks to public health, welfare, and the environment; to protect or provide a supply of water; to address sources of contamination; or to control or contain contamination where such actions are expected to reduce the scope or cost of the remedy needed at the site. The following sections describe the ERAs conducted or currently underway at the WVBA Site.

2.4.1 Facility-Specific Response Actions

ADEQ conducted an ERA at the ALSCo facility to address a known source of VOC contamination. The ERA was initiated to reduce VOC concentrations in soils and control the migration of VOCs to, and in, groundwater beneath the facility. As part of the ERA, a SVE, air sparge (AS), and groundwater extraction and treatment remediation system were installed and operated periodically from 2001 to 2003. Confirmation sampling following system shut down indicated that the ERA remedial action objectives (RAOs) were accomplished. The ending soil gas PCE and TCE concentrations indicated that the unsaturated zone RAOs of 20 μg/L for PCE and 14 μg/L for TCE were met, and VOC concentrations detected in downgradient wells were similar to those in upgradient wells. According to a 2006 WVBA Site *Fact Sheet* prepared by ADEQ (ADEQ, 2006a), over 900 pounds of VOCs were removed by the SVE/AS system before it was shut down in October 2002. The groundwater pump and treat system was shut down in September 2003 after treating approximately 118 million gallons of groundwater and removing 24 pounds of VOCs.

2.4.2 Roosevelt Irrigation District Early Response Actions

RID currently is conducting a voluntary ERA to address the widespread threat and impact of COCs on its wells and water supply in the WVBA Site. The groundwater contamination in the WVBA Site has impacted[44] or threatens to impact all 32 of the RID water supply wells located within the WVBA Site boundary and at least one down gradient well.[45]

[44] *See* Agreement to Conduct Work between ADEQ and RID, dated October 8, 2009 (ADEQ determined that releases or threatened releases of hazardous substances have occurred, resulting in groundwater contamination that has impacted multiple RID water supply wells which may present an imminent and substantial endangerment to the public health, welfare or the environment within the WVBA Site). (ADEQ, 2009)

[45] RID well 82 is located at 83rd Avenue and McDowell, approximately one mile beyond the currently defined western boundary of the WVBA Site. In sampling conducted in March 2014, RID well 82 had 3.53 μg/L PCE and 1.22 μg/L TCE.

Pursuant to AAC R18-16-405.I, the RID ERA is "necessary" as a matter of law because "[i]n considering whether an early response action is necessary to protect or provide a supply of water because a well is threatened by contamination, a well located in the area within ¼ mile upgradient, ½ mile cross-gradient and 1 mile down-gradient of the areal extent of contamination at the site shall be presumed to be threatened by the contamination." RID's wells and water supply in the WVBA Site already are either impacted or threatened by COCs in the groundwater as defined in AAC R18-16-405.I. The RID ERA was initiated voluntarily and is "necessary" to mitigate threats and impacts to RID wells, its operations and water uses; to mitigate current risks to public health from exposures to contaminants in the groundwater and to contaminants that volatilize into the air; to reduce the scope and costs of the final groundwater remedy; and, ultimately, to provide RID with unrestricted use of its water supply for all reasonably foreseeable end uses.[46]

In early 2009, RID initiated voluntary remedial actions to address the COC groundwater contamination impacting and threatening its wells and water supply in the WVBA Site. These actions began shortly after the ADEQ Draft Remedial Investigation Report (Terranext, 2008) was issued. From early 2009 to the present, RID has attempted to engage stakeholders in order to develop a cost-effective regional groundwater remedy. Significant milestones in this process are as follows:

- Jan 2009: RID and ADEQ meet with EPA to discuss remedial actions
- Feb 2009: RID meets with ADEQ and Attorney General's Office to discuss proposed remedial actions
- Feb 2009: RID attends WVBA Community Advisory Board (CAB) meeting
- Sep 2009: RID meets with PRP Group to discuss response actions and settlement opportunities
- Oct 2009: RID submits Draft Early Response Action Work Plan to ADEQ
- Oct 2009: RID enters into agreement with ADEQ to conduct voluntary ERA and FS in the WVBA Site
- Dec 2009: RID attends and presents at WVBA CAB meeting
- Jan 2010-Jun 2010: RID responds to public comments on RID ERA Work Plan
- Mar 2010: RID attends and presents at WVBA CAB meeting
- Jun 2010: ADEQ grants approval of the RID ERA Work Plan with conditions
- Sep 2010: RID holds meetings with prospective contractors to conduct ERA work
- Jun 2011: RID attends and presents at WVBA CAB meeting
- Jul 2011: RID releases Request for Qualifications (RFQ) for design/build/own/operate for RID-95 Wellhead Pilot Treatment Systems

[46] *See* AAC R18-16-405.A.

- Aug 2011: RID submits RID-95 Wellhead Treatment Systems Proposal to ADEQ
- Sep 2011: ADEQ agrees to RID-95 Wellhead Treatment Systems Proposal
- Sep 2011: RID issues Notice to Proceed for RID-95 Wellhead Pilot Treatment Systems
- Feb 2012: RID initiates treatment at RID-95
- Mar 2012: RID submits Technology/Design Demonstration Report to ADEQ: RID-95 Pilot System completed, treatment initiated at three (3) additional treatment sites pursuant to RID-95 Wellhead Treatment Systems Proposal
- Jul 2012: RID submits Draft Modified ERA Proposal to ADEQ
- Aug 2012: ADEQ issues Final RI Report
- Oct 2012: RID submits Modified ERA Work Plan to ADEQ
- Dec 2012: RID attends and presents at WVBA CAB meeting
- Dec 2012-Jan 2013: RID responds to public comments on Modified ERA Work Plan
- Feb 2013: ADEQ issues approval of RID Modified ERA Work Plan with conditions
- Feb 2013: RID submits Draft Feasibility Study Work Plan to ADEQ
- Feb 2013-Jun 2013: RID responds to public comments on RID Draft Feasibility Study Work Plan
- Apr 2013: RID completes the Long-Term Operational Assessment of wellhead treatment systems and submits report to ADEQ
- Apr 2013: RID attends and presents at WVBA CAB meeting
- Jul 2013: ADEQ approves RID Feasibility Study Work Plan

The original ERA Work Plan submitted by Montgomery & Associates (M&A) in February 2010, on behalf of RID, included four (4) conceptual components: 1) a new priority pumping regimen for the RID well field to maximize removal of COCs from the groundwater and to protect RID's threatened wells while maintaining current annual groundwater withdrawal rates and meeting the seasonally variable demand of RID's customers; 2) construction of a new centralized groundwater treatment facility (CGTF) to reliably remove COCs and reduce their concentrations to meet standards acceptable for all reasonably foreseeable end uses of the waters of the state in the WVBA Site; 3) physical improvements to selected RID wells and canals to control emission of COCs from water to air and to control exposure to COCs; and 4) discharge of remediated water supply to the RID Main Canal for irrigation use or to a delivery system for potable use.

Under the original ERA Work Plan, the ERA would predominantly use existing RID pipelines and canals to convey up to a nominal 20,000 gallons per minute (gpm) of contaminated groundwater pumped from the 10 most highly contaminated RID wells to the CGTF that would be constructed on RID property adjacent to the Main Canal at 84th Avenue. A new pipeline would be constructed from the terminus of the Salt Canal at 83rd Avenue to the CGTF. Separate new pipelines would be installed later in the ERA to convey groundwater with lower VOC concentrations (RID wells 105, 109, and 110) south to the Main Canal and to convey groundwater with higher VOC concentrations (RID wells 89, 92, 95, and 100) north to the Salt Canal and then to the CGTF for treatment. Installation of these pipelines would enable treatment of impacted groundwater from RID wells with the highest COC concentrations, which would afford public health and welfare protection from the higher concentrations of these contaminants and provide substantial COC mass removal from the environment during the ERA.

Under the original ERA Work Plan, the new treatment facility would remove thousands of pounds of COCs from the groundwater annually and discharge remediated water of sufficient quality for all RID current and reasonably foreseeable end uses. Under state law,[47] no remedial or response action can reduce the quantity of RID's water supply or restrict the quality of RID's water supply from its "maximum beneficial use" or its "current or reasonably foreseeable end uses."

The objectives of the voluntary RID ERA remedial action are:

- To protect and provide a water supply from the most highly contaminated RID wells in the WVBA Site that is protective of all RID current and reasonably foreseeable municipal, agricultural, and industrial end uses; and,
- To address current and future risks to public health, welfare and the environment from exposures to contaminants in the groundwater that are known to volatilize into the air when pumped from the most highly contaminated RID wells.

ADEQ approved the original ERA Work Plan[48] with conditional tasks in a letter dated June 24, 2010 (ADEQ, 2010a). The conditional tasks included a public health exposure assessment, well investigations, groundwater modeling and engineering studies. The work conducted for each task is summarized in **Appendix A**.

[47] *See* ARS § 49-282.06.A.2 and B.4.b

[48] Contrary to claims by parties identified as Potentially Responsible Parties (PRPs), who may be liable for the costs incurred to address the groundwater contamination, ADEQ's approval of the original RID ERA Work Plan was a formal approval that is protected by statutory protections like any ADEQ-approved permit. *See* Letter from Henry Darwin, ADEQ Deputy Director, to David Armstrong, attorney for SRP, re: ADEQ Response to Request for Interim Decision (Oct. 13, 2010) (declaring that "ADEQ's June 24, 2010 approval of RID's February 3, 2010 ERA Work Plan is a final decision" and that "ADEQ has and will continue to evaluate RID's adherence to [procedures, statute and rule] … and if compliance is not achieved revoke the approval under the appropriate legal procedures." (ADEQ, 2010b)

A Modified ERA Work Plan (Synergy, 2012d) was submitted by RID to ADEQ on October 19, 2012 to improve upon the original ERA (M&A, 2010a). The Modified ERA Work Plan proposed using wellhead treatment systems at select RID well sites in lieu of the central groundwater treatment facility. The modification to the original ERA was proposed in order to provide a more cost-effective approach to protect the RID water supply while achieving all of the statutory and regulatory requirements for an ERA.

The Modified ERA Work Plan provided a more efficient approach to address these objectives and incorporated information and insights gained from the conditional tasks prescribed by ADEQ in the original ERA Work Plan approval letter and the RID-95 Wellhead Treatment Systems Proposal (summarized in **Appendix A**). The modifications proposed to the ERA were consistent with WQARF program authority[49] and certain[50] stakeholder input submitted to ADEQ during the public comment period of the original RID ERA. Among those substantial comments, a recurring critique was that the proposed original RID ERA, as approved by ADEQ, was large, costly, technically complex, and unsound to treat huge volumes of water at a centralized plant. Specifically, the comments noted that,

- *"…the contaminated plume can be remediated in a far more efficient approach by focusing on contaminant source areas and zones of highest contaminant concentrations."* (City of Phoenix, 2010b)
- *"…RID does not mention the possibility of targeting the wells with the highest levels of contaminants … numerous reasonable options could be envisioned for targeting "hot spots" in the West Van Buren Plume … this option could result in the targeted removal of contaminant mass at similar levels as RID's proposal, but with a much more simplified system and at much lower cost."* (Honeywell, 2010)
- *"Groundwater pump-and-treat, if selected as an ERA or a final remedy, should focus first, and perhaps only, on areas having the highest concentrations within the plume. This strategy has proven to be very effective in the Motorola 52nd Street Operable Unit 2 groundwater extraction system."* (Dolphin, 2010)
- *"…an effective early response action would consider* [among other listed elements] *… strategically located capture wells for containing the regional plume … supplemented with pumping at the leading downgradient edge of the plume … some or all of the groundwater*

[49] AAC R18-16-405.H.3.
[50] Substantial stakeholder comments were received from parties that are identified as PRPs for releases of hazardous substances and have vested interests in avoiding remedial actions that will impose costs to address site-wide groundwater contamination. Additionally, certain parties with professed competing water rights raised comments that are in direct contradiction to RID's basic right provided by the WQARF program, pursuant to AAC R18-16-411.G, that allows any water provider to take necessary actions, **in its sole discretion** (emphasis added), to implement an ERA that will address the use of its impacted or threatened wells in a WQARF site.

could be treated to reduce the transfer of VOCs from the current plume to the air." (Salt River Project, 2009)

Based on the insights and information indicated above, the Modified ERA Work Plan proposed the following modifications to the original ADEQ-approved ERA Work Plan, which are consistent with the prior stakeholder comments:

- Utilization of wellhead treatment at the most highly contaminated RID wells and blending to effectively reduce the concentration of VOCs from several additional wells, with lower contaminant concentrations, to achieve target water quality. This approach will result in a lower volume of contaminated water being directly treated while providing a higher total volume of contaminated well water that will be remediated to meet applicable MCLs to ensure protection of all RID current and reasonably foreseeable water supply end uses.
- Elimination of approximately 25,000 feet of north-south lateral pipelines between the southern tier wells and the Salt Canal; and
- Elimination of the gravity pipeline between the end of the Salt Canal and the RID Maintenance Yard (i.e., the central water treatment facility location).

The proposed modifications also provided additional ancillary benefits believed to result in the following performance improvements as compared to the original ERA Work Plan:

- Reduce capital costs by approximately 50%, from approximately $34 million to approximately $18 million;
- Reduce operation and maintenance (O&M) costs by approximately 50%, from approximately $3.0 million to $4.0 million per year to approximately $1.5 million to $2.0 million per year;
- Enable blending of treated water with untreated water from wells having lower contaminant concentrations along the Salt Canal, thereby increasing the total volume of contaminated well water that will be remediated to meet applicable MCLs by approximately 50%;
- Significantly reduce the time required to implement the early response pump and treatment action due to the simplified and modular nature of the wellhead treatment systems (compared to central water treatment facility) and the elimination of the complex and disruptive construction of north-south lateral pipelines; and,
- Reduce the scope and cost of the groundwater remedy at the WOC WQARF Site by addressing the groundwater contamination that is migrating into the WVBA Site and impacting and threatening to impact RID's water supply wells.

ADEQ approved the Modified ERA Work Plan with conditions on February 1, 2013 (ADEQ, 2013a). As provided by ADEQ in that letter, ADEQ's approval is subject to the following conditions:

1. RID must maintain historical pumping rates to ensure that there are no adverse impacts to groundwater quality and levels; and,
2. RID must follow through on the commitment to implement measures to limit exposures to public from the contamination being released from the RID water systems.

RID has maintained historical pumping rates in the RID wells located in the WVBA Site and will continue to do so until modeling has demonstrated that increased extraction at the most highly contaminated RID wells with wellhead treatment will not adversely impact groundwater levels in the region or groundwater quality. RID also implemented volatilization control measures at the four (4) RID wells with wellhead treatment and enclosed one of the laterals used to convey impacted groundwater. RID intends to continue to implement these engineering control measures to limit potential public exposure and has included these measures in each of the groundwater alternative remedies considered in this FS Report.

Pursuant to the Agreement to Conduct Work with ADEQ, dated October 8, 2009, RID is committed voluntarily to implementing the Modified ERA Work Plan as well as conducting the Feasibility Study. RID also is committed to implementing any of the groundwater alternative remedies evaluated in this FS Report that may be selected by ADEQ as the final groundwater remedy and intends to modify Section 5 of the current Agreement to Conduct Work accordingly. This commitment is consistent with RID's intention to exercise its "sole discretion" to implement the final regional groundwater remedy as provided in AAC R18-16-411.G.

2.5 PUBLIC INVOLVEMENT

Public participation and community relations activities during the FS process has and will adhere to the community involvement requirements of AAC R18-16-404 and ADEQ's *Community Involvement Plan for West Van Buren WQARF Site, Phoenix, Arizona* (CIP) (ADEQ, 2011a). Consistent with the CIP, ADEQ will lead the public outreach and coordinate public communication and comments. Specific community involvement activities may include the preparation and distribution of public notices describing the availability of this FS Report for public review and participation in public meetings to discuss the document. ADEQ's future efforts will continue the Agency's practice of complying with the public participation requirements of the WQARF program evident during the RI reports, RID's ERA, the RO Report and the FS Work Plan. In fact, ADEQ maintains an Internet website[51] that contains a large number of relevant documents about the WVBA Site, including the public participation efforts.

In order to broaden communication outreach and enhance transparency, RID, in coordination with ADEQ, will continue to deliver messages and information through the various communications channels and platforms developed for its ADEQ-approved ERA. These channels and platforms may include one-on-one briefings, group presentations, electronic and print media, and web-based communications. RID has continually used these various channels and platforms to reach out to the local community and involve stakeholders during the past four (4) years regarding all work activities undertaken at the WVBA Site. Specifically, RID has participated in over 50 separate meetings with various external stakeholders including the EPA, ADEQ, ADWR, Central Arizona Project (CAP), community leaders, individual PRPs and PRP groups, elected officials, COP, COT, City of Avondale, City of Goodyear and City of Buckeye.

RID has been diligent in its efforts to keep the public informed of planned and on-going field programs. RID hand delivered informational flyers, in both English and Spanish, to residents and businesses in the areas where installation of RID's wellhead treatment systems were planned (to date about 1,000 flyers have been provided) and continues to distribute email updates of monthly progress reports and other project information to interested parties. Likewise, RID offers tours of the treatment facilities to interested parties to inform them of RID's treatment progress.

RID has been involved in every WVBA CAB meeting since December 2009. Although the WVBA CAB has not met very regularly, RID has approached ADEQ and offered to provide presentations to the WVBA CAB at more frequent intervals to update the CAB on the progress of the ADEQ-approved ERA and the RID-95 Wellhead Pilot Treatment Systems Initiative. Despite the lack of WVBA CAB meetings, RID developed and continues to maintain an Internet website[52] that contains updated information on RID's work activities and provides all relevant information relating to the ADEQ-approved ERA that is accessible to the general public.

The Community Involvement Area for the WVBA, as described in the CIP, is located in Congressional District 7. The WVBA also is located within the boundaries of Legislative Districts 19, 27, and 30, COP Council Districts 4, 7, and 8 and Maricopa County Supervisors District 5. The following elected officials represent these affected districts:

- Congressional District 7: Representative Paul Gosar

[51] Accessible through ADEQ Waste Programs page or http://www.azdeq.gov/environ/waste/sps/wvb.html
[52] http://www.wvgroundwater.org

- Arizona Legislative District 19: Senator Anna Tovar
Representative Lupe Chavira Contreras
Representative Mark A. Cardenas

- Arizona Legislative District 27: Senator Leah Landrum Taylor
Representative Norma Munoz
Representative Catherine Miranda

- Arizona Legislative District 30: Senator Robert Meza
Representative Jonathan Larkin
Representative Debbie McCune Davis

- Phoenix City Council District 4: Councilwoman Laura Pastor

- Phoenix City Council District 7: Councilman Michael Nowakowski

- Phoenix City Council District 8: Councilwoman Kate Gallego

- Maricopa County Supervisor District 5: Supervisor Marie Lopez Rogers

RID, in coordination with ADEQ, will provide periodic briefings and updates to elected officials in the WVBA to assure that they are informed with regards to the ongoing remediation efforts and the development and implementation of a final groundwater remedy.

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3.0 SITE CHARACTERIZATION

This section describes the geology and hydrogeology of the WVBA and adjacent areas, identifies the contaminant sources, and summarizes the nature and extent of contamination at the WVBA Site.

3.1 GEOLOGY

The following describes geologic conditions of the West Salt River Valley (SRV) and WQARF/CERCLA sites in the eastern portion of the West SRV basin.

3.1.1 Regional

The WVBA Site and adjacent regional contaminant sites are located in the West SRV in a broad sediment-filled basin formed as a result of basin-and-range structural development that mostly occurred between 15 and 8 million years ago (Brown and Pool, 1989). Basin and Range physiography typically consists of flat, arid valleys or basins alternating with and bounded by narrow uplifted mountain chains. Crustal extension, which caused the downward faulted sedimentary basin, created a large structural depression that contains more than 11,000 feet of basin-fill sediments in the central part of the West SRV (Brown and Pool, 1989). Basin fill sediments derive from the surrounding mountains and through-flowing streams such as the Salt, Gila, and Agua Fria rivers. The West SRV basin is almost completely surrounded by mountains composed of granitic, metamorphic and volcanic rocks.

The geology of the West SRV is well known (Brown and Pool, 1989; Corkhill et al., 1993) through interpretation of available lithologic, geologic, and geophysical data from the drilling of deep wells throughout the West SRV. Generally,[53] the basin fill deposits are differentiated into three (3) distinctive hydrogeologic units that are referred to as (from oldest to youngest) the: Lower Alluvial Unit (LAU), Middle Alluvial Unit (MAU), and Upper Alluvial Unity (UAU).

According to the Final RI Report, the sedimentary basin-fill units are semi-consolidated to unconsolidated Late Tertiary to Quaternary deposits consisting of interbedded cobbles, gravel, sand, silt, clay, and evaporites. The lithologic relationships appear to represent alluvial fan, flood plain, and playa deposits formed in a closed basin during the early and middle stages of basin development followed by fluvial and alluvial fan deposits formed during the late stages of basin development after the establishment of through-flowing drainages (Corkhill et al., 1993).

[53] This discussion of regional sedimentology excludes the Red Unit. According to Brown and Pool (1989), the Red Unit was deposited prior to the basin-and-range structural development and is found mostly in the southeast part of the West SRV.

The following descriptions taken from Brown and Pool (1989) and Terranext (2012) provide a basic overview of the three (3) principal basin-fill sedimentary units:

Lower Alluvial Unit

The LAU consists mainly of conglomerate and gravel grading into mudstones in the center of the basin. The unit generally is fine-grained with coarser-grained facies at the basin margins and at depth. The LAU is subdivided into lower and upper parts. Both parts are generally fine-grained, but differ in consolidation, homogeneity, types of evaporite deposits and structure. The lower part of the LAU is moderately to well-cemented mudstone, siltstone, sand and gravel containing significant gypsum, anhydrite, and halite. The upper part of the LAU is weakly to moderately cemented and consists of silt, clay, mudstone, siltstone, and gypsum with interbedded sand and gravel. The LAU may be as much as 1,000 feet thick at basin margins and more than 10,000 feet thick in the center of the basin.

The depth to the LAU is not well understood due to the gradational transition between the LAU and overlying MAU and the fact that few wells have been drilled into the LAU. Moreover, lithologic descriptions found in driller's logs are often open to interpretation. However, based on the available records from RID deep wells in the WVBA Site, the MAU/LAU contact is thought to occur at a depth of around 760 feet below land surface (bls) in well RID-95. To the north in the WOC WQARF Site, the LAU contact was believed to be reached at a depth of 912 feet bls (GeoTrans, 2004).

Middle Alluvial Unit

The MAU overlies the LAU and consists of weakly consolidated, but moderately to well-cemented silt, clay, silty sand, and gravel. Collectively, the MAU contains more than 40 percent sand and gravel throughout most of the basin. Generally, grain size decreases downward in the MAU. The MAU ranges in thickness from 0 to 800 feet in the West SRV. The contact between the LAU and MAU is gradational, but distinguishable by a greater bedding frequency or heterogeneity and a buff or brown color as opposed to red-brown. The uppermost interval of the MAU is characterized by a clay layer at least 40 feet thick, that is typically described as a hard brown clay or sticky brown clay.

Upper Alluvial Unit

The UAU consists of unconsolidated Quaternary-aged silt, sand, and gravel that extend from the top of the MAU to ground surface. The gravel-size sediments can be quite coarse and include cobbles and boulders. UAU sediments range in thickness from 200 to 500 feet.

3.1.2 West Van Buren Area

Geology in vicinity of the WVBA Site is known based on numerous wells that have been drilled as part of remedial investigations conducted to characterize groundwater conditions and contaminant distribution. In this regard, the bulk of the monitoring is focused on characterizing contamination in the UAU. For example, within the WVBA Site, ADEQ currently monitors 145 groundwater monitor wells screened in the UAU and only eight (8) groundwater monitor wells screened in the MAU. ADEQ monitor wells have not been completed in the LAU within the WVBA Site.

Terranext (2012) prepared six geologic cross-sections across the WVBA Site from available well logs. The cross-sections and the boring and geophysical logs used to develop the interpretation are included in the Final RI Report. The cross-sections feature interpretation of the UAU and upper MAU. Based on this information, Terranext (2012) generated the following observations regarding alluvial unit stratigraphy in the WVBA Site, many of which carry forward the interpretation developed by Weston (2000) as the conceptual model for the Central Phoenix Plume Model (CPPM).

Upper Alluvial Unit

Based on distinctions of UAU lithology, the UAU is differentiated as two sub-layers referred to as UAU1 and UAU2. The uppermost layer, UAU1, is comprised of loose surface soils grading downward into inter-fingered sand and gravel lenses. When present, clay layers are usually characterized as clayey sands. The loose surface soils comprising the uppermost UAU1 interval consist of unconsolidated mixtures of clay, silt, and sand that may extend to depths ranging from approximately 10 feet bls in the vicinity of ChemResearch facility to 50 feet bls at the Dolphin facility. Below these depths, the unsaturated zone predominantly consists of gravels and cobbles with varying amounts of sand, clay, and silt. Depths to groundwater currently range from 75 to 140 feet bls (Terranext, 2012).

The UAU1 layer ranges in thickness from approximately 170 to 310 feet bls. Although the unconsolidated sediments are dominantly coarse-textured, the UAU1 appears to become finer-grained near the western boundary and in the northwest portion of the WVBA Site. The transition between UAU1 and underlying UAU2 is gradational and characterized by an increase in clay content until clays dominate the lithologic horizons. The thickness of the UAU2 is variable, ranging from approximately 30 to 260 feet or greater. In general, the UAU2 tends to be finer-grained to the south and west.

Middle Alluvial Unit

Fewer well data are available to characterize the MAU geology in the WVBA Site. The Final RI Report includes minimal site-specific description of MAU sediments other than the unit has a marked increase in the amount of fine-grained materials present and the upper contact of the MAU is characterized by at least 40 feet of material referred to as hard brown clay or sticky clay. The UAU/MAU contact is typically picked at the top of this clay interval, which is encountered at depths ranging from 260 to 500 feet bls. The depth to the MAU contact generally increases from east to west across the WVBA Site. The thickness of the MAU at the RID-95 well location is inferred to be 400 feet.

3.1.3 Motorola 52nd Street CERCLA Site

Geologic characterization in the adjacent Motorola 52nd Street (M52) CERCLA Site, located to the east, is primarily focused on the UAU. The unconsolidated UAU sediments in the vicinity of the M52 Site are underlain by bedrock composed of sedimentary, volcanic, and crystalline rock that generally slope downward from east to west (Reynolds and Bartlett, 2002). Although groundwater and contaminant movement between the alluvium and fractured bedrock occurs in the eastern portion of the M52 Site (ADEQ, 2011b), it is not overly significant in the area immediately upgradient of WVBA and will not, therefore, be further considered.

The UAU within the M52 Site is principally differentiated into an upper interval primarily composed of coarse-grained sands and gravels that overlie a lower interval composed of massively bedded fine-grained silt or clay with sand (ERM, 2010). The upper interval, as the focus of widespread, area-wide contaminant investigations, is further subdivided into a shallow zone of Salt River Gravels and an intermediate zone of interbedded coarse and fine-grained basin-fill deposits. According to Reynolds and Bartlett (2002), the Salt River Gravels include rocks not found in local mountains and represent deposits of the ancestral Salt River whereas basin-fill deposits are finer-grained and more cemented than Salt River Gravels, and represent lithologies that are mostly locally derived. Some investigators further define the intermediate zone as having two intervals of basin-fill that are separated by a fine-grained layer (ADEQ, 2011b).

The UAU stratigraphy in the M52 Site is substantially similar to that in the WVBA Site. Although not differentiated to the same degree, the UAU1 horizon in the WVBA Site appears to correlate to the shallow and intermediate hydrostratigraphic zones in OU3. The deep basin-fill zone in OU3 correlates to the UAU2 horizon in the WVBA Site. Geologic cross-sections depicted in the *OU3 RI/FS Work Plan* indicate the coarse, gravelly deposits of the shallow and intermediate zones extend to depths of approximately 200 to 220 feet bls, and the thickness increases to the west (ERM, 2010). Further, the shallow zone (Salt River Gravels) extends eastward into the

M52 OU2 area, and the intermediate zone (upper basin-fill) is present in all three M52 OUs (ADEQ, 2011b).

3.1.4 West Osborn Complex WQARF Site

Geologic characterization in the adjacent West Central Phoenix (WCP) Area to the north also is focused on the UAU. As indicated by wells at the WOC Site penetrating the UAU, the unconsolidated UAU basin-fill sediments extend from ground surface to a depth of 287 feet bls (GeoTrans, 2004). At most of the deeper borings, three or four subunits of the UAU can be recognized, including in descending order: 1) an upper fine-grained horizon that is approximately 50 to 70 feet thick; 2) an upper coarser-grained subunit which is referred to as the Shallow Groundwater System (SGWS) and is about 70 feet thick; 3) a middle fine-grained unit (MFGU) that may be 120 feet thick; and, 4) a lower sand and gravel subunit (LSGS) that is approximately 40 feet thick (GeoTrans, 2004).

The UAU lithology in the vicinity of the WOC Site is reported to be more fine-grained than observed in the main portion of the WVBA Site to the south. In particular, the WOC Site RI/FS reports indicate silty sediments dominate the bulk of the UAU in the WOC Site, and the coarse gravelly sediments are much less prominent (limited to the distinctive SGWS and LSGS horizons). Stratigraphically, the UAU subunits recognized at the WOC Site, which extend to the continuous LSGS interval encountered at depths of around 245 to 285 feet bls, appear to correlate to the UAU1 sub-layer in the WVBA. Sediments that may correlate to the UAU2 sub-layer in the WVBA Site are not present in the vicinity of the WOC Site or are otherwise not differentiated from the predominantly fine-grained MAU.

3.2 HYDROGEOLOGY

The following describes hydrogeologic conditions of the West SRV and WQARF/CERCLA sites in the eastern portion of the West SRV basin.

3.2.1 Regional

In the West SRV, groundwater occurs in the UAU, MAU and LAU, and is stored and moves under different regimes based on hydraulic properties within the aquifer units. The following information, taken from Brown and Pool (1989) and Terranext (2012), provides a basic overview of regional hydrogeologic conditions in the West SRV.

Groundwater movement in the West SRV is generally in response to water inflow and outflow to the basin. Major sources of inflow include infiltration and recharge from agricultural and urban irrigation, canal leakage, and river channels during flow events. Outflow to the basin is primarily due to groundwater pumping. Groundwater movement is generally to groundwater depressions created by groundwater withdrawals. For example, notable pumping centers in the vicinity of the Luke Air Force Base and WVBA Site have had a significant impact on the regional flow system. Where groundwater flow is not affected by local pumping centers, flow is generally to the west.

Groundwater levels have fluctuated across the West SRV over time, dependent on the occurrence and changes in pumping and surface water infiltration. Development of irrigated agriculture and the effects it has had on both groundwater recharge and discharge from the West SRV caused significant impact to groundwater flow conditions in the early half of the 20th Century. In the more recent decades since the 1940s, however, groundwater flow conditions have been relatively stable (Bartlett et al., 2006).

Hydraulic properties vary between and within the alluvial aquifers due to notable heterogeneities that exist across the West SRV. As reported by Brown and Pool (1989), groundwater in the UAU is unconfined and the most permeable and productive of the hydrostratigraphic units. Wells completed within the UAU yield between 1,500 and 5,500 gpm. Hydraulic conductivity in the UAU ranges from 50 to 1,700 feet per day (ft/d) and transmissivity from 150,000 to over one million gallons per day per foot (gpd/ft).

Groundwater in the underlying MAU and LAU is under confined (Weston, 2000) to leaky and semi-confined conditions (Brown and Pool, 1989). Yield to wells in the MAU and LAU is appreciably less than the UAU, ranging from several hundred to 2,000 gpm. Hydraulic conductivity in the MAU and LAU is generally in the range of 3 to 60 ft/d whereas transmissivity is estimated to range from 0 to 150,000 gpd/ft. According to Terranext (2012), it is apparent from pumping data and observed water level responses in nearby wells that the three units are hydraulically interconnected.

3.2.2 West Van Buren Area

The Final RI Report provides detailed hydrogeologic information and site-specific data to document water levels, hydraulic gradients, and aquifer properties within the WVBA Site. This information is derived from on-going monitoring conducted at the WVBA Site since at least 1993 and is incorporated into the conceptual model developed by Weston (2000) for the CPPM. The following are notable highlights of the available information in the Final RI Report, particularly as it relates to evaluating hydrogeologic conditions for the final groundwater remedy in the WVBA Site:

- Groundwater movement within the WVBA Site is predominantly controlled by pumping and the areal distribution of Salt River recharge. Groundwater pumping by RID represents the major outflow from the groundwater system within the WVBA Site.
- Since 1993, water levels in both shallow and deeper wells have declined over 35 feet. The decline in water levels appears to have stopped within the past two years and was most likely due to prevailing drought conditions, which increased groundwater withdrawals and reduced surface water quantities for infiltration.
- Water level monitoring data indicate that UAU groundwater levels fluctuate on a semi-annual basis, with water levels lower in the summer and higher in the winter. The fluctuations primarily correspond to seasonal pumping of RID water supply wells during the summer months.
- Groundwater elevations within UAU1 indicate groundwater flow in the eastern portion of the WVBA Site is generally in a westerly direction, while in the north-central portion of the Site (between approximately 35th and 63rd Avenues) groundwater flow is to the south.
- Water level monitoring data indicate that there are vertical gradients between the UAU and MAU indicative of both upward and downward vertical flows.
- Information on hydraulic properties within the WVBA Site was compiled using aquifer tests performed by ADEQ and others. Transmissivity values in the vicinity of the WVBA Site were found to range from 4,000 to 160,000 gpd/ft in wells completed across multiple aquifer units. These values correspond to a hydraulic conductivity of the UAU ranging from 5 to 700 ft/d.

RID pumpage within the WVBA Site[54] has ranged from around 75,000 to 94,000 acre-feet (AF) per year from 2008 to 2012, with an annual average of about 83,500 AF. As noted in the Final RI Report, pumping of this magnitude exerts significant hydraulic control on area-wide groundwater within the WVBA and the upgradient WOC and M52 Sites. RID pumping is very seasonal with monthly groundwater withdrawal, in the period 2008 through 2012, ranging from a low of 1,372 AF in December to almost 10 times that amount, or 11,294 AF, in July. The demand for water in the summertime frequently requires pumping of all RID wells in this area at their maximum groundwater extraction rate of around 85,000 gpm.

RID has conducted investigations at select RID water supply wells that add to the understanding of WVBA Site hydrogeology. Based on an ADEQ request that was part of the Agency's approval of RID's original ERA Work Plan (M&A, 2010a), RID conducted investigations at wells RID-92, RID-95, and RID-111R. Summary information regarding the well investigation activities were submitted to ADEQ in *Technical Memoranda* dated July 25, 2011 (M&A, 2011a) and January 11,

[54] Consisting of 33 RID wells, designated by consecutive well numbers RID-82 through RID-114.

2012 (M&A, 2012) for RID-95 and June 21, 2013 for RID-92 (Synergy, 2013b) and RID-111R (Synergy, 2013c). A summary of the key findings of the Phase I Well Investigations was submitted to ADEQ in a letter dated March 5, 2014 (Synergy, 2014).

The well investigation work conducted by ADEQ provides meaningful information to validate and add to the understanding of the conceptual site model developed during the WVBA Site RI and incorporated in the FS groundwater model. Specifically, the findings of the recent RID well investigations indicate:

- Well video logs indicate casing integrity is adequate for continued use as extraction wells in groundwater remedial actions and can withstand mechanical well rehabilitation to sustain production capacity.
- The bulk of fluid flow in the RID wells was from the UAU and largely from depths that correspond to the UAU1 interval. For example, approximately 73 percent of the water entering well RID-92 was from above the pump intake set at 280 feet bls. At newly installed RID-111R, which did not have the mineral encrustation and build-up observed in older RID wells, an estimated 82 percent of the total groundwater yield to the well entered from the uppermost interval to a depth of 253 feet bls.
- Analysis of depth-specific samples obtained during pumping at wells RID-92 and RID-95 indicate the VOC contamination impacting the wells is almost exclusively restricted to the UAU, and predominantly yielded from the UAU1 subunit.
- Groundwater flow within the UAU is not uniform and data obtained at RID-111R highlight the vertical heterogeneity of fluid flow. Spinner logging data obtained while pumping RID-111R demonstrated that 1,500 gpm of the 2,500 gpm yield of the well was derived from a 30-foot interval from 223 to 253 feet bls.
- The transmissivity of the UAU is estimated to range from 110,000 to about 168,000 gpd/ft, based on drawdown and recovery data obtained during the short duration pumping tests conducted at RID-111R, a new well completed in the UAU only.[55]
- Groundwater flow from the MAU was not observed during the pumping and testing of RID-92 and RID-95. Groundwater flow from the LAU was observed in deep well RID-95.[56] Fluid flow measurements made at RID-95 under non-pumping conditions identify an upward vertical hydraulic gradient where groundwater from about 700 to

[55] As discussed with ADEQ, RID-111R was installed to enable the well investigation task that was stipulated by ADEQ as a condition of the original ERA Work Plan approval to proceed expeditiously and be completed during RID high demand periods.
[56] The need to brush and remove heavy mineral deposition on the RID-95 well casing likely impacted the hydraulics of the well in subsequent fluid flow investigations, possibly resulting in different flow conditions than during prior well operation.

1,100 feet bls enters the well, moves upward at an estimated rate of 80 to 100 gpm, and exits the well in the UAU interval above a depth of about 320 feet bls.

3.2.3 Motorola 52nd Street CERCLA Site

Groundwater flow within the M52 OU3 Study Area is primarily found within the unconsolidated UAU. The top of the groundwater table has been measured at 50 to 85 feet bls. As indicated by historic groundwater elevation data, the primary direction of groundwater flow within all UAU subunits is toward the west and southwest (ERM, 2010). The proximity of the Salt River to the OU3 Study Area may result in seasonal variations in hydrogeologic conditions in response to flood-related events. Surface water flows in the normally dry Salt River reportedly change the groundwater flow to a more westerly (ERM, 2010) or northwesterly direction (Bartlett et al., 2006), depending on the location within the M52 Site.[57]

The distinguishing hydrogeologic characteristic of the UAU in this area relates to the respective permeabilities of the main hydrostratigraphic subunits. According to Reynolds and Bartlett (2002), the basin fill is generally finer-grained and more consolidated and cemented than the Salt River Gravels. Although interbedded gravel lenses may readily transmit water, the basin-fill hydraulic conductivity is observed to range from 1 to 60 ft/d. In contrast, Salt River Gravels, due to their coarseness and general lack of fines, have considerably higher hydraulic conductivity ranging from between 200 and 450 ft/d (Reynolds and Bartlett, 2002). The westward thickening and wedge-shaped geometry of the Salt River Gravels result in greater hydraulic transmissivity in the western parts of the M52 Site.

3.2.4 West Osborn Complex WQARF Site

In the vicinity of the WOC Site, there are two principal subunits in the saturated portion of the UAU that are the focus of remedial investigations and actions, the SGWS and LSGS. According to the RI Report for the WOC Site (GeoTrans, 2004), the SGWS is composed of unconsolidated silts and sands typically present at a depth of 70 to 130 feet bls. Average transmissivity values for the SGWS at the WOC Site range from 2,600 to 56,000 gpd/ft and hydraulic conductivity ranges from 35 to 210 ft/d. The direction of groundwater flow in the SGWS away from the WOC Site is generally in a southeasterly to southerly direction. Groundwater flow is more southwesterly in the southern portion of the WOC Site. Lining of the SRP Grand Canal in vicinity

[57] These findings for the M52 OU3 Study Area are consistent for the entire M52 Site. Groundwater at OU1 and OU2 occurs within the unconsolidated sedimentary deposits, and the UAU is the primary focus of contaminant investigation. The depth to groundwater ranges from approximately 25 to 95 feet bls, and groundwater flow direction is to the west. ADEQ and EPA, *2011 Sitewide Five-Year Review Report, Motorola 52nd Street Superfund Site, Phoenix, Arizona*, 12-13. (ADEQ, 2011b)

of the WOC Site is said to have contributed to rapidly declining water levels and potential dewatering of part of the SGWS.

The LSGS consists of sands and gravels that may be 40 feet thick at the base of the UAU. According to the RI Report for the WOC Site (GeoTrans, 2004), the LSGS is the most significant water-bearing zone in the vicinity of the WOC. Aquifer tests show that it also has the capacity to transmit large quantities of water. Reported transmissivity for the LSGS is estimated at 86,000 to 104,000 gpd/ft and hydraulic conductivity ranges from 350 to 380 ft/d. The direction of groundwater flow in the LSGS away from the WOC Site is generally in a southwesterly to south-southwesterly direction.

A sequence described as the MFGU that is over 100 feet in thickness separates the more permeable SGWS and LSGS. Other than to refer to the MFGU as an aquitard, little or no information is presented in the WOC Site RI Report to characterize hydrogeologic conditions of the MFGU. Based on the significantly different response to recharge and pumping in the area exhibited by the SGWS and LSGS, hydraulic communication between the units is believed to be minimal.

3.3 IDENTIFICATION OF CONTAMINANT SOURCES

The Final RI Report provides results of approximately 50 soil and/or groundwater investigations conducted by facility owners and operators at suspected source areas within the WVBA Site. The following subsections summarize facility-specific investigations and resulting actions, as well as identify contaminant sources from the adjacent regional groundwater contaminant sites.

3.3.1 West Van Buren Area Facilities

As a result of over 20 years of ADEQ investigations, the Final RI Report provides and references considerable data that document the types of contaminants, observed concentrations, facility locations, and source area remediations within the WVBA Site. ADEQ has conducted or directed numerous facility investigations that are summarized in Section 2.0 (*Previous Investigations*) and Section 4.2 (*Source Investigations*) of the Final RI Report. The findings indicate that over 50 facilities in the WVBA Site were determined to have had documented COC contamination in soils or soil gas. These facilities were investigated by ADEQ or requested by ADEQ to conduct subsequent work to determine if their soil contamination exacerbated site-wide groundwater contamination. As noted in the Final RI Report, ADEQ decided to focus on the following nine facilities[58] for subsequent ADEQ source area investigations within the WVBA Site:

- Air Liquide America Specialty Gases, LP (ALASG);
- ALSCo;
- ChemResearch;
- U.S. Department of Energy (USDOE);
- Dolphin;
- Maricopa County Materials Management (MCMM);
- Prudential Overall Supply (POS);
- Reynolds Metals; and,
- Van Waters & Rogers (now Univar USA, Inc.).

The Final RI Report provides a comprehensive summary of facility-specific investigations and source control remedial actions that have been conducted at the nine (9) facilities identified above. According to the Final RI Report, ALSCo, Dolphin, MCMM, Reynolds Metals, and Univar have conducted soil remedial actions and satisfied ADEQ's requirement for No Further Action associated with soil remediation. Soil investigations and/or remediation are still in progress at the ALASG, POS, and USDOE facilities. Information provided in the Final RI Report indicates that remediation of VOC-impacted soil at the ChemResearch facility has not been performed. **Appendix B** summarizes facility operations, investigations and remedial activities conducted at each facility, as originally presented in the Final RI Report.

3.3.2 Motorola 52ND Street CERCLA Site

The M52 Site encompasses the regional groundwater contamination plume to the east of the WVBA Site as shown in **Figure 2**. The M52 Site is generally defined by the extent of contaminated groundwater that underlies a 7-mile stretch of a highly urbanized region of east-central Phoenix from just east of Sky Harbor Airport (around 52nd Street) to downtown Phoenix. EPA proposed listing the M52 Site on the National Priorities List (NPL) in 1984, final listing occurred in 1989, after investigation at the former Motorola facility, located at 5005 E.

[58] The rationale to exclude certain facilities from further groundwater investigations is unclear since it appears a number of facilities never completed the investigative work required by ADEQ. Additionally, as noted in stakeholder comments to ADEQ on the Draft RI Report, at least 16 of the 42 facilities where further investigations were not performed had detectable concentrations of at least one VOC in soil (Univar USA, Inc. 2008). It is indicated that this is particularly significant because soil investigations conducted to determine the releases of VOCs in soils were done at a time when soil sampling did not include procedures to minimize VOC loss during sampling. Consequently, Univar stressed that the presence of VOCs in soils indicated the potential for the presence of an onsite source of VOCs to groundwater. It is important to note that these VOCs are not naturally occurring and the presence of the VOCs in the soil must have resulted from a release at the facility.

McDowell Road, revealed VOC contamination in soil, groundwater, and bedrock underlying the facility. TCE was the major groundwater contaminant identified and found to occur in dissolved phase and as a non-aqueous phase liquid (NAPL).[59] Freescale Semiconductor has since acquired the Motorola 52nd Street facility and assumed Motorola's CERCLA liability at the M52 Site in 2004.

The M52 Site is subdivided into three operable units: OU1, OU2, and OU3. As previously mentioned, the M52 Site is a federal site under CERCLA authority. Although the M52 Site is a federal CERCLA site, EPA designated ADEQ as the lead agency for oversight of OU1 and OU2 on the basis that interim groundwater remedies have been developed and implemented at these OUs to address impacted groundwater.

OU1

In 1988, prior to final NPL listing, ADEQ and EPA approved a groundwater recovery and treatment program as an interim remedy, and entered into a Consent Order with Motorola in 1989 for a groundwater containment and SVE remedy that established OU1 to partially clean up VOC contamination in soil and groundwater. The remediation area addressed by this groundwater containment remedy encompasses approximately 500 acres of the former Motorola facility and immediate downgradient area (URS Corporation, 2011). Expanded groundwater treatment began in 1992 and included off-site extraction of groundwater designed to contain contaminant migration at the Old Crosscut Canal at approximately 46th Street.

The initial groundwater extraction flow rate was 810 gpm with treatment by a combination of air stripping and polishing by liquid-phase granular activated carbon (LGAC). Vapor controls using vapor-phase GAC (VGAC) were used to remove VOCs in air stripper off gas. Treated groundwater from the OU1 remedy was originally used by Motorola and its successors for on-site manufacturing operations and later discharged to the COP sanitary sewer. According to the most recent *OU1 Effectiveness Report* (Clear Creek Associates, 2013), groundwater remedial actions at OU1 have resulted in extraction of 3,436 million gallons of contaminated groundwater and removal of an estimated 22,736 pounds of VOCs removed as TCE from project inception in 1992 through 2012. Due to regional water level declines from extended drought, the average pumping rates of groundwater extraction wells have declined to 234 gpm in 2012.

[59] Due to the fact that the specific gravity of TCE is greater than that of water, it is often referred to as a dense non-aqueous phase liquid, or DNAPL, to more precisely describe its characteristics.

OU2

Further investigation of the area downgradient of OU1 led to EPA designation of OU2 in the region encompassing the contaminant plume from 46th Street to 20th Street. Covering approximately 3,800 acres, the OU2 area is primarily located south of Arizona State Route 202 (or Loop 202) and north of Sky Harbor Airport (URS Corporation, 2011). At the time OU2 was established, TCE contaminated groundwater migrating downgradient of OU1 and the former Motorola facility was the primary known source of contamination in OU2. By 1992, however, remedial investigations conducted by Honeywell indicated large and widespread releases of VOCs to soil and groundwater at the Honeywell facility at 111 South 34th Street, and EPA identified Honeywell as a PRP under CERCLA in the M52 Site. According to EPA (2009a), an estimated 10 million pounds of TCE and 16 million pounds of TCA were purchased for use at the Honeywell facility between 1952 and 1995. TCE and TCA and their break down products[60] are the major groundwater contaminants identified at the Honeywell 34th Street facility and occur dissolved in groundwater and bulk jet fuel found as free product in the subsurface. Honeywell was required to further characterize and address contamination at the 34th Street facility under ADEQ administrative actions and conduct soil removal, SVE, and free product removal as interim remedial measures.

Within the OU2 area, Motorola, and subsequently Honeywell, were required to delineate the extent of contamination and design, construct, and operate a groundwater extraction and treatment system. In July 1994, ADEQ and EPA issued a Record of Decision (ROD) selecting an interim OU2 groundwater remedy that was to further contain contaminated groundwater in the region downgradient of OU1. The primary ROs of OU2 are to establish a capture zone across the entire north-south width and depth of the contaminant plume and to reduce

[60] Researchers have identified the following compounds as daughter compounds of TCE, TCA, and PCE degradation: (1) 1,1-dichloroethene (DCE); (2) 1,2-DCE; (3) 1,1-DCA; (4) chloroethane; (5) chloroethene; (6) ethanol; (7) acetic acid; and, (8) carbon dioxide. Suzanne Lesage, Richard E. Jackson, Mark W. Priddle, & Peter G. Riemann, *Occurrence and Fate of Organic Solvent Residues in Anoxic Groundwater at the Gloucester Landfill, Canada*, 24 Environmental Science and Technology, 559, 564 (1990) (providing a flowchart of parent compounds degrading into daughter compounds). Researchers and EPA have taken the position that abundant sources of organic carbon, including fuel hydrocarbons, are a driving force behind the chemical reactions, which create chlorinated daughter compounds inside VOC-contaminated groundwater. *See* EPA, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*, 3, 23-26 (1998) (explaining that the chemical reaction facilitated by organic carbon is "reductive dechlorination") (EPA, 1998). In fact, ADEQ reviewed leaking underground storage tanks as potential sources for VOC-contaminated groundwater *"because of the potential for petroleum hydrocarbon contamination to facilitate natural biodegradation of VOCs."* ADEQ, *Final Remedial Investigation Report, WCP East Grand Avenue WQARF Site, Phoenix, Arizona, 2-15* (ADEQ, 2006b). As noted in Honeywell's Additional Site Characterization Work Plan (April 2003), "an important aspect of the presence of fuel hydrocarbons is the chlorinated solvent biodegradation (anaerobic dechlorination) stimulated by the fuel hydrocarbons. … Therefore, the areas at the Site where anaerobic biodegradation of chlorinated solvents is enhanced coincide with the areas of free-phase and dissolved-phase fuel hydrocarbons. … In summary, detection of the chlorinated solvent byproducts of TCE and 1,1,1-TCA in groundwater samples collected from groundwater monitor wells indicates that reductive dechlorination occurs within and downgradient of the Honeywell Site."

contaminant concentrations within the alluvial aquifer upgradient of the extraction wells. The major components of the selected remedy, as modified by the *Explanation of Significant Differences* (EPA, 1999) dated September 1999, are:

- Installation of wells and extraction of groundwater in the vicinity of Interstate 10 and Van Buren Street;
- Treatment of extracted groundwater to drinking water standards using carbon adsorption and ultraviolet oxidation at a treatment plant located near extraction wells; and,
- Discharge of treated water to the SRP Grand Canal for agricultural irrigation and livestock watering.

The interim OU2 groundwater remedy was started in late 2001 and consisted of three (3) extraction wells and a central treatment facility. The extraction wells were drilled to the bedrock contact and are generally screened across the basin-fill and Salt River Gravel subunits to depths up to 220 feet bls. The OU2 groundwater extraction and treatment system was designed to treat 5,300 gpm, but has averaged 2,450 gpm in more recent years due to dewatering of the alluvium (URS Corporation, 2011). The OU2 interim groundwater remedy has extracted 12.341 billion gallons of contaminated groundwater and removed an estimated 13,715 pounds of VOCs from project inception in 2001 through 2012 (Conestoga-Rovers & Associates, 2013).

OU3

To address comingling of regional VOC plumes hydraulically downgradient of OU2, EPA and ADEQ established the boundaries of the OU3 Study Area in 1997. The OU3 Study Area is directly west of OU2 and is bordered on the north by McDowell Road, on the west by 7th Avenue, and on the south by Buckeye Road (URS Corporation, 2011). EPA has directed PRPs to conduct facility-specific work and an area-wide RI (EPA, 2010). A working group, composed of Honeywell and Arizona Public Service, is conducting RI/FS work for the OU3 Study Area.

Sky Harbor International Airport Area

Before the establishment of OU2 and OU3 by EPA, those areas were being investigated by ADEQ as part of the East Washington Area (EWA) WQARF Site, which was originally placed on the WQARF Registry as a priority site in November 1987. Early investigations in the EWA WQARF Site listed a number of facilities in the area of SHA as requiring further investigations. In 1989, the COP obtained a list of “218 Sky Harbor facilities, including both current and past tenants and areas of concern,"[61] which was further screened down "because the list was so extensive" to 61 Sky Harbor facilities that would be further assessed in greater detail in a Phase I WQARF Study. The Phase I WQARF Study was conducted during April through July of 1990 and identified "six areas of potential environmental concern … for further study."[62] Although the Phase II WQARF Study was intended "to investigate COP areas of potential environmental concern … and evaluate if these areas may have contributed to the VOC contamination detected in the groundwater in the vicinity of [Phoenix Sky Harbor]," ADEQ's hydrologist reviewing the Phase II Study Results in 1994 acknowledged and noted that "no attempt appears to have been made to find patterns or draw specific conclusions which might point to a potential source."[63] However, ADEQ's "hydrology support staff believe this [contribution] has already been confirmed" and determined that *"the contaminant plumes from the sources in each site* [EWA, SHA and M52] *have merged into one large plume."*[64]

Although the COP rescinded its request for matching WQARF funding to continue the SHA investigation, ADEQ chose to maintain the funding for investigations in SHA Area by assuming the project from the COP. Despite ADEQ's recommendation that SHA should be absorbed into EWA,[65] SHA was not included in OU2 when EWA was absorbed by the M52 Site.[66] Nevertheless, ADEQ continues to consider SHA to be part of the M52 Site.[67] The M52 Site boundaries of OU2 encompass a portion of SHA and will be treated as part of OU2 for the purposes of this FS Report.

[61] Camp Dresser & McKee and Earth Technology Corporation, Facility Prescreening Results (November 7, 1989)
[62] COP, Work Plan for the Phase II WQARF Study of Phoenix Sky Harbor International Airport, 1-3 (September 1992). According to various ADEQ documents, groundwater data within SHA have exceeded the AWQSs/MCLs for the target COCs. For example, according to the preliminary assessment of the former Aviola building, which is part of the Acquired Western Commercial Area that the COP identified as a potential source area in the Phase I WQARF Study, TCE was detected at 56 µg/L. Another monitor well, WSH-20, located close to the former Aviola building detected TCE at 50 µg/L in a November 24, 1992 sampling event. Likewise, according to another report, June 2000 sampling detected TCE above 15 µg/L at three monitor wells located near the West Sky Harbor Fuel Storage Area, which the COP identified as a potential source area (under the name of the Old Aircraft Maintenance Area) in the Phase II Work Plan). These potential sources may have contributed to the contamination of other downgradient wells and monitor wells (such as ADOT wells and monitor wells at the Garrett and Hertz facilities) where TCE and other target COCs have exceeded AWQSs/MCLs.
[63] Memorandum from Keith Ross, ADEQ Hydrologist, to Linda Burgess, ADEQ Project Manager, re: "Phoenix Sky Harbor WQARF Phase II Study Results", January 5, 1994. (ADEQ, 1994a)
[64] Memorandum from Jeff Kulon, ADEQ Project Manager, to Al Brown, ADEQ Manager, re: "Sky Harbor/East Washington WQARF Sites", August 18, 1994. (ADEQ, 1994b)
[65] *Ibid.*
[66] According to ADEQ's 2011 Statewide Five-Year Review of the M52 Site, OU2 is *"adjacent to the western boundary of OU1 and the eastern boundary of OU3* [and] *primarily located south of State Route 202 and north of Sky Harbor Airport."* (ADEQ, 2011b)
[67] Email from Scott Clink, ADEQ Records Administrative Services Officer, to Stuart Kimball, re: "ADEQ File Request", June 2, 2014. (ADEQ, 2014b)

Potentially Responsible Parties in M52 Site

There are numerous PRPs identified in the M52 Site. Motorola is a listed PRP in both OU1 and OU2, and Honeywell is designated as a PRP in OU2. In addition, according to ADEQ's Narrative Site Information for the M52 Site, on September 3, 2003, EPA issued CERCLA General Notice letters to the following companies in OU2:

- D-Velco Manufacturing of Arizona
- Honeywell International, Inc.
- COP
- U.S. Air Force
- ITT Industries
- Kachina Technical Services and Processes, Inc.
- Phoenix Industrial Properties, Ltd.
- Joray Corporation
- Laundry and Cleaners Supply, Inc.
- Papago Plating Company, Inc.
- B and G Investments
- Thomas and Nancy Stonebraker

According to information presented by Terranext (2012) in the WVBA Final RI Report, the following parties have been identified as PRPs at OU3:

- Arizona Public Service/Pinnacle West Capital Corporation
- Arvin Meritor/Adobe Air/Cooper Industries
- Baker Metal Products
- Capitol Engineering
- Fruehauf Trailer Sales/Wabash National Trailer Centers
- McCoy's Laundry and Dry Cleaners
- Milum Textile Services Company
- Phoenix Newspapers
- Salt River Project
- Walker Power Systems/Tierney Turbines
- Union Pacific Railroad
- Westinghouse

According to ADEQ records,[68] the following facilities were within the scope of the investigation being conducted by the COP in SHA:

- Arizona Wholesale Supply
- Continental Airlines
- DynAir Tech.
- Lockheed Air Terminal
- Arizona Tool Products
- C.S.&W Contractors
- Frontier Airlines
- Pacific Southwest Airlines
- Pride Expeditors
- PSA/US Air
- Sky Harbor Airport Airline Maintenance
- Trans World Airlines
- Transco
- United Airlines
- Wien Air Alaska

Groundwater in M52 Site

Groundwater monitoring data obtained from the many environmental investigations conducted in the M52 Site indicate groundwater flow and contaminant transport in UAU groundwater is east to west. EPA (2009a) found that "*groundwater contaminated by VOCs from the former Motorola (now Freescale Semiconductor) and Honeywell facilities, as well as other potential sources within OU1 and OU2 commingle and flow westward into OU3, where it commingles with sources within OU3*."[69] As a result, "*groundwater data indicate that TCE, 1,1-DCE, and PCE (to a lesser extent) groundwater contamination originates from the OU3 area east of Seventh Avenue and flows into the WVBA Site from the east*."[70]

ADEQ reviewed groundwater monitoring data throughout the M52 Site to evaluate the effectiveness of interim groundwater remedies implemented at OU1 and OU2 and reported their findings in the *2011 Sitewide Five-Year Review Report* (URS Corporation, 2011). In general,

[68] Memorandum from David Hawkins to Lowell Carty, Project Manager for East Washington WQARF Site, re: "List of facilities to be evaluated in the East Washington Study Area" (ADEQ, 1989). However, as noted above, the COP initially identified 218 facilities within the SHA Site, but not all of these were investigated.
[69] Findings of Fact, Administrative Settlement Agreement and Order of Consent for Remedial Investigation and Feasibility Study, Motorola 52nd Street Superfund Site Operable Unit 3, USEPA Region 9, Docket No. 2008-17, (EPA, 2009a).
[70] WVBA Site Final RI Report (Terranext, 2012)

ADEQ concluded that the remedies appear to be achieving the primary goal of the remedial actions, which is containment of VOC-contaminated groundwater in the alluvial aquifer. Data from the monitor well network indicate the actions are effectively decreasing TCE concentrations in the vicinity of the groundwater extraction wells and in the alluvial groundwater plume west of the extraction wells. These results support the conclusion that the extent of the contaminant plume is likely reducing downgradient of the extraction system and migration of contamination into downgradient OUs is being mitigated. In particular, it is noted that the width of the TCE plume has narrowed in OU3 in all UAU hydrostratigraphic subunits, with the deepest unit demonstrating the least change in TCE concentrations over time.

3.3.3 West Osborn Complex WQARF Site

Contaminated groundwater north of the WVBA Site between 27th and 51st Avenues is associated with the WCP Area and is being managed by ADEQ. The WCP Area was placed on the WQARF Registry as a priority site in 1987 and later divided into five (5) separate WQARF Registry sites in 1998: 1) East Grand Avenue, 2) West Grand Avenue, 3) North Plume, 4) North Canal Plume, and 5) West Osborn Complex (WOC), of which the WOC is the southernmost site and, therefore, most closely associated with the WVBA Site.

The WCP-WOC WQARF Site encompasses the groundwater contamination plume to the north of the WVBA Site as shown in **Figure 2**. According to the *ADEQ Registry Report*[71] for the WCP-WOC Site prepared by ADEQ, the WOC was originally one large property encompassing about 15 acres built in the late 1950s. Since the 1950s, many companies have operated at the site, manufacturing electronic components. Many of these businesses used industrial solvents such as TCE in their production and cleaning processes. Former employees and documents indicate that TCE and other chemicals were disposed into septic tanks and seepage pits.

As indicated in the Final RI Report, three (3) facilities have been identified as likely sources of groundwater contamination in the WOC Site:

- United Industrial Corporation (UIC)
- Corning Inc./Components Inc.
- NUCOR Corporation

UIC, based on requirements set forth in a Consent Decree that was lodged in Federal District Court in February 1996, has conducted a RI/FS and agreed to pay for a part of the WOC Site groundwater cleanup.

[71] Information obtained from the ADEQ Web Site:
http://www.azdeq.gov/environ/waste/sps/download/phoenix/wcpega/wcpwocb.pdf

Remedial Objectives for the WOC Site were formalized in the May 2005 *Remedial Objectives Report* prepared by ADEQ. With regard to water use, the required treatment of the extracted contaminated groundwater to drinking water standards is based on the reasonably foreseeable end uses of groundwater from the site for drinking water purposes identified by the COP and SRP. Moreover, in determining the treatment technology applied to the site remedial actions, GeoTrans (2012a) concluded that treatment should ultimately achieve drinking water standards, defined as MCLs and AWQSs, for the COCs due to the general drinking water protected use classification for all Arizona aquifers under ARS § 49-224.

GeoTrans, on behalf of UIC and their successors, prepared and issued the WOC Site RI Report in July 2004, the Final WOC Site FS Report for the SGWS in January 2012, and the Final WOC Site FS Report for the LSGS in May 2012. Among the findings in the RI/FS reports, it is reported that:

- Manufacturing operations at the WOC Site began in 1957 and chlorinated solvents including TCE were used in the manufacturing processes. Use of chlorinated solvents continued into the 1980s.
- There was no municipal sewer system in place when the WOC Site began operations, and the operators used on-site septic tanks and seepage pits for wastewater disposal. Five septic tanks and 17 seepage pits were found at the facility.
- TCE, PCE, and TCA were observed in samples of septic tank contents and in seepage pits and underlying soils at concentrations up to 85,000, 550, and 98 micrograms per kilogram (μg/kg), respectively. An interim SVE remedy was implemented to achieve short-term removal of VOCs in soils. A total of 447 pounds of VOCs were extracted by SVE and treated between June 1999 and October 2002.
- Chlorinated solvents released to subsurface soils migrated downward to the SGWS found at a depth of around 70 to 130 feet bls. Upon encountering the SGWS, the VOCs began dissolving in groundwater and flowing south where a relatively large area has been impacted by plume migration. TCE concentrations as high as 600 μg/L were observed on site in the SGWS and are between 100 and 200 μg/L in the core of the plume.
- Downward infiltration of solvents in the saturated zone was stopped by the higher clay content in the MFGU that underlies the SGWS.
- VOCs found in the LSGS, at a depth of approximately 300 feet bls, are thought to derive from conduit flow in an irrigation well located at the WOC Site. The VOC plume currently extends to the west-southwest of the facility. The irrigation well was abandoned in 2004.

- Treatment technology used to address groundwater contamination would require air controls to provide a high degree of public protection against potential exposure to VOCs in air.

The FS reports (GeoTrans, 2012a and 2012b) evaluated alternative approaches to address groundwater contamination at the WOC Site that ultimately resulted in proposed groundwater remedies for the SGWS and LSGS. The following remedial actions have been selected by ADEQ as groundwater remedies:

- Pursuant to the Final WOC Site Proposed Remedial Action Plan (PRAP) issued for the SGWS (URS, 2013a), the selected remedy consists of the installation of an estimated 30-gpm groundwater pump and treat (P&T) system for hydraulic containment and remediation of contaminated groundwater at the WOC Site. The P&T system is for source control of the groundwater contamination emanating from the WOC Site as well as the North Canal Plume WQARF Site. Extracted groundwater would be treated using LGAC to achieve drinking water standards for COCs and discharged to the SRP Grand Canal for irrigation end use. In addition, the WOC Site PRAP includes groundwater monitoring to evaluate the efficacy of Monitored Natural Attenuation (MNA) to address the larger portion of the plume, which has migrated downgradient (south) of the WOC Site.

- Pursuant to the WOC Site PRAP issued for the LSGS (URS, 2013b), the selected remedy consists of MNA of the contaminant plume and provisions for specified remedial measures at COP and SRP groundwater supply wells should the water providers need to operate the wells. If the COP chooses to use WOC Site groundwater prior to the conclusion of MNA, installation of a wellhead treatment system using LGAC to remove COCs at COP wells 70 and 71 is included in the Proposed Remedy. The Proposed Remedy concludes that SRP wells 9.5E-7.7N and 8.5E-7.5N in the WOC Site would not be pumped in the future. If SRP should require water from these wells, the Proposed Remedy provides for the purchase of replacement water. Provision of treatment or replacement water fulfills the water providers' ROs.

3.3.4 Areas of Uncertainty

With respect to the M52 Site, a great deal of investigative work has been conducted and site conditions and contaminant fate and transport are reasonably well understood in OU1 and OU2. However, the level of understanding of the nature and extent of groundwater contamination is not as well defined in the OU3 Study Area (EPA, 2009a). Although work is underway to further investigate this area, the information is not yet available to determine whether and the extent to which remedial action is needed to prevent, mitigate or otherwise respond to contaminants in groundwater. In addition, some contaminant mass may still be migrating into OU3 from outside the capture zone of the OU2 interim groundwater remedy (URS Corporation, 2011).

With respect to the WOC Site, the RI/FS reports do not highlight critical data gaps and uncertainties that are important to understand the extent of dissolved phase contamination and contaminant fate and transport, particularly as it relates to the SGWS plume. In this regard, the report and graphical representations of the SGWS plume convey the impression that the lateral extent of the plume is known and delineated, when in reality there are no outlying monitor wells to delineate the extent of the SGWS plume to the south, east, and west. This point takes on particular significance regarding the extent of downgradient migration to the south given the reported southwesterly groundwater flow in the SGWS. The extent and magnitude to which the WOC Site plume has impacted the WVBA Site is not mentioned in the RI/FS reports. Instead, the WOC Site RI/FS reports depict and address the SGWS plume as if it ends at McDowell Road, the southern boundary of the WOC Site.[72]

The WOC Site RI/FS work also provides little information to understand the vertical extent of contamination underlying the SGWS. Although the RI/FS reports refer to the MFGU sediments underlying the SGWS as typically consisting of silt and clay and as an aquitard to vertical groundwater movement, lithologic logs included in the FS Report (GeoTrans, 2012a) indicate the sediments have significant amounts of sand, silt and gravel, particularly above 200 feet bls. The lithology suggests the significant potential of the upper UAU, not just the limited monitored interval designated as the SGWS, to laterally transmit water and groundwater contaminants.

The reliance on MNA as a groundwater remedial action[73] in the WOC Site is based on the assumption that there are no potential receptors of groundwater contaminants in the contaminant plume extending south of the WOC Site and that this non-exposure pathway will remain in the foreseeable future (GeoTrans, 2012a). This is a flawed assumption since the extent of SGWS contamination is not defined. Given that ADEQ has identified that TCE concentrations are entering the central portion of the WVBA Site from the north, it is likely that the shallow WOC Site groundwater contamination extends well into the WVBA Site and may have impacted existing wells within the WVBA and/or will do so in the foreseeable future.

Data presented in the WOC Site RI/FS reports also throw into question the effectiveness of MNA as a groundwater remedial action. The fact that there is an "*absence of TCE breakdown products (i.e. cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, ethene, ethane),*" as cited in the FS

[72] According to the Final RI Report, ADEQ notes that "TCE and other VOCs appear to be entering the central portion of the WVBA from the North" (*i.e.*, the WOC Site).
[73] MNA also was justified by GeoTrans because it was considered the most practical and least costly option since it involves no capital and O&M, which are associated with active remediation systems.

Report (GeoTrans, 2012a), points to the lack of on-going biodegradation as a removal mechanism. Further, sorption to organic materials is expected to play only a relatively minor role in the retardation of contaminant transport due to the low organic carbon content of the aquifer materials at the WOC Site (GeoTrans, 2004).

It also appears clear that sources other than the WOC Site have impacted shallow and possibly deeper contamination in the plumes at the WOC Site. In this regard, historical VOC releases associated with the nearby North Canal Plume and East and West Grand Avenue WQARF sites are suspected by GeoTrans (2012a and 2012b) to have commingled with groundwater contamination in the WOC Site plume.

With respect to the North Canal Plume, GeoTrans (2012a) asserts that lining of the SRP Grand Canal in 1998 modified prevailing gradients and flow in the SGWS. Prior to canal lining, mounding of water leaked from the canal created a groundwater divide beneath the canal that prevented southerly groundwater flow and contaminant transport from the North Canal Plume. Once the canal was lined, the mound dissipated and groundwater underlying the North Canal Plume Site migrated southwesterly with prevailing regional flow in the UAU, which is now evidenced by anomalous PCE, TCE and 1,1-DCE distributions in detached plumes in the WOC Site.

GeoTrans (2012a) also noted that anomalous TCE concentrations within the SGWS plume extending south of the WOC Site are likely from another source to the northeast. TCE concentrations at MW-204S, located over a half mile south of the WOC Site, are not consistent with the observed distribution of TCE in the WOC Site. GeoTrans believes the substantial TCE concentration in this area originates from sources in the West and East Grand Avenue WQARF Sites. The WOC Site FS Report notes in particular that high TCE concentrations have been observed at the East Grand Avenue source area and that because monitor wells have not been sampled in this upgradient area since 2002, the migration of contamination through the existing monitoring network may have been missed. The ADEQ Registry Report[74] for the East Grand Avenue WQARF Site indicates that groundwater underlying the Van Waters and Rogers facility in this area had TCE, PCE, and 1,1-DCE concentrations as high as 2,700, 1,800, and 290 μg/L, respectively.

3.4 NATURE AND EXTENT OF CONTAMINATION

As summarized in the previous section, site investigations have been conducted at numerous industrial and commercial facilities throughout the regional groundwater contaminant area

[74] Information obtained from the ADEQ Web Site:
http://www.azdeq.gov/environ/waste/sps/West_Central_Phoenix_East_Grand_Avenue.html

over the past 25 years. These investigations have identified many widespread sources of VOC contamination in soil and groundwater throughout the WVBA Site and adjacent regional groundwater contaminant sites. The impact of these source areas on area-wide groundwater has been documented by remedial investigations that include data from a network of over 100 monitor wells.

The following sections summarize the nature and extent of COCs and the potential routes of migration of these contaminants in the environment within the WVBA Site. While the scope of this assessment is focused on contaminant movement within the WVBA Site, a summary of the nature of groundwater contamination entering the WVBA from the M52 Site to the east and the WCP sites to the north is included to provide a more comprehensive picture (to define COC flux from external sources, from the adjacent groundwater contaminant sites, and COC flux within the WVBA Site).

3.4.1 Soil/Unsaturated Zone

The unsaturated zone within the WVBA Site is comprised of loose surface soils grading into interfingered sands and gravels with the uppermost portion consisting of unconsolidated mixtures of clay, silt, and sand that may extend to depths ranging from approximately 10 feet bls in the vicinity of ChemResearch facility to 50 feet bls at the Dolphin facility. Below these depths, the unsaturated zone predominantly consists of gravels and cobbles with varying amounts of sand, clay, and silt. Depths to groundwater currently range from 75 to 140 feet bls.

As discussed in Section 3.3, numerous facilities within the WVBA Site and adjacent M52 Site and WCP sites have documented releases of PCE, TCE, and other chlorinated VOCs that comprise the COCs in the regional groundwater contaminant plume. Releases of solvents in chemical products and wastes containing VOCs as a result of spills, leaks, discharges, and waste disposal practices provide a direct mechanism for downward vertical contaminant migration through the unsaturated zone and/or possibly migration as soil vapor to the land surface.

Terranext (2012) indicates that COCs released to surface or subsurface soils will migrate by unsaturated flow as either a dissolved component of infiltrating moisture in the unsaturated zone (given a low release rate) or as a dense non-aqueous phase liquid (DNAPL) (given a high release rate). The primary unsaturated flow of COCs is downward from the release source area. Aside from the rate of COC release, the rate of migration in the unsaturated zone depends on the form and chemical and physical properties of the COCs and physical properties of sediments in the unsaturated zone.

According to the Final RI Report, *"the overall coarse-grained nature of the unsaturated zone is generally not conducive to the retention of contaminants that may be released to the* *subsurface"* and will favor more rapid unsaturated flow and increase the likelihood of the contaminants reaching groundwater.[75] This is particularly true in the sand, gravel, and cobble interval of the UAU1 unsaturated zone within the WVBA Site and adjacent regional groundwater contaminant sites. Moreover, it is noted that any condition that shortens residence time within the unsaturated zone increases the amount of COCs entering groundwater. In this regard, some facilities used drywells, cisterns, septic tanks, seepage pits and other similar disposal systems to directly discharge solvent wastes, wastewater, and stormwater to the permeable subsurface.[76] The net result is that once VOCs are released to the surface or subsurface soils, unsaturated flow is primarily downward and typically continues until the groundwater table is encountered.

The physical and chemical properties of chlorinated solvents such as the target COCs make these substances particularly likely causes of groundwater contamination. PCE and TCE releases as a DNAPL and releases of their degradation byproducts (*e.g.,* DCE, DCA, and TCA) will move downward through unsaturated soils relatively rapidly, particularly in comparison to infiltrating groundwater, due to the low viscosity and interfacial tension of the VOC contaminants (Pankow and Cherry, 1996). These properties allow DNAPLs to readily enter into porous media, facilitating deep penetration into the subsurface.

Within the WVBA Site, depth to groundwater currently ranges from approximately 75 to 140 feet bls (Terranext, 2013). In past decades, when historic releases more likely occurred, groundwater levels were significantly higher resulting in a more direct and rapid pathway for contaminant transport to groundwater as well as greater potential for vapor flux from shallow groundwater contamination to migrate upwards to the ground surface.

Terranext (2012) also indicates that COCs released to the unsaturated zone can volatilize into soil gas, which will migrate upwards to the ground surface. Depending on the extent of facility development, the soil gas may discharge directly to the atmosphere, become trapped beneath impermeable structures, or migrate into structures either beneath or at ground surface.

This FS Report assumes that actions taken to date under ADEQ oversight have adequately characterized and addressed the known sources of hazardous substances impacting the surface and subsurface soils in the WVBA Site. It also is assumed that any additional source control actions that may be required to eliminate or mitigate a continuing source of contamination or address vapor intrusion will be facility-specific and subject to ADEQ's lead and oversight.

75 Terranext, 2012

76 *See* Memorandum from Michael Leach, ADEQ Hydrologist, to Tom Curry, ADEQ WQARF Coordination Unit, re: "Van Buren Tank Farm – Final Summary Site Assessment Report" (Feb. 26, 1990) noting that "contaminants from the other Van Buren Tank Farm facilities could also reach the water table by way of surface conduits (such as drywells) with very little detectable contamination of the vadose zone." (ADEQ,1990)

The scope of this FS will, therefore, not include source control actions for surface and subsurface soils in consideration of groundwater alternative remedies for the final groundwater remedy. Should any further information arise that identifies the need to address a presently unknown source of hazardous substances or loss or impairment of land use caused by contamination of surface and subsurface soils, it is further assumed that ADEQ will, independent of the WVBA Site groundwater remedy, assure that necessary actions are taken to remediate or control the hazardous substances causing the impairment or restriction to the land and/or groundwater use.

3.4.2 Groundwater

Information from the Final RI Report indicates that VOCs are prevalent in groundwater throughout a large portion of the WVBA Site. The data indicate widespread VOC contamination within the UAU and, to a significantly lesser degree, the MAU by TCE, PCE, 1,1-DCE, and other compounds that may be breakdown products. Further, the Final RI Report indicates that these same VOC contaminants are entering the WVBA Site from upgradient areas to the east (M52 Site) and north (WOC Site).[77]

Terranext (2012) indicates that PCE is the predominant COC for the WVBA Site. Although this may be true in terms of the magnitude of contamination detected historically within the WVBA Site, at present TCE occurs as prevalently, if not more so, than PCE. In fact based on data reported in first quarter 2013 (Terranext, 2013) and provided in **Table 1**, 52 of the 94 UAU monitor wells sampled have detectable PCE concentrations while 56 wells have detectable TCE levels. The maximum PCE concentration measured at this time was 87.5 μg/L at well AVB 119-01, whereas the maximum TCE concentration was 177 μg/L at well AVB 132-01. Additionally, concentrations of up to 31.7 μg/L cis-1,2-DCE, 29.4 μg/L 1,1-DCE, and 10.4 μg/L 1,1-DCA were observed. Based on this data and the recent EPA toxicity studies,[78] TCE is the more significant COC for the WVBA Site.

PCE and TCE are similarly prevalent in RID water supply wells in the WVBA Site and vicinity. Of the 33 RID wells in the WVBA Site, 22 wells had detectable PCE concentrations and 19 wells had detectable TCE concentrations when sampled in 2013 (see **Table 2**). The maximum PCE concentration measured at this time was 22.1 μg/L at well RID-106, whereas the maximum TCE concentration was 86.4 μg/L at well RID-92. The concentration of PCE, TCE, and 1,1-DCE in the RID water supply wells over time is shown on graphs provided in **Figure 3**.

[77] As discussed in prior sections, additional information prepared by and for ADEQ indicates VOCs from the upgradient SHA and other WCP sites are commingling with contaminants from the M52 Site and WOC Site and are entering into the WVBA Site.
[78] *See* footnote 21.

Given that groundwater within the WVBA Site largely moves in response to pumping, PCE and TCE contamination transport in groundwater is generally by advection, which is through bulk groundwater movement. Although chlorinated solvent compounds such as PCE and TCE may biodegrade under appropriate conditions, this occurs slowly, if at all, in aerobic groundwater such as the UAU (ERM, 2010). With exception of portions of the M52 Site, the SHA Site and the Phoenix Fuel Terminal, located between 51st and 55th Avenue along Van Buren Street, where bulk petroleum products leaked to shallow groundwater, conditions within the regional commingled groundwater contaminant plume are not conducive to biodegradation.

Concentrations of individual VOCs detected in RID water supply wells and at WVBA Site groundwater monitor wells are not uniform, and there are notable spatial variations that suggest multiple sources have contributed to the regional commingled groundwater contaminant plume, and are still contributing to the plume. The spatial variations in VOC concentrations are particularly evident in UAU1 groundwater in earlier representations of water quality data provided in the Final RI Report (e.g. years 1998 and 2003). Maps showing the distribution of PCE concentrations in UAU1 groundwater monitoring wells in 1998 and 2003 are provided in **Figures 4 and 5** and indicate relatively high PCE concentrations present in groundwater at four (4) locations, or hotspots, in the vicinity of:

- Monitor well AVB40—07 at the ALSCo facility;
- Monitor wells CMW-1 and AVB11-02 at/near the ChemResearch facility;
- Monitor well DIMW-1 at the Dolphin facility; and
- Monitor wells AVB92-01 and AVB-93-01 near the POS facility.

Additionally, there is a broad region of elevated PCE concentrations in an elongated plume from east of 43rd Avenue to around 59th Avenue midway between Van Buren Street and Buckeye Road.

Maps showing the distribution of TCE concentrations observed in these same wells in 1998 and 2003 are provided in **Figures 6 and 7** and show more extensive regions of elevated TCE concentrations as opposed to hot spots as defined by the PCE occurrence. For example, a broad region of relatively high TCE concentrations occurs in the east-central WVBA Site. This suggests that a plume of commingled TCE contamination originates from sources upgradient of the WVBA Site (e.g., the M52 Site) as well as within this portion of the WVBA Site. It should be noted that the apparent westward margin of this elevated TCE plume in the 1998 map, which extends to around 35th Avenue (**Figure 6**), is likely an artifact of not having sampled RID wells in the center of the WVBA Site (especially RID-89, -92, and -95; which have always shown consistently higher TCE levels) during this monitoring period. In 2003, when the RID water supply wells were sampled, the regional extent of TCE contamination was more clearly delineated. Additionally, as new monitor wells were sampled on the northern WVBA Site boundary in 2003, an additional source of TCE was delineated that correlates to the TCE plume that has migrated south of the WOC Site.

More recent maps depicting PCE and TCE occurrence in UAU1 and UAU2 groundwater monitoring wells are provided in **Figures 8 through 11**. As evident, the areal extent of PCE and TCE plumes is approximately the same as the earlier monitoring periods, but with the exception of relatively high TCE concentrations throughout the east-central WVBA, the COC concentrations have substantially declined. The MAU is indicated to have very limited impact with monitoring data indicating only two wells in the vicinity of 67th Avenue and Van Buren Street to be impacted above AWQSs.

High PCE concentrations that were historically observed at source areas such as the Dolphin, Inc. and ALSCo facilities have attenuated substantially over time. As reported in the Final RI Report, PCE concentrations, that were reported to be as high as 95,000 μg/L in 1998 from a groundwater sample obtained in the 70 to 90 feet bls interval of the uppermost UAU groundwater at the Dolphin facility, were found to be 10 μg/L in 2008. At the ALSCo facility, PCE concentrations that were reported to be as high as 42,000 μg/L in the UAU1 interval are presently 24.5 μg/L as of March 2013. At both sites, source control remedial actions appear to have substantially reduced PCE concentrations. The residual PCE levels at the Dolphin and ALSCo facilities no longer indicate DNAPL presence in the subsurface in these monitored intervals.

With respect to groundwater contamination entering the WVBA Site from the east, monitoring data in both the M52 Site and eastern part of the WVBA Site indicate M52 Site remedial actions are effectively decreasing TCE concentrations in the UAU groundwater plume. For example, as shown in **Figure 3**, since initiation of groundwater pumping of OU2 extraction wells in 2001, TCE levels at RID-114 and other RID wells in the eastern core of the WVBA plume have declined appreciably. The data suggest that the significant decline in TCE concentrations occurring at RID-114 by at least 2011 correlate to OU2 groundwater remedial actions to cut off and contain westward contaminant migration that began 10 years earlier. In this regard, the data trends are notable in documenting changes to water quality in RID water supply wells that are at least four miles downgradient from OU2 extraction wells within 10 years of remedy implementation. The data suggests particularly high rates of groundwater flow and contaminant transport and gives empirical substantiation of the highly transmissive nature of unconsolidated sand and gravel units within the UAU in this region. In response to the reduced mass loading associated with M52 Site interim groundwater remedies, TCE concentrations are expected to slowly decrease in the eastern portion of the WVBA Site over time.

With respect to groundwater contamination entering the WVBA Site from the north, the WOC Site Final FS Report (GeoTrans, 2012a) confirms a relatively large geographic area has been impacted by plume migration to the south of the WOC Site. Conservative contaminant concentrations derived from the central portion of the SGWS include TCE at 180 μg/L, PCE at 5 μg/L, and 1,1-DCE at 25 μg/L. Based on observed water quality data from the monitor well network in this area, as shown in **Figure 12**, the COC concentrations in the shallow groundwater plume extending south toward the WVBA Site have remained relatively constant over time and suggest persistent COC mass is migrating from the WOC Site to the WVBA Site. Additionally, other sources such as releases of COCs at the North Canal Plume and East Grand Avenue WQARF Sites may be contributing to the contaminant loading observed to the south of the WOC Site (GeoTrans, 2012a). The limited scope of the proposed WOC Site groundwater remedy is not anticipated to reduce COC mass loading entering the WVBA Site from the WOC Site.[79]

Sampling results from RID wells provide a useful basis to interpret water quality impacts within the WVBA Site. As opposed to monitoring wells that can only characterize discrete depth intervals of the contaminant plume, water quality data at RID water supply wells represent composite conditions throughout the primary zone of groundwater contamination since RID wells typically produce groundwater from the entire contaminated UAU aquifer. The historical trends of COC concentrations[80] in RID wells are indicators of area-wide fate and transport of COCs from the various source contributions.[81] As will be discussed in Section 7, differentiating the WVBA Site into five (5) specific regions based on the temporal and spatial COC concentration trends in the RID well field, as shown in **Figure 13**, helps define priorities for applied remedial strategies and measures to achieve a more focused and cost-effective final groundwater remedy for the WVBA Site.[82]

Eastern Core

Within this region, as shown in **Figure 14**, RID-110, RID-112, RID-113, and RID-114 are predominantly impacted by TCE at concentrations generally ranging from 10 to 100 μg/L, whereas PCE concentrations are consistently less than 5 μg/L. The largest TCE concentrations

[79] The Proposed Remedial Action Plan for the SGWS consists of 30 gpm groundwater extraction and treatment for source control at the WOC Site along with Monitored Natural Attenuation of the plume south of the WOC Site. Prevailing groundwater flow in the WOC Site is generally to the south in response to annual RID pumping of around 50,000 gpm of groundwater, on average.

[80] As mentioned in Section 2.2, PCE and TCE are the predominant COCs at the WVBA Site and will be the focus of the discussion that follows.

[81] With regard to area-wide groundwater contamination, ADHS (1992) completed a health risk assessment addressing the potential threat to drinking water wells in the WVBA vicinity. The study was conducted in anticipation of potential contamination of water supply wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in the WVBA Site.

[82] WQARF rules allow an approach that may incorporate different strategies for portions of the aquifer pursuant to AAC R18-16-407.E.1.

observed in this region occur at RID-114, which formerly had levels as high as 110 μg/L in 2006 that have declined to 45.6 μg/L in 2014. TCE concentrations in all wells in this region have similarly declined since the mid 2000s. The RID water supply wells in this region appear to be impacted by dissolved phase transport of TCE from multiple, indistinct releases in the eastern portion of the WVBA Site and in groundwater entering the WVBA Site from the M52 Site.

Southeast Lobe

Within this region, as shown in **Figure 15**, RID-99, RID-102, and RID-104 are almost exclusively impacted by PCE at variable but relatively low level concentrations ranging from about 5 to 10 μg/L. TCE, if detected, is typically found at concentrations less than 1 μg/L. RID-99 with a concentration of 8.3 μg/L PCE is the only well in this region that exceeds AWQSs. PCE concentrations in all wells appear to be declining somewhat. Commingled groundwater contamination within this region is more limited and localized.

Southern Flank

Within this region, as shown in **Figure 16**, RID-89, RID-92, and RID-95 are dominantly impacted by TCE at concentrations ranging from about 30 to 80 μg/L, although PCE also is observed at concentrations ranging from 5 to 20 μg/L. RID-92 has the highest TCE and PCE concentrations in this region at about 80 and 15 μg/L, respectively. TCE and PCE levels in the RID water supply wells in this region are not declining which suggests the wells are impacted by dissolved phase contamination that may be associated with continuing source contribution and/or the presence of DNAPLs, possibly from multiple sources. Recent monitoring data obtained at RID water supply wells along the Main Canal, such as RID-91, indicate TCE contamination is increasingly impacting threatened RID wells in this region.

North Central

Within this region, as shown in **Figure 17**, RID-107, RID-108, RID-109, and RID-110 are impacted by variable, but relatively lower level concentrations of both TCE and PCE ranging from 5 to 10 μg/L. RID-109 currently has the highest TCE and PCE concentrations observed in this region at about 10.6 and 7.2 μg/L, respectively. There are no clear spatial or temporal trends apparent in this region suggesting that multiple, indistinct sources, such as dissolved phase transport from local facility releases within the WVBA Site and from groundwater entering the WVBA Site from the WOC Site, are commingling and likely contributing to well impacts in this region.

Leading Edge

Within this region, as shown in **Figure 18**, RID-84 and RID-106 are predominantly impacted by PCE at concentrations ranging from 10 to 25 μg/L and lesser TCE concentrations. RID-106 currently has the highest PCE and TCE concentrations observed in this region at about 22 and 8 μg/L, respectively, although both wells had PCE concentrations at around 50 μg/L in the past. Over the past 10 years, COC concentrations have slowly declined indicating dissolved phase transport of PCE and TCE, likely attributed to multiple releases in the western portion of the WVBA Site. Even though the Final RI Report indicates the western boundary of the WVBA Site extends to around 75th Avenue, it should be noted that PCE and TCE contamination at 3.53 μg/L and 1.22 μg/L, respectively, is present in RID well 82, located at 83rd Avenue and McDowell.[83]

3.4.3 Potential Occurrence of DNAPLs

Groundwater within the WVBA Site is impacted by VOCs that are chlorinated solvents, which are denser than water. The potential presence of liquid-phase VOCs from releases of these chlorinated solvents (commonly referred to as DNAPLs) can serve as a long-term source of dissolved contaminant plumes and persist in groundwater over a long time. Studies at industrial sites show, with few exceptions, DNAPLs will tend to penetrate through the vadose zone into the groundwater where much of the DNAPL mass then accumulates to cause persistent contamination (Pankow and Cherry, 1996). According to EPA (1993), the presence of DNAPLs in soils and aquifers can control the ultimate success or failure of remediation at a site (as it relates to time to clean up). As indicated in a recent National Research Council's (NRC) publication entitled, *Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites* (2013), sites contaminated with DNAPLs like TCE and PCE are particularly challenging to restore because of their complex contaminant distribution in the subsurface. In this case, the NRC study concludes, "*complete restoration of contaminated groundwater is difficult, and in a substantial fraction of contaminated sites, is not likely to be achieved in less than 100 years*."[84]

DNAPLs are difficult to delineate in the subsurface and may often be undetected by direct methods (EPA, 1993), which lends support to the conclusion drawn in the Final RI Report (Terranext, 2012) that the presence of DNAPLs in the WVBA Site has not been adequately characterized. However, Terranext does state that the overall coarse-grained nature of the unsaturated zone is not conducive to the retention of contaminants and the heterogeneous nature of the vadose zone prevents contaminants from migrating uniformly through the unsaturated zone. Therefore, Terranext concludes it is difficult to collect soil and soil gas

[83] Based on RID well sampling conducted in March 2014.
[84] National Research Council, 2013

samples that may be ideally located for the detection and characterization of contaminants in the unsaturated zone. Moreover, as Pankow and Cherry (1996) have noted, conventional site characterization methods are usually not effective in delineating DNAPL contamination due to the scale at which geologic variability affects DNAPL flow and distribution.

Although the task of delineating site contamination by direct detections of residual or free-phase DNAPL presents tremendous challenges (Pankow and Cherry, 1996), the presence of a DNAPL can often be inferred based on site characterization data. For example, groundwater indicators are based on the presence of one or more DNAPL-related compounds at various percentages of the solubility of each compound (Cohen and Mercer, 1993; EPA, 2009b). Under this approach, DNAPL is suspected to be present where the concentration of a chemical in groundwater is greater than one (1) percent of its pure-phase solubility. The suspected DNAPL threshold for WVBA Site target COCs relative to one (1) percent of the chemical pure-phase solubility is:

Chlorinated Solvent	Aqueous Solubility (µg/L @ 20° C)	1% of Aqueous Solubility (µg/L @ 20° C)
PCE	150,000	1,500
TCE	1,100,000	11,000
1,1-DCE	400,000	4,000

Other indicators may include spatial patterns in groundwater or temporal trends in concentrations that may indicate a subsurface DNAPL source or soil concentrations greater than 10,000 mg/kg. As discussed in the preceding section, spatial and temporal trends in COC concentrations at RID water supply wells are useful to identify regions of the plume that are potentially impacted by DNAPLs. Specifically, persistent TCE and PCE concentrations observed in RID wells over the past 10 years in the southern flank of the WVBA Site (encompassing RID wells 89, 92, and 95) suggest these water supply wells are impacted by dissolved phase contamination that may be associated with continuing source contribution and/or the presence of DNAPLs, possibly from multiple sources.

Water quality data compiled in the Final RI Report (Terranext, 2012) provide indications of notably high PCE concentrations that are in excess of the one (1) percent of solubility rule of thumb at the following locations[85]:

- 95,000 µg/L PCE in groundwater sample obtained from monitor well DIMW-1 at the Dolphin facility in 1998.

[85] This assessment does not include the USDOE facility because data are generally unavailable in the Final RI Report to quantify the nature and extent of groundwater contamination underlying these sites.

- 42,000 μg/L PCE in groundwater sample obtained from monitor well AVB40-07 at the ALSCo facility in 1998.
- 3,800 μg/L PCE in groundwater sample obtained from the MCMM facility (well identifier and date not indicated in Final RI Report).
- 1,800 μg/L PCE in groundwater sample obtained from the ChemResearch (well identifier and date not indicated in Final RI Report).

TCE and 1,1-DCE were not found at concentrations exceeding one (1) percent of pure phase solubility of these compounds, nor were any soil samples known to exceed 10,000 mg/kg for the COCs[86].

PCE concentrations observed at the four (4) facilities identified above indicate the potential occurrence of subsurface DNAPL. To further assess the likelihood of the presence of DNAPL, EPA (1993) developed a ranking methodology that is based on the maximum percentage solubilities of DNAPL compounds present at their highest concentrations in groundwater.

Accordingly, this analysis would rate the likelihood of subsurface DNAPL as follows:

- **VERY HIGH** at the Dolphin facility because the maximum observed PCE concentration in groundwater (63% of PCE aqueous solubility) exceeds 50% of its pure-phase solubility.
- **HIGH** at the ALSCo facility because the maximum observed PCE concentration in groundwater (28% of PCE aqueous solubility) is between 10 and 50% of its pure-phase solubility of PCE.
- **MEDIUM** at the MCMM facility because the maximum observed PCE concentration in groundwater (2.8% of PCE aqueous solubility) is between 1 and 3% of its pure-phase solubility of PCE.
- **MEDIUM** at the ChemResearch facility because the maximum observed PCE concentration in groundwater (1.2% of PCE aqueous solubility) is between 1 and 3% of its pure-phase solubility of PCE.

The foregoing analysis and ranking of the potential occurrence of subsurface DNAPL is based on EPA analysis and correlation of data obtained from a wide variety of Superfund sites known to have DNAPLs present. Although the magnitude of groundwater contaminants suggests the likelihood of DNAPL in the WVBA Site, it is nevertheless an indirect indicator that does not confirm the presence of a pure-phase DNAPL source in the subsurface. By the same token, the lack of high dissolved-phase contaminant concentrations does not constitute evidence that DNAPLs are absent at a facility.

[86] However, as noted in Univar (2008) comments to ADEQ on the Draft RI Report, facility investigations of soil contamination reported by ADEQ were conducted "*at a time when soil sampling for VOCs did not include procedures to minimize VOC loss during sampling.*"

3.4.4 Canal/Surface Water

There has been limited characterization of the nature and extent of contamination in surface water at the WVBA Site. The work that has been done pertains to RID water conveyance canals, since the RID water distribution system is the only surface water resource impacted by WVBA Site COCs. In this regard, the Final RI Report indicated that the RID water supply wells that extract and discharge VOC-contaminated groundwater to surface water are the major outflow of contamination from the WVBA Site, and noted that the RID canals provide a potential route of surface water and contaminant migration downstream of the WVBA Site.

Characterization of the fate and transport of contaminants in the RID water conveyance canals within the WVBA Site is provided in two references: 1) the *Roosevelt Irrigation District Canal Characterization Report* (BE&K/Terranext, 2001) and 2) the *Public Health Exposure Assessment and Mitigation Summary Report* (Synergy, 2011c). In addition to these studies, ADEQ, with RID's cooperation, has collected water quality samples from the RID Main and Salt Canals at various times throughout the course of the WVBA Site remedial investigation.

Roosevelt Irrigation District Canal Characterization Report

ADEQ contracted BE&K/Terranext to conduct investigations to evaluate the effect of pumping groundwater from the WVBA Site into the RID Main Canal (BE&K/Terranext, 2001). The objectives of the canal characterization were to:

- Assess concentrations of VOCs in RID water supply wells within the WVBA Site.
- Evaluate VOC concentrations within RID Main Canal water downstream of discharging RID water supply wells.

BE&K/Terranext sampled 17 RID wells in April 2000 and selected two wells for monitoring the mixing of VOCs into the RID receiving surface waters: wells RID-84 and RID-92. Well RID-84 was investigated because it contained the highest PCE concentration (76 μg/L) of all RID wells sampled and discharged to the RID Main Canal. BE&K/Terranext conducted a survey of physical parameters of the Main Canal water including surface water flow, temperature, and conductivity at locations up and down stream of RID-84. Based on the results of that survey, BE&K/Terranext collected eight (8) samples from the RID Main Canal in the vicinity of RID-84. Well RID-92 was investigated because it contained the highest TCE concentration (72 μg/L) of the sampled RID wells and discharged to an open concrete-lined lateral canal that flows south where it then enters the Main Canal.

Analytical results for the samples collected from well RID-84 and the adjacent Main Canal indicated that VOC concentrations in the canal were substantially lower than in groundwater discharged from the well. VOC contaminant concentrations at well RID-84 decrease rapidly in the Main Canal, within approximately 125 feet of the well, as a result of dilution and/or volatilization.

Analytical results for the samples collected from well RID-92 and the adjacent lateral indicated that elevated concentrations of VOCs were present in the pumped groundwater and downstream in the lateral. The findings indicated that VOC concentrations in the lateral downstream from well RID-92 dropped appreciably within 200 feet of the well discharge (i.e., from 72 μg/L to 56 μg/L, a loss of approximately 22% of the total TCE mass). Losses of 32% were similarly recorded for PCE. Following this initial volatilization loss, VOC concentrations remained steady for the 1,000 feet that was sampled downstream from the well discharge. VOC concentrations did not decrease substantially with distance from RID-92 as compared to RID-84 since there was no addition of other sources of water to provide dilution.

No air sampling was conducted during the canal characterization activities. While acknowledging in the BE&K/Terranext report that the …"VOCs *likely volatilize…"*, there were no attempts to quantify or confirm this mass transfer mechanism.[87]

Public Health Exposure Assessment and Mitigation Summary Report

As part of its approval of RID's original ERA Work Plan (Montgomery & Associates, 2010a), ADEQ requested that RID provide specific documentation to assess potential public health exposure to VOCs and how these potential exposures would be mitigated during ERA implementation. In response to ADEQ's request, air and water sampling was conducted in June 2011 in accordance with the *Public Health Exposure Assessment and Mitigation Work Plan* (hereafter, *Task 1 Work Plan*; [Synergy, 2011a]). This sampling program provided data to assess potential exposure of the public to VOCs released during RID's pumping and conveyance of contaminated groundwater in RID's water supply distribution system[88] and provide insight into the fate and transport of these contaminants.

The sampling approach and methodology used to evaluate the extent and magnitude of VOC contaminants in RID water supply conveyance canals was specified in the ADEQ-approved Task 1 Work Plan (Synergy, 2011a) dated June 16, 2011. In general, the approach consisted of the measurement of target COC concentrations in water in several predetermined locations.

[87] BE&K/Terranext, 2001.
[88] The RID water supply system is largely open to public access. RID has taken a number of measures to limit and prevent public use of open RID canals and laterals, including signage to warn people not to swim or consume water and the use of contractor security personnel to patrol sections of the water system. RID also has taken steps to close open sections of laterals by installing and burying pipelines for water conveyance. For example, when it came to RID's attention that the public was swimming and drinking highly contaminated water at an open lateral on 27th Avenue, RID took immediate action to install piping to limit public access.

Water sampling results from RID wells, canals, and laterals were compared to Arizona Surface Water Quality Standards (SWQSs) developed by ADEQ pursuant to AAC R18-11-109. The SWQSs were used in this screening-level assessment to evaluate whether the observed concentrations of COCs in water could potentially present hazards for adverse health effects associated with public exposure due to swimming and bathing in the RID canals and/or consuming fish caught in the Salt and Main Canals. Despite deterrents by RID, all of these uses[89] are known to occur.

RID conducted water sampling on June 28-29, 2011 that included the points of discharge from impacted RID water supply wells and points within the Salt Canal, the open lateral serving RID-92, and the Main Canal, and analyzed the samples for VOC contaminants. The results of the investigation are included in the *Public Health Exposure Assessment and Mitigation Summary Report* (Synergy, 2011c) dated September 16, 2011. Data obtained by sampling and analysis of COCs in the RID-92 and RID-114 water supply systems document the occurrence of COCs at levels safely below numeric limits established for Arizona SWQSs that are believed to have an adverse health effect from dermal exposure by partial- and full body contact during bathing and swimming in the open RID laterals and canals as well as ingestion of fish caught in these waterways.

3.4.5 Air

There also has been limited characterization of the nature and extent of contamination in air potentially attributed to the WVBA Site. The Final RI Report indicates that vapor intrusion is one of *"... four potential routes of migration ... identified for VOCs released into the unsaturated zone in the WVBA"* (see vapor intrusion summary by Terranext included in Section 2.2).

The Final RI Report neglects to identify or elaborate on contaminant migration from volatilization of contaminants that occurs during discharge and conveyance of contaminated groundwater in the RID water supply delivery system. Such neglect is inconsistent with ADEQ's policy to prohibit the transfer of contaminants from one environmental media to another (*e.g.*, from groundwater to air).[90] The fate of COCs in groundwater pumped from RID water supply

[89] Ingestion of water from RID canals and laterals also is known to occur at points where the COCs exceed drinking water MCLs. This potential exposure pathway was not assessed since the extent, duration, and magnitude of potential exposure to COCs from ingestion have not been established.

[90] This policy was not neglected in ADEQ's approval of RID's ERA Work Plan or modified ERA Work Plan: "long-term effects are uncertain and data also show that 'significant volatilization and transfer of contaminants, from the water to air, is occurring and ongoing'" such that a specific condition within ADEQ's approval of the modified ERA Work Plan is for RID "to implement measures to limit these exposures." ADEQ's policy was not recognized in the WVBA CIP that instead concluded: "*In spite of the contaminants currently found in some soils and in the groundwater at the site, the public health impacts are minimal because none of the drinking water wells in use within the site have been found to be contaminated.*"

wells and conveyed through gravity pipelines and open canals is determined, in large measure, by the individual contaminant's physical and chemical properties. The main route of transfer of PCE, TCE, and 1,1-DCE from water is volatilization (EPA, 1981). This behavior is consistent with the compounds' relatively high Henry's Law constants. Laboratory studies cited in toxicity profiles generated by ATSDR (1997) have demonstrated that PCE and TCE rapidly volatilize from water. Although volatilization is rapid, actual transfer rates are dependent upon temperature, water movement and depth, associated air movement, and other factors. The volatilization half-life of PCE and TCE from a rapidly moving, shallow river[91] has been estimated to be 4.2 and 3.4 hours, respectively (Thomas, 1982).

Volatilization that occurs in the RID water supply delivery system transfers COCs from groundwater to ambient air. Air quality monitoring in the greater Phoenix metropolitan area associated with the regional Joint Air Toxics Assessment Project (Hafner and O'Brien, 2006) has shown that TCE and PCE are commonly found in ambient air samples collected at several monitoring sites in close proximity to the WVBA Site, and their average annual concentrations exceed national averages. Based on sampling conducted in 2005, the average PCE concentrations ranged from 0.89 to 0.94 $\mu g/m^3$ and the average TCE concentration ranged from 0.27 to 0.42 $\mu g/m^3$ at these monitoring sites.

Based on the last 10 years of data (2004-2013), the magnitude of the impact at the WVBA Site, estimated by ADEQ wellhead sample results from impacted RID water supply wells (see **Table 2**) and RID historical pumping records (discharge volume), is approximately 2,900 pounds of target COCs released to the local environment annually. A summary of the estimated mass of target COCs released by year to the local environment is included as follows:

RID WATER SUPPLY WELLS – MASS REMOVAL ESTIMATES, 2004-2013
WVBA Site
(values presented are in approximate pounds of target COCs released)

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	TOTAL
3,500	2,975	3,575	3,150	3,330	2,815	2,760	2,625	2,200	2,070	**29,000**

It should be noted that the estimated mass removal rates identified above pertain to RID pumping under an operating strategy that intentionally restricts pumping of the most highly contaminated wells. Historically, RID operations favored pumping of their larger producing wells on the Main Canal, which are on the periphery of the plume, more than the contaminated

[91] Shallow water here is defined as *"one meter deep, flowing one meter per second with a wind velocity of three meters per second."*

wells located in the interior plume. In more recent years, RID has limited discretionary pumping of the most highly contaminated wells so as to reduce pollutant transfer.[92]

Roosevelt Irrigation District Canal Characterization Report

As stated in the Roosevelt Irrigation District, Canal Characterization Report (BE&K/Terranext, 2001), the focus of the investigation was *"... to evaluate the impact of pumping groundwater from the Central Phoenix Groundwater Plume into the RID canal."* The sampling conducted during this investigation focused exclusively on water and no air sampling was conducted. Air emissions were addressed only qualitatively through mass balance observations and deduction. While the report did conclude that *"... VOCs likely volatilize ..."*, there were no attempts to quantify this mass transfer mechanism.

Public Health Exposure Assessment

RID conducted limited-scope sampling of air and water from RID water supply well discharges and surface conveyances of contaminated groundwater to measure VOC contamination entering the environment and provide insight into the fate and transport of these contaminants. The purpose of the assessment was to evaluate the potential for acute public exposure to COCs in the WVBA Site from the transfer of pollutants in groundwater to air.

Based on air sampling data from this assessment, reported in the *Public Health Exposure Assessment and Mitigation Summary Report* (Synergy, 2011c), the magnitude of target COC concentrations determined in the exposure assessments varied considerably, depending on where in the RID system the samples were collected. The highest observed target COC levels in air samples were obtained at wellhead discharge receiving structures and in the water supply distribution system openings to the atmosphere. For example, the maximum target COC concentrations measured in air samples collected at the RID well discharge structures were 115 $\mu g/m^3$ for PCE, 4,080 $\mu g/m^3$ for TCE, and 1,390 $\mu g/m^3$ for 1,1-DCE. The relatively high concentrations of target COCs occurring in air at the RID well sites in the receiving boxes indicate that the highly turbulent discharge acts much like a small air stripper, removing COCs from water and transferring them into the air. Samples obtained from the breathing zone outside of the well sites, where the public may be exposed to the air emissions, had substantially lower levels of target COCs than the well discharge structure, although

[92] Under an approved remedial action plan, RID will prioritize pumping of the most highly contaminated wells equipped with treatment to enhance VOC mass removal. For example, had RID conducted priority pumping in 2013 consistent with that deemed feasible in the remedial alternatives evaluated in this FS Report, then the projected mass removal would have ranged from 2,500 to about 3,200 pounds of target COCs. Such priority pumping would increase mass removal by approximately 25 to 50 percent.

concentrations up to 5.22 μg/m^3 of PCE, 29 μg/m^3 of TCE, and 3.92 μg/m^3 of 1,1-DCE were measured in ambient air.

The limited-scope sampling event was intended to facilitate a preliminary assessment of the potential risk to the public health from inhalation of COCs released to the air from RID water supply system operations in the WVBA Site. The findings indicate concentrations of target COCs in ambient air are less than screening-level guidelines for acute and sub-acute exposures developed by the ADHS and ATSDR. As such, it is reasonable to conclude that the current air emissions from RID water supply well discharges and water supply conveyance do not pose an acute risk to public health.

While there does not appear to be an acute exposure risk to the public from these contaminants, the long-term effects from public exposure to uncontrolled air emissions cannot be determined by this limited-scope sampling event.[93] The results revealed the presence of WVBA Site target COCs in all air samples obtained in and proximal to the RID water supply wells and water supply conveyance systems. In contrast, target COCs were not detected in air samples collected in background locations situated away from the RID water supply system. The data demonstrate that the presence of target COCs in air is directly associated with the RID pumping and conveyance of contaminated groundwater in the WVBA Site. Additionally, mass balance determinations indicated substantial transfer of target COCs from water to air from discharge of contaminated groundwater and conveyance into the RID receiving water system.

[93] *See* ADEQ's Approval of RID's Modified Early Response Action Work Plan (February 1, 2013) requiring that measures be implemented to limit exposures that might cause long-term effects based on data that significant volatilization and transfer of contaminants, from water into the air, is occurring and ongoing. (ADEQ, 2013a)

4.0 FEASIBILITY STUDY SCOPING

This section presents information on FS regulatory requirements, ROs identified by ADEQ for the WVBA Site, ROs at adjacent sites, land use in the WVBA Site, water providers and water use in the WVBA Site, the conceptual site model (CSM) and groundwater model development.

4.1 REGULATORY REQUIREMENTS

The Arizona legislature has established specific remedial action criteria pursuant to ARS § 49-282.06 that must be met in consideration and selection of remedial action(s) for the WVBA Site.

Among other requirements, remedial actions[94] shall:

- Assure the protection of public health and welfare and the environment;
- Provide for the control, management or cleanup of the hazardous substances in order to allow the maximum beneficial uses of waters of the state, to the extent practicable; and,
- Be reasonable, necessary, cost-effective, and technically sound.

Additionally, for remediation of waters of the state, "the selected remedy must address, at a minimum, any well that at the time of the remedial action either supplies water for municipal, domestic, irrigation or agricultural uses or is part of a public water system if the well would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end uses without treatment due to the release of hazardous substances."[95]

Additionally, the following factors must be considered in selecting remedial actions:[96]

1. Population, environmental and welfare concerns at risk;
2. Routes of exposure;

[94] Pursuant to ARS § 49-281, "remedial action" means "those actions that are reasonable, necessary, cost-effective and technically feasible in the event of the release or threat of release of hazardous substances into the environment, such actions as may be necessary to investigate, monitor, assess and evaluate such release or threat of release, actions of remediation, removal or disposal of hazardous substances or taking such other actions as may be necessary to prevent, minimize or mitigate damage to the public health or welfare or to the environment which may otherwise result from a release or threat of release of a hazardous substance. Remedial actions include the use of biostimulation with indigenous microbes and bioaugmentation using microbes that are nonpathogenic, that are nonopportunistic and that are naturally occurring. Remedial actions may include community information and participation costs and providing an alternative drinking water supply."

[95] *See* ARS § 49-282.06.B.4.b.

[96] *See* ARS § 49-282.06.C.

3. Amount, concentration, hazardous properties, environmental fate, such as the ability to bioaccumulate, persistence and probability of reaching the waters of the state, and the form of the substance present;
4. Physical factors affecting human and environmental exposure such as hydrogeology, climate and the extent of previous and expected migration;
5. The extent to which the amount of water available for beneficial use will be preserved by a particular type of remedial action;
6. The technical practicality and cost-effectiveness of alternative remedial actions applicable to the site; and,
7. The availability of other appropriate federal or state remedial action and enforcement mechanisms, including, to the extent consistent with this article, funding sources established under CERCLA, to respond to the release.

The ADEQ WQARF Remedy Selection Rule, as presented in *Title 18, Environmental Quality, Chapter 16, Department of Environmental Quality WQARF Program, Article 4, Remedy Selection, R18-16-407, Feasibility Study*, states that a FS is a process to identify a reference remedy and alternative remedies that appear to be capable of achieving ROs and to evaluate the remedies based on the comparison criteria to select a final remedy that complies with ARS § 49-282.06.

4.2 WORK PLANNING AND WORK PRODUCT DEVELOPMENT

The RID technical team met regularly with ADEQ to develop and refine the scope of the FS for the WVBA Site in order to facilitate conduct of this work. Accordingly, the following meetings were convened to inform the ADEQ on work planning and to streamline the FS Report and groundwater model development.

- August 15, 2013 – Define remedy scope, establish project schedule, and coordinate subsequent ADEQ review meetings (handouts available);
- September 17, 2013 – Present preliminary screening of remedial alternatives to focus FS and groundwater modeling effort (handouts available);
- October 24, 2013 – Review groundwater modeling approach and calibration and define process to update for use in FS modeling (handouts available);
- December 20, 2013 – Discuss ADEQ expectations for FS, regional commingled groundwater contaminant plume, model status, and modeling work plan approval (no handouts); and,
- January 30, 2014 – Present analysis of conceptual site model and formulation of groundwater alternative remedies for detailed analysis (handouts available).

Work to develop a groundwater flow model for use in this FS has been underway for many years. Beginning in 2009, M&A, on behalf of RID, began refining the original ADEQ groundwater flow model[97], developed for the WVBA WQARF Site, for model evaluations as part of the conditions in ADEQ's approval of RID's original ERA Work Plan. In 2011, the updated model was used to evaluate the proposed changes to RID's pumping regimen under a modified ERA. M&A has further updated and applied this model for use in the FS in accordance with a draft *Work Plan for Feasibility Study Groundwater Modeling* dated October 3, 2013 (M&A, 2013), which was approved by ADEQ on November 27, 2013.

ADEQ and its modeling consultant have been involved in the key meetings listed above in which planned groundwater modeling activities to analyze comparative pumping scenarios for the FS evaluation were discussed. Additionally, M&A met subsequently with ADEQ's modeling consultant to provide a technical briefing and status update of the model calibration process. Feedback from ADEQ indicated that its modeling consultant concluded that model calibration was proceeding appropriately for its use in the FS, particularly given the limited objectives for applying the model to the FS evaluation.

4.3 REMEDIAL OBJECTIVES

ROs are goals to be achieved by the final selected remedy under an approved remedial action plan. Final ROs for the WVBA Site are provided in Appendix AA of the Final RI Report for land use, groundwater use (municipal, agricultural, and commercial/industrial/domestic uses considered separately), and surface water use. The reference remedy and alternative remedies evaluated for this FS must achieve these ROs,[98] which have been established as follows.

4.3.1 Remedial Objectives for Land Use

Although this FS does not specifically include analysis of source control actions associated with surface and subsurface soils in developing remedial alternatives for the final groundwater remedy, the ROs for current and reasonably foreseeable land uses are included for completeness and are as follows:

- Protect against possible exposure to hazardous substances in surface and subsurface soils that could occur during development of property based upon applicable zoning regulations.

[97] ADEQ, through their subcontractor Roy F. Weston previously developed the Central Phoenix Plume Model for the WVBA Site and surrounding area in the late 1990s. More information regarding groundwater model development is provided in Section 4.9 of this FS Report.
[98] AAC R18-16-407.E.1.

- Protect against possible leaching of hazardous substances in surface and subsurface soils to the groundwater.

- Protect against the loss or impairment of current and all reasonably foreseeable future uses of land as provided in zoning regulations and the Land and Water Use report as a result of hazardous substances in surface and subsurface soils. Appropriate remedial actions will be implemented as an ERA or after the ROD is finalized whichever is warranted and continued until hazardous substances causing the impairment or restriction to the land use are remediated.

4.3.2 Remedial Objectives for Groundwater Use

ROs for groundwater use are divided into three subsets: Municipal, Agricultural and Commercial/Industrial/Domestic. Each of these groundwater use classifications is addressed in the following sections.

Municipal Groundwater Use

Based upon review of public comments, which identified water quality degradation and the potential establishment of more stringent MCLs, ADEQ's ROs for Municipal Groundwater Use are the following:

- To protect, restore, replace or otherwise provide a water supply for municipal use by currently and reasonably foreseeable future municipal well owners within the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

- To protect, restore, replace or otherwise provide a water supply for municipal groundwater use by currently and reasonably foreseeable future municipal well owners outside the current plume boundaries of the WVBA WQARF site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as need for the water exists, the resource remains available and the contamination associated with the WVBA WQARF Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

Agricultural Groundwater Use

Based upon review of public comments, ADEQ's ROs for Agricultural Groundwater Use are as follows:

- To protect, restore, replace or otherwise provide for the current and reasonably foreseeable future supply of groundwater for agricultural/irrigation use and for the associated recharge capacity that is threatened by or lost due to contamination associated with the WVBA Site. Remedial actions will be in place for as long as the need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

Commercial/Industrial/Domestic Groundwater Use

Based upon review of public comments, ADEQ's ROs for Commercial, Industrial, and Domestic Groundwater Use are as follows:

- To protect, restore, replace or otherwise provide a water supply for potable or non-potable use by currently impacted commercial, industrial, and domestic well owners within the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as the need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

- To protect, restore, replace or otherwise provide a water supply for potable or non-potable use by commercial, industrial, and domestic well owners outside the current plume boundaries of the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as the need for the water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

4.3.3 Remedial Objectives for Canal/Surface Water Use

ROs for surface water use are divided into two subsets: RID Canal Water Use and SRP Canal Water Use. Both of these surface water uses are addressed in the following sections.

RID Canal Water Use

Based upon review of public comments, ADEQ's ROs for RID Canal Water Use are as follows:

- To protect, restore, replace or otherwise provide a water supply for potable or non-potable use by currently impacted RID wells within the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as the need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

- To protect, restore, replace or otherwise provide a water supply for potable or non-potable use by RID wells outside the current plume boundaries of the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as the need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

SRP Canal Water Use

Based upon review of public comments, ADEQ's ROs for SRP Canal Water Use are as follows:

- To protect, restore, replace or otherwise provide a water supply for potable or non-potable use by SRP wells outside the current plume boundaries of the WVBA Site if the current and reasonably foreseeable future uses are impaired or lost due to contamination from the Site. Remedial actions will be in place for as long as the need for water exists, the resource remains available and the contamination associated with the WVBA Site prohibits or limits groundwater use. Remedial actions to meet ROs will be implemented upon issuance of the ROD. If there is an imminent risk to human health or the environment, then an ERA may be initiated prior to implementation of the ROD.

4.4 REMEDIAL OBJECTIVES AT ADJACENT SITES

The ROs for CERCLA and WQARF sites adjacent to the WVBA Site are provided in the following sections.

4.4.1 Motorola 52nd Street CERCLA Site

The OU1 remedy was designed to meet the substantive requirements of applicable permits. Although not explicitly stated as a remedial action objective, the OU1 Letter of Determination indicates that, *"the intent of the interim remedy is to be part of a final remedy for the Site that will protect human health and the environment by containing the migration of high concentrations of VOCs in groundwater via extraction and treatment to a level commensurate with its use. These efforts would thus reduce the toxicity, mobility, or volume of contamination present at the Site"* (ADEQ, 2011b). The major components of the interim remedy selected include the following:

- Extraction and treatment of groundwater from the Courtyard/50th Street area at the M52 Facility;
- Extraction and treatment of vapor phase organic contaminants from soils at the Courtyard/50th Street, the Acid Treatment Plant, and the Southwest Parking Lot areas of the M52 Facility;
- Extraction of groundwater designed to contain contaminant migration in alluvium groundwater (east of) at the Old Crosscut Canal;
- Treatment at the M52 Facility of groundwater extracted from the Old Crosscut Canal containment system; and
- Use of all treated groundwater at the M52 Facility to replace water currently purchased from the COP.

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The primary ROs of the M52 OU2 area are to establish a capture zone across the entire north-south width and depth of the contaminant plume and to reduce contaminant concentrations within the alluvial aquifer upgradient of the extraction wells. The major components of the selected remedy, as modified by the *Explanation of Significant Differences* (EPA, 1999) dated September 1999, are:

- Installation of wells and extraction of groundwater in the vicinity of Interstate 10 and Van Buren Street;

- Treatment of extracted groundwater to drinking water standards using carbon adsorption and ultraviolet oxidation at a treatment plant located near extraction wells; and,
- Discharge of treated water to the SRP Grand Canal for agricultural irrigation and livestock watering.

No ROs have been established for the OU3 Study Area as Honeywell and Arizona Public Service are currently conducting RI activities.

4.4.2 West Osborn Complex WQARF Site

The ROs for the WCP-WOC Site were formalized in the *Remedial Objectives Report*, prepared by ADEQ, and dated May 2005 (ADEQ, 2005). The RO Report for the WOC Site indicated that ROs are not needed for land use. Current and/or potential groundwater uses that were identified within the WOC Site include: 1) the current and future use of groundwater for drinking water purposes by the COP; and, 2) the current and future use of SRP wells for municipal and irrigation use.

COP Municipal Use

The RO for the COP current municipal use is:

- To restore, replace, or otherwise provide for the COP groundwater supply that has currently been lost due to PCE and/or TCE contamination associated with the Site. This action is needed as soon as possible. This action is needed for as long as the need for the water exists, the resource remains available, and PCE and/or TCE concentrations in the water prohibit or limit its use.

The RO for the COP future municipal supply use is:

- To protect for the use of the COP municipal groundwater supply threatened by the PCE and/or TCE contamination emanating from the Site. According to the COP, this use may be the year 2010. This action would be needed for as long as the level of contamination in the identified groundwater resource threatens or prohibits its use.

SRP Municipal and Irrigation Use

The RO for the SRP current and future municipal and irrigation use of the wells is:

- To protect for the use of the SRP groundwater supply threatened by the PCE and/or TCE contamination emanating from the Site. According to SRP, this use may be needed as soon as is technically feasible. This action would be needed for as long as the level of contamination in the identified groundwater resource threatens or prohibits use.

4.4.3 56th Street and Earll Drive WQARF Site

The major components of the early response action are:

- Installation of wells and extraction of groundwater located along the bank of the Grand Canal to the east of 32nd Street;
- Treatment of extracted groundwater to drinking water standards using carbon adsorption; and;
- Discharge of treated water to the SRP Grand Canal for agricultural irrigation.

4.5 LAND USE IN THE WEST VAN BUREN AREA

As noted in the RO Report, the WVBA Site is located within two (2) of the 15 "urban villages" that comprise the COP: the Central City and Estrella Villages. Within the WVBA Site, there are no village cores (i.e., a central focus with a pedestrian-oriented mix of land uses) or special planning districts. There are, however, large acreages of agricultural land available to be developed, especially in the western Estrella Village. Consequently, as an identified COP targeted growth area, Estrella Village is expected to experience significant increases in both employment and residential growth. As the entity that regulates land use in the area that encompasses the WVBA Site, the COP has urged ADEQ to select remedial objectives for the Site that are supportive of unrestricted land use.[99]

Land use in eastern COT, adjacent to the WVBA Site, is primarily agricultural/vacant and industrial. Based on data obtained by the U.S. Census Bureau indicating a 32 percent increase in population since 2000, this area, similar to the COP Estrella Village area, also is expected to experience significant increases in growth.

[99] Letter from Phil McNeeley, COP Office of Environmental Programs, to Julie Riemenschneider, ADEQ Remedial Projects Section Manger, re: Suggested Remedial Objectives for the West Van Buren WQARF Site, dated January 7, 2010.

4.6 WATER PROVIDERS AND WATER USE IN THE WEST VAN BUREN AREA

The scope of the FS requires consideration of the well owners and water providers in the area in identifying the remedial measures necessary for each groundwater alternative remedy that must meet the ROs. As provided in AAC R18-16-407.G,*"remedial measures necessary for each alternative remedy developed under subsection (E) to achieve remedial objectives or to satisfy the requirements of ARS § 49-282.06(B)(4)(b) shall be identified in consultation with water providers or known well owners whose water supplies are affected by ... a hazardous substance."* AAC R18-16-407(G) additionally states that "in identifying the remedial measures, the needs of the well owners and the water providers and their customers, including the quantity and quality of water, water rights and other legal constraints on water supplies, reliability of water supplies and any operational implications shall be considered." The preamble to AAC R18-16-407 further emphasizes that these remedial "[m]easures taken to address contaminated or threatened wells must be identified in consultation with water providers or well owners to ensure the action meets their water use needs."[100] There are five (5) water providers that have wells within the WVBA Site or within the immediate surrounding area; RID, SRP, COP, COT and APS. There are several other water providers outside the general vicinity of the WVBA Site plume whose operations could potentially be affected by remedial actions at the Site: City of Goodyear, City of Buckeye, and the City of Avondale.

Additional information regarding water provider infrastructure in the WVBA Site, current water use, and water development plans is provided in Section 9.4 and, for those water providers responding to the Water Provider Information Request, in **Appendices C, D and E**.

4.6.1 Roosevelt Irrigation District

In 1921, SRP entered into an agreement wherein it agreed to deed certain lands and wells to Carrick and Mangham Agua Fria Lands and Irrigation Company (Carrick & Mangham).[101] That 1921 agreement also contemplated that an irrigation district would be formed. Subseqently, in 1923, RID was formed pursuant to the laws of the State of Arizona. In 1923, Carrick and Mangham assigned the 1921 agreement and any and all other water supply-related rights to RID.[102] In 1927, the 1921 agreement was amended and SRP deeded the referenced lands and wells "free and clear of all liens and encumbrances" to RID.[103] Under the 1927 agreement, "the

[100] *See* 8 AAR 1503.
[101] Water Contract between Carrick & Mangham and SRP, dated August 25, 1921.
[102] Assignment between Carrick & Mangham, dated July 11, 1923.
[103] The 1921 and 1927 agreements and a 1950 agreement that capped the amount of water RID could pump from its wells have been "ratified, confirmed and declared to be valid" by the federal government. See Salt River-Maricopa Indian Community Water Rights Settlement Act of 1988, Pub. L. No. 100-512, § 6, 102 Stat. 2552. Also, after a 2013 ADWR analysis of these three agreements, ADWR as a matter of law "determined that the duration of these contracts would not affect the legal availability of groundwater pumped by RID for use within its boundaries, for

use of water within the District for irrigation or for any other purposes beneficial to the lands, landowners, or residents within the District shall be construed as 'beneficial use,'"[104] which was an important element in establishing and maintaining RID's legal right to withdraw groundwater from these deeded lands and wells as a matter of applicable state water law at that time.[105]

Pursuant to state law, RID has an established right to withdraw water from water supply wells in the WVBA Site and to transport that water to its service area.[106] In addition, pursuant to ARS § 48-2978.15, RID is authorized to provide its service area with water, electricity and other public conveniences and necessities, and engage in any and all activities, enterprises, and occupations within the powers and privileges of municipalities generally.

RID owns and operates approximately 104 water supply wells with roughly half located west of the Agua Fria River and half east of the Agua Fria River. RID's water supply wells in the WVBA Site, east of the Agua Fria River, are generally the highest yielding and most efficient to operate of all RID water supply wells. These wells usually contain lower dissolved salts, hardness, and other inorganic solutes (such as nitrate) than RID's water supply wells located west of the Agua Fria River. Consequently, the water supply produced in the WVBA Site wells is a valuable water resource to RID.

With the exception of the VOC contamination, RID water supply wells in the WVBA Site are the best source of RID water to develop a municipal and industrial (M&I) water supply.[107] For this reason, RID is evaluating the design and construction of a water supply delivery pipeline from

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purposes of Assured Water Supply determinations." Letter from Andrew Craddock, Manager of ADWR's Recharge, Assured & Adequate Water Supply Program to Donovan Neese, RID Superintendent, re: ADWR's Review of RID-SRP Agreements, October 21, 2013. (ADWR, 2013)

[104] Paragraph 8(e) of the Supplemental Agreement between RID and SRP, dated February 3, 1927.

[105] The right to withdraw and use groundwater for a beneficial use is an appurtenance to realty that comes with land ownership. *See* Fourzan v. Curtis, 43 Ariz. 140,147 (1934) (confirming the ruling in Howard v Perrin, 8 Ariz. 347 (1904) that it is the law of Arizona that percolating water belongs to the owner of the land on which they are found); Neal v. Hunt, 112 Ariz. 307, 310 (1975) (confirming decision in George v Gist, 33Ariz. 93 (1928) that water rights on land must be conveyed in a deed); and Town of Chino Valley v. City of Prescott, 131 Ariz. 78, 82 (1981) (clarifying prior cases in holding that there is no right of ownership of groundwater in Arizona prior to its capture, withdrawal and beneficial use from the common supply and that the right of the owner of the overlying land is simply to the usufruct of the water." The Arizona Groundwater Management Act in 1980 modified state water law in newly identified "active management areas," which include the RID, that grandfathered RID's existing water right. *See* ARS § 49-494.1.b.

[106] *See* ARS § 49-494.1.b. (ensuring that an irrigation district existing and engaged in the withdrawal, delivery and distribution of groundwater as of January 1, 1977, "shall have the right … if legally withdrawing and transporting groundwater from outside its service area for use within its service area as of January 1, 1977, to continue to withdraw and transport the amount of groundwater legally being withdrawn as of January 1, 1977.")

[107] Lands within the RID have been transitioning from agricultural to residential land use, similar to the conversion that occurred within the Salt River Project service area in Phoenix. Cities and developers within RID's service area have asked RID to provide a potable water supply.

the wells in the WVBA Site to the west valley, along the right-of-way of the RID Main Canal. This pipeline could be used to direct-deliver remediated groundwater to RID customers, west valley municipalities, and other potential end users. RID anticipates a pipeline will be installed and available to deliver M&I water supplies within the next five years. In the reasonably foreseeable future (*i.e.* within the 100-or-more year horizon contemplated by the WQARF Program), RID anticipates that all RID water supply wells, including RID water supply wells currently discharging to the Main Canal, will be developed as M&I drinking water sources.[108]

Water Infrastructure

RID water infrastructure in the WVBA Site includes 33 water supply wells, approximately five (5) miles of lateral canals, over 7.5 miles of Salt Canal (along Van Buren Street) and approximately ten (10) miles of Main Canal. Of the five (5) miles of laterals, only one (1) section of approximately 400 feet is open channel with the remainder being hard-piped. Of the 7.5 miles of Salt Canal, only two (2) sections of approximately 320 feet and 1,130 feet remain open channel with the remainder being hard-piped. Of the ten (10) miles of RID Main Canal in the WVBA Site, only one (1) mile is covered with the remaining channel being open canal.

RID also owns and operates approximately 20 water supply wells to the west of the WVBA Site boundary, east of the Agua Fria River. All well water in the RID network currently is conveyed to the Main Canal via gravity.

The RID water supply wells in the WVBA Site are most commonly constructed into the UAU; however, there are a number of wells constructed and perforated in both the UAU and MAU, and some wells are constructed and perforated in the UAU, MAU and the LAU. Well construction details are provided in **Table 4**.

Water Quality Impacts

According to the most recent water quality data from the RID water supply wells within the WVBA Site, 24 wells have been impacted by the VOC contamination. Of those 24 impacted wells, 13 wells have target COC concentrations above the current AWQSs/MCLs (refer to **Table 2**).

RID has adopted and maintains a policy regarding federal and state Superfund sites, addressing the use of remediated water in the RID system. In that policy, RID requires that any wells located in a state WQARF or federal Superfund site that are contaminated with hazardous substances must be remediated pursuant to an approved remedial action plan to mitigate the actual and/or potential harm to public health, welfare, and the environment. RID requires that

[108] RID is pursuing designation of the Main Canal as a public water source.

discharges of remediated water into the RID water supply distribution system must be of a quality that meets or exceeds MCLs and the AWQSs for the associated hazardous substances. The policy further states that implementation of a remedial action plan developed to protect RID's water supply wells and water operations shall provide for the maximum beneficial use of the water supply and that the remedial action should not reduce the quality or quantity of water available to RID pursuant to ARS § 49-282.06.B.4.b. A copy of this policy statement is included in **Appendix C**.

Water Use

Consistent with its practice since 1927, RID does not deliver water for use within the WVBA Site. All of the groundwater produced by RID in the WVBA Site is conveyed, by gravity, through the RID laterals, the Salt Canal, or direct discharge to the Main Canal where it is transported to the approximately 38,000-acre RID service area. Currently, this water is available for non-potable agricultural, domestic, municipal and industrial purposes. RID is planning to accommodate delivery of water for potable M&I use within the RID service area based on the expressed interests of its customers, including the cities of Goodyear and Buckeye and real estate developers, which will be beneficially used by RID's landowners and residents within the RID service area.[109]

4.6.2 Salt River Project

The SRP is a federal Reclamation Project, which originated in 1906 as the Salt River Valley Water Users Association (SRVWUA), when landholders in the central Phoenix area and east valley pledged their land as collateral for funds to build Roosevelt Dam on the Salt River. The landholders of the SRVWUA received the rights to stored surface-water in Roosevelt Lake and other reservoirs subsequently developed on the Salt and Verde Rivers. As a federal Reclamation Project, the surface-water supply developed for "member" lands within the 248,000-acre service area must be used within Project boundaries.

SRP now operates six (6) reservoirs that collect surface-water runoff over a 13,000-square-mile watershed and distribute water to approximately two million people for domestic and agricultural uses. In a typical year, SRP delivers approximately one million AF of water for its shareholders' use. Because surface-water runoff and surface-water supplies are highly variable and periodic droughts have occurred, SRP maintains over 200 production wells that were

[109] Letters from Jackie Meck, Mayor, City of Buckeye to Ben Grumbles, Director, ADEQ, re: RID Remediation Project (September 23, 2010) and from Charles McDowell, Public Works Director, City of Goodyear to Ben Grumbles, Director, ADEQ, re: RID Project (September 24, 2010) stating interest in utilization of treated water from the RID remediation effort. See Land and Water Use Questionnaire completed by Stan Ashby, Manager, RID Superintendent (January 7, 2010).

primarily drilled in the 1930s through the 1950s to augment surface-water supplies. In a year with normal surface-water runoff, surface water constitutes about 80 percent (800,000 AF) and groundwater 20 percent (200,000 AF) of SRP's water supply. In years with excess surface water, SRP operates at a minimum pumping level and pumps only those wells that are required for operating and system head requirements, and certain municipal contract wells. In drought years, SRP will operate additional groundwater wells to meet their water-supply demands.

SRP historically has utilized a number of wells in southwest Phoenix to help meet its irrigation supply needs, particularly during periods of drought. These groundwater supply wells discharge water to a network of laterals that deliver water by gravity flow for urban and agricultural uses generally in the area extending south to the Salt River and west to the Agua Fria River.

Water Infrastructure

Based on the information provided by SRP in response to the Water Provider Information Request dated January 17, 2014 (**Appendix D**), and the WVBA Site boundaries shown in the Final RI Report, SRP water infrastructure within the WVBA Site includes one (1) well and many miles of north-south laterals.[110] This well, SRP 5.0E-4.5N, is located on 75th Avenue between Van Buren Street and Buckeye Road, on the western margin of the contaminant plume and is completed to a depth of 800 feet bls and is perforated between 300 and 800 feet bls (in the UAU, MAU and the LAU).

SRP owns and operates seven (7) additional groundwater supply wells within areas immediately surrounding the WVBA Site. All SRP wells within and adjacent to the WVBA Site are south of the SRP Grand Canal and thus are only available to serve local irrigation demands in the rather limited area of southwest Phoenix downgradient from the wells. As noted in the SRP response, use of these wells has decreased in recent years due to the fact that the area within the WVBA Site is mostly urbanized. Consequently, these wells are a lower priority water resource to SRP.

[110] Prior to 1927, SRP had an interest in twenty-six (26) additional pumping plants located within the WVBA Site. However, pursuant to an August 25th, 1921 agreement with Carrick & Mangham Agua Fria Lands and Irrigation District (the predecessor to RID), as modified by the supplemental agreement which became effective in 1927, the Salt River Valley Water Users' Association by deed, dated December 27, 1927,"granted, sold, conveyed and transferred … free of all liens and encumbrances, unto said Roosevelt Irrigation District, all of the right, title, claim and interest which said Salt River Valley Water Users' Association has in and to certain twenty-six (26) pumping plants, consisting of wells with pumps." At that time, SRP also conveyed to RID the "right to the possession of and use by the district of said ditches [approximately fifteen and three-fourths (15¾) miles of pump laterals]," also known as the Salt Canal along Van Buren Road. The title to these pump laterals remained vested in the United States, while other of the aforementioned pump laterals were constructed under a license with the Maricopa County Board of Supervisors and only SRP's interest under the license agreements was conveyed to RID.

Water Quality Impacts

According to recent data provied by SRP, the well located within the WVBA Site (SRP 5.0E-4.5N) has shown occassional detectable concentrations of PCE (0.7 µg/L in 2009 and 0.5 µg/L in 2012), below the applicable AWQS/MCL of 5.0 µg/L. Of the seven (7) wells adjacent to the WVBA Site, two (2) wells (SRP 4.0E-5.0N and SRP 5.0E-6.0N) also have shown VOC concentrations slightly above detection levels but, again, well below applicable AWQSs/MCLs.

SRP also owns wells in the adjacent WOC Site that have been impacted by groundwater contamination. As previously noted, the ROs established for the WOC Site included protection of these agricultural use wells for all beneficial end uses, including use as drinking water. During the WOC Site FS and Proposed Remedial Action Plan process, impacted SRP wells in the area were addressed through replacement with an alternative supply of water from the Central Arizona Project canal.[111]

SRP has adopted and maintains a policy regarding the use of remediated water and wastewater within the SRP transmission and distribution system. A copy of SRP requirements and specific conditions under which remediated water may be delivered into its water distribution systems, if authorized by SRP, is included in **Appendix D**. SRP currently requires that any remediated water discharged into its system be treated to drinking water quality (MCLs) regardless of the receiving water location under license agreement approved by the SRP Board of Directors.[112]

Water Use

SRP water use in the WVBA Site consists of deliveries of on-demand water from well SRP 5.0E-4.0N to downstream local agricultural uses, averaging approximately 65 acre-feet per year (AFY) for years 2005 through 2012. As noted in SRP's responses to the Water Provider Information

[111] These reports noted "*for a period of time ending in about 2005, ADEQ was paying SRP a fee of $13 per AF for water that would have been pumped before in production wells located in the area of the Site to meet demands for irrigation water. Payment was made in accordance with an agreement established between the ADEQ and SRP, whereby ADEQ would reimburse SRP for a portion of its costs to secure CAP water from the CAP Banking Authority rather than pump its groundwater production wells.*" (GeoTrans, 2012b)

[112] This policy is in place at M52 OU2 and the 56th Street and Earll Drive WQARF Site where the PRPs were required to enter into an agreement with SRP to ensure that the pumped groundwater is treated to drinking water standards before being discharged into SRP's system to be used for irrigation purposes. This policy was featured in SRP's Irrigation Newsletter, mailed out to SRP Agricultural & Other Urban shareholders on the week of August 16, 1999, where SRP noted that "SRP will help Motorola and Allied Signal implement a groundwater cleanup project" in OU2 by agreeing "to accept treated groundwater generated by the project" but ensuring its shareholders that "the water will be cleaned to meet drinking water standards at a treatment plant … and then piped to SRP's Grand Canal, where the water will be used for irrigation purposes." SRP explained to its shareholders that SRP supported the project because "pumping the groundwater and cleaning it at a treatment facility will prevent the further spread of contamination to SRP and city wells … [and] will improve groundwater quality in the central Phoenix area over time."

Request (**Appendix D**), SRP provides only raw water to users, and the area within the WVBA Site is mostly urbanized. However, in response to ADEQ's Land and Water Use Survey for the WVBA Site, SRP stated that they believed the water use "*will transition to drinking water supply as the area develops. SRP is in discussions with the COP about providing additional groundwater to the City when surface water supplies are unavailable or insufficient and to give the City more operational flexibility.*"[113]

4.6.3 City of Phoenix

COP was incorporated in 1881 with a population of approximately 2,500. Today, Phoenix is the nation's sixth largest city, encompassing about 540 square miles with a population of more than approximately 1.4 million. Phoenix Water Services' annual operating budget is approximately $278 million, serving approximately 1.4 million customers and 400,000 connections, and its five-year Capital Improvement Plan totals about $1.6 billion. During calendar years 2011-2012, the COP provided approximately 309,700 AFY of water to its customers.

The COP provides municipal and industrial water to residents and businesses in all areas of the regional commingled groundwater contaminant plume from water resources that are not impacted by the groundwater contamination. These areas within the regional plume are all within the SRP service area, "on project", and are typically served from water supplied by SRP that is delivered to COP water treatment plants on the SRP Arizona Canal.

<u>*Water Infrastructure*</u>

COP water infrastructure within the WVBA Site consists of four (4) wells within the WVBA Site along with many miles of municipal and industrial water distribution lines. The groundwater wells, identified as the Falcon Park Pool well, Alkire Park Pool well, University Park well, and Phoenix Police well have been "capped" or "disconnected" since the mid-1990s. As stated in the COP response to the Water Provider Information Request, dated October 18, 2013 (**Appendix E**), the COP is currently *"... determining the status or absence of these wells..."* Based on futher input, the City has confirmed the Parks Department will not be using these wells.[114]

The COP also owns a number of wells within areas immediately surrounding the WVBA Site, including wells up-gradient of the WVBA Site to the east (in the area of the M52 Site) and up-gradient of the WVBA Site to the north-northeast (in the area of the WOC Site). Three (3) COP

[113] SRP Land and Water Use Questionnaire completed by Dan Casiaro, Manager, SRP Environmental Compliance. (September 21, 2007)
[114] Confirmed by email correspondence from Gary Gin of the COP Water Services Department dated June 20, 2014.

wells exist in the OU3 Study Area identified as the University Park Well, the Phoenix Police Well and the Harmon Park Well. All of these wells are listed as "capped" or "disconnected". Four (4) COP wells exist in the area of the WOC Site: COP 68, COP 70, COP 71, and COP 157. All of these wells similarly are listed as "capped" or "disconnected".

There are seven (7) wells in the area of the Salt River to the south and east of the regional commingled groundwater contaminant plume; LACC-1, RSPW-2, RSW-6, RSSW-5, Rio Solado Park Well, RSSW-3, and RSSW-4. There also are two (2) wells to the north and east of the regional plume, the Encanto West and Encanto East wells. None of these wells are impacted or threatened by the contamination in the WVBA Site due to RID pumping that influences the direction of groundwater movement in the area and prevents migration of the contaminants to the north or to the south.

COP has plans to develop a new well field, the Western Canal Well Field, approximately 1.5 to 2 miles south of the RID well field and the WVBA Site. This new well field will consist of five (5) to six (6) wells located along the southern margin of the Salt River from 35th to 55th Avenues. These wells will be screened exclusively in the LAU to exploit better inorganic water quality.

COP owns and operates a wastewater treatment facility at 23rd Avenue and Lower Buckeye Road, the 23rd Avenue Wastewater Treatment Plant. This treatment facility has interconnections to wheel untreated wastewater to the COP 91st Avenue Wastewater Treatment Plant or to discharge treated effluent to the Salt River or to the RID Main Canal.

Water Quality Impacts

There is little information available regarding COC impacts to the "capped" and "disconnected" wells in vicinity of the WVBA and WOC sites, with the exception of COP 70 and COP 71, located within the WOC Site. These wells were shut down in the 1980s, and water quality data from 1982 indicated TCE levels of 8.9 and 29 μg/L, respectively. As stated in the COP response to the Water Provider Information Request, dated October 18, 2013 (**Appendix E**), *"Potable wells impacted by groundwater contamination were shut down, disconnected, capped, and/or abandoned"*

As noted in the Land and Water Use Survey submitted to ADEQ by the COP in September of 2007, *"the City identified 5 wells proximal and down-gradient to the WVB WQARF site boundary. The impacts of the WQARF site contamination on these wells, if any, is undetermined."* These five (5) wells (well numbers 68, 154, 155, 156, and 179) were either disconneted or abandoned due to elevated total dissolved solids (salts) or elevated nitrates.

Overall, the City has 20 active wells currently in production, all of which are located at least one (1) mile from any WQARF Site boundaries. Due to water quality degradation (and the establishment of more stringent MCLs), other wells were placed on inactive status. Of these inactive wells (Terranext, 2012):

- six (6) wells were closed due to MCL exceedances of TCE;
- fourteen (14) wells were placed on inactive status due to detectable TCE (but below MCLs);
- eight (8) wells were closed due to pesticide contamination;
- thirty-nine (39) wells were abandoned/sold/placed on inactive status due to nitrate contamination (approaching or exceeding the MCL); and,
- seven (7) wells were placed on inactive status due to chromium contamination.

Water Use

COP water usage in the WVBA Site consists of municipal, industrial/commercial, and landscape consumption. During calendar years 2011 and 2012, the percentages of the total water consumed for each of those uses in this part of COP's service area was approximately 56%, 36% and 8%, respectively. The vast majority of water provided by COP in its service area is treated surface water, between 89% and 94%. Only 2% to 5% of water supplied is groundwater, and between 4% and 6% is reclaimed water. Water usage reported by the COP in response to the Water Provider Information Request indicates that approximately 30,000 AFY is delivered to customers in the area bounded between 7th and 80th Avenues and Indian School to Lower Buckeye Roads.

The COP has expressed contradictory positions on water usage in the WVBA Site. On one hand, COP indicated its support of local groundwater remediation efforts in the WVBA Site (COP, 2011), indicating, *"... the City has encouraged EPA and ADEQ to expedite remediation actions as the supply is expected to be an important component in meeting future service area demand during surface water shortfalls,"* which is consistent with the COP's earlier statement to ADEQ and their response to the Land and Water Use Survey for the WVBA Site and suggested ROs for the WVBA Site[115] (COP, 2010a) stating, "*[T]he City of Phoenix requests that the aquifer be available for drinking water use, and not cause damage or harm to our future wells. Phoenix has plans to develop a new water resource project and recharge facilities in an area within close proximity to the West Van Buren Site."* Yet this position supporting remediation to protect future service area demand is inconsistent with statements provided by the City, on behalf of

[115] COP Land and Water Use Questionnaire completed by Donn Stoltzfus, Manager, COP Environmental Program Specialist. (September 21, 2007)

the PRPs, regarding RID's ERA.[116] Furthermore, the statement regarding the COP's interest in future use of groundwater in the WVBA Site must be reconciled with their stated view in the Water Provider Information Request, indicating *"Phoenix operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the distribution line."*

4.6.4 City of Tolleson

COT was incorporated in 1929 and consists of about six (6) square miles, located approximately ten (10) miles west of downtown Phoenix, and has a population of approximately 6,700. COT is located due west of and adjacent to the WVBA Site. COT land use is approximately 12% residential, 44% commercial/industrial, 12% vacant and about 32% agricultural. While the COT did not respond to the Water Providers Information Request, which was distributed to provide the COT with the opportunity to offer input into the FS process, the following information relevant to this FS was obtained from public sources.

Water Infrastructure

COT has two (2) primary sources of water: groundwater and purchased COP water.[117] Groundwater is collected through a series of wells and is subsequently treated by electro-dialysis reversal and disinfected prior to distribution. This source accounts for approximately 16% of COT total drinking water supplied in 2012. The larger source of potable water to the COT comes from the COP potable water system, receiving an average of between 3 to 4 million gallons per day through two (2) interconnections with the COP potable water system. COT maintains approximately 12,000 AFY of CAP water allocation, much of which is wheeled to the COP, treated and distributed to COT under an Intergovernmental Agreement.

[116] Letter from Philip McNeely, Manager of City of Phoenix Office of Environmental Programs to Henry Darwin, ADEQ Director, re: RID's Modified ERA for WVBA Site (December 3, 2012) requesting ADEQ to deny approval of the Modified ERA because "*RID has again failed to demonstrate that the proposed work is necessary for any environmental reason*," "*there is no current unacceptable risk to the public*," and "*regional remedial actions at Phoenix Area Federal Superfund sites* [Paradise Valley and Scottsdale] … *do not provide meaningful precedent for WQARF ERAs* [in West Phoenix.]") (City of Phoenix, 2012). Even these statements are inconsistent with comments made by COP in an earlier letter from Philip McNeeley to Julie Riemenschneider, Remedial Projects Section Manager, re: Suggested Remedial Objectives for the West Van Buren WQARF Site" (January 7, 2010) which commented that "*As an interim measure, water produced for irrigation or non-potable uses should be applied, or if necessary, treated appropriately, to prevent a health risk to the end users or others with an exposure pathway to the water.*" (City of Phoenix, 2010a)

[117] City of Tolleson 2012 Water Quality Report, May, 2013.

As indicated in the Final RI Report, COT currently operates four (4) water supply wells that are used mainly during summer months for backup supply purposes.

Water Quality Impact

In October 1992, ADHS completed a health risk assessment addressing the potential threat to COT drinking water wells. The study was conducted in anticipation of potential groundwater contamination of COT wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in ADEQ monitor wells located near 67th Avenue and West Van Buren Street. COT's most easterly well is located at approximately 83rd Avenue and Harrison Street. In response, COT removed the potentially affected wells from service.

As indicated in the Final RI Report, COT currently receives most of its water from the COP through an Intergovernmental Agreement. The four (4) operating COT wells are used mainly during summer months for backup supply purposes. Two (2) ADEQ monitor wells have been installed at 79th Avenue, north and south of the RID Main Canal, between the leading edge of the plume and the COT municipal well field to monitor groundwater quality in the area of concern.

Although COT wells are potentially threatened by the WVBA Site groundwater contaminant plume, there is no evidence of current impact to the Tolleson well field, due to the RID pumping within the WVBA Site that influences the direction of groundwater movement and prevents migration of the contaminants to the west.

Water Use

COT has no service area within the WVBA Site and has no service interconnect between the groundwater in the WVBA Site and the Tolleson service area.

4.6.5 Arizona Public Service

Arizona Public Service (APS) is a provider of electricity and has been serving customers in Arizona for over 125 years. While APS did not respond to the Water Providers Information Request, which was distributed to provide APS with the opportunity to offer input into the FS process, the following information relevant to this FS was obtained from public sources, including the Land and Water Use Study Questionnaire completed on September 14, 2007 and submitted to ADEQ as part of the RI process. That questionnaire and other water provider responses are included in the Final RI Report as Appendix K.

Water Infrastructure

APS water infrastructure within the WVBA includes five (5) relatively deep wells located at the West Phoenix Power Plant, across from RID-92 on 43rd Avenue. These wells, drilled to depths of approximately 1,800-1,900 feet bls and completed exclusively in the LAU (1,100 feet bls to total depth), serve the cooling needs of the power plant.

This power plant was commissioned in 1930 and consists of five (5) combined cycle generating units (operated daily), two (2) combustion turbine generating units (operated during summer months), and three (3) steam generating units (emergency operation only). These electrical generating units use groundwater from the LAU for cooling and produce a significant amount of concentrated waste water which is managed through on-site brine concentrators, evaporation basin and discharge to the APS Lateral Canal/SRP Irrigation Lateral 16.4.

Water Quality Impacts

All of APS' production wells are completed in the LAU and, therefore, are not impacted by the WVBA Site groundwater contamination which is largely confined to the UAU with some intrusion into the MAU. APS does have a number of UAU monitoring wells (approximately six (6)) on the West Phoenix Power Plant site that are sampled by ADEQ on a periodic basis.

Water Use

APS water use in the WVBA Site consists of industrial cooling by groundwater extracted from the LAU to support cooling needs of the power plant through large scale evaporative cooling towers. No contaminated groundwater in the WVBA Site is used by APS.

4.7 EXTENT OF IMPACTS TO AREA WATER PROVIDERS

As discussed in the preceding section, there are five (5) major water providers with water supply wells in the WVBA vicinity: RID, SRP, APS, and the Cities of Phoenix and Tolleson. Of these providers, the only operating water supply wells currently impacted by target COCs at concentrations above applicable AWQSs and MCLs belong to RID. RID has 33 operating water supply wells in the WVBA Site vicinity of which 24 are actually impacted by COCs, thirteen (13) of these impacted wells exceed AWQSs and MCLs for one or more of the target COCs, while the other eleven (11) impacted RID wells currently exhibit concentrations of the target COCs below

AWQSs and MCLs. The remaining nine (9) RID water supply wells are potentially threatened[118] by WVBA Site contamination.

The impact to other water providers is currently limited. COP has two (2) shallow Parks Department wells within the WVBA Site that have been disconnected from use since the mid-1990s. All other COP wells are outside the WVBA Site and not currently threatened by WVBA Site groundwater contamination.[119]

Water supply wells operated by APS, SRP, and Tolleson that are within or downgradient of the WVBA Site are potentially threatened or currently are nominally impacted by the WVBA Site groundwater contamination; however, the extent to which the wells may be impacted will depend on the actions decided for the WVBA Site final groundwater remedy. In this regard,

Certain SRP and COT wells downgradient of the WVBA Site groundwater contaminant plume have historically had low levels of detectable COC concentrations. As indicated in the plume map shown in **Figure 2**, these wells are presently outside of the estimated extent of contamination defined by the 5 μg/L AWQS plume boundary for TCE and PCE. To prevent future impacts to downgradient SRP and COT wells, the WVBA Site final groundwater remedy will require sufficient, sustained groundwater extraction from the contaminated UAU aquifer within the WVBA Site to hydraulically contain the plume and prevent westward contaminant migration beyond its current limit.

- APS has production wells within the WVBA Site, but they produce water from the LAU only. The WVBA Final RI Report indicates that the LAU does not appear to be contaminated within the WVBA Site. To limit future impacts to deep APS wells, it will be important to monitor vertical gradients and the potential for downward groundwater flow and address any conditions that could lead to vertical cross contamination of aquifers.

In consideration of potential future groundwater use in this region, the COP had indicated their need to assure groundwater resources are available to augment City drinking water supplies to reduce drought impacts. In both the COP's response to ADEQ's Land and Water Use Survey for the WVBA Site and its suggested ROs for the Site,[120] COP emphasized future drinking water

[118] For the purposes of identifying wells "threatened" by groundwater contamination, this FS Report utilizes the convention defined in AAC R-18-16-405(I) that considers a well located in the area within one-quarter mile upgradient, one-half mile cross-gradient, or one mile downgradient of the areal extent of contamination at the Site as presumed to be threatened by the contamination.

[119] At least two (2) COP wells are impacted by the contaminant plume in the WOC Site to the north of the WVBA Site, but the planned WOC Site final groundwater remedy addresses these wells.

[120] COP Land and Water Use Questionnaire completed by Donn Stoltzfus, Manager, COP Environmental Program Specialist (September 21, 2007) and letter from Philip McNeeley, Manager COP Environmental Programs to Julie Riemenschneider, Manager, ADEQ Remedial Projects Section. (January 7, 2010)

supply usage of the groundwater in the WVBA Site. However, there is no reasonable prospect of the City installing shallow wells within the WVBA Site in the near future due to the fact that the City has long-standing policies[121] that discourage or outright prohibit the introduction of contaminated groundwater through a treatment plant directly into the City distribution system. Moreover, as is the case in the planning for the new Western Canal Well Field,[122] COP would be expected, at least in the near future, to construct any new water supply wells exclusively in the LAU to target better inorganic water quality.

SRP also has expressed an interest in developing water supply resources in the area to augment drinking water supplies for their shareholders. Similar to the COP and RID, SRP has emphasized future drinking water supply usage of groundwater in the WVBA Site and further indicates the plan to provide SRP wells for use by the COP.[123] Again, it is not reasonable to assume that SRP would consider or plan new shallow wells within the WVBA Site since SRP already has a number of underutilized wells throughout west Phoenix and Tolleson. These wells are outside the WVBA Site and could be connected for City use. More importantly, use of these outlying wells would not conflict with COP policies that prohibit the use of treated groundwater from a contaminated site.

In sum, the WVBA Site final groundwater remedy must, consistent with ARS § 49-282.06.B.4.b., protect all existing water supply wells that are not fit for their current or reasonably foreseeable water end uses over at least the next 100 years,[124] as well as the needs of the water providers to assure their water supply in their wells is not diminished in quality, quantity, and/or reliability by implementation of any remedial strategies or measures. Groundwater alternative remedies have been developed pursuant to the FS to address the impacted and threatened water provider wells, as required by the ROs and ARS §§ 49-282.06.A. and 49-282.06.B.4.b.

4.8 CONCEPTUAL SITE MODEL

Numerous facilities within the WVBA Site and adjacent M52 Site and WCP sites have documented releases of PCE, TCE, and other chlorinated VOCs that comprise the COCs in the regional commingled groundwater contaminant plume. Releases of solvents in chemical products and wastes containing VOCs as a result of spills, leaks, discharges, and waste disposal practices provide a direct mechanism for downward vertical contaminant migration through the unsaturated zone.

[121] The reference to City policies on remediated water use is based on information COP provided in **Appendix E**.
[122] *See* discussion on COP water infrastructure in Section 4.6.3.
[123] *See* footnote 113.
[124] *See* AAC R18-16-406.D.

Although some COC mass at source areas may pose a threat of vapor transport to the surface and potential vapor intrusion to indoor air, the overall coarse-grained nature of the unsaturated zone is generally not conducive to the retention of contaminants that may be released to the subsurface. This is particularly true in the sand, gravel, and cobble interval of the UAU1 unsaturated zone within the WVBA Site and adjacent areas. Moreover, some facilities used drywells, cisterns, septic tanks, seepage pits and other similar disposal systems to directly discharge solvent wastes, wastewater, and stormwater to the permeable subsurface.[125] The net result is that once VOCs are released to the surface or subsurface soils, unsaturated flow is primarily downward and typically continues until the groundwater table is encountered (Terranext, 2012).

Within the WVBA Site, depth to groundwater currently ranges from approximately 75 to 140 feet bls (Terranext, 2013). In past decades, when historic releases more likely occurred, groundwater levels were significantly higher resulting in a more direct and rapid pathway for contaminant transport to groundwater as well as greater potential for vapor flux from shallow groundwater contamination to migrate upwards to the ground surface.

The physical and chemical properties of chlorinated solvents such as PCE and TCE make these substances particularly likely causes of groundwater contamination. PCE and TCE releases as a DNAPL and releases of their degradation byproducts (*e.g.,* DCE) will move downward through unsaturated soils relatively rapidly, particularly in comparison to infiltrating groundwater, due to the low viscosity and interfacial tension of the VOC contaminants (Pankow and Cherry, 1996). These properties allow the DNAPLs to readily enter into porous media, facilitating deep penetration into the subsurface.

According to the Final RI Report, upon reaching the groundwater table as unsaturated flow in the WVBA Site, COCs dissolve into the uppermost UAU1 aquifer and migrate both laterally and vertically within UAU1. COCs that enter groundwater in a dissolved phase generally move in response to groundwater flow and are dominantly transported in the coarse sands and gravel layers comprising the UAU. The more permeable layers are capable of transmitting large amounts of water as indicated by fluid flow investigations at newly-installed well RID-111R, which demonstrated the 30-foot thick interval at the base of UAU1 yielded 1,500 gpm of the total 2,500 gpm of groundwater withdrawn from this well. Although horizontal groundwater flow is preferential, downward vertical gradients within the WVBA Site have resulted in downward migration of VOC contaminants into increasingly finer-grained sediments comprising the UAU2 and upper MAU intervals. The LAU does not appear to be contaminated at this time.

[125] *See* Memorandum from Michael Leach, ADEQ Hydrologist, to Tom Curry, ADEQ WQARF Coordination Unit, re: "Van Buren Tank Farm – Final Summary Site Assessment Report" (Feb. 26, 1990) (noting that "contaminants from the other VBTF facilities could also reach the water table by way of surface conduits (such as drywells) with very little detectable contamination of the vadose zone." (ADEQ, 1990)

Throughout the adjacent M52 and WOC sites, COCs are restricted to UAU groundwater and also move preferentially in high permeability sand and gravel layers, and less in the interbedded silty and clayey zones (GeoTrans, 2012a and 2012b; ERM, 2010). Data obtained from the monitor well network in the OU3 Study Area, located to the east, indicate the M52 Site remedial actions taken to contain groundwater contamination in the upgradient OUs are effectively decreasing TCE concentrations in the UAU groundwater flowing into the WVBA Site, particularly in the upper UAU interval. In response to the reduced mass loading, TCE concentrations are expected to slowly decrease in the eastern portion of the WVBA Site over time, potentially taking many decades for COC concentrations to reach AWQSs.

Data obtained from the monitor well network in the WOC Site to the north indicate TCE concentrations in the shallow groundwater plume extending south toward the WVBA Site have remained relatively constant over time and suggest persistent COC mass is migrating from the WOC Site to the WVBA Site. The limited scope of the proposed WOC Site groundwater remedy is not anticipated to notably reduce COC mass loading entering the WVBA Site from the WOC Site. It is anticipated that COCs will continue to migrate into the WVBA Site from the north for many decades.

The plumes of contaminated groundwater underlying the M52 and WOC sites flow toward and enter the WVBA Site in response to large-scale RID pumping. COCs from these adjacent sites, along with releases that have impacted groundwater within the WVBA Site, contribute to widespread commingled groundwater contamination observed in RID water supply wells. Based on recent RID well testing, 24 RID water supply wells have detectable concentrations of one or more COCs, while 13 of these wells exceed AWQSs/MCLs for the COCs. Although APS, COP, SRP, and COT have water supply wells in the WVBA Site vicinity, with minor exceptions,[126] there are no indications that these wells are presently impacted by COCs in a way that would restrict their current or reasonably foreseeable water end uses, including as a drinking water supply.

Concentrations of COCs detected in RID water supply wells and at WVBA Site groundwater monitor wells are not systematically distributed throughout the plume. In fact, there are notable spatial variations that indicate multiple sources have contributed, and may still be contributing, to the regional commingled groundwater contaminant plume. Differentiating the WVBA Site into five (5) specific regions, illustrated on **Figure 13**, based on temporal and spatial COC concentration trends within the RID well field helps establish priorities for applying remedial strategies and measures to achieve a more focused and cost-effective final groundwater remedy.

[126] The COP has four (4) existing shallow water supply wells located at public parks or City properties within the WVBA Site that are not currently in service and will not be used in the future according to COP (see footnote 113).

RID pumping represents the major outflow from the groundwater system in the WVBA Site. In fact, RID is the only water provider known to pump UAU and MAU groundwater within the WVBA Site groundwater contaminant plume and has annually pumped an average 83,500 AF of groundwater from its wells within the WVBA Site over the 5-year period from 2008 to 2012. Groundwater pumping of the RID well field in the WVBA Site hydraulically contains the regional commingled groundwater contaminant plume and constrains the impact of this plume on peripheral wells of other water providers. Absent RID pumping in the WVBA, the plume would migrate with prevailing westerly regional groundwater flow and impact downgradient COP, COT, and SRP wells.[127]

Based on ADEQ-measured contaminant concentrations in the RID well field over the past 10 years, an estimated 29,000 pounds of the target COCs have been extracted by RID water supply wells in the WVBA Site, an average of 2,900 pounds per year. Contaminated groundwater pumped by RID discharges to a surface conveyance system where COCs in the water supply are known to partition to air relatively rapidly, based on the individual contaminant physical and chemical properties. Volatilization that occurs in the RID water supply delivery system transfers COCs from groundwater to ambient air.

4.9 GROUNDWATER MODEL DEVELOPMENT

A numerical groundwater model was used to evaluate the remedial alternatives. A detailed summary of the groundwater modeling is included in **Appendix F**. The basis for the RID WVBA Site FS model was a previously developed model for the WVBA Site and surrounding area. The previous model was known as the CPPM and was developed for ADEQ during the late 1990s (Weston, 2000). The most recent activity conducted on the groundwater model by ADEQ included validation simulations for the period from 1996 through 1998 (Weston, 2001).

The CPPM was designed to model aquifer conditions and groundwater movement, including the effects of existing groundwater pumping in the WVBA area (Terranext, 2012). Further, the purpose of the CPPM model was to assist in the evaluation of remedial strategies and their effects on groundwater movement and the WVBA Site contaminant plume. In this regard the Final RI Report concludes, *"…. (b)ased on model calibration and validation, the CPM*[128] *meets its intended purpose to evaluate remedial alternatives and contaminant movement in the CPM*

[127] ADHS (1992) completed a health risk assessment addressing the potential threat to drinking water wells in the WVBA vicinity. The study was conducted in anticipation of potential contamination of water supply wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in WVBA Site.

[128] Terranext (2012) referred to the Central Phoenix Plume Model using the acronym CPM.

area." The CPPM model code, area, grid, and layering were retained for the RID WVBA Site FS model[129].

Previous Modeling

The model code MODFLOW-SURFACT (HydroGeoLogic, 1996) was used for the FS Model. The model grid encompasses the WVBA Site and is bounded by 99th Avenue on the west, Camelback Road on the north, 56th Street on the east, and Dobbins Road on the south. The model is a 5-layer transient groundwater flow model that simulates seasonal pumping during the period from 1972 through 2012. Groundwater pumping was simulated using three stress periods per year that corresponded to seasonal pumping variations (e.g., high demand period in summer and low demand in winter/spring). The stress period lengths were developed by Weston based on analysis of RID and other water providers pumping records.

RID obtained the CPPM from ADEQ in 2009 for the model evaluations required by ADEQ for the conditional approval of the original ERA. Initial work on the model included updating it to incorporate pumping and groundwater monitoring data through 2007 and verifying the calibration through 2007. In 2011, the updated model was used to evaluate the proposed changes to RID's pumping regimen under the Modified ERA. The results of this modeling phase were presented to ADEQ in September 2011. In October 2011, RID submitted a work plan to ADEQ for additional groundwater modeling associated with the Modified ERA (M&A, 2011b). ADEQ provided comments on this work plan in a letter to RID dated April 19, 2012 (ADEQ, 2012a). To the extent possible and required, these comments were addressed in the 2013-2014 modeling conducted for the WVBA Site FS.

RID WVBA Site FS Modeling

Modeling for the WVBA FS was conducted pursuant to an ADEQ-approved work plan (M&A, 2013; ADEQ, 2013b). The model was updated to include pumping[130] and groundwater elevation data[131] (i.e., for calibration targets) through 2011. The updated model was calibrated to groundwater elevation data through 2011 using the parameter estimation software PEST (Doherty, 2010a,b). During the calibration process, the model initial and boundary conditions were modified to improve calibration. Results of the model update and calibration were presented to Mr. John Ward, a consultant to ADEQ, in a meeting on April 9, 2014.

The updated and calibrated model was used to simulate the remedial alternatives. The objective of these simulations was to compare the hydrologic effects from the proposed

[129] Hereafter referred to as the "FS Model".
[130] Complete pumping records for the model area were available from ADWR through 2011.
[131] Obtained from the ADEQ database and ADWR records.

remedial alternatives to that of a baseline simulation of continued current RID operations. In accordance with the groundwater modeling work plan, a summary of the work done to update, calibrate, and validate the FS Model is provided in **Appendix F**, along with an explanation of the approach taken to develop and apply the FS Model to simulations of proposed remedial alternatives and the conclusions reached based on model results.

5.0 SCREENING OF REMEDIAL STRATEGIES AND MEASURES

Pursuant to ARS § 49-287.03, the "feasibility study shall … include an alternative screening step to select a reasonable number of alternatives in a manner consistent with the rules and procedures adopted pursuant to section 49-282.06." Consistent with ARS § 49-282.06.B.4., ADEQ's "rules shall provide for the selection of a remedial action by comparison of alternative remedial actions, which may include no action, monitoring, source control, controlled migration, physical containment, [and] plume remediation." Furthermore, ARS § 49-282.06.B.4. requires that "the selected remedial action meet the requirements of [ARS § 49.282.06.A.] and [ARS § 49-282.06.B.4.b.] for remediation of waters of the state." These mandated statutory requirements for a selected remedial action include:

1. Assure the protection of public health and welfare and the environment;
2. To the extent practicable, provide for the control, management and cleanup of the hazardous substances in order to allow for the maximum beneficial use of the waters of the state;
3. Be reasonable, necessary, cost effective and technically feasible; and,
4. Address, at a minimum, any well that at the time of selection of the remedial action either supplies water for municipal, domestic, industrial, irrigation or agricultural uses or is part of a public water system if the well would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable use without treatment due to the release of hazardous substances.

According to the rules adopted pursuant to ARS § 49-282.06, AAC R18-16-407.E.1 requires that the reference remedy and each alternative remedy shall consist of a remedial strategy and specify all remedial measures to be employed. Importantly, the combination of the remedial strategy and the remedial measures for each alternative also must achieve the ROs (as described in Section 4.3).[132] Furthermore, pursuant to ARS § 49-282.06.B.4.b., the "specific measures to address any such well [protected by ARS § 49-282.06.B.4.b.] shall not reduce the supply of water available to the owner of the well."

The reference remedy and alternative remedies also may incorporate different strategies for different aquifers or portions of aquifers and also may include contingent remedial strategies or measures to address reasonable uncertainties regarding achievement of ROs or uncertainty in the time-frames in which the ROs are expected to be achieved.[133]

[132] AAC R18-16-407.E.1
[133] *Ibid.*

In consideration of the unique aspects that make up the WVBA Site as described in Sections 4.7 and 4.8, both the remedial strategies and remedial measures have been screened to determine the extent of conformance with the legal requirements listed above. These screening level discussions and determinations are detailed in the following sections.

5.1 SCREENING OF REMEDIAL STRATEGIES

Guidance for consideration and screening of remedial strategies is provided in AAC R18-16-407.F:

The remedial strategies to be developed under subsection (E) are listed below. Source control shall be considered as an element of the reference remedy and all alternative remedies, if applicable, except for the monitoring and no action alternatives. A strategy may incorporate more than one remediation technology or methodology, such as a plume remediation strategy that consists of a combination of pumping and treating in portions of an aquifer and monitored natural attenuation for other portions of the aquifer.

Remedial strategies, as defined in ARS § 49-282.06.B.4. and AAC R18-16-407.F, consist of:

- Plume Remediation
- Physical Containment
- Controlled Migration
- Source Control
- Monitoring
- No Action

Remedial strategies form the framework of the possible remedies and, by incorporating remedial measures, define the detailed approach for implementing the selected final remedy. Therefore, in determining which strategies are suitable for achieving a compliant final groundwater remedy at the WVBA Site, each strategy was considered in the context of whether the strategy is capable of achieving the legal requirements set forth in Section 5.0.

Screening of remedial strategies was the first step in developing the reference remedy and the alternative remedies. Pursuant to AAC R18-16-407.E.2, the reference remedy and the alternative remedies were developed based on best engineering, geological and hydrological judgment following engineering, geological, and hydrological standards of practice, considering the following:

- The information from the remedial investigation;
- The best available scientific information concerning available remedial technologies; and,
- Preliminary analysis of the comparison criteria and the ability of the reference remedy to comply with ARS § 49-282.06.

Each of these remedial strategies is discussed in more detail in the following sections along with a determination of their suitability for further consideration in developing the reference and alternative remedies, given the unique characteristics of the WVBA Site.

5.1.1 Plume Remediation

Plume remediation is a strategy to achieve water quality standards for COCs in waters of the state throughout the site.[134] This strategy typically involves groundwater extraction and treatment to achieve capture and removal of COCs from impacted groundwater but may also, in appropriate conditions, consist of in-situ treatment approaches.

The remedial strategy of plume remediation was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.0. Plume remediation through groundwater extraction and treatment will address the groundwater contamination that "ADEQ has determined … may present an imminent and substantial endangerment to the public health, welfare or the environment within the [WVBA] Site."[135] ADEQ already has determined that plume remediation within the WVBA Site is "reasonable, necessary, cost-effective and technically feasible".[136] In fact, ADEQ's approval of the original ERA Work Plan[137] emphasized the importance of maximizing "*the benefit of pumping and treating contaminated groundwater, which is intended to result in aquifer restoration and reduce the cost of the final remedy*." ADEQ went on to say that, "*one of the goals of the ERA is to remediate groundwater … RID must maximize, to the extent practicable, the removal of contaminants from the subsurface.*"

Given that the existing groundwater quality in the WVBA Site significantly exceeds applicable AWQSs, plume remediation will provide for the "cleanup of the hazardous substances in order to allow for the maximum beneficial use of the waters of the state" as required by ARS § 49-282.06.A. In fact, the "maximum beneficial use" as a potential municipal water supply is one of

[134] AAC R18-16-407.F.1
[135] *See* Agreement to Conduct Work between ADEQ and RID, dated October 8, 2009.
[136] *See* ADEQ approval of RID's ERA and Modified ERA Work Plans.
[137] ADEQ letter from Director Ben Grumbles to RID Superintendent Stan Ashby June 24, 2010.

the "current or reasonably foreseeable water end uses" established by ADEQ in the WVBA Site RO Report and protected by ARS § 49-482.06.B.4.b.

Suitability Determination - Plume Remediation

Plume remediation is considered a viable strategy for the reference remedy and alternative remedies, and will be retained for further consideration in the development of the reference and alternative remedies.

5.1.2 Physical Containment

Physical containment is a strategy to hydraulically contain and limit the extent of contaminants within defined boundaries of the groundwater flow system.[138] The containment strategy requires sufficient hydraulic control to prevent the migration of contaminants beyond the boundaries of the containment zone at concentrations exceeding AWQSs. Therefore, a containment strategy is generally coupled with plume remediation (via groundwater extraction and treatment within the containment zone[139]), or other associated remedial actions such as injection and/or some form of physical barrier at the margins of the containment zone to restrict contaminant movement. Physical containment of the plume is verified by groundwater monitoring.

The remedial strategy of physical containment was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.0. Physical containment of the plume, through groundwater extraction and treatment, will assure protection of public health and welfare and the environment by protecting surrounding communities as a result of limiting the extent of the groundwater containment plume so that the contaminants will not impact threatened wells of WVBA water providers (e.g. RID, SRP, COP and COT wells) and result in the transfer of contaminants from the water to the air. As demonstrated by existing groundwater data, physical containment of the plume is reasonable and technically feasible when coupled with plume remediation to control and protect defined western and southern boundaries of the plume. Physical containment is necessary and cost-effective to protect the threatened wells from additional costs that would be required to remediate impacts to the wells that would not allow for the maximum beneficial use of the groundwater because the wells are not fit for their current or reasonably foreseeable water end uses pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b.

[138] AAC R18-16-407.F.2
[139] For example, one aspect of the OU2 interim remedy at the M52 Site is a containment remedy that requires groundwater extraction on the western boundary in order to establish a capture zone across the entire north-south width and depth of the contaminant plume.

Suitability Determination - Physical Containment

Physical containment coupled with plume remediation is considered a viable strategy for the reference and alternative remedies. This strategy will be retained for further consideration in the development of the reference and alternative remedies.

5.1.3 Controlled Migration

Controlled migration is a strategy to control the direction or rate of migration, but not necessarily to contain migration of contaminants.[140] This strategy, as with physical containment, requires some form of hydraulic control to influence the direction of contaminant movement, but does not necessarily achieve containment of the contaminants and prevent them from migrating beyond a specific defined boundary. Consistent with the discussions regarding the physical containment strategy in Section 5.1.2, a controlled migration strategy generally is coupled with plume remediation to influence the groundwater migration patterns through hydraulic control. Controlled migration of the plume is verified by groundwater monitoring.

The remedial strategy of controlled migration was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.0. Controlled migration of the commingled plumes entering into the WVBA Site, through groundwater extraction and treatment, will assure protection of public health and welfare and the environment by ensuring that contaminated groundwater from adjacent sites is addressed in a timely manner. As demonstrated by existing groundwater data, controlled migration of the commingled groundwater contaminant plumes entering into the WVBA Site is reasonable and technically feasible when coupled with plume remediation to ensure that contaminated groundwater from adjacent sites is addressed. Controlled migration is necessary and cost-effective to protect the threatened wells from additional costs that would be required to establish separate remedies in the adjacent sites and/or at the threatened wells to address the groundwater contamination that would not allow for the maximum beneficial use of the groundwater because impacted wells are not fit for their current or reasonably foreseeable water end uses pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b.

Suitability Determination - Controlled Migration

Controlled migration coupled with plume remediation and physical containment is considered a viable strategy for the reference and alternative remedies. This strategy will be retained for further consideration in the development of the reference and alternative remedies.

[140] AAC R18-16-407.F.3

5.1.4 Source Control

Source control is a strategy to eliminate or minimize a continuing source of contamination.[141] As discussed herein, source control applies to facilities within the WVBA Site where releases of hazardous substances to surface and subsurface soils may have contributed to groundwater contamination. As noted in AAC R18-16-407.F, "source control shall be considered as an element of the reference remedy and all alternative remedies, if applicable." Although source control is related and is a significant component of the WVBA Site, source control is not directly applicable to the scope[142] of this FS, which is focused on the groundwater portion of the feasibility study.[143]

Source control is not applicable and, therefore, not explicitly included in the reference or alternative remedies on the belief, as stated in the FS Work Plan (Synergy, 2013a), that actions taken to date under ADEQ oversight[144] have adequately characterized and addressed the known sources of hazardous substances that may be impacting groundwater. Although these historical source control activities are not featured in this FS, the actions have beneficially lessened COC mass loading[145] to UAU groundwater by removing continuing sources of groundwater contamination. Should any further information arise that identifies the need to address a known source or a presently undefined source of hazardous substances, it is assumed that ADEQ will, independent of the groundwater remedy selected by this FS, assure that necessary actions are taken to remediate or control the hazardous substances causing the impairment or restriction to groundwater use.

The remedial strategy of source control was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.0. Source control does not assure the protection of public health and welfare and the environment from the contaminants that have already impacted the groundwater above AWQSs nor from the volatilization and transfer of contaminants from water to air into surrounding communities. Although source control has benefits in eliminating continued sources of soil contamination to groundwater, it is not, in and of itself, reasonable, necessary, cost-effective or technically feasible to address the existing groundwater contamination within the WVBA Site. Likewise, source control will not

[141] AAC R18-16-407.F.4
[142] *See* AAC R18-16-407.B (finding that "a work plan shall be developed and implemented for all or a portion of a feasibility study for a site or a portion of a site")
[143] Source control also is outside the scope of this FS because, as previously discussed with ADEQ, RID has volunteered to implement the final groundwater remedy selected by ADEQ, pursuant to AAC R18-16-411.G, and RID does not have the authority or access to address the facilities and sources of the released COCs within the WVBA Site or the adjacent sites that contribute to the regional commingled groundwater contaminant plume.
[144] According to Section 4.2 of the Final RI Report, there have been source investigations at nearly 50 facilities within and adjacent to the WVBA WQARF Site.
[145] For example, source control at the ALSCo and Dolphin facilities have significantly reduced PCE concentrations from potential DNAPL sources, as discussed in Section 3.4.3.

allow for the maximum beneficial use of the waters of the state and will not address the impacted and threatened water provider wells to ensure that their current or reasonably foreseeable water end uses are protected pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b.

Suitability Determination - Source Control

Source control, by itself and in the context of this regional groundwater remedy, is not adequate to achieve the groundwater ROs and other statutory requirements. Therefore, source control is not considered a viable strategy for the reference and alternative remedies to address existing groundwater contamination. This strategy will not be retained for consideration in the development of the reference and alternative remedies. It is, however, important that ADEQ and the facilities/owners/operators of known continuing sources of contamination continue efforts to reduce ongoing contributions to the regional groundwater contaminant plume[146].

5.1.5 Monitoring

Monitoring is a strategy to observe and evaluate contamination at a site through the collection of data.[147] This strategy is typically employed as a remedial action in situations where there is no significant impairment or restriction to current or reasonably foreseeable future land and/or water uses caused by the contamination and where natural processes, such as biodegradation, sorption, or dispersion, are reasonably expected to reduce the concentration of contaminants over time. Monitoring is also an essential part of groundwater P&T remedial actions for the purposes of assessing attenuation of contaminants (i.e., assessing trends in contaminant concentrations in certain wells/areas) and verifying hydraulic capture and plume containment within defined areas.

The remedial strategy of monitoring was considered in terms of the legal requirements set forth for the reference and alternative remedies, as described in Section 5.0. Monitoring alone does not assure the protection of public health and welfare and the environment from the contaminants impacting the groundwater above AWQSs nor from the volatilization and transfer of contaminants from water to air into surrounding communities. Monitoring, in and of itself, is not reasonable, necessary, cost-effective or technically feasible to address the existing

[146] In addition to any ADEQ efforts, it is anticipated that the Stakeholder Group will pursue source control activities under their feasibility study. Similar to the reason RID should implement the groundwater remedy (authority and access to implement the remedy), the Stakeholder Group has the authority and access to perform source control activities since its members are the owners and operators of the facilities where hazardous substances have been released.

[147] AAC R18-16-407.F.5

groundwater contamination within the WVBA Site. Likewise, monitoring will not allow for the maximum beneficial use of the waters of the state and will not address the impacted and threatened water provider wells to ensure that their current or reasonably foreseeable water end uses are protected pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b.

Suitability Determination - Monitoring

Monitoring by itself is not a viable strategy for the reference and alternative remedies. This strategy will not be retained for further consideration in the development of the reference and alternative remedies. However, RID understands that continued monitoring will be an important aspect of any groundwater alternative remedies being considered to verify performance of the groundwater remedy and ensure that the WVBA Site groundwater ROs are met and that the current and reasonable foreseeable water end uses at all wells of all water providers within and adjacent to the WVBA Site are protected pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b. Therefore, monitoring will be retained as an ancillary component to the reference and alternative remedies.

5.1.6 No Action

No action is a strategy that consists of no action at a site.[148] As with monitoring, this strategy is typically employed in situations where there is no significant impairment or restriction to current or reasonably foreseeable future land and/or water uses caused by the contamination.

The remedial strategy of no action was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.0. The no action strategy does not assure the protection of public health and welfare and the environment from the contaminants impacting the groundwater above AWQSs nor from the volatilization and transfer of contaminants from water to air into surrounding communities. The no action strategy is not a reasonable, necessary, cost-effective or technically feasible strategy to address existing groundwater contamination within the WVBA Site. Likewise, the no action strategy will not allow for the maximum beneficial use of the waters of the state and will not address the impacted and threatened water provider wells to ensure that their current or reasonably foreseeable water end uses are protected pursuant to the WVBA Site ROs and ARS § 49-282.06.B.4.b.

148 AAC R18-16-407.F.6

Suitability Determination - No Action

No action is not an appropriate strategy to address the impacts of the existing groundwater contaminant plume in the WVBA Site and will not be retained for further consideration in the development of the reference and alternative remedies.

5.2 SCREENING OF REMEDIAL MEASURES

In developing alternative remedies, all necessary remedial measures must "achieve remedial objectives [and] satisfy the requirements of ARS § 49-282.B.4.b."[149] The remedial measures "shall be identified in consultation with water providers or known well owners whose water supplies are affected by the release or threatened release of a hazardous substance." Remedial measures, as discussed in AAC R18-16-407.G, may include but are not limited to:

- Well Replacement
- Well Modification
- Water Treatment
- Provision of Replacement Water Supplies
- Engineering Controls

Each of these remedial measures is discussed in more detail in the following sections along with their suitability for continued consideration given the unique WVBA Site characteristics and the applicable statutory and regulatory requirements. Specifically, each remedial measure must meet the ROs established by ADEQ for the WVBA Site, satisfy the requirements of ARS § 49-282.06.B.4.b. and consider the needs of affected water providers and known well owners, including:

1. Quantity and quality of water;
2. Water rights and other legal constraints on water supplies;
3. Reliability of water supplies; and,
4. Operational implications.

5.2.1 Well Replacement

The remedial measure of well replacement consists of drilling a new well, or replacing an impacted well with an existing well, in an area where contamination has not impacted the

[149] AAC R18-16-407.G

aquifer (i.e., replacing contaminated water with uncontaminated water). Well replacement, however, also can consist of replacing a lower capacity well with a higher capacity well in an area of active P&T remediation in order to enhance groundwater remediation.

Well replacement would require conformity with other applicable regulations established by ADWR. Well replacement for the purpose of replacing contaminated with uncontaminated water involves providing new (or transfer of existing) well(s), in addition to interconnecting the replacement well(s) to the existing water conveyance systems. The installation of a new well is regulated under R12-15-1302 through R12-15-1307, which includes well spacing criteria designed to prevent unreasonably increasing damage to surrounding land or water users from the concentration of wells. However, well replacement for the purpose of enhancing extraction at an existing impacted well site, to increase the effectiveness of a groundwater P&T remediation action, is regulated by R12-15-1308, which requires the replacement well to be drilled within 660 feet of the existing well and to interconnect to existing conveyances.

The remedial measure of well replacement was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.2. Well replacement could possibly achieve the WVBA Site ROs of replacing or otherwise providing a water supply for current or reasonably foreseeable water end uses. Likewise, well replacement could satisfy the requirements of ARS § 49-282.06.B.4.b. by ensuring that the “specific measures to address any such well [not fit for its current or reasonably foreseeable end uses without treatment] shall not reduce the supply of water available to the owner of the well.” In consideration of all affected water providers and wells owners (including RID, SRP, COP, APS and COT), well replacement could be a viable measure as long as the ADWR regulations would not impact the quality or quantity of the water, water rights, reliability of water supplies, and operations.

Suitability Determination - Well Replacement

Well replacement is retained as a viable measure to be considered in the development of the reference and alternative remedies.

5.2.2 Well Modification

Well modification is a measure that may consist of making changes to impacted or threatened well(s) to:

- eliminate or minimize capture of impacted groundwater from contaminated portions of the aquifer, in order to reduce contaminant loading in produced water;

- exclude uncontaminated portions of the aquifer, in order to increase the COCs in the produced water to enhance treatment efficiency (mass of VOCs removed per volume of groundwater treated); or,
- increase overall production from an existing well by increasing the number and/or size of perforations in the existing well casing, without measures to isolate contaminated and uncontaminated groundwater.

Well modification to exclude capture of water from contaminated portions of the aquifer may be done by sealing any portion of the well casing in order to decrease the concentrations of COCs in groundwater withdrawn from the well to avoid treatment or impairment of use. On the other hand, well modifications to exclude capture of water from uncontaminated portions of the aquifer would focus on sealing off and minimizing flow from the clean portions of the aquifer. Well modifications for the purpose of enhancing production capacity at an existing well, to increase the amount of groundwater extracted for treatment or containment, would involve aggressive well rehabilitation, potentially using physical and/or chemical methods to enhance flow, and possibly re-perforating the existing well casing to allow more groundwater to enter the well.

The remedial measure of well modification was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.2. Well modification could possibly achieve the WVBA Site ROs of protecting or otherwise providing a water supply for current or reasonably foreseeable water end uses. Likewise, well modification could satisfy the requirements of ARS § 49-282.06.B.4.b. by ensuring that the "specific measures to address any such well [not fit for its current or reasonably foreseeable end uses without treatment] shall not reduce the supply of water available to the owner of the well." In consideration of all affected water providers and wells owners (including RID, SRP, COP, APS and COT), well modification could be a viable measure as long as there is no impact on the quality or quantity of the water, water rights, reliability of water supplies, and operations.

Suitability Determination - Well Modifications

Well modification is retained as a viable measure to be considered in the development of the reference and alternative remedies.

5.2.3 Water Treatment

Water treatment is a measure that consists of implementing some form of treatment of the contaminated groundwater, either through in-situ processes (treating contaminated groundwater where it resides in the aquifer) or through ex-situ processes (pumping and treating contaminated groundwater at the ground surface).

Additionally, the P&T approach for groundwater remediation can consist of either active removal of contaminants or through a more passive treatment approach involving blending of contaminated water with uncontaminated (treated or untreated) or less contaminated water in order to achieve water quality goals.[150]

The remedial measure of water treatment was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.2. Water treatment would achieve the WVBA Site ROs of protecting, restoring or otherwise providing a water supply for current or reasonably foreseeable water end uses. Likewise, water treatment could satisfy the requirements of ARS § 49-282.06.B.4.b. by ensuring that the "specific measures to address any such well [not fit for its current or reasonably foreseeable end uses without treatment] shall not reduce the supply of water available to the owner of the well." In consideration of all affected water providers and wells owners (including RID, SRP, COP, APS and COT), water treatment would be a viable measure as long as there is no impact on the quality or quantity of the water, water rights, reliability of water supplies, and operations.

Suitability Determination - Water Treatment

Water treatment is retained as a viable measure to be considered in the development of the reference and alternative remedies.

5.2.4 Provision of Replacement Water Supplies

Replacing water supplies is a measure that consists of providing uncontaminated water from another source to allow a well owner to cease pumping of, and reliance on, the water produced from contaminated well(s).

The remedial measure of replacement water supplies was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.2. Replacement water supplies could achieve the WVBA Site ROs of replacing or otherwise providing a water supply for current or reasonably foreseeable water end uses. Likewise, replacement water supplies could satisfy the requirements of ARS § 49-282.06.B.4.b. by ensuring that the "specific measures to address any such well [not fit for its current or reasonably foreseeable end uses without treatment] shall not reduce the supply of water

150 While treatment by blending results in some release of COCs from water to air, the magnitude of these releases is small compared to releases from the highest contaminated wells, and water quality goals can be achieved through this treatment approach.

available to the owner of the well." In consideration of all affected water providers and wells owners (including RID, SRP, COP, APS and COT), replacement water supplies could be a viable measure as long as there is no impact on the quality or quantity of the water, water rights, reliability of water supplies, and operations.

Suitability Determination - Replacement Water Supplies

Provision of replacement water supplies is retained as a potentially viable measure to be considered in the development of the reference and alternative remedies.

5.2.5 Engineering Controls

Engineering control(s) is a measure that consists of a variety of actions implemented to restrict the use of or exposure to contaminated water in order to reduce or eliminate risk of exposure to hazardous substances. Engineering controls could consist of system modifications to prevent point-source discharges of concentrated volatile contaminants. Other engineering controls could consist of restrictions of access to or uses of surface waters impacted by contaminated groundwater.

The remedial measure of engineering controls was considered in terms of the legal requirements for the reference and alternative remedies, as described in Section 5.2. Engineering controls would not achieve the WVBA Site ROs of replacing or otherwise providing a water supply for current or reasonably foreseeable water end uses. Likewise, engineering controls would not satisfy the requirements of ARS § 49-282.06.B.4.b. of ensuring that the "specific measures to address any such well [not fit for its current or reasonably foreseeable end uses without treatment] shall not reduce the supply of water available to the owner of the well." In consideration of all affected water providers and wells owners (including RID, SRP, COP, APS and COT), engineering controls would not be a viable measure given the impact on the quality or quantity of the water, water rights, reliability of water supplies, and operations.

Suitability Determination – Engineering Controls

Engineering controls by itself is not a viable measure for development of the reference and alternative remedies. This measure will not be retained for further consideration in the development of the reference and alternative remedies. However, RID understands that engineering controls will be an important ancillary component to protect the public health and welfare and the environment from the transfer of contaminants from the water to the air into surrounding communities. Therefore, engineering controls will be retained as an ancillary component to the reference and alternative remedies.

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6.0 IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

A detailed discussion of the identification and screening of available remediation technologies for potential implementation at the WVBA Site, based on the best available scientific information, is presented below. These sections define and describe remediation technology screening assumptions as well as treatment technologies for achieving the WVBA Site groundwater ROs and to comply with the requirements of AAC R18-16-407. All remedial actions considered shall be consistent with ARS § 49-282.06.A. which requires all remedial actions to: assure protection of public health and welfare and the environment; to the extent practicable, provide for the control, management, or cleanup of the hazardous substances in order to allow the maximum beneficial use of the waters of the state; and be reasonable, necessary, cost-effective and technically feasible. Additionally, any selected remedial action for waters of the state shall address, at a minimum, any existing well impacted by hazardous substances that could restrict the current or reasonably foreseeable water end use of that well pursuant to ARS § 49-282.06.B.4.b.

6.1 TECHNOLOGY SCREENING

This FS assumes that actions taken to date under ADEQ oversight have adequately characterized and addressed the known source areas of hazardous substance releases to surface and subsurface soils. Consequently, the scope of this FS is limited to consideration of available remediation technologies for the final groundwater remedy. Appropriate remedial technologies to address COC contamination impacting WVBA Site groundwater and capable of meeting the WVBA Site ROs for water end uses will be identified and screened according to the following criteria:

- Performance capability of treatment technology – each technology will be assessed regarding its performance capability of meeting or exceeding target treatment levels;
- Consistency with regional remedial actions sites – each technology will be compared to other technologies used at Arizona CERCLA/WQARF sites that have similar (or the same) COCs;
- Contaminant treatment effectiveness and reliability – each technology will be assessed for its ability to treat COCs to target treatment levels over a long period of time;
- Viability – each technology will be evaluated for its feasibility/practicability to be constructed/installed given the existing infrastructure and other construction requirements;

- O&M requirements – each technology will be assessed for the level of operator oversight/interaction required;
- Generation and management of residual waste products – each technology will be assessed for its anticipated volume of residual waste products and the level of effort required to manage/dispose of wastes; and,
- Cost-effectiveness.

The following WVBA Site assumptions and requirements were used during the identification and screening of groundwater remedial technologies:

- Contaminant – One or more target COCs have concentrations above AWQSs and MCLs at 13 water supply wells within the WVBA Site, with wells located as far as six (6) miles apart;
- Remedial Efficiency – Must achieve drinking water standards (i.e., AWQSs/MCLs) for the target COCs;
- End Use – Reasonably foreseeable water end use is drinking water; and,
- Flow Rate - Depends on historical flow rates for contaminated water supply wells, which can vary from approximately 1,200 gpm to approximately 3,700 gpm.

The available groundwater remediation technologies that pass the technology screening will be retained for use in development of the reference and alternative remedies.

6.2 TREATMENT TECHNOLOGIES

Groundwater treatment is a measure that consists of implementing some form of treatment of the contaminated groundwater, either through in-situ processes (treating contaminated groundwater where it resides in the aquifer) or through ex-situ processes (pumping and treating contaminated groundwater at the ground surface). Due to the widespread distribution of relatively low concentrations of dissolved phase contaminants over large areas, it is generally accepted that in-situ treatment approaches are technically impractical for large-scale, distributed plumes such as the WVBA Site plume.[151] Pump and treat remedies, on the other hand, have been widely demonstrated to be an effective measure for removal of contamination from groundwater. Therefore, further technology considerations are limited to ex-situ

[151] Although limited in-situ treatment projects have been implemented at some Arizona sites, typically as pilot projects to enhance source area remediation and/or reduce the impact of residual DNAPL, this approach is not utilized to address regional groundwater contaminant plumes at any of the major VOC contaminated sites in the state.

treatment approaches.[152] The ex-situ treatment technologies commonly used for treating the concentrations of the target COCs encountered at the WVBA Site are summarized in the following sections, including the basic treatment mechanisms and suitability/limitations of each.

The ex-situ groundwater treatment technologies considered in the following sections can be implemented in either a centralized design approach or in a distributed configuration. The centralized approach consists of a single, large-scale treatment facility fed by contaminated groundwater that is conveyed to the facility through interconnecting pipelines. The distributed treatment approach, also referred to as wellhead treatment, consists of individual treatment systems located at the site of the contaminated wells and fed by contaminated groundwater directly from the impacted well.

The original ERA Work Plan (M&A, 2010a) proposed a centralized treatment approach based on governmental agency preference and the belief that it would be impractical to implement wellhead treatment due to limited space at many of the RID well sites, particularly in the central plume area where street expansions have significantly encroached upon the RID wells. However, RID reconsidered the wellhead treatment approach based on discussions with ADEQ and, in part, on comments from the PRPs[153] who suggested that there *"appears to be ample room at most of RID's well sites for wellhead treatment facilities…"*. While it is arguable that there is "ample" room at many of the RID well sites, especially those with the highest levels of contamination (e.g. the RID-106 well site which is only 1,200 square feet), RID did undertake the RID-95 Wellhead Pilot Treatment Systems evaluation to assess the viability of the wellhead treatment approach.

As demonstrated in the RID-95 Wellhead Pilot Treatment Systems evaluation, and as documented in the *Long-Term Operational Assessment Report, RID-95 Wellhead Pilot Treatment Systems* (Synergy, 2012b), the wellhead treatment approach is practical in terms of implementation and is by far the more cost effective alternative compared to the centralized approach. The results of this pilot system evaluation resulted in the modification of the ERA Work Plan, and the Modified ERA Work Plan elaborated on the benefits of this distributed approach compared to the centralized approach, as summarized below:

- Reduces capital costs by approximately 50%;
- Eliminates the need for construction of new conveyance pipelines;

[152] Further, extensive groundwater extraction occurs throughout the WVBA Site and, consistent with state statutes and rules, this FS must address the impact of hazardous substances on the current and reasonably foreseeable end uses of groundwater at all existing water provider wells in the WVBA Site.
[153] Letter from Honeywell International Inc. to ADEQ dated April 22, 2010, page 22.

- Reduces O&M costs by approximately 50%;
- Enables treatment of more highly contaminated groundwater, eliminating the commingling of lower concentration impacted water;
- Enables blending of treated water with untreated water to achieve remediated water quality goals; and,
- Significantly reduces the time required to implement the remedy.

Moreover, implementation of wellhead treatment rather than centralized treatment is also responsive to PRP comments previously listed in Section 2.4.2 that advocated targeting the wells with the highest levels of contaminants rather than treating large volumes of water with low VOC concentrations at a central plant. The use of wellhead treatment also avoids the impact to the local community associated with the installation of approximately 25,000 feet of interconnecting pipelines that was part of the original ERA Work Plan approved by ADEQ.

6.2.1 Carbon Adsorption

GAC is an appropriate treatment media for many organic compounds, including VOCs, semi-VOCs, and other non-VOCs. Based upon treatment technologies used at other large regional groundwater remediation sites, the target COCs present in the WVBA Site contaminant plume (i.e., TCE, PCE and 1,1-DCE) are amenable to treatment by GAC. Carbon adsorption is commonly used to remove VOCs present in either vapor-phase or liquid-phase. For water treatment, GAC is used as either a primary treatment mechanism or in combination with other treatment methods.

Carbon adsorption is a relatively low-cost, low-maintenance and reliable alternative for treating non-polar organic contaminants, which can be removed from vapor or liquid by adsorption to GAC. Pre-packaged systems are available from multiple manufacturers and installation of modular components is relatively quick and easy. The modular components can be scaled based on flow rate(s). Carbon use rates are a function of the influent (raw water) concentrations and the adsorptive capacity of the carbon for the COCs. For VGAC, pre-treatment to remove humidity and/or to lower the vapor temperature can increase the carbon adsorptive capacity and reduce its use. For LGAC treatment, pre-treatment by air-stripping (A/S) or advanced oxidation can reduce carbon use.

For both VGAC and LGAC treatment, system maintenance consists of periodic removal and replacement of the carbon when the adsorption capacity is reached. Maintenance for LGAC also may consist of periodic backwashing of the LGAC vessels when the pressure drop becomes excessive due to fouling with suspended solids, or either iron and/or carbonate (hardness) scale. Pre-treatment with filtration (e.g., bag filters) and/or antiscalent chemicals can be performed to minimize these effects, but will add additional O&M costs.

Since carbon adsorption satisfies all screening criteria presented in Section 6.1, the treatment technology ***is retained*** for further consideration in the development of the reference and alternative remedies.

6.2.2 Air Stripping

Air stripping is an effective treatment technology for removing VOCs and, to a limited extent, semi-VOCs from groundwater. A/S removes VOCs from the waste stream by transferring the compounds from the aqueous phase to the vapor phase. In a packed-tower air stripper, contaminated groundwater flows downward by gravity through a circular or rectangular column filled with packing material. The packing material is designed to maximize the available surface area for contact between the water and air, for volatilization of contaminants from the water. A blower delivers air into the tower, which flows upward through the packed-bed and countercurrent to the flow of water. A/S is a demonstrated technology with numerous systems treating groundwater reliably for decades. Packed tower systems can treat high flows with low liquid pressure drop.

A/S systems are simple, relatively inexpensive, and reliable. O&M costs are generally low, because systems can be operated unattended with proper instrumentation and controls, and associated labor and material costs are minimal. Pre-packaged systems are available from numerous manufacturers and installation of modular components is relatively quick and easy. A/S systems also are commonly manufactured to meet specific requirements of each application. Computer models are available to design and optimize shallow-tray and packed-tower A/S systems. Electrical power consumption is a function of the air-to-water ratio required for treatment and the system groundwater flow rate. O&M includes periodic inspections and servicing of the aeration blower. Depending upon groundwater characteristics, such as concentrations of dissolved iron, manganese and hardness; the A/S system internal structures, effluent piping and/or internal packing may require periodic cleaning. If fouling is expected based on the groundwater characteristics, it can be prevented with pre-treatment for hardness removal. Biological fouling also can be a problem with A/S systems, if the untreated groundwater contains sufficient organic matter to sustain biological growth. Biological fouling can be prevented by injecting disinfectants (e.g., sodium hypochlorite) to the untreated groundwater with proper feed rates, to minimize the production of potentially harmful by-products (e.g., trihalomethanes).

Iron fouling in A/S systems is another common problem. When ferrous iron comes in contact with oxygen during the A/S process, it is oxidized to ferric iron, which forms an insoluble precipitate that causes fouling. A/S systems have been used with carbon adsorption installed downstream as a polishing step to remove residual contaminants from the treated water.

Treatment of A/S system off-gas also could be required, depending on the effluent concentrations and corresponding mass discharge rates of VOCs emitted to the atmosphere. In the adjacent WCP-WOC Site (GeoTrans, 2012a), ADEQ has taken the position that vapor phase air controls are a necessary component of A/S treatment technology. ADEQ imposed this requirement in order to restrict the relocation or transfer of contaminants from one media (groundwater) to another (air).[154] Consistent with the considerations developed to guide technology screening at the WOC Site, it is assumed that ADEQ would require VGAC downstream of the A/S discharge vent so as to provide a high degree of public protection against potential exposure to VOCs in air.

Since A/S with VGAC satisfies all screening criteria presented in Section 6.1, the treatment technology ***is retained*** for further consideration in the development of the reference and alternative remedies.

6.2.3 Chemical Oxidation

Chemical oxidation often is used in water treatment to remove iron and manganese, control biological growth, and remove color, tastes, and odor. Chemical oxidants also can react with organic contaminants and oxidize the chemicals to harmless end products. However, chemical oxidants often are highly selective, reaction rates are often slow, and competing reactions can reduce the effectiveness of oxidants for treating organic chemical contaminants. Therefore, use of common chemical oxidants usually is not cost-effective, and treatability testing would be required before the performance capability and reliability of chemical oxidation could be applied with confidence for meeting or exceeding target treatment levels. Although chemical oxidation may offer certain advantages in reducing and/or limiting the generation and management of residual waste products, chemical oxidation is not consistent with other technologies used at Arizona CERCLA/WQARF sites that have similar COCs as the WVBA Site, and viability of the technology is currently unknown.

Chemical oxidation ***will not be retained*** as a treatment technology for further consideration in the development of the reference and alternative remedies due to its inability to satisfy all screening criteria presented in Section 6.1.

[154] Letter from ADEQ Waste Programs Director to EPA Region 9 Superfund Director dated November 14, 2007. (ADEQ, 2007)

6.2.4 Ultraviolet Oxidation

Advanced oxidation, such as ultraviolet oxidation (UV/Ox), can be used to destroy all types of organic compounds and does not need off-gas treatment. This technology uses high intensity UV light to generate hydroxyl radicals from an oxidant. The hydroxyl radicals induce a chain of oxidation reactions that mineralize organic pollutants to bicarbonate, or ultimately to carbon dioxide. A potential advantage of UV/Ox is that contaminants are transformed into non-toxic by-products (carbon dioxide, water, and salts), eliminating the need for air emission treatment or disposal of sorbed contaminants. UV/Ox is effective in treating a broad range of organic contaminants, including some constituents such as 1,4-dioxane that are not easily removed by other methods (Trach, 1996).

UV/peroxide treatment has become more common for treating organic contaminants in groundwater, and packaged systems are available from several manufacturers (e.g., TrojanUVPhox™ UV-oxidation system by TrojanUV). Considerations for application include maintenance requirements, required pre- and post-treatment, and overall cost. Pre-treatment for hardness removal can be required to minimize interference by carbonates and maintain light transmittance. Post-treatment by LGAC is often used to minimize UV system requirements and to remove residual hydrogen peroxide.

Although the performance capability, reliability and viability of UV/Ox should be comparable to carbon adsorption and air stripping for meeting or exceeding target treatment levels, the capital and O&M costs typically are higher for UV/Ox as compared to A/S and LGAC. For example, the capital and O&M costs (consumables) for an approximate 1,850 gpm capacity system are a minimum of 1.5 times more expensive (each) than a LGAC treatment system with same capacity (as quoted by TrojanUV and Siemens Water Technologies [now Evoqua Water Technologies], respectively).

The UV/Ox treatment offers certain advantages in reducing and/or limiting the generation and management of residual waste products; however, this treatment technology generally is more operator intensive. UV/Ox is considerably more likely to require pre-treatment for metals and/or solids to prevent fouling and can result in poor performance due to increased turbidity, hardness, and iron manganese content. Also, O&M requirements for handling and storage of oxidizers require special material handling and safety precautions (Trach, 1996).

UV/Ox ***will not be retained*** as a treatment technology for further consideration in the development of the reference and alternative remedies due to its inability to satisfy all screening criteria presented in Section 6.1.

6.2.5 Ion Exchange/Adsorption

Ion exchange removes ions from the aqueous phase by the exchange of cations and anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached. They also may be inorganic and natural polymeric materials. After the resin capacity has been exhausted, resins can be regenerated for reuse.

The most common application of ion exchange is for water softening. Target ions are adsorbed onto the medium in exchange for a loosely bound ion, such as sodium. Ion exchange is particularly effective for treating high-contaminant concentrations, especially with on-site regeneration. Ion exchange also can be appropriate for treating some constituents that are not effectively removed by GAC. Treatment by ion exchange is contaminant-specific and not appropriate for treating process water that contains many constituents. Also, ion exchange is typically more expensive than GAC or A/S. The performance capability, O&M requirements, reliability and viability of ion exchange should be comparable to carbon adsorption and air stripping for meeting or exceeding target treatment levels, however, it is not consistent with other technologies used at Arizona CERCLA/WQARF sites that have similar COCs as the WVBA Site. Due to limited applications in treating VOC-contaminated water, the impact on generation and management of residual waste products is currently unknown.

Ion exchange ***will not be retained*** as a treatment technology for further consideration in the development of the reference and alternative remedies due to its inability to satisfy all screening criteria presented in Section 6.1.

6.2.6 Membrane Filtration

Membrane filtration includes several different technologies, such as reverse osmosis, electro-dialysis, and ultra-filtration (UF). In domestic water treatment, membrane processes are most commonly used in desalinization and for removing ions that are otherwise difficult to displace. Reverse osmosis and UF can remove some dissolved organic compounds. However, membrane processes are generally not effective at removing low molecular weight compounds, such as those COCs present in the WVBA Site contaminant plume. As a result, the performance capability, reliability and viability of membrane filtration to meet target treatment levels are questionable. In addition, membrane filtration is not consistent with other technologies used at Arizona CERCLA/WQARF sites. Due to the level of on-going maintenance required by membrane processes and management of residual waste products, the technology is generally expensive compared to other treatment technologies.

Membrane filtration ***will not be*** retained as a treatment technology for further consideration in the development of the reference and alternative remedies due to its inability to satisfy all screening criteria presented in Section 6.1.

6.2.7 Biological Degradation

Ex-situ biological treatment can mineralize dissolved contaminants to the harmless end-products of carbon dioxide and water. The technology is often effective for treating constituents that are not easily removed by A/S or GAC (e.g., ketones, ammonia). Chlorinated hydrocarbons have been treated successfully by aerobic biodegradation; however, the process requires a co-substrate, such as methanol or phenol to stimulate microbial degradation of the contaminants. Biological processes typically are not used for treating drinking water because of concerns about transmitting microorganisms into the drinking water supply. The performance capability and reliability of biological degradation to meet target treatment levels for the COCs would require treatability testing. Further, biological degradation is not consistent with other technologies used at Arizona CERCLA/WQARF sites, is relatively operator-intensive compared to A/S or GAC, and it generates solids and/or wastes that may require off-site disposal.

Ex-situ biological treatment ***will not be retained*** as a treatment technology for further consideration in the development of the reference and alternative remedies due to its inability to satisfy all screening criteria presented in Section 6.1.

6.3 RETAINED TECHNOLOGIES

The treatment technologies retained for further evaluation, associated with the active remediation technologies screened in this FS, are GAC and A/S. Treatment technology alternatives that were evaluated include:

- Alternative 1: P&T using A/S with VGAC for air emission controls
- Alternative 2: P&T using LGAC only

The retained technology alternatives have been proven to satisfy all screening criteria presented in Section 6.1. Following is a detailed evaluation of the retained treatment technology alternatives with respect to contaminant treatment efficiency and O&M requirements.

6.3.1 Alternative 1: P&T using A/S and VGAC

This alternative pertains to the treatment of extracted groundwater utilizing A/S and VGAC treatment technologies.

Treatment Efficiency

The design treatment efficiency for A/S of the target COCs for the WVBA Site could exceed 99%. Air strippers are designed to achieve the air-to-water ratio required to attain the target removal efficiency. However, air stripper size and power consumption must increase to achieve a greater removal efficiency. Therefore, air strippers generally are designed to meet minimum design requirements. In our case, the design criteria is to treat groundwater to below MCLs for the target COCs in the treated effluent from the air stripper with a factor of safety over two (e.g., design air stripper effluent TCE, PCE and 1,1-DCE levels of ½ the MCL (i.e., 2.5 μg/L, 2.5 μg/L and 3.5 μg/L, respectively). Additionally, this alternative assumes[155] that ADEQ would require VGAC treatment downstream of the air stripper discharge vent to provide a high degree of public protection against potential exposure to VOCs in air. VGAC treatment, as compared to other off-gas treatment options (i.e., thermal oxidation and biofiltration), would be the most reliable and cost-effective technology to abate the low-concentration air stripper emissions. The VGAC treatment system would be designed for a minimum of 99% removal efficiency of target COCs prior to discharge to the atmosphere.

O&M

The O&M considerations for this alternative are reasonable assuming scaling problems do not frequently occur. Periodic inspections (i.e., weekly) are recommended to confirm proper operation. Routine maintenance would include servicing the aeration blower, checking ancillary equipment and controls, and cleaning system components as necessary to mitigate fouling. The A/S may require periodic treatments to remove scale. Since inorganic water quality (i.e., hardness at 242 mg/L and iron at 0.067 mg/L in samples collected from RID-95, for example) indicate scaling potential, dosing the A/S influent (raw water) with an antiscalent sequestering agent utilizing a chemical feed pump would be necessary. The appropriate concentration and dosage rate of the sequestering agent can be determined from a pilot study during the start-up phase of the A/S system. O&M associated with the VGAC treatment system would include performance monitoring/testing and periodic carbon changes to replace exhausted VGAC. To improve the VGAC adsorption capacity, a duct heater could be utilized between the A/S and VGAC systems to reduce relative humidity in the VOC-containing vapor. Another option could be to plumb the air blower in an induced draft arrangement where the air would flow upwards through the aeration trays under negative (vacuum) pressure rather than

[155] According to the Final FS Report for the Shallow Groundwater System at the WOC WQARF Site, VGAC was included for treatment of air stripper off-gas because "it would be required by ADEQ" (GeoTrans, 2012a).

positive pressure. This arrangement would raise the vapor temperature on the pressure side of the blower to reduce the relative humidity. Regardless of the blower plumbing arrangement, O&M of the off-gas treatment would involve monitoring concentrations and replacement of exhausted carbon.

6.3.2 Alternative 2: P&T using LGAC only

This alternative pertains to the treatment of extracted groundwater utilizing LGAC as the only treatment technology.

Treatment Efficiency

LGAC treatment systems can reliably achieve high removal efficiency. Dissolved organic contaminants that pass through an LGAC vessel are completely removed until contaminant breakthrough occurs, initially at low concentrations. If the carbon is not replaced, effluent concentrations would steadily increase until they were equivalent to influent concentrations.

The adsorption capacity of LGAC for a specific contaminant is characterized by an empirical adsorption isotherm. The isotherm is described by an equation that defines the capacity of the carbon for the adsorbed contaminant and the strength of the attraction. For a given LGAC vessel, the isotherm is used to estimate the time to breakthrough for a contaminant and mass-loading rate, which allows for the carbon usage rate to be determined. However, predicting GAC usage rates is complicated by the presence of multiple contaminants as is the case in the WVBA Site. Considerable discussion on this issue was provided in the *Long-Term Operational Assessment Report, RID-95 Wellhead Pilot Treatment Systems* (Synergy, 2012b).

O&M

Carbon adsorption systems are reliable and typically require little routine maintenance. Routine operation consists of periodic checks of pressure drop across the LGAC vessels and monitoring for contaminant breakthrough in the vessel effluent. If pressure within the vessels increases, they can be backwashed to help restore carbon permeability. Once the carbon capacity is reached and contaminant breakthrough occurs in the first (or lead) vessel of a lead/lag configuration, the exhausted or spent carbon requires replacement. By changing valve positions, the lag vessel is reconfigured as the lead vessel and the new lag vessel contains fresh carbon.

Carbon-only treatment systems are simple, quiet, and produce no emissions. The largest readily available units contain 20,000 pounds of GAC and treat up to 1,000-1,100 gpm. For treating flow rates greater than this capacity, the treatment system would require additional treatment skids.

6.3.3 Proposed Treatment Technology

Based on detailed review of groundwater treatment technology alternatives, the use of LGAC treatment technology is the proposed treatment technology.

As a treatment technology, LGAC is proven and reliable because it can assure protection of public health and welfare and the environment; provides for the control, management, and cleanup of the hazardous substances (to the extent practicable) in order to allow the maximum beneficial use of the waters of the state; and is reasonable, necessary, cost-effective and technically feasible as required in ARS § 49-282.06.A.; and, at a minimum, it protects the current and foreseeable water end uses (as required in ARS § 49-282.06.B.4.b.) identified by the water providers and ADEQ in the ROs for the WVBA Site.

LGAC not only is the selected groundwater treatment technology at many other CERCLA/WQARF sites with similar (or the same) COCs as the WVBA Site (i.e., including, but not limited to: Phoenix Goodyear Airport-North Superfund Site, North Indian Bend Wash Superfund Site [NIBW GAC Treatment Facility], M52 Site OU2, and the Payson PCE Site), wellhead LGAC treatment specifically has been proven for the WVBA Site as described in the *Long-Term Operational Assessment Report (LTOAR), RID-95 Wellhead Pilot Treatment Systems* (Synergy, 2012b).

Air stripping also has been utilized in remedial actions at other CERCLA sites with similar COCs as the WVBA Site. This technology, however, has significant operational problems in terms of scale formation in the packed towers where the groundwater is notably "hard", which is the case at the WVBA Site. Additionally, as noted in the Modified ERA Work Plan (Synergy, 2012d), A/S has potential issues from both an operational and a regulatory acceptance standpoint. Discussions with ADEQ indicated the agency position that single-stage A/S is a less reliable treatment technology for remedial actions that have a reasonably foreseeable drinking water end use because failure of the A/S system could result in a direct discharge of untreated groundwater into a public water supply. ADEQ has suggested that selection of A/S would require added safeguards, such as secondary treatment through A/S or polishing through LGAC to assure protection of public health against such failure, consistent with AAC R18-16-411(C). Two-pass A/S would result in significant maintenance issues due to scale formation in the tower packing, and liquid-phase polishing through LGAC would be very costly.

For the reasons described, the proposed groundwater treatment technology is *Alternative 2, LGAC.*

7.0 DEVELOPMENT OF REFERENCE AND GROUNDWATER ALTERNATIVE REMEDIES

Based on the results of the screening of remedial strategies, remedial measures, remedial technologies and evaluations of treated water discharge in Sections 5 and 6, a reference remedy has been developed along with three (3) alternative remedies for comparison. The reference remedy, and each alternative remedy, consists of remedial strategies and measures to achieve the specified groundwater ROs for the WVBA Site and to comply with ARS § 49-282.06.[156] As stated earlier, the specified groundwater ROs for the WVBA Site were developed through a public participation process and specified in the *Remedial Objectives Report* (ADEQ, 2012b) provided as Appendix AA of the Final RI Report (Terranext, 2012).

7.1 REMEDIAL STRATEGIES AND MEASURES

The combination of remedial strategies and remedial measures for each remedy are designed to achieve the WVBA Site groundwater ROs and to comply with ARS § 49-282.06. The reference remedy and each alternative remedy may also include contingent remedial strategies or remedial measures to address reasonable uncertainties regarding the achievement of the WVBA Site groundwater ROs, or uncertain time frames in which groundwater ROs will be achieved.[157]

Remedial Strategies

As determined on the basis of the screening of remedial strategies conducted in Section 5.1, the following primary remedial strategies are incorporated into the reference and alternative remedies in order to address, at a minimum, all thirteen (13) existing wells that are impacted by groundwater contamination above AWQSs and MCLs pursuant to the WVBA Site groundwater ROs and ARS § 49-282.06.B.4.b.:

- plume remediation to achieve water quality standards for target COCs in waters of the state throughout the WVBA Site;
- physical containment to hydraulically contain contaminants within definite boundaries;
- controlled migration to control the direction or rate of migration but not necessarily to contain migration of contaminants; and,
- monitoring to observe and evaluate groundwater conditions and water quality at the WVBA Site through collection of data.

[156] *See* AAC R18-16-407.A
[157] *See* AAC R18-16-407.E

Plume remediation and physical containment of the plume are the primary remedial strategies identified in the reference and alternative remedies based on the CSM, as described in Section 4.8, that indicates the existing, large-scale pumping of RID wells is the dominant control on groundwater flow and contaminant removal and transport in the area encompassing the WVBA Site, and upgradient WOC Site and OU3 Study Area. The regional pumping center created by groundwater withdrawals within the RID well field removes contaminants and contains the extent of groundwater contamination in the WVBA Site, as well as controls the migration of contaminants from the adjacent, upgradient regional groundwater contaminant sites.

Remedial strategies defined as "source control"[158] also are related and are significant components of the WVBA Site, but are not directly applicable to the scope[159] of this FS, which is focused on the groundwater portion of the feasibility study.[160] Source control is not applicable and, therefore, not explicitly included in the reference and alternative remedies on the belief, as stated in the FS Work Plan (Synergy, 2013a), that actions taken to date under ADEQ oversight have adequately characterized and addressed the known sources of hazardous substances that may be impacting groundwater. Although these historical source control activities are not featured in this FS, the actions have beneficially lessened COC mass loading[161] to UAU groundwater by removing continuing sources of groundwater contamination. Should any further information arise that identifies the need to address a known source or a presently undefined source of hazardous substances, it is assumed that ADEQ will, independent of the groundwater remedy selected by this FS, assure that necessary actions are taken to remediate or control the hazardous substances causing the impairment or restriction to groundwater use.

Provision of replacement water supplies was dismissed as a remedial strategy in the reference and alternative remedies that follow. This strategy is constrained by the magnitude of water supply that would be required to replace contaminated groundwater from impacted RID water supply wells. RID's operational needs require that water be available, in very large volumes and on an "on-demand" basis, particularly during peak-demand (typically from the beginning of April through the end of September). In fact, RID has historically pumped their wells in the WVBA Site in high demand periods at a capacity in excess of 80,000 gpm (or more than 115 million gallons per day) and produces approximately 80,000 to 85,000 AF of water from this

[158] As discussed herein, "source control" applies to facilities within the WVBA Site and in the adjacent upgradient regional groundwater contaminant sites where releases of hazardous substances to surface and subsurface soils may have contributed to groundwater contamination.
[159] See AAC R18-16-407.B. (finding that "a work plan shall be developed and implemented for all or a portion of a feasibility study for a site or a portion of a site").
[160] Source control also is outside the scope of this FS because, as previously discussed with ADEQ, RID has volunteered to implement the final groundwater remedy selected by ADEQ, pursuant to AAC R18-16-411.G, and RID does not have the authority or access to address the facilities and sources of the released COCs.
[161] For example, source control at the ALSCo and Dolphin facilities have significantly reduced PCE concentrations from potential DNAPL source, as discussed in Section 3.4.3.

well field annually. To meet these needs, RID maintains and operates a network of water supply wells that provide near instantaneous response to changes in demand, tailoring the production capacity as required. RID has been operating the well field that provides this capacity and reliability for over 80 years.

Providing a reliable replacement water supply of this magnitude to meet the RID water supply needs would be extremely challenging. Moreover, in the event it was possible to provide a replacement water supply in lieu of pumping contaminated groundwater from the WVBA Site, the consequence would be detrimental to the stated needs of WQARF remedial actions (*i.e.,* to control, manage or cleanup the contaminated aquifer) as provided in ARS § 49-282.06.A.2. As will be shown in Section 7.2, failure to maintain plume containment and migration control, provided by the historical and ongoing RID pumping in the WVBA Site, would result in widespread movement of the regional groundwater contaminant plume to peripheral and downgradient wells of other water providers (including COP, COT, and SRP) that have not yet been impacted above AWQSs and MCLs and present an imminent and substantial endangerment to public health and welfare.[162]

Remedial Measures

Remedial measures necessary for each possible groundwater alternative remedy have been identified with consideration of the needs of the water providers whose water supplies are affected by the release of hazardous substances (RID, COP and SRP) and their customers. These considerations include the quantity and quality of water, water rights, other legal constraints, reliability of water supplies and operational implications. The nature and degree of the impact to these water providers are summarized in Section 4.6 and described in the Water Provider Information Request surveys included in this report as **Appendices C through E**.

As determined on the basis of the screening of remedial measures conducted in Section 5.2, remedial measures that are incorporated into the reference and alternative remedies are listed below:

- Ex-situ water treatment using LGAC;
- well replacement; and,
- engineering controls.

[162] ADHS (1992) completed a health risk assessment addressing the potential threat to drinking water wells in the WVBA vicinity. The study was conducted in anticipation of potential contamination of water supply wells by the westerly groundwater movement of the WVBA Site plume. The study concluded there would be significant health effects from domestic consumption of groundwater containing COCs at concentrations similar to those found in WVBA Site.

Where remedial measures are necessary to achieve WVBA Site groundwater ROs or to comply with ARS § 49-282.06.B.4.b., such remedial measures will remain in effect as long as required to ensure the continued achievement of those objectives or satisfaction of those applicable requirements pursuant to AAC R18-16-407.G.

The integration and specific application of these remedial measures to the reference and alternative remedies is described in the following sections. An added component that is termed "operational control" also is included in the reference and alternative remedies. As applied to the WVBA Site and this FS, the meaning of "operational control" is described as follows.

Operational Control

RID historically (and currently) operates its water supply wells in the WVBA Site using a prioritization approach that primarily considers well efficiency, with the first priority placed on those wells that produce the most water for the least amount of energy, the highest-efficiency wells. The highest-efficiency RID wells within the WVBA Site are, for the most part, located on the Main Canal and on the southern margin of the plume. This prioritization of well operation also has minimized the amount of contamination that RID pumps from the groundwater and that is subsequently transferred into local conveyance systems and local air.

With the incorporation of wellhead treatment, as conceived in the reference and alternative remedies, RID will modify the pumping priority as feasible to place the contaminated wells situated in the center of the plume, those wells with wellhead treatment, as first-on and last-off. The wells on the margins of the plume will be designated as last-on and first-off. By this reprioritization of well operation, RID will attempt to maximize groundwater extraction in the center of the plume and minimize, to the extent practicable, the pumping on the margins of the plume. This reprioritization will serve to enhance plume remediation and containment.

7.2 INTEGRATED PLANNING FOR RID REMEDIAL ACTIONS

Model simulations of groundwater flow and VOC plume movement demonstrate the critical importance of RID groundwater pumping in managing the overall impact of groundwater contamination in the entire region. Advective migration of the current VOC plume over the next 30 years was simulated (using particle tracking) for two (2) scenarios: (1) current RID pumping rates; and (2) RID pumping ceases. For scenario 1, pumping from the RID wells was simulated as the average of actual pumping rates from 2008 through 2012.[163] The projected

[163] RID-111R started operating in 2012. For scenario 1, referred to as the Baseline Scenario, RID-111R was simulated at a pumping rate of 2,800 AFY.

pathlines shown on **Figures 19** and **20,** delineate the direction and extent of 30-year advective VOC plume movement for scenarios 1 and 2, respectively. For additional details on these simulations see **Appendix F**.

These model results demonstrate that groundwater pumping by RID in the WVBA Site stabilizes, for the most part, the regional groundwater contaminant plume. Without RID pumping, the VOC plume in the WVBA Site (with contributions from the M52 Site) would move west toward COT. Additionally, absent RID pumping in the WVBA Site, the contaminant plume associated with the WOC Site (and other WCP Area WQARF sites) would move westerly from its current area of impact to portions of west Phoenix. In this scenario, regional groundwater contamination shown on **Figure 2** would impact areas not currently affected by groundwater contamination and impact and/or threaten a substantial number of uncontaminated SRP, COP, and COT wells.

Based on the consideration of groundwater contamination impacts to existing RID water supply wells observed in the WVBA Site (illustrated in **Figures 13 through 18**) and the statutory obligation to protect all existing RID, COP, SRP, APS and COT water supply wells that may in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end uses over at least the next 100 years without treatment,[164] the following priorities emerge for integrated remedial strategies that would best address and achieve applicable groundwater remedial action requirements for all existing wells within or outside the WVBA Site that could be impacted or threatened by the groundwater contamination. The remedial strategies for different portions of the aquifer are ranked from highest to lowest priority.

1. Conduct plume remediation via ex-situ pumping and treatment to remove TCE and PCE impacting existing wells in the Southern Flank of the WVBA Site contaminant plume; ensure containment of the plume to protect threatened wells; control migration of commingled plumes from adjacent groundwater contaminant sites entering into the WVBA Site.
    - RID-89, RID-92, and RID-95 contain relatively higher TCE and, to a lesser extent, PCE concentrations that need to be treated to meet applicable AWQS/MCL water quality standards.
    - Contaminant concentrations are not declining; there are persistent contaminant sources.
    - TCE concentrations in RID wells along the Main Canal are increasing.

[164] *See* ARS § 49-282.06.B.4.b and AAC R18-16-406.D.

- Prioritized groundwater extraction and treatment of RID-89, RID-92, and RID-95 will increase VOC mass removal, improve plume containment, and aid in mitigating impacts to threatened water provider wells.

2. Conduct plume remediation via ex-situ pumping and treatment to remove PCE impacting existing wells in the Leading Edge of the WVBA Site contaminant plume; ensure containment of the plume to protect threatened wells.

   - RID-106 and, to a lesser extent, RID-84 are impacted by PCE that need to be treated to meet applicable AWQS/MCL water quality standards.
   - Contamination extends significantly west of RID-106.
   - Prioritized groundwater extraction and treatment at RID-106 will assist with containment of the Leading Edge of the WVBA Site plume to address impacted well RID-84 and threatened water provider wells.

3. Conduct plume remediation via ex-situ pumping and treatment to remove TCE impacting an existing well in the Eastern Core of the WVBA Site contaminant plume; ensure containment of the plume to protect threatened wells; control migration of commingled plumes from adjacent groundwater contaminant sites entering into the WVBA Site.

   - RID-114 contains relatively high TCE concentrations that need to be treated to meet applicable AWQS/MCL water quality standards.
   - Prioritized groundwater extraction and treatment will increase mass removal and capture contaminants from upgradient WVBA Site sources and/or the M52 Site.

4. Conduct plume remediation via ex-situ pumping and treatment to remove TCE and PCE impacting an existing well in the North Central region of the WVBA Site contaminant plume; ensure containment of the plume to protect threatened wells; control migration of commingled plumes from adjacent groundwater contaminant sites entering into the WVBA Site.

   - RID-109 and, to a lesser extent, other wells in this region are impacted by TCE and PCE that need to be treated to meet applicable AWQS/MCL water quality standards.
   - Prioritized groundwater extraction and treatment will capture contaminants from sources in the WVBA and WCP/WOC sites.

5. Conduct plume remediation via ex-situ pumping and treatment to remove PCE impacting an existing well in the Southeast Lobe region of the WVBA Site contaminant plume; ensure containment of the plume to protect threatened wells.

   - RID-99 is impacted by PCE that needs to be treated to meet applicable AWQS/MCL water quality standards.

- Focused groundwater extraction will capture contaminants from limited and localized source.

7.3 REFERENCE REMEDY

The Reference Remedy includes the remedial strategies and measures that follow.

7.3.1 Summary of Reference Remedy

The Reference Remedy integrates the following remedial strategies and measures:

- Wellhead treatment using LGAC at nine (9) existing water supply wells impacted above AWQSs/MCLs, including RID-84, RID-89, RID-92, RID-95, RID-100, RID-106, RID-109, RID-112, and RID-114; the locations of these water supply wells are shown in **Figure 3.**
- Priority pumping of all nine (9) impacted wells equipped with treatment to enhance mass removal, plume containment, migration control of the contaminants within and entering into the WVBA Site, and to allow blending of other impacted existing wells such as RID-99, RID-107, RID-110 and RID-113 to achieve, at a minimum, necessary water quality for all current and reasonably foreseeable water end uses at all thirteen (13) existing wells impacted above AWQSs and MCLs as required by ARS § 49-282.06.B.4.b.
- Installation of higher capacity replacement wells, completed solely in contaminated aquifer, at RID-92 and RID-106 to enhance hydraulic capture in critical areas of plume containment and to provide water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Replacement of the pump (using the same motor) in RID-114 to enhance hydraulic capture and to provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Engineering controls to limit potential routes of public exposure to COCs within the RID water delivery system.
- Groundwater monitoring to verify plume remediation and containment and assess the progress toward groundwater remediation, and whether any contingency measures are necessary to be implemented.

7.3.2 Remedial Strategies

The primary remedial strategies associated with the Reference Remedy are plume remediation and physical containment of the WVBA Site groundwater plume to address, at a minimum, all thirteen (13) existing water supply wells impacted above AWQSs and MCLs (while at the same time through physical containment protecting existing water supply wells impacted below AWQSs and MCLs, and any existing threatened water supply wells that are not currently impacted by COCs, including RID, SRP, COP, APS and COT wells) pursuant to the WVBA Site groundwater ROs and ARS §§ 49-282.06.A. and 49-282.B.4.b. These primary remedial strategies will control migration of commingled plumes within the WVBA Site and from adjacent groundwater contaminant sites entering into the WVBA Site. Monitoring will continually be conducted throughout the WVBA Site for target COC concentrations in existing impacted water supply wells, threatened water supply wells, and ADEQ monitor wells in both the areas of active plume remediation and in the areas outside of the influences of remedial measures.

7.3.3 Remedial Measures

The remedial measures to be implemented include water treatment, well replacement, and engineering and operational controls.

Water Treatment

Water treatment for plume remediation is included in the Reference Remedy and will be accomplished through pumping and treatment (P&T) of contaminated groundwater using existing RID wells. Treatment will be accomplished using wellhead P&T systems and blending of untreated wells (those that exceed one [1] or more MCLs) with treated water or wells with COCs below the MCLs.

P&T systems will utilize LGAC technology for contaminant removal at the wellhead. This technology was selected as the proposed treatment technology as described in Section 6.4.3. Wellhead P&T systems will be employed at nine (9) existing water supply wells impacted above AWQSs/MCLs as follows:

- RID-89, RID-92, RID-95 and RID-114: Wellhead treatment systems currently exist and are in operation at these four (4) water supply well sites. The treatment systems were installed by RID in late 2011/early 2012 as part of the *Well-95 Wellhead Pilot Treatment Systems Proposal*, agreed to by ADEQ on September 2, 2011, and later incorporated into Phase 1 of the Modified ERA Work Plan (Synergy, 2012d), approved by ADEQ on February 1, 2013 (ADEQ, 2013a).

- RID-100, RID-106, RID-109 and RID-112: Wellhead treatment at these four (4) impacted water supply wells[165] was authorized by ADEQ in the Modified ERA Work Plan. The wellhead treatment systems were to be installed in Phase 2 of the Modified ERA Work Plan, but now have been incorporated into the FS.

- RID-84: This water supply well currently exceeds the AWQS/MCL for PCE and also contains TCE and 1,1-DCE. The well discharges directly to the Main Canal, precluding the possibility of blending with an uncontaminated well prior to discharge.

Installation and operation of LGAC wellhead treatment systems result in an increase in pressure head and a corresponding loss of pumping capacity at these wells. This is reflected both in the decrease of overall water production and an increase in the electrical costs. Both of these impacts will be addressed in the Reference Remedy through well replacement (replacing water losses) and as a line item in the projected O&M annual cost estimates.

Table 5 presents information on the water supply wells to be treated with wellhead treatment systems under the Reference Remedy, including the targeted well production capacity, the number of LGAC skids required and the anticipated well production losses for each well.

Treatment through blending will be utilized for three (3) existing impacted water supply wells on the Salt Canal (RID-107, RID-110 and RID-113). These water supply wells will be blended with remediated water from the four (4) wells along the Salt Canal with treatment systems to ensure that the water quality of the combined flows will be remediated to concentrations less than AWQSs/MCLs. Similarly, well RID-99 will be blended with remediated water from the treatment system at RID-100 to achieve and maintain AWQSs/MCLs. These "to be blended" wells currently exceed AWQSs/MCLs for one or more target COC, but will be combined with remediated water or with uncontaminated/lower contaminated wells "in pipe", remediating the combined contaminant concentrations to below AWQSs/MCLs.

Well Replacement

Well replacement will be included in the Reference Remedy in order to enhance groundwater extraction and contaminant removal at RID-92 and RID-106.

- RID-92 is the highest contaminated RID water supply well, and has historically operated at about 1,500 to 2,000 gpm. The current well site is only large enough for a single skid

[165] The Modified ERA Work Plan anticipated wellhead treatment would be added to RID-100, RID-106, RID-112, and RID-113. In implementing Task 3 of this Work Plan, *Data Collection and Analysis*, it became evident that RID-109 was a better candidate well for treatment than RID-113 due to the occurrence of higher and more persistent COC concentrations at RID-109.

of LGAC treatment vessels, which restricts the well production capacity to approximately 1,200 gpm. Replacing the existing well with a new well, completed only in the UAU, would likely result in extraction rates in the neighborhood of 2,000 to 2,200 gpm, and allow for enhanced contaminant removal. Expanded groundwater extraction at this well site also will enhance containment of the southern flank of the WVBA Site plume, and help prevent further contaminant migration to threatened water provider wells located south of the WVBA Site groundwater contaminant plume.

- RID-106 is the westernmost well on the Salt Canal within the WVBA Site contaminant plume. Consequently, RID-106 is the most suitable location to influence capture of the leading edge of the regional contaminant plume. Presently, RID-106 produces approximately 1,500 gpm of groundwater from a screened interval of 80 to 776 feet bls. Well replacement is proposed at RID-106 by drilling a replacement well at this location completed in the UAU and upper MAU[166]. Based on recent experience gained from drilling of replacement well RID-111R, the expected extraction rate at RID-106 is about 3,000 gpm. Expanded groundwater extraction at this well site will enhance containment of the leading edge of the plume, assist in preventing further migration of contaminants to the west, and protect threatened water provider wells outside of the WVBA Site groundwater contaminant plume.

Increasing the groundwater capture at RID-92 and RID-106 through well replacement also could provide for the replacement of any reduction in the available supply of water encountered from the increased head at the wellhead treatment systems pursuant to ARS § 49-282.06.B.4.b. Increasing the capacity of RID-92 and RID-106 will require acquisition of additional property adjacent to the well sites. The replacement wells will be drilled within the required 660 feet of the existing wells, consistent with ADWR requirements.

Well Modification

Modification of RID-114 is proposed to consist of replacement of the existing pump with a larger capacity pump (using the same motor) to enhance hydraulic capture and provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.

[166] The targeted depth of completion would be at least 420 feet bls to ensure production throughout not only the UAU but also the upper MAU interval, which was shown to have PCE, TCE, and 1,1-DCE concentrations of 70.2, 21.2, and 29.4 µg/L, respectively, at nearby ADEQ monitor well AVB82-01 in March 2013.

Engineering Controls

Engineering controls will be implemented to control point source and fugitive emissions of contaminants (as previously described in Section 7.1), including:

- enclose well discharge boxes at all water supply wells exceeding AWQSs/MCLs (13 wells).
- enclose open section of the RID-92 lateral (1 segment);
- modify lateral and well discharge structures into the Main Canal,
- enclose open sections of the Salt Canal (2 segments); and,
- replace/seal manhole covers on the Salt Canal (numerous locations).

Operational Controls

Operational controls will be implemented to optimize the RID well pumping priorities as previously described in Section 7.1. The modifications to RID's pumping priorities will result in increased pumping in the center of the plume and an equivalent decrease in pumping on the plume margins. The intention is to enhance plume remediation and to physically contain the movement of the groundwater contamination to protect the less impacted and threatened wells, including water provider wells, along the southern and western boundaries of the plume.

7.3.4 Treated Water End Use

Treated water that is conveyed via the Salt Canal will be used for either agricultural purpose, by discharge into the Main Canal, or M&I use. M&I use will require the construction of a pipeline along the RID Main Canal easement/right-of-way, to convey this remediated water to users in the west valley. Discussions are currently underway with the City of Buckeye, City of Goodyear and others in this regard, based on their stated interest in acquiring this water as source water for treatment and municipal use.[167] RID anticipates a pipeline will be installed and available to deliver M&I water supplies within the next five (5) years.

For the near term, treated water to be conveyed through the Main Canal (and feeder laterals) to RID lands will continue for its current use as an agricultural water supply. However, RID

[167] *See* footnote 109.

anticipates that all RID water supply wells will be developed as future M&I drinking water supply sources in the reasonably foreseeable future.[168]

7.3.5 Permitting and Approvals

Site improvements proposed at RID well sites and along RID conveyance canals are on land owned by RID or within established RID easements and rights-of-way. As a municipal corporation, RID is not subject to the COP requirements that typically apply to privately owned properties such as zoning, use permits, plans review, permits, inspections, and certificates of occupancy. Therefore, improvements at RID well sites can be implemented without building permits from the COP and no encroachment permits will be required for work at RID water supply wells or enclosing open sections along the Salt Canal and RID-92 lateral.

COP rights-of-way (encroachment) permits will be required during construction of the wellhead treatment systems in order to accommodate cranes and other large construction support vehicles. Encroachment permits also will likely be needed for periodic LGAC change out activities as part of normal O&M procedures.

ADWR approval of a notice of intent (NOI) will be required prior to re-drilling RID-92 and RID-106, and for abandonment of the existing wells once the replacement wells are installed.

A Poor Quality Groundwater Withdrawal Permit (PQGWP) may be required by ADWR in accordance with ARS § 45-516.

When remediated water is conveyed to Goodyear, Buckeye, or developers within RID's service area lands for M&I use, the water provider will need to obtain source approval from the Maricopa County Environmental Services Department (MCESD). While the future drinking water use of remediated water is an important feature of this groundwater remedy to RID and their customers, construction of the pipeline or other water infrastructure and any necessary water management changes to deliver the RID treated water and associated permitting are not part of this FS.

7.3.6 Source Control

As stated in Section 5.1.4, source control is not applicable for the scope of this FS, but RID believes ADEQ will undertake any necessary source control measures that have not currently

[168] Such potential future M&I use of this water supply from these wells may require RID to discontinue the delivery of treated effluent in the Main Canal. RID is pursuing designation of the Main Canal as a public water source. The use of effluent in the Main Canal may phase out in the near future.

been addressed or ADEQ will provide oversight to any source control measures performed by the owners or operators of the source facilities.[169]

7.3.7 Uncertainties and Contingencies

The COP owns four (4) shallow production wells in the WVBA Site contaminant plume. Although the City has indicated it does not intend to use the wells and the wells are currently capped and out of service, the City has an established right to withdraw groundwater. Should the City require the wells for some non-potable use[170] in the future, then it will be necessary to evaluate potential remedial measures and take appropriate actions to address the water provider needs.

The extent to which physical containment is able to limit increasing COC impacts to existing water supply wells and any threatened or peripheral wells that are not currently impacted by COCs will be determined by ongoing groundwater monitoring. Given current understanding of contaminant fate and transport in the WVBA Site, the probability of the Reference Remedy to fully contain the plume is thought to be high. However, current interpretation of the extent of groundwater contamination is based on available data that, in certain areas of the WVBA and WOC sites, may not adequately delineate the extent of contamination. Should future monitoring data indicate that water provider wells within or outside of the plume show increasing COC impacts, contingent actions may be necessary to more fully contain the contaminant plume or directly address those wells pursuant to applicable state law.

There is some degree of uncertainty that the MCL for TCE may be reduced through pending action by EPA. If this change occurs, there may be need to treat additional water supply wells since the target for blending (the MCL) is now 5 µg/L for TCE and the revised MCL could be substantially lower. Concentrations in individual wells also will change with time. Adjustments to the remedy could be warranted based on these changes. The modular nature of the wellhead treatment systems will facilitate relocation of treatment systems should contaminant distribution change significantly.

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[169] As noted before, this FS is limited to the groundwater remedy for the WVBA Site and unlike the discretion that RID possesses, as a matter of AAC R18-16-411.G, RID does not have the authority or right to access the source properties. However, according to the Working Group FS Work Plan, source control will be applicable and the members of the Working Group possess that authority and right to access the source facilities given that the members are owners or operators of the facilities with an identified release of the hazardous substances that have impacted or threaten to impact the existing water supply wells within and adjacent to the WVBA Site.

[170] As noted previously, COP operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the potable distribution system (see **Appendix E**).

Replacement of RID-92 and RID-106 may not provide sufficient capacity to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b. It may be necessary to replace the pump in an additional well, such as RID-114, to increase the pumping rate and associated production capacity. RID-114 is well suited for this contingency since it is one of the higher contaminated water supply wells, and the existing treatment systems have approximately 500 gpm of additional (i.e., unused) capacity (**Table 5**).

There also is uncertainty in the acquisition of additional land adjacent to the well sites targeted for installation/expansion of wellhead treatment systems. This includes wells RID-92, RID-100, RID-106, RID-109 and RID-112. Land adjacent to RID-92 is owned by the Western Area Power Administration (WAPA), a WVBA Site PRP, the level of cooperation provided by WAPA in this process will directly influence the project schedule. Acquisition of land adjacent to the other well sites also could pose uncertainty in both schedule and cost.

7.4 LESS AGGRESSIVE GROUNDWATER ALTERNATIVE REMEDY

The Less Aggressive groundwater alternative remedy includes the remedial strategies and measures that follow. The Less Aggressive groundwater alternative remedy reduces the scope of proposed remedial actions from those approved by ADEQ in the Modified ERA Work Plan (Synergy, 2012d).

7.4.1 Summary of Less Aggressive Groundwater Alternative Remedy

The Less Aggressive groundwater alternative remedy integrates the following remedial strategies and measures:

- Wellhead treatment using LGAC at six (6) existing water supply wells impacted above AWQSs/MCLs, including RID-89, RID-92, RID-95, RID-106, RID-109, and RID-114; the locations of these wells are shown in **Figure 3.**
- Priority pumping of all six (6) impacted wells equipped with treatment to enhance mass removal, plume containment, migration control of the contaminants within and entering into the WVBA Site, and to allow blending of other impacted existing wells such as RID-99, RID-100, RID-107, RID-110, RID-112 and RID-113 to achieve, at a minimum, necessary water quality for all current and reasonably foreseeable water end uses at all thirteen (13) existing wells impacted above AWQSs and MCLs as required by ARS § 49-282.06.B.4.b.

- Installation of a higher capacity replacement well, completed solely in the contaminated aquifer, at RID-106 to address RID-84, to enhance hydraulic capture at the leading edge of the plume, and to provide water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Replacement of the pump (using the same motor) in RID-114 to enhance hydraulic capture and to provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Engineering controls to limit potential routes of public exposure to COCs.
- Groundwater monitoring to verify plume remediation and containment and assess the progress toward groundwater remediation and whether any contingency measures are necessary to be implemented.

7.4.2 Remedial Strategies

The primary remedial strategies to be employed for the Less Aggressive groundwater alternative remedy are plume remediation and physical containment of the WVBA Site groundwater plume to address, at a minimum, all thirteen (13) existing water supply wells impacted above AWQSs and MCLs (while at the same time through physical containment, protecting existing water supply wells impacted below AWQSs and MCLs, and any existing threatened wells that are not currently impacted by COC, including RID, SRP, COP, APS and COT wells) pursuant to the WVBA Site groundwater ROs and ARS §§ 49-282.06.A. and 49-282.B.4.b. These primary remedial strategies also will control migration of commingled plumes from adjacent groundwater contaminant sites entering into the WVBA Site. Monitoring will continually be conducted throughout the WVBA Site for target COC concentrations in existing impacted water supply wells, threatened water supply wells and ADEQ monitor wells in both the areas of active plume remediation and in the areas outside of the influences of the remedial measures.

7.4.3 Remedial Measures

The remedial measures to be implemented include water treatment, well replacement, well modifications, and engineering and operational controls.

<u>*Water Treatment*</u>

Water treatment for plume remediation is included in the Less Aggressive groundwater alternative remedy and will be accomplished through P&T of impacted groundwater using existing wells. Treatment will be accomplished using wellhead P&T systems and blending of untreated wells (those that exceed one [1] or more MCLs) with treated water or wells with COCs below the MCLs.

P&T systems will utilize LGAC technology for contaminant removal at the wellhead. This technology was selected as the proposed treatment technology as described in Section 6.4.3. Wellhead P&T systems will be employed at six (6) existing water supply wells impacted above AWQSs/MCLs as follows:

- RID-89, RID-92, RID-95 and RID-114: Wellhead treatment systems currently exist and are in operation at these four (4) water supply well sites. The treatment systems were installed by RID in late 2011/early 2012 as part of the *Well-95 Wellhead Pilot Treatment Systems Proposal*, agreed to by ADEQ on September 2, 2011, and later incorporated into Phase 1 of the Modified ERA Work Plan (Synergy, 2012d), approved by ADEQ on February 1, 2013 (ADEQ, 2013a).

- RID-106 and RID-109: Wellhead treatment at these two (2) wells was authorized by ADEQ in the Modified ERA Work Plan. These wellhead treatment systems were to be installed in Phase 2 of the Modified ERA Work Plan, but now have been incorporated into the FS.

Installation and operation of LGAC wellhead treatment systems result in an increase in pressure head and a corresponding loss of pumping capacity at these wells. This is reflected both in the decrease of overall water production and an increase in the electrical costs. Both of these impacts will be addressed in the Less Aggressive groundwater alternative remedy through well replacement (replacing water losses) and as a line item in the projected O&M annual cost estimates.

Table 5 presents information on the water supply wells to be treated with wellhead treatment systems under the Less Aggressive groundwater alternative remedy, including the targeted well production capacity, the number of LGAC skids required, and the anticipated well production losses for each well.

Treatment through blending will be utilized for six (6) existing impacted wells (i.e., RID-99, RID-100, RID-107, RID-110, RID-112 and RID-113). These “to be blended” wells currently exceed AWQSs/MCLs for one or more target COC, but will be combined with remediated water or with uncontaminated/lower contaminated wells “in pipe”, remediating the combined contaminant concentrations to below AWQSs/MCLs prior.

Well Replacement

Well replacement is proposed at RID-106. As discussed in the preceding section, a replacement well is proposed to be drilled/completed in the UAU and upper MAU. Expanded groundwater extraction at this well site will enhance containment of the leading edge of the plume, assist in preventing its further migration of contaminants to the west, and protect threatened water provider wells outside of the WVBA Site groundwater contamination plume.

Increasing the groundwater capture at RID-106 through well replacement also could provide for the replacement of any reduction in the available supply of water encountered from the increased head at the wellhead treatment systems pursuant to ARS § 49-282.06.B.4.b. It is uncertain regarding the magnitude of the increase in production capacity and, therefore, it may be necessary to consider contingency measures in this regard.

Increasing the capacity of RID-106 will require acquisition of additional property adjacent to the well site. The replacement well will be drilled within the required 660 feet of the existing well, consistent with ADWR requirements.

Well Modifications

Modification of RID-114 is proposed to consist of replacement of the existing pump with a larger capacity pump (using the same motor) to enhance hydraulic capture and provide additional water supply to any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.

Engineering Controls

Engineering controls will be implemented to control point source and fugitive emissions of contaminants (as previously described in Section 7.1), including:

- enclose well discharge boxes at all water supply wells exceeding AWQSs/MCLs (13 wells);
- enclose open section of the RID-92 lateral (1 segment);
- modify lateral and well discharge structures into the Main Canal;
- enclose open sections of the Salt Canal (2 segments); and,
- replace/seal manhole covers on the Salt Canal (numerous locations).

Operational Controls

Operational controls will be implemented to optimize the RID well pumping priorities as previously described in Section 7.1. The modifications to RID's pumping priorities will result in increased pumping in the center of the plume and an equivalent decrease in pumping on the plume margins. The intent is to enhance plume remediation and to physically contain the movement of the contamination to protect the less impacted and threatened wells, including the water provider wells, along the southern and western boundaries of the plume.

7.4.4 Treated Water End Use

Treated water that is conveyed via the Salt Canal will be used for either agricultural purpose, by discharge into the Main Canal, or M&I use. M&I use will require the construction of a pipeline along the RID Main Canal right-of-way, to convey this remediated water to users in the west valley. Discussions are currently underway with the City of Buckeye, City of Goodyear and others in this regard, based on their stated interest in acquiring this water as source water for treatment and municipal use.[171] RID anticipates a pipeline will be installed and available to deliver M&I water supplies within the next five (5) years.

For the near term, treated water to be conveyed through the Main Canal (and feeder laterals) to RID lands will continue for its current use as an agricultural water supply. However, RID anticipates that all RID water supply wells will be developed as future M&I drinking water supply sources in the reasonably foreseeable future.[172]

7.4.5 Permitting and Approvals

Site improvements proposed at RID well sites and along RID conveyance canals are on land owned by RID or within established RID easements and rights-of-way. As a municipal corporation, RID is not subject to COP requirements that typically apply to privately owned properties such as zoning, use permits, plans review, permits, inspections, and certificates of occupancy. Therefore, improvements at RID well sites can be implemented without building permits from the COP and no encroachment permits will be required for work at RID water supply wells or replacement of open sections on the Salt Canal and RID-92 lateral.

COP rights-of-way (encroachment) permits will be required during construction of the wellhead treatment systems in order to accommodate cranes and other large construction support

[171] *See* footnote 109.
[172] *See* footnote 168.

vehicles. Encroachment permits also will likely be needed for periodic LGAC change out activities as part of normal O&M procedures.

ADWR approval of a NOI will be required prior to re-drilling RID-92 and RID-106, and for abandonment of the existing wells once the replacement wells are installed.

A PQGWP may be required by ADWR in accordance with ARS § 45-516.

When remediated water is conveyed to Goodyear, Buckeye, or developers within RID's service area lands for M&I use, the water provider will need to obtain source approval from the MCESD. While the future drinking water use of remediated water is an important feature of this groundwater remedy to RID and their customers, construction of the pipeline or other water infrastructure and any necessary water management changes to deliver the RID treated water and associated permitting are not part of this FS.

7.4.6 Source Control

As stated in Section 5.1.4, source control is not applicable for the scope of this FS, but RID believes ADEQ will undertake any necessary source control measures that have not currently been addressed or ADEQ will provide oversight to any source control measures performed by the owners or operators of the source facilities.[173]

7.4.7 Uncertainties and Contingencies

Issues listed in Section 7.3.7 regarding existing, out of service COP wells, plume containment, the uncertainty of future changes to the established AWQS/MCL for TCE, amount of replacement water required, and acquisition of land for new treatment systems also are relevant concerns for the Less Aggressive groundwater alternative remedy that may require additional actions.

Further, the Less Aggressive groundwater alternative remedy is proposing replacement of RID-106 to address PCE contamination in excess of the AWQS/MCL at RID-84, which discharges directly into the RID Main Canal. With RID-106 replaced with a higher capacity well and pumping near continuously from the contaminated aquifer, it is anticipated that the increased local extraction will result in a positive hydraulic influence on nearby well RID-84, effectively reducing the flow of contaminants to this well located on the southern margin of the plume. If this declining trend is not observed and well RID-84 does not show significant reduction in

[173] *See* footnote 14.

contaminant concentrations in subsequent monitoring, well modifications could be warranted at RID-84 as a contingent measure to enable injection of water from the adjacent RID Main Canal. This contingent measure[174] would be implemented to create a seasonal mounding to reverse the hydraulic gradient and attenuate contaminant concentrations in the local groundwater. This action could control the migration of the plume in this area and reduce the concentration of contaminants in well RID-84, preventing the need to treat this well in the future.

Modification of RID-84, to convert the well to accommodate injection of canal water during part of the year, is proposed as a contingent measure if, after three (3) years of implementation of the remedy, PCE concentrations are not declining at this well. Modification of well RID-84 would include reconfiguring the well with the necessary equipment to enable injection of water from the RID Main Canal. Further information regarding the approach and permitting needs to reconfigure an existing RID well for injection are provided in Section 7.3.7. If monitoring of RID-84 demonstrates that the injection as a contingent measure is not successful, direct treatment of RID-84 would be necessary to address PCE contamination in excess of the AWQS/MCL.

The extent to which physical containment is able to limit increasing impacts to existing water supply wells and any threatened or peripheral wells that are not currently impacted by COCs will be determined by ongoing groundwater monitoring. Given current understanding of contaminant fate and transport in the WVBA Site, the probability of the Less Aggressive groundwater alternative remedy to fully contain the plume is thought to be high. However, current interpretation of the extent of groundwater contamination is based on available data that, in certain areas of the WVBA and WOC sites, may not adequately delineate the extent of contamination. Should future monitoring data indicate that water provider wells within or outside of the plume show increasing COC impacts, contingent actions may be necessary to more fully contain the contaminant plume or directly address those wells pursuant to applicable state law.

Additionally, the COP owns four (4) shallow production wells in the WVBA Site contaminant plume. Although the City has indicated it does not intend to use the wells and the wells are currently capped and out of service, the City has an established right to withdraw groundwater. Should the City require the wells for some non-potable use[175] in the future, then it will be necessary to evaluate potential remedial measures and take appropriate actions to address the water provider needs.

[174] This discussion of uncertainties and contingencies with respect to RID-84 is also dependent upon whether there is a change in the MCL for PCE as discussed in footnote 29.
[175] As noted previously, COP operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the potable distribution system (see **Appendix E**).

There is some degree of uncertainty that the MCL for TCE may be reduced through pending action by EPA. If this change occurs, there may be need to treat additional water supply wells since the target for blending (the MCL) is now 5 µg/L for TCE and the revised MCL could be substantially lower. Concentrations in individual wells also will change with time. Adjustments to the remedy could be warranted based on these changes. The modular nature of the wellhead treatment systems will facilitate relocation of treatment systems should contaminant distribution change significantly.

Replacement of RID-106 may not provide sufficient capacity to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b. It may be necessary to replace the pump in an additional well, such as RID-114, to increase the pumping rate and associated production capacity. RID-114 is well suited for this contingency since it is one of the higher contaminated wells, and the existing treatment systems have approximately 500 gpm of additional (i.e., unused) capacity (**Table 5**).

There also is uncertainty in the acquisition of additional land adjacent to the RID-106 well site targeted for installation/expansion of wellhead treatment systems. Acquisition of land adjacent to the RID-106 well site also could pose uncertainty in both schedule and cost.

7.5 MORE AGGRESSIVE GROUNDWATER ALTERNATIVE REMEDY

The More Aggressive groundwater alternative remedy includes the remedial strategies and measures that follow. The More Aggressive groundwater alternative remedy consists of all actions defined for the Less Aggressive groundwater alternative remedy plus a limited-scope groundwater injection component to improve plume containment.

7.5.1 Summary of More Aggressive Groundwater Alternative Remedy

The More Aggressive groundwater alternative remedy integrates the following remedial strategies and measures:

- Wellhead treatment using LGAC at six (6) existing water supply wells impacted above AWQSs/MCLs, including RID-89, RID-92, RID-95, RID-106, RID-109, and RID-113; the locations of these wells are shown in **Figure 3.**
- Priority pumping of all six (6) impacted wells equipped with treatment to enhance mass removal, plume containment, migration control of the contaminants within and entering into the WVBA Site, and to allow blending of other impacted existing wells such as RID-99, RID-100, RID-107, RID-110, RID-112 and RID-114 to achieve, at a minimum,

necessary water quality for all current and reasonably foreseeable water end uses at all thirteen wells impacted above AWQSs and MCLs as required by ARS § 49-282.06.B.4.b.

- Installation of a higher capacity replacement well, completed solely in the contaminated aquifer, at RID-106 to enhance hydraulic capture at the leading edge of the plume and to provide water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Well modifications to reconfigure five (5) RID wells to inject effluent that is available in low demand periods from the COP 23rd Avenue Waste Water Treatment Plant (WWTP); the proposed wells to be used for effluent injection include RID-84, RID-85, RID-90, RID-91, and RID-93 and are shown in **Figure 3**.
- Replacement of the pump (using the same motor) in RID-114 to enhance hydraulic capture and provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Engineering controls to limit potential routes of public exposure to COCs.
- Groundwater monitoring to verify plume remediation and containment and assess the progress toward groundwater remediation and whether any contingency measures are necessary to be implemented.

7.5.2 Remedial Strategies

The primary remedial strategies to be employed for the More Aggressive groundwater alternative remedy are plume remediation and physical containment of the WVBA Site groundwater plume to address, at a minimum, all thirteen (13) existing water supply wells impacted above AWQSs and MCLs (while at the same time through physical containment, protecting existing water supply wells impacted below AWQSs and MCLs, and any existing threatened wells that are not currently impacted by COCs, including RID, SRP, COP, APS and COT wells) pursuant to the WVBA Site groundwater ROs and ARS §§ 49-282.06.A. and 49-282.B.4.b. These primary remedial strategies also will control migration of commingled plumes within the WVBA Site and from adjacent groundwater contaminant sites entering into the WVBA Site. Monitoring will continually be conducted throughout the WVBA Site for target COC concentrations in existing impacted water supply wells, threatened wells and ADEQ monitor wells in both the areas of active plume remediation and in the areas outside of the influences of remedial measures.

7.5.3 Remedial Measures

The remedial measures to be implemented include water treatment, well replacement, well modifications, and engineering and operational controls.

Water Treatment

Water treatment for plume remediation is included in the More Aggressive groundwater alternative remedy and will be accomplished through P&T of impacted groundwater using existing wells. Treatment will be accomplished using wellhead P&T systems and blending of untreated wells (those that exceed one [1] or more MCLs) with treated water or wells with COCs below the AWQSs/MCLs.

P&T systems will utilize LGAC technology for contaminant removal at the wellhead. This technology was selected as the proposed treatment technology as detailed in Section 6.4.3. Wellhead P&T systems will be employed at six (6) existing water supply wells impacted above AWQSs/MCLs as follows:

- RID-89, RID-92, RID-95 and RID-114: Wellhead treatment systems currently exist and are in operation at these four (4) water supply well sites. The treatment systems were installed by RID in late 2011/early 2012 as part of the *Well-95 Wellhead Pilot Treatment Systems Proposal*, agreed to by ADEQ on September 2, 2011, and later incorporated into Phase 1 of Modified ERA Work Plan (Synergy, 2012d), approved by ADEQ on February 1, 2013 (ADEQ, 2013a).

- RID-106 and RID-109: Wellhead treatment at these two (2) water supply wells was authorized by ADEQ in the Modified ERA Work Plan. These wellhead treatment systems were to be installed in Phase 2 of the Modified ERA Work Plan, but now have been incorporated into the FS.

Installation and operation of LGAC wellhead treatment systems result in an increase in pressure head and a corresponding loss of pumping capacity at these wells. This is reflected both in the decrease of overall water production and an increase in the electrical costs. Both of these impacts will be addressed in the More Aggressive groundwater alternative remedy through well replacement (replacing water losses) and as a line item in the projected O&M annual cost estimates.

Table 5 presents information on the water supply wells to be treated with wellhead treatment systems under the More Aggressive groundwater alternative remedy, including the targeted well production capacity, the number of LGAC skids required and the anticipated well production losses for each well.

Treatment through blending will be utilized for six (6) existing impacted wells (i.e., RID-99, RID-100, RID-107, RID-110, RID-112 and RID-113). These "to be blended" wells currently exceed AWQSs/MCLs for one or more target COC, but will be combined with remediated water or with uncontaminated/lower contaminated wells "in pipe", remediating the combined contaminant concentrations to below AWQSs/MCLs prior.

Well Replacement

Well replacement is proposed at RID-106. As discussed in the preceding section, a replacement well is proposed to be drilled and completed in the UAU and upper MAU. Expanded groundwater extraction at this well site will enhance containment of the leading edge of the plume, assist in preventing its further migration to the west, and protect threatened water provider wells outside of the WVBA Site groundwater contamination.

Increasing the groundwater capture at RID-106 through well replacement also could provide for the replacement of any reduction in the available supply of water caused encountered from the increased head at the wellhead treatment systems pursuant to ARS § 49-282.06.B.4.b. It is uncertain regarding the magnitude of the increase in production capacity and, therefore, it may be necessary to consider contingency measures in this regard.

Increasing the capacity of RID-106 will require acquisition of additional property adjacent to the well site. The replacement well will be drilled within the required 660 feet of the existing well, consistent with ADWR requirements.

Well Modifications

Modifications are proposed to convert up to five (5) existing impacted wells into injection wells during part of the year: RID-84, RID-85, RID-90, RID-91, and RID-93. Injection is conceived to reduce the concentrations of COCs impacting RID-84 above the AWQSs and MCLs and to control migration of the plume, intending to prevent further impacts to less impacted and threatened wells, including water provider wells along the southern and western boundaries of the plume and preventing the need to treat these threatened wells in the future. Specifically, injection is targeted to limit plume encroachment at and in the vicinity of RID-84 and at RID-85, RID-90, RID-91, and RID-93. Currently, PCE concentrations exceed the AWQS/MCL at RID-84 whereas TCE concentrations are less than AWQSs/MCLs, but systematically increasing, at RID-85, RID-90, RID-91, and RID-93.

The source of water available for injection is Class A+ treated effluent from the COP 23rd Avenue WWTP. RID receives up to 30,000 AFY of the COP effluent to offset local groundwater pumping pursuant to a 1993 water exchange agreement. The effluent is fully utilized in high demand periods; however RID cannot receive the effluent continuously in the low demand period due to daily discrepancies between supply availability and RID demands. As described in the *West Van Buren Area Aquifer Storage and Recovery Well Feasibility Report*, prepared by HydroSystems, Inc. (2014), which is provided in **Appendix G** significant excess effluent is available but not used by RID during low irrigation demand periods. According to analysis of effluent supply and RID usage, up to 6,000 to 8,000 AF of this under-utilized effluent may be available for recharge from around mid-September to mid-March, thus improving containment.

This alternative assumes that the five (5) identified existing wells would be modified with the required equipment to allow for injection of under-utilized effluent from the RID Main Canal. In general, the modifications would require a submersible pump in the Main Canal with piping to deliver water from the canal (utilizing the seasonally-available excess effluent) to media filters prior to injection in the column pipe of a submersible pump equipped with a down-hole flow control valve. Further information concerning the conceptual approach, equipment requirements, and costs for reconfiguring RID wells for injection is provided in the HydroSystems (2014) report in **Appendix G**.

Modification of RID-114 is proposed to consist of replacement of the existing pump with a larger capacity pump (using the same motor) to enhance hydraulic capture and provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.

Engineering Controls

Engineering controls will be implemented to control point source and fugitive emissions of contaminants (as previously described in Section 7.1), including:

- enclose well discharge boxes at all water supply wells exceeding AWQSs/MCLs (13 wells).
- enclose open section of the RID-92 lateral (1 segment);
- modify lateral and well discharge structures into the Main Canal,
- enclose open sections of the Salt Canal (2 segments); and,
- replace/seal manhole covers on the Salt Canal (numerous locations).

Operational Controls

Operational controls will be implemented to optimize the RID well pumping priorities as previously described in Section 7.1. The modifications to RID's pumping priorities will result in increased pumping in the center of the plume and an equivalent decrease in pumping on the plume margins with the intention of enhancing plume remediation and physical containment to control the movement of the contamination to protect the less impacted and threatened wells, including water provider wells, along the southern and western boundaries of the plume.

7.5.4 Treated Water End Use

Treated water that is conveyed via the Salt Canal will be used for either agricultural purpose, by discharge into the Main Canal, or M&I use. M&I use will require the construction of a pipeline along the RID Main Canal easement/right-of-way, to convey this remediated water to users in the west valley. Discussions are currently underway with the City of Buckeye, City of Goodyear and others in this regard, based on their stated interest in acquiring this water as source water for treatment and municipal use.[176] RID anticipates a pipeline will be installed and available to deliver M&I water supplies within the next five (5) years.

For the near term, treated water to be conveyed through the Main Canal (and feeder laterals) to RID lands will continue for its current use as an agricultural water supply. However, RID anticipates that all RID water supply wells will be developed as future M&I drinking water supply sources in the reasonably foreseeable future.[177]

7.5.5 Permitting and Approvals

Site improvements proposed at RID well sites and along RID conveyance canals are on land owned by RID or within established RID easements and rights-of-way. As a municipal corporation, RID is not subject to COP requirements that typically apply to privately owned properties such as zoning, use permits, plans review, permits, inspections, and certificates of occupancy. Therefore, improvements at RID well sites can be implemented without building permits from the COP and no encroachment permits will be required for work at RID water supply wells or replacement of open sections on the Salt Canal and RID-92 lateral.

COP rights-of-way (encroachment) permits will be required during construction of the wellhead treatment systems in order to accommodate cranes and other large construction support

[176] *See* footnote 109.
[177] *See* footnote 168.

vehicles. Encroachment permits also will likely be needed for periodic LGAC change out activities as part of normal O&M procedures.

ADWR approval of a NOI will be required prior to re-drilling RID-106, and for abandonment of the existing well once the replacement well is installed.

Several permits may be required to develop the existing RID wells for injection of an effluent-dominated water supply, including an Underground Storage Facility Permit, Water Storage Permit, and Recovery Well Permit issued by ADWR, and an Aquifer Protection Permit issued by ADEQ. Additionally, since the source of recharge water is effluent, the recharge facility that constitutes well injection program must receive an Approval of Construction permit issued by the MCESD.

A PQGWP may be required by ADWR in accordance with ARS § 45-516.

When remediated water is conveyed to Goodyear, Buckeye, or developers within RID's service area for M&I use, the water provider will need to obtain source approval from the MCESD. While the future drinking water use of remediated water is an important feature of this groundwater remedy to RID and their customers, construction of the pipeline or other water infrastructure and any necessary water management changes to deliver the RID treated water and associated permitting are not part of this FS.

7.5.6 Source Control

As stated in Section 5.1.4, source control is not applicable for the scope of this FS, but RID believes ADEQ will undertake any necessary source control measures that have not currently been addressed or ADEQ will provide oversight to any source control measures performed by the owners or operators of the source facilities.[178]

7.5.7 Uncertainties and Contingencies

Issues listed in Section 7.3.7 regarding existing, out of service COP wells, plume containment, the uncertainty of future changes to the established AWQS/MCL for TCE, amount of replacement water required, and acquisition of land for new treatment systems also are relevant concerns to the More Aggressive groundwater alternative remedy that may require additional actions.

[178] *See* footnote 14.

The extent to which Injection may enhance plume containment is not known. This is a limited-scope injection concept since the availability of a water source for injection is limited. In fact, the same wells that are used to inject water in the low demand period will be required to pump groundwater at other times to meet RID water needs. Due to the highly transmissive nature of UAU groundwater, it is likely that high rates of injection can be achieved, but the hydraulic effects are unknown. Therefore the degree to which injection is capable of mitigating water quality impacts at these wells is uncertain. Given the dynamic of both injection and pumping occurring at these wells during the course of a year and the significant heterogeneities in the UAU groundwater flow system, it may be unreasonable to expect the results of injection can be simulated effectively by modeling.

The availability of effluent in future years for injection during low demand periods is not assured. Presently, the effluent is delivered to RID as part of a three-way water exchange between RID, COP, and SRP that is associated with settlement of water claims with the Salt River-Pima-Maricopa Indian Community (SRPMIC). Aside from enabling settlement of SRPMIC claims, the water exchange has certain tangible benefits to COP in that it acquires surface water from SRP that is available for M&I use through the exchange of treated wastewater to RID. Consequently, it is reasonable to assume that effluent deliveries to RID will continue for the near term future, perhaps over the next 10 to 15 years, but the availability for injection in out years is less certain. By the same token, as the selected groundwater remedy is implemented, it may not be necessary to inject water to mitigate the impact of plume encroachment on threatened wells in future decades.

The impact of injection on RID well use is likely to be a factor in their future operations. The dual use of RID wells for aquifer storage and recovery may potentially result in reduced well efficiency, production capacity, and operating life.

The extent to which physical containment is able to limit increasing impacts to existing water supply wells and any threatened or peripheral wells that are not currently impacted by COCs will be determined by ongoing groundwater monitoring. Given our current understanding of contaminant fate and transport in the WVBA Site, the probability of the More Aggressive groundwater alternative remedy to fully contain the plume is thought to be high. However, current interpretation of the extent of contamination is based on available data that, in certain areas of the WVBA and WOC sites, may not adequately delineate the extent of groundwater contamination. Should future monitoring data indicate that water provider wells within or outside of the plume show increasing COC impacts, contingent actions may be necessary to more fully contain the contaminant plume or directly address those wells pursuant to applicable state law.

Additionally, the COP owns four (4) shallow production wells in the WVBA Site contaminant plume. Although the City has indicated it does not intend to use the wells and the wells are currently capped and out of service, the City has an established right to withdraw groundwater. Should the City require the wells for some non-potable use[179] in the future, then it will be necessary to evaluate potential remedial measures and take appropriate actions to address the water provider needs.

There is some degree of uncertainty that the MCL for TCE may be reduced through pending action by EPA. If this change occurs, there may be need to treat additional water supply wells since the target for blending (the MCL) is now 5 μg/L for TCE and the revised MCL could be substantially lower. Concentrations in individual wells also will change with time. Adjustments to the remedy could be warranted based on these changes. The modular nature of the wellhead treatment systems will facilitate relocation of treatment systems should contaminant distribution change significantly.

Replacement of RID-106 may not provide sufficient capacity to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b. It may be necessary to replace the pump in an additional well, such as RID-114, to increase the pumping rate and associated production capacity. RID-114 is well suited for this contingency since it is one of the higher contaminated wells, and the existing treatment systems have approximately 500 gpm of additional (i.e., unused) capacity (**Table 5**).

There also is uncertainty in the acquisition of additional land adjacent to the RID-106 well site targeted for installation/expansion of wellhead treatment systems. Acquisition of land adjacent to the RID-106 well site also could pose uncertainty in both schedule and cost.

7.6 MOST AGGRESSIVE GROUNDWATER ALTERNATIVE REMEDY

The Most Aggressive groundwater alternative remedy includes the remedial strategies and measures that follow. The Most Aggressive groundwater alternative remedy assumes that treatment is required at any RID well that currently exceeds MCLs for the WVBA Site COCs.

7.6.1 Summary of Most Aggressive Groundwater Alternative Remedy

The Most Aggressive groundwater alternative remedy integrates the following remedial strategies and measures:

[179] As noted previously, COP operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the potable distribution system (see **Appendix E**).

- Wellhead treatment using LGAC at thirteen (13) existing water supply wells impacted above AWQSs/MCLs, including RID-84, RID-89, RID-92, RID-95, RID-99, RID-100, RID-106, RID-107, RID-109, RID-110, RID-112, RID-113, and RID-114; the locations of these wells are shown in **Figure 3.**
- Priority pumping, to the extent feasible, of all thirteen (13) impacted wells equipped with treatment to enhance mass removal, plume containment, and migration control of the contaminants within and entering into the WVBA Site and to achieve, at a minimum, necessary water quality for all current and reasonably foreseeable water end uses at all existing wells impacted above AWQSs and MCLs as required by ARS § 49-282.06.B.4.b.
- Installation of higher capacity replacement wells, completed solely in the contaminated aquifer, at RID-92 and RID-106 to enhance hydraulic capture in critical areas of plume containment and to provide water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Replacement of the pump (using the same motor) in RID-114 to enhance hydraulic capture and provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.
- Engineering controls to limit potential routes of public exposure to COCs.
- Groundwater monitoring to verify plume remediation and containment and assess the progress toward groundwater remediation, and whether any contingency measures are necessary to be implemented.

7.6.2 Remedial Strategies

The primary remedial strategies to be employed for the Most Aggressive groundwater alternative remedy are plume remediation and physical containment of the WVBA Site groundwater plume to address, at a minimum, all thirteen (13) existing water supply wells impacted above AWQSs and MCLs (while at the same time through physical containment protecting existing water supply wells impacted below AWQSs and MCLs, and any existing threatened wells that are not currently impacted by COCs, including RID, SRP, COP, APS and COT wells) pursuant to the WVBA Site groundwater ROs and ARS §§ 49-282.06.A. and 49-282.B.4.b. These primary remedial strategies also will control migration of commingled plumes within the WVBA Site and from adjacent groundwater contaminant sites entering into the WVBA Site. Monitoring will continually be conducted throughout the WVBA Site for target COC concentrations in existing impacted water supply wells, threatened water supply wells and ADEQ monitor wells in both the areas of active plume remediation and in the areas outside of the influences of remedial measures.

7.6.3 Remedial Measures

The remedial measures to be implemented include water treatment, well replacement, and engineering and operational controls.

Water Treatment

Water treatment for plume remediation is included in the Most Aggressive groundwater alternative remedy and will be accomplished through P&T of contaminated groundwater using existing impacted wells. Treatment will be accomplished using wellhead P&T systems. P&T systems will utilize LGAC technology for contaminant removal at the wellhead. This technology was selected as the proposed treatment technology as described in Section 6.4.3. Wellhead P&T systems will be employed at the thirteen (13) existing water supply wells impacted above AWQSs/MCLs as follows:

- RID-89, RID-92, RID-95 and RID-114: Wellhead treatment systems currently exist and are in operation at these four (4) water supply well sites. The treatment systems were installed by RID in late 2011/early 2012 as part of the *Well-95 Wellhead Pilot Treatment Systems Proposal*, agreed to by ADEQ on September 2, 2011, and later incorporated into Phase 1 of Modified ERA Work Plan (Synergy, 2012d), approved by ADEQ on February 1, 2013 (ADEQ, 2013a).

- RID-100, RID-106, RID-109 and RID-112: Wellhead treatment for these four (4) impacted wells was authorized by ADEQ in the Modified ERA Work Plan. These treatment systems were to be installed in Phase 2 of the Modified ERA Work Plan, but now have been incorporated into the FS.

- RID-107, RID-110, RID-113: These three (3) wells are above the AWQSs/MCLs for one or more target COCs and are located on the Salt Canal.

- RID-84 and RID-99: These two (2) wells are above the AWQSs/MCLs for one or more target COC and are located on the south-western margin of plume (RID-84) and the south-central section of the plume, due south of RID-100 (RID-99) as shown on **Figure 3**.

Installation and operation of LGAC wellhead treatment systems result in an increase in pressure head and a corresponding loss of pumping capacity at these wells. This is reflected both in the decrease of overall water production and an increase in the electrical costs. Both of these impacts will be addressed in the Most Aggressive groundwater alternative remedy through well replacement (replacing water losses) and as a line item in the projected O&M annual cost estimates.

Table 5 presents information on the water supply wells to be treated with wellhead treatment systems under Most Aggressive groundwater alternative remedy, including the targeted well production capacity, the number of LGAC skids required and the anticipated well production losses for each well.

Well Replacement

Well replacement will be included in the Most Aggressive groundwater alternative remedy in order to enhance groundwater extraction and contaminant removal at RID-92 and RID-106.

- RID-92 is the highest contaminated RID water supply well, and has historically operated at about 1,500 to 2,000 gpm. The current well site is only large enough for a single skid of LGAC treatment vessels, which restricts the well production capacity to approximately 1,200 gpm. Replacing the existing well with a new well, completed only in the UAU, would likely result in extraction rates in the neighborhood of 2,000 to 2,200 gpm, and allow for enhanced contaminant removal. Expanded groundwater extraction at this well site also will enhance containment of the southern flank of the WVBA Site plume, and help prevent further contaminant migration to threatened water provider wells located south of the WVBA Site groundwater contaminant plume.·

- RID-106 is the westernmost well on the Salt Canal within the WVBA Site contaminant plume. Consequently, RID-106 is the most suitable location to influence capture of the leading edge of the regional contaminant plume. Presently, RID-106 produces approximately 1,500 gpm of groundwater from a screened interval of 80 to 776 feet bls. Well replacement is proposed at RID-106 by drilling a replacement well at this location completed in the UAU and upper MAU.[180] Based on recent experience gained from drilling of replacement well RID-111R, the expected extraction rate at RID-106 is about 3,000 gpm. Expanded groundwater extraction at this well site will enhance containment of the leading edge of the plume, assist in preventing further migration of contaminants to the west, and protect threatened water provider wells outside of the WVBA Site groundwater contaminant plume.

Increasing the groundwater capture at RID-92 and RID-106 through well replacement also could provide for the replacement of any reduction in the available supply of water encountered from the increased head at the wellhead treatment systems pursuant to ARS § 49-282.06.B.4.b. Increasing the capacity of RID-92 and RID-106 will require acquisition of additional property

[180] The targeted depth of completion would be at least 420 feet bls to ensure production throughout not only the UAU but also the upper MAU interval, which was shown to have PCE, TCE, and 1,1-DCE concentrations of 70.2, 21.2, and 29.4 µg/L, respectively, at nearby ADEQ monitor well AVB82-01 in March 2013.

adjacent to the well sites. The replacement wells will be drilled within the required 660 feet of the existing wells, consistent with ADWR requirements.

Well Modification

Modification of RID-114 is proposed to consist of replacement of the existing pump with a larger capacity pump (using the same motor) to enhance hydraulic capture and provide additional water supply to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.

Engineering Controls

Engineering controls will be implemented to control point source and fugitive emissions of contaminants (as previously described in Section 7.0), including:

- enclose well discharge boxes at all water supply wells exceeding AWQSs/MCLs (13 wells).
- enclose open section of the RID-92 lateral (1 segment);
- modify lateral and well discharge structures into the Main Canal,
- enclose open sections of the Salt Canal (2 segments); and,
- replace/seal manhole covers on the Salt Canal (numerous locations).

Operational Controls

Operational controls will be implemented to optimize the RID well pumping priorities as previously described in the introduction to this section. The modifications to RID's pumping priorities will result in increased pumping in the center of the plume and an equivalent decrease in pumping on the plume margins. The intention is to enhance plume remediation and to physically contain the movement of the contamination to protect the less impacted and threatened wells, including water provider wells, along the southern and western boundaries of the plume.

7.6.4 Treated Water End Use

Treated water that is conveyed via the Salt Canal will be used for either agricultural purpose, by discharge into the Main Canal, or M&I use. M&I use will require the construction of a pipeline along the RID Main Canal easement/right-of-way, to convey this remediated water to users in the west valley. Discussions are currently underway with the City of Buckeye, City of Goodyear and others in this regard, based on their stated interest in acquiring this water as source water for treatment and municipal use.[181] RID anticipates a pipeline will be installed and available to deliver M&I water supplies within the next five (5) years.

For the near term, treated water to be conveyed through the Main Canal (and feeder laterals) to RID lands will continue for its current use as an agricultural water supply. However, RID anticipates that all RID water supply wells will be developed as future M&I drinking water supply sources in the reasonably foreseeable future.[182]

7.6.5 Permitting and Approvals

Site improvements proposed at RID well sites and along RID conveyance canals are on land owned by RID or within established RID easements and rights-of-way. As a municipal corporation, RID is not subject to the COP requirements that typically apply to privately owned properties such as zoning, use permits, plans review, permits, inspections, and certificates of occupancy. Therefore, improvements at RID well sites can be implemented without building permits from the COP and no encroachment permits will be required for work at RID wells or enclosing open sections along the Salt Canal and RID-92 lateral.

COP rights-of-way (encroachment) permits will be required during construction of the wellhead treatment systems in order to accommodate cranes and other large construction support vehicles. Encroachment permits also will likely be needed for periodic LGAC change out activities as part of normal O&M procedures.

ADWR approval of a NOI will be required prior to re-drilling RID-92 and RID-106, and for abandonment of the existing wells once the replacement wells are installed.

A PQGWP may be required by ADWR in accordance with ARS § 45-516.

When remediated water is conveyed to the Cities of Goodyear and Buckeye, or developers within RID's service area for M&I use, the water provider will need to obtain source approval from the MCESD. While the future drinking water use of remediated water is an important feature of this groundwater remedy to RID and their customers, construction of the pipeline or other water infrastructure and any necessary water management changes to deliver the RID treated water and associated permitting are not part of this FS.

[181] *See* footnote 109.
[182] *See* footnote 168.

7.6.6 Source Control

As stated in Section 5.1.4, source control is not applicable for the scope of this FS, but RID believes ADEQ will undertake any necessary source control measures that have not currently been addressed or ADEQ will provide oversight to any source control measures performed by the owners or operators of the source facilities.[183]

7.6.7 Uncertainties and Contingencies

Issues listed in Section 7.3.7 regarding the uncertainty of existing COP Park Department wells, plume containment, future changes to the established MCL for TCE, amount of replacement water required, and acquisition of land for new treatment systems (with additions of RID-99, RID-107, RID-110, and RID-113 for this alternative), also are relevant concerns to the Most Aggressive groundwater alternative remedy that may require additional actions.

The extent to which physical containment is able to limit increasing impacts to existing water supply wells and any threatened or peripheral wells that are not currently impacted by COCs will be determined by ongoing groundwater monitoring. Given current understanding of contaminant fate and transport in the WVBA Site, the probability of the Most Aggressive groundwater alternative remedy to fully contain the plume is thought to be high. However, current interpretation of the extent of groundwater contamination is based on available data that, in certain areas of the WVBA and WOC sites, may not adequately delineate the extent of contamination. Should future monitoring data indicate that water provider wells within or outside of the plume show increasing COC impacts, contingent actions may be necessary to more fully contain the contaminant plume or directly address those wells pursuant to applicable state law.

Additionally, the COP owns four (4) shallow production wells in the WVBA Site contaminant plume. Although the City has indicated it does not intend to use the wells and the wells are currently capped and out of service, the City has an established right to withdraw groundwater. Should the City require the wells for some non-potable use[184] in the future, then it will be necessary to evaluate potential remedial measures and take appropriate actions to address the water provider needs.

[183] *See* footnote 14.

[184] As noted previously, COP operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the potable distribution system (see **Appendix E**).

There is some degree of uncertainty that the MCL for TCE may be reduced through pending action by EPA. If this change occurs, there may be need to treat additional water supply wells since the target for blending (the MCL) is now 5 µg/L for TCE and the revised MCL could be substantially lower. Concentrations in individual wells also will change with time. Adjustments to the remedy could be warranted based on these changes. The modular nature of the wellhead treatment systems will facilitate relocation of treatment systems should contaminant distribution change significantly.

Replacement of RID-92 and RID-106 may not provide sufficient capacity to restore any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b. It may be necessary to replace the pump in an additional well, such as RID-114, to increase the pumping rate and associated production capacity. RID-114 is well suited for this contingency since it is one of the higher contaminated water supply wells, and the existing treatment systems have approximately 500 gpm of additional (i.e., unused) capacity (**Table 5**).

There also is uncertainty in the acquisition of additional land adjacent to the well sites targeted for installation/expansion of wellhead treatment systems. This includes wells RID-92, RID-100, RID-106, RID-109 and RID-112. Land adjacent to RID-92 is owned by the Western Area Power Administration (WAPA), a WVBA Site PRP, the level of cooperation provided by WAPA in this process will directly influence the project schedule. Acquisition of land adjacent to the other well sites also could pose uncertainty in both schedule and cost.

8.0 DETAILED ANALYSIS OF PROPOSED REMEDIES

The Reference Remedy and alternative remedies[185] require comparison to determine which remedy should be proposed as the final groundwater remedy and subjected to the regulatory process described in A.A.C. R18-16-408, Proposed Remedial Action Plan. Therefore, the four (4) remedies previously discussed in Section 7 will be evaluated using the comparison criteria described in the following section to enable detailed and methodical consideration of each remedial alternative.

8.1 EVALUATION CRITERIA

In accordance with the remedy selection process described in A.A.C. R18-16-407, this FS has been conducted to ensure achievement of the WVBA Site groundwater ROs and to satisfy the requirements of ARS § 49-282.06, including specifically ARS § 49-262.06.B.4.b. As discussed in Section 7, the proposed remedies were developed with consideration of the water resource needs of the water providers within WVBA Site and specifically formulated to best address the impacts and threats to the wells and water supply of said water providers consistent with applicable groundwater remedial action requirements under the Arizona WQARF program. This FS was conducted to provide a comparative evaluation of the Reference Remedy and the alternative remedies. For each alternative, the comparison includes a demonstration that the WVBA Site groundwater ROs will be achieved, an evaluation of consistency with the water management plans of affected water providers and evaluations of practicality, risk, cost and benefit/value as set forth in AAC R18-16-407.H.3.

8.1.1 Achievement of ROs

As stated in AAC R18-16-407.H.1, the comparative evaluation shall include a demonstration that each alternative remedy will achieve the ROs established by ADEQ. ADEQ has determined, after reviewing public comments, that the selected remedy should achieve the WVBA Site groundwater ROs for current and reasonably foreseeable future municipal groundwater use, agricultural groundwater use and commercial/industrial/domestic groundwater use.

The ROs for municipal groundwater use require the selected remedy to *"protect, restore, replace or otherwise provide a water supply for municipal use by currently and reasonably foreseeable future municipal well owners within the WVBA …* [and] *outside the current plume*

[185] Throughout this section, the Reference Remedy and alternative remedies will be referred to as an "alternative remedy."

boundaries of the WVBA WQARF Site if the current and reasonably foreseeable uses are impaired or lost due to contamination from the site."

The ROs for agricultural groundwater use require the selected remedy to *"protect, restore, replace or otherwise provide for the current and reasonably foreseeable future supply of groundwater for agricultural/irrigation use and for the associated recharge capacity that is threatened by or lost due to contamination associated with the WVBA WQARF site."*

The ROs for commercial/industrial/domestic groundwater use require the selected remedy to *"protect, restore, replace or otherwise provide a water supply for potable or non-potable use by currently impacted commercial, industrial, and domestic well owners within the WVBA …* [and] *outside the current plume boundaries of the WVBA Site if the current and reasonably foreseeable uses are impaired or lost due to contamination from the site."*

8.1.2 Consistency with Water Management Plans

As stated in AAC R18-16-407.H.2, the comparative evaluation shall evaluate the consistency of each alternative remedy with the water management plans of affected water providers. The water management plans of affected water providers within and adjacent to the WVBA Site is included in Section 4.6.

8.1.3 Practicability

As stated in AAC R18-16-407.H.3.a, the comparative evaluation shall evaluate the practicability of each alternative remedy and shall consider:

- feasibility of the remedial alternative;
- short- and long-term effectiveness of the remedial alternative; and,
- reliability of the remedial alternative.

The evaluations of practicability included in this FS Report address site-specific conditions, characteristics of the contamination, performance capabilities of available technologies to permanently and significantly reduce toxicity, mobility, or volume of hazardous substances, and institutional aspects.

8.1.4 Risk

As stated in AAC R18-16-407.H.3.b., the comparative evaluation shall evaluate the risk of each alternative remedy and shall consider:

- fate and transport of contaminants and concentrations and toxicity over the life of the remediation;
- current and future land and resource use;
- exposure pathways, duration of exposure, and changes in risk over the life of the remediation;
- protection of public health and aquatic and terrestrial biota, during and after the remedial action; and,
- residual risk in the aquifer at the end of the remediation.

These evaluations are intended to address the overall protectiveness of the public health, welfare, and the environment, for each alternative remedy, under reasonably foreseeable land use scenarios as well as reasonably foreseeable end uses of this water resource. As identified in Section 2.2, the exposure pathway and potential for target COC releases to impact aquatic and terrestrial biota is of low concern. Consequently, further discussion of routes of potential exposure to target COCs and associated risks in this FS will focus on the substantially more significant concern for potential hazards to human health.

To date, ADEQ has not conducted a numerical human health risk assessment for the releases of hazardous substances in the WVBA. As established in the Public Health Exposure Assessment conducted in 2011 (Synergy, 2011c), there does not presently appear to be an acute health risk associated with potential public exposure to the WVBA Site contamination. However, there is no basis to interpret potential long-term, chronic risks to public health or welfare from releases of hazardous substances that have been occurring in the WVBA for decades. Therefore, and in accordance with the ADEQ-approved FS Work Plan (Synergy, 2013a), the evaluations of risk included in this FS Report will be relative to a screening-level comparative analysis of each remedy's ability to mitigate risk to public health, welfare, and the environment prospectively.

In addition, these evaluations incorporate the concept of "imminent and substantial endangerment" to the public health, welfare and the environment. EPA[186] has clarified the definition of imminent and substantial endangerment as it applies to a release of hazardous substances as follows:

> *...an endangerment may be "imminent" if factors giving rise to it are present, even though the harm may not be realized for years.*
>
> *Courts have also interpreted "substantial" broadly, to mean a reasonable cause for concern that someone or something may be exposed to a risk of harm by a release or a threatened release of a hazardous substance.*

[186] Memorandum to EPA Regional Counsel from Directors of the EPA Office of Site Remediation Enforcement and the EPA Office of Regulatory Enforcement, and Chief of EPA Environmental Enforcement Section dated January 18, 2001. (EPA, 2001)

...an "endangerment" is not necessarily an actual harm, but may be a threatened or potential harm. A risk of harm may suffice, and the risk need not be quantified.

8.1.5 Cost

As stated in A.A.C. R18-16-407.H.3.c., the comparative evaluation shall evaluate the cost of each alternative remedy and shall consider, where applicable:

- expenses and losses including capital, O&M[187] and life cycle costs;
- uncertainties that may impact the cost of a remedial alternative;
- analysis of projected water uses and costs associated with use-based treatment;[188]
- other use impairment costs of water not treated to water quality standards;
- transaction costs necessary to implement the remedial alternative (including transactional costs of establishing long-term financial mechanisms); and,
- cost of measures such as alternative water supply or treatment.

The evaluations included in this FS Report address the overall cost effectiveness of each alternative remedy. As indicated throughout Section 8.4, RID's cost estimates for each groundwater alternative remedy were strictly for design, construction, and O&M of the wellhead treatment systems and other remedial measures included in each alternative. The O&M costs included three transactional cost components:

1) an annualized three (3) percent assessment based on the total capital equipment cost, to provide contingency funds to cover periodic costs needed for equipment maintenance, repair, and replacement;

2) an annualized six (6) percent assessment of the estimated O&M cost for project administration and reporting; and,

3) an annual $10,000 per skid charge for the additional power requirements for pumping at higher discharge pressures through the wellhead treatment units.

[187] A summary of estimated capital and O&M costs is presented in **Table 7**. Projected capital and O&M costs of the proposed alternative remedies are reasonably well understood and defined. In contrast to usual FS cost estimates which typically range from +50% to -30% (EPA, 2000), the information gained from implementation of the RID-95 Wellhead Pilot Initiative (Synergy, 2012b) provides the basis to estimate remedial action costs more precisely and consistent with the expected cost accuracy (+15% to -10%) of the remedial design activity.

[188] **Table 7** includes annual O&M associated with treatment system operations as well as increased costs to pump groundwater through LGAC wellhead treatment systems due to increases in operating pressure. The "power penalty" is identified as the estimated cost increase to produce the same historical volume of groundwater through treatment.

RID believes accounting for these specific design, construction, and O&M costs offers the most precise and objective basis for comparative evaluation of life-cycle costs of the proposed groundwater alternative remedies, as required by the FS process. Therefore, for the purposes of this FS, only these direct capital and O&M costs are included in the FS costing.

RID did not include transactional costs in the cost estimate that meet the definition of "remedial actions" in ARS § 49-281.12 because they are not "necessary to implement the remedial alternative" as specified in AAC R18-16-407.H.3.c. However, consistent with the Agreement to Conduct Work with ADEQ, dated October 8, 2009, RID has incurred at least $9.5 million in remedial action transaction costs in conducting the remedial actions. These costs span a wide range of required project support, including evaluating the scope and impact of groundwater contamination, developing and implementing response action work plans, conducting required actions, and responding to extensive stakeholder input. These costs are in addition to the approximate $6.2 million of direct costs expended to date for design, construction and O&M of wellhead treatment systems at four RID wells, and do not include debt services or legal costs in support of litigation.

RID did not include these and other transactional costs in the cost estimate, such as costs to establish long-term funding mechanisms for payment of recurring O&M costs, because they are not "necessary to implement the remedial alternative" as specified in AAC R18-16-407.H.3.c. In a separate and unrelated matter, RID is pursuing a federal cost recovery action against the PRPs legally responsible for the groundwater contamination impacting RID's wells within the WVBA WQARF Site. Although the FS Report or the implementation of the final remedy is not included in the current RID federal cost recovery action, a similar action could constitute a long-term financial mechanism for funding the selected remedy. Any recoverable monies in such an action would cover in perpetuity the funds necessary to implement the selected remedy and ensure that the State of Arizona and the Arizona taxpayers would not be burdened for the response costs that should be borne by the identified polluters. It is not yet determined how or under what arrangements the PRPs will pay these costs. However, if an account is established with funds available for payment of long-term response costs then there should be no real transactional costs associated with administering this funding mechanism. Rather, the funds deposited to cover these costs will generate some level of investment return and this return will help offset future costs. For this reason, the RID FS Report used a discounted basis to forecast the net present value of long-term recurring O&M costs.

8.1.6 Benefit/Value

As stated in AAC R18-16-407.H.3.d., the comparative evaluation shall evaluate the benefit or value of each alternative remedy and shall consider:

- lowered risk to human and aquatic and terrestrial biota;
- reduced concentration and reduced volume of contaminated water;
- decreased liability and degree of acceptance by the public;
- aesthetic aspects including preservation of existing uses;
- enhancement of future uses; and,
- improvements to local economies.

The evaluations included in this FS Report address the overall benefit and value to the public within the WVBA Site, to the public adjacent to the Site, and all parties that would likely be impacted by each alternative remedy being considered.

Additionally, the extent to which each alternative remedy provides benefit or value in assuring the primary remedial strategies, plume remediation and physical containment are achieved will be evaluated by groundwater flow modeling.

8.2 GROUNDWATER MODEL PROJECTIONS

The Final RI Report describes efforts by ADEQ and its former contractor, Weston, to develop, calibrate, and validate a groundwater flow model for the WVBA Site (Weston, 2000 and 2001) as well as other models previously developed that encompassed the domain of the Weston model. This model is known as the CPPM and includes a model grid extending from 99th Avenue on the west to 56th Street on the east and from Dobbins Road on the south to Camelback Road on the north.

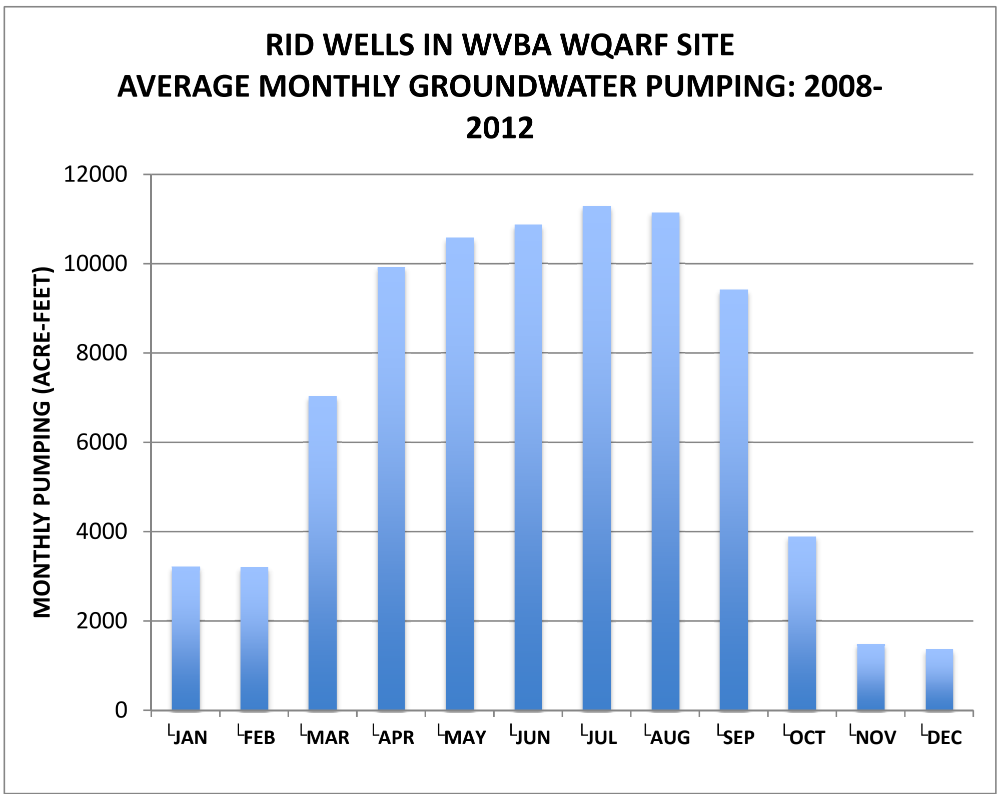
The CPPM was designed to model aquifer conditions and groundwater movement and assist in the evaluation of remedial strategies and their effects on groundwater movement and the contaminant plume. Based on Terranext's review of model development, calibration, and validation, the Final RI Report concludes that the CPPM is capable of serving its intended purpose to evaluate remedial alternatives and contaminant movement in the study area.

As discussed in Section 4.9, M&A updated and recalibrated the CPPM with relevant data through 2011 to serve as the basis for modeling to simulate effects on groundwater from the remedial alternatives.

8.2.1 Summary of Pumping Inputs for Model Simulations

M&A, in conjunction with Synergy, developed pumping well data files for simulation of the alternative remedies. Initially, a Baseline Scenario was developed that simulates the historical average pumping of all wells projected into the future. As noted previously, RID is the main groundwater user in the area. Over the period of 2008 through 2012, RID pumped at an average rate of approximately 83,500 AFY from 33 RID wells within the WVBA Site.[189] ADWR records indicate that pumping by these 33 RID wells within the WVBA Site represents approximately 65% of the pumping in the entire model domain for the period 2008 through 2011, the latest year for which pumping records were available from the ADWR, and the end of the historic model simulation.

As noted in Section 3.2.2, groundwater production from RID water supply wells in the WVBA Site is highly seasonal. The water demand may vary from year to year depending on factors such as weather and crop/commodity pricing, but generally necessitates full-capacity production from all RID wells from March through September. At other times of the year, the demand and associated production falls off substantially as shown in the following bar chart.



[189] Including 32 wells within the defined boundaries of the WVBA Site and RID-82. RID-82, which is west of the WVBA Site boundary, is included as part of RID well field because it is impacted by COCs from the WVBA Site.

The seasonal groundwater pumping from RID and SRP wells in the model domain is simulated in the model in three (3) stress periods per year. The first stress period (SP1) coincides with the low demand period in January and February, the second stress period (SP2) coincides with the high demand period from March through September, and the third stress period (SP3) coincides with the low demand period of October through December.

In developing the Baseline Scenario, the average monthly pumping for each RID well within the WVBA Site from 2008 to 2012 was determined in each stress period. This pumping distribution is shown in **Table 6**. Over the past five (5) years, total RID pumping in the WVBA Site has averaged 3,214 AF per month in SP1, 10,043 AF per month in SP2, and 2,254 AF per month in SP3. On average, RID produces over 70,000 AF, or 84 percent, of the total annual pumping during the high demand period coinciding with SP2.

In the Baseline Scenario, this distribution and average amount of RID pumping was simulated over the next 30 years. The Baseline Scenario projects the future groundwater conditions resulting from continued RID pumping. The projected groundwater conditions resulting from the alternative remedies are compared to the baseline groundwater conditions to project the net hydrologic effect of the various alternatives. Since all four (4) remedial alternatives involve operational changes intended to optimize groundwater extraction and enhance plume containment, pumping data files were developed according to anticipated pumping schemes that prioritize pumping at the wells equipped with treatment. As discussed in the following section, the projected future groundwater conditions for the various remedial alternatives, as projected over the next 30 years, are compared to groundwater conditions for the Baseline Scenario to project changes in groundwater conditions associated with the proposed remedial alternatives.

The pumping data files and an explanation of the assumptions used to apportion pumping under each of the remedial alternatives are provided in **Appendix F**. The overarching logic to the proposed pumping schemes for each remedial alternative assumes that significant changes to the RID pumping scheme are only possible in the low demand periods represented by SP1 and SP3. In these periods, it is assumed that RID wells equipped with treatment will be the "first wells on" and "last wells off" to meet water demand and RID wells considered to be most threatened by plume migration would not operate or be used only sparingly (i.e., first off, last on). In the high demand period, SP2, all wells are required to operate, and they typically operate almost continuously, so notable pumping reprioritization is not possible.

The extent to which the proposed priority pumping schemes can realistically be attained will depend on many factors. Some of these factors, such as the number of wells to be treated, are known and can be incorporated into operations, while other factors such as daily water orders, weather conditions, well operability, and the volume of effluent available to RID are variable and unpredictable. The pumping data files attempt to predict realistic well use predicated on a broad understanding of RID water operations.

8.2.2 Development of Model Output

The calibrated model was used to simulate the Baseline Scenario and each of the four (4) groundwater alternative remedies for a 30-year projection period. For each scenario, a groundwater flow and particle tracking simulation was run. The results of the groundwater flow simulations were compared to determine differences among the projected groundwater elevations at the end of the 30-year projection period. The results of the particle tracking simulations were compared to determine differences between the projected hydraulic capture and projected plume movement (with focus on WOC and M52 plumes) over 30 years. The projected differences between groundwater elevations, capture, and plume movement were used to analyze the hydrologic impacts of each remedial alternative.

8.3 DETAILED EVALUATION OF REMEDIES: THRESHOLD REQUIREMENTS

Each remedial alternative must meet two threshold requirements as explained in Section 8.1:

1. A demonstration that the proposed remedy will achieve the WVBA Site groundwater ROs, as set forth in AAC R18-16-407.H.1; and
2. An evaluation of the consistency with water management plans of affected water providers and the general land use plans of local governments with land use jurisdiction, as set forth in AAC R18-16-407.H.2.

Consequently, the following discussion in this section applies to **all** four (4) remedial alternatives evaluated.

8.3.1 Achievement of Remedial Objectives (ROs):

As noted before, the scope of this FS is to identify possible groundwater remedies to address target COCs in groundwater within the WVBA Site, which also has been commingled with target COCs from adjacent regional groundwater contaminant sites. Consequently, this study is focused on groundwater contamination and addressing the impacts to water providers as defined in Section 4.7 (Extent of Impact to Area Water Providers) and protecting, at a minimum, all "current and reasonably foreseeable water end uses" as defined in the WVBA Site RO Report.[190] As shown in **Table 9**, all proposed groundwater remedial alternatives meet essential

[190] See ARS § 49-282.06.B.4.b.

WQARF requirements established to assure the selected final groundwater remedy, at a minimum, meets ROs for "current and reasonably foreseeable water end uses" within and outside the WVBA Site.

The detailed analysis provided for each groundwater alternative remedy in Section 7 identified the specific remedial measures, including proposed actions that would be taken to treat, replace or otherwise modify water provider wells, to assure ROs are achieved. Proposed actions of each alternative will assure that all impacted water provider wells, principally RID wells, which are not suitable for current or reasonably foreseeable water end uses without treatment are adequately addressed. Where information is uncertain, such as the current situation affecting the COP wells, potential requirements to address the wells are identified as a contingency. Importantly, the proposed actions to address impacted wells with the WVBA Site contaminant plume will ensure that water provider wells downgradient from or peripheral to the plume that are less impacted or threatened by the contamination are protected for their "current and reasonably foreseeable water end uses."

With regard to WVBA Site ROs associated with land use and impacts, numerous facility investigations have been conducted throughout the WVBA Site over the past 25 years to characterize and remediate the impacts of hazardous substance releases. The scope of this FS, which is a regional groundwater remedy evaluation, does not include past or future work to address soil contamination at sources areas, nor the impacts, if any, on the loss or impairment to land uses. Instead, this FS assumes that the actions taken under ADEQ oversight have adequately addressed the known sources of hazardous substances impacting surface and subsurface soils and the potential this may have to cause a loss or impairment of land use. Further, should any additional information arise that identifies the need to address a presently unknown source of hazardous substances in surface or subsurface soil, it is assumed that ADEQ will assure that actions taken will not adversely impact or impair land uses in the WVBA Site.

8.3.2 Consistency with Water and Land Use Plans

As discussed above and shown in **Table 9**, all proposed groundwater remedial alternatives meet essential WQARF requirements that have been established to assure the proposed groundwater remedy meets the water management needs of affected water providers. Specifically, as it pertains to RID, the remedial alternatives evaluated in this FS Report are consistent with established RID policy to assure: 1) all wells located in the WVBA Site that are contaminated with hazardous substances are remediated to mitigate the actual and/or potential harm to public health, welfare, and the environment, 2) discharges or delivery of remediated water into the RID water distribution system meet MCLs and AWQSs for the COCs, and 3) response actions developed to protect RID wells provide for the maximum beneficial use of the water supply and do not reduce the quantity of water available to RID.

The proposed groundwater remedial alternatives also were developed in consideration of the stated water management plans, policies, and future needs of COP and SRP, as documented in Sections 4.6 and 4.7. In particular, as expressed in suggested ROs by COP (2010a), the objective of the groundwater remedy "*should be for the long-term groundwater use*" and "*where treatment is necessary to protect future long-term groundwater use, the remedy should include measures to provide for the long-term operation and maintenance of reliable and cost-effective water treatment technologies.*" The City further noted, "*[a]s an interim measure, the water produced from the contaminated area during remediation that is intended for irrigation or non-potable uses, should be applied, or if necessary, treated appropriately to prevent a health risk to the end users or others with an exposure pathway to the water.*" Although there are currently limited impacts to these water providers, the proposed actions to address impacted wells within the WVBA Site contaminant plume will ensure that COP, SRP, and other water provider wells that are threatened by the contamination are protected for their "current and reasonably foreseeable water end uses."

With regard to land use plans, the scope of this FS, which addresses a regional groundwater remedy for the WVBA Site, is anticipated to have relatively limited impacts to land use. In general, land use impacts are primarily associated with site improvements proposed at RID well sites and along RID conveyance canals on land owned by RID or within established RID easements and rights-of-way. As a municipal corporation, RID is not subject to City requirements that typically apply to privately owned properties, such as zoning, use permits, plan reviews, and inspections. In implementing the selected remedy, RID is the best party to assure the remedial measures do not excessively impair land use and will lead the design and construction effort of the selected remedy to appropriately manage the impact to RID lands and easements.

Remedial measures identified for all proposed groundwater remedial alternatives involve a select number of new wellhead treatment systems where it will be necessary to acquire land to build out the remedy components. Installation of LGAC treatment systems will impact land use in vicinity of these wells. Review of aerial photographs of the well sites targeted for treatment indicates there is generally vacant or undeveloped land adjacent to these wells, the surrounding land use is commercial and industrial, and the planned remedial measures are consistent with existing land uses.

8.4 DETAILED EVALUATION OF REMEDIES: COMPARISON CRITERIA

The following sections provide a summary of detailed evaluations of the comparison criteria listed in Section 8.1.3 through 8.1.6 for **each** of the four (4) groundwater alternative remedies: the "Reference Remedy", the "Less Aggressive" alternative, the "More Aggressive" alternative, and the "Most Aggressive" alternative.

8.4.1 Reference Remedy

The Reference Remedy includes:

- installation of five (5) additional wellhead treatment systems at RID-84, RID-100, RID-106, RID-109 and RID-112 (in addition to the four (4) wellhead systems already in place at RID-89, RID-92, RID-95 and RID-114) to achieve AWQSs and MCLs;
- blending of four (4) other impacted wells such as RID-99, RID-107, RID-110 and RID-113 with treated, unimpacted or low-concentration contaminated groundwater to achieve AWQSs/MCLs;
- replacement of well RID-106 to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.);
- replacement of well RID-92 to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.);
- expansion of the existing RID-92 wellhead treatment system (1 additional skid) to accommodate the increased well capacity; and,
- replacing the existing pump (and perhaps motor) at well RID-114 to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.).

Practicability

The Reference Remedy is practicable since it has been demonstrated that wellhead treatment systems can be readily installed at existing well sites. Four (4) of the well sites proposed for treatment systems (RID-100, RID-106, RID-109, and RID-112) under this remedy are small and would likely require acquisition of additional land from adjacent property owner(s). Similarly, drilling a replacement well at RID-92, and expanding treatment capacity at this site, also would require acquisition of additional land and a temporary access agreement from the adjacent property owner.

The Reference Remedy would be effective, in both the short- and long-term, at removing significant contaminant mass from the environment. Upon implementation of the Reference Remedy, treatment of groundwater at nine (9) of the most highly contaminated RID wells will significantly reduce the transfer of contaminants from groundwater to air. Groundwater extraction and treatment, as part of the long-term groundwater remedy, will permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances in the regional aquifer.

The reliability of the Reference Remedy is robust. The proven design of the LGAC treatment systems, standard instrumentation and controls (with alarm interlocks), and the redundant lead-lag configuration makes these systems extremely reliable. The existing treatment systems were designed to minimize the frequency of system failures that could affect public health and, consistent with ADEQ requirements[191], have necessary safeguards to assure protection of public health against such failures. Subsequent treatment system installations also will be similarly designed and constructed.

Risk

The Reference Remedy would reduce the risk of imminent and substantial endangerment to public health and welfare and the environment by preventing uncontrolled releases of hazardous substances into the environment through the use of treatment systems at the nine (9) most highly contaminated RID wells and by optimizing the pumping of RID wells to prevent plume migration and to contain the plume. The remedial strategies and remedial measures contained in the Reference Remedy would reduce the primary exposure pathways for COCs in groundwater, surface water, and air at the WVBA Site. Given that groundwater pumpage is the major outflow from the groundwater system, the Reference Remedy would substantially reduce the potential for exposed populations and environmental receptors to come in contact with COCs by the following mechanisms:

- Operational controls will be implemented to optimize pumping of RID wells in the WVBA Site to increase COC mass removal and enhance plume containment. Priority pumping of RID wells in the center of the plume will prevent contaminant migration to other threatened water provider wells (including RID, SRP, and City of Tolleson water supply wells) and the direct use of this water supply at wells that are peripheral to and downgradient of the current plume boundary.
- GAC treatment systems will be installed at the mostly highly contaminated RID wells within the plume and operational controls for blending with groundwater extracted at certain other less contaminated RID wells within the plume will be implemented to remove COCs from extracted groundwater to prevent the release of volatile chemicals into the environment above any applicable environmental or public health standards and therefore reduce the risk of imminent and substantial endangerment to public health and welfare from exposure to hazardous air pollutants by inhalation.

[191] *See* AAC R18-16-411.C

- Engineering controls will be implemented to restrict point source and fugitive emissions of COCs at well discharge structures and in open water conveyance laterals within the WVBA Site to eliminate incidental exposure risk to nearby residents and (unauthorized) public use of the RID water systems for swimming, bathing, and drinking.

The Reference Remedy would be operated until the contaminant concentrations in groundwater have been reduced to applicable AWQSs that are protective of human health and the environment. While the duration of groundwater remediation cannot be predicted with any certainty, the remedial strategies and remedial measures of the Reference Remedy would systematically remove COC mass and reduce residual COC concentrations in groundwater during implementation. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional. Further, the duration of the groundwater remedy will depend on other factors that are presently uncertain, including the presence of DNAPLs, changes in MCLs, and changes in aquifer conditions.

Based on existing contamination levels at the wells designated for treatment and planned wellfield operational controls, the Reference Remedy would address and permanently remove approximately 83% of the total VOC mass impacting the RID well field each year and prevent the transfer of that contamination into local surface waters and the air. Fate and transport of contaminants would be controlled at the wells with treatment systems, with essentially all of the contaminants removed by GAC. When the GAC becomes saturated, the spent GAC will be shipped to a permitted regeneration facility for destruction of the contaminants during the GAC regeneration process.

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There will be no "duration of exposure" or "changes in risk over the life of the remediation" associated with the Reference Remedy since the remedial strategies and remedial measures would substantially limit the exposure route for contaminant impacts to environmental receptors from COC releases to groundwater, surface water, and air. As a result, there is no continuing endangerment to the public health and welfare or unacceptable impact on water use once the remedy is implemented. Priority pumping to contain the plume will protect additional groundwater supplies outside the plume from being polluted and will assure peripheral and downgradient wells that are threatened by the contaminant plume will remain available for unrestricted use for the long-term future. Installed GAC treatment systems at the most highly contaminated RID wells and blending of certain less contaminated RID wells will capture, remove and reduce target COCs to assure the wells and water supply are available for all beneficial uses and prevent these contaminants from discharging into local surface waters and the air above any applicable environmental or public health standards.

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While the chemical toxicity of contaminants remaining in the groundwater over the course of the remediation would not change, the concentrations in groundwater are expected to decline over time. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional.¶

The residual risk in the aquifer is addressed by employing groundwater extraction and treatment as a principal element of the Reference Remedy to permanently and significantly reduce the toxicity, mobility, concentration and volume of the hazardous substances. Consistent with RID requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until AWQSs are attained and the groundwater supply is available for unrestricted use. The treatment systems are modular and can be relocated or replaced as needed to provide continued protection from residual contamination. Spent GAC media from the groundwater treatment process is sent to a permitted regeneration facility for permanent destruction of any residual contaminants.

Considering current and future land and resource use, this remedy will reduce the risk to public health in all use scenarios. Land use in the WVBA Site is currently a mixture of residential, commercial/industrial and agricultural. The trend, however, is a transition from agricultural land use towards increased residential, commercial and industrial development. The Reference Remedy would restore this contaminated groundwater resource to the quality required for future use as a source water for M&I use. All major water providers indicated support for restoration of the contaminated groundwater supply.

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This remedy would substantially reduce the mass of hazardous substances released to local surface water and air and restore the quality of the water supply to below MCLs. Therefore, the Reference Remedy would reduce the risk to public health regardless of future land or groundwater use. Reductions in contaminant releases to the environment would also be more protective of aquatic and terrestrial biota even though, as indicated in Section 2.2, the overall ecological risk associated with the target COCs is generally of low concern.

Cost

Estimated costs for the Reference Remedy are provided in **Table 7**.[192] Capital costs are estimated to be \$13.6 million with an estimated annual O&M cost of \$3.0 million.[193] These costs include installation of infrastructure (including replacement of wells RID-92 and RID-106 and replacing the pump at RID-114) and the additional operational costs associated with

[192] Projected capital and O&M costs of the proposed remedies are reasonably well understood and defined. In contrast to usual FS cost estimates which typically range from +50% to -30% (EPA, 2000), the information gained from implementation of the RID-95 Wellhead Pilot Initiative (Synergy, 2012b) provides the basis to estimate remedial action costs more precisely and consistent with the expected cost accuracy (+15% to -10%) of the remedial design activity.

[193] The estimated costs are strictly for design, construction, and O&M of the wellhead treatment system and other remedial measures described in Section 7.4.3. RID has incurred other notable costs that have gone into development of the RID response action, including legal, technical, and financial transaction costs, that are not included in the estimate of capital costs.

recovering production capacity lost at each treated well due to increased head losses through treatment.

Uncertainties that could significantly impact the future cost of the Reference Remedy include the cost of consumables, primarily GAC, and, to a lesser extent, fluctuations in the cost of electricity.

Benefit/Value

Groundwater treatment associated with the Reference Remedy would provide benefit to water providers within and adjacent to the WVBA Site whose wells are impacted or threatened by the contamination. Water impacted above AWQSs/MCLs could be remediated to allow the "maximum beneficial use of the waters of the state,"[194] while containment of the plume will ensure that wells impacted below AWQSs/MCLs and wells threatened, but not impacted by COCs, including the RID, SRP, COP, APS and COT wells within and adjacent to the WVBA Site, will produce water fit for their "current or reasonably foreseeable end uses."[195]

Groundwater treatment associated with the Reference Remedy provides a high degree of public protection against potential exposures to COCs by preventing uncontrolled emissions of hazardous substances into the environment at the most highly contaminated RID wells and eliminating public access to open laterals that transmit contaminated water. Treatment of the extracted groundwater would permanently remove a substantial mass of hazardous substances from extracted groundwater and prevent the transfer of that contamination into local surface waters and the air.

As stipulated in the WQARF process, this evaluation addresses the overall benefit and value to the public within and adjacent to the WVBA Site.[196] The public benefits from the remedial strategies and remedial measures contained in the Reference Remedy because they will reduce the concentration of contaminated groundwater and achieve the "maximum beneficial use of the waters of the state" that could be utilized by municipalities to spur local economic development. The public also would benefit from the Reference Remedy by remediating contamination in the regional aquifer and by lowering the risk to public health and welfare by providing a high degree of public protection against potential exposures to hazardous air pollutants, which should garner political and public acceptance.

Based on the result of FS groundwater modeling, implementation of the Reference Remedy would not significantly alter future hydrologic or plume conditions in the WBVA Site or

[194] ARS § 49-282.06.A.2.
[195] ARS § 49-282.06.B.4.b.
[196] AAC R19-16-407.H.3.d

surrounding area, compared to the Baseline Scenario (continued current RID operations).[197] Overall, projected regional groundwater elevations, flow directions, and gradients for both simulations are similar. Proposed actions to prioritize and increase pumping at key RID wells as part of the Reference Remedy are projected to slightly improve hydraulic containment of the WVBA plume, particularly in the central and western portions of the WVBA. The most pronounced differences in the projected local water table elevation and groundwater flow conditions are in the vicinity of RID-92 and RID-106, where the extent of capture is projected to expand as a result of increased pumping of new replacement wells at these sites included in the Reference Remedy. **Appendix F** includes a detailed summary of the model results.

8.4.2 Less Aggressive Groundwater Alternative Remedy

The Less Aggressive groundwater alternative remedy includes:

- installation of two (2) additional wellhead treatment systems at RID-106 and RID-109 (in addition to the four (4) wellhead systems already in place at RID-89, RID-92, RID-95 and RID-114) to achieve AWQSs and MCLs;
- blending of six (6) other impacted wells such as RID-99, RID-100, RID-107, RID-110, RID-112 and RID-113 with treated, unimpacted or low-concentration contaminated groundwater to achieve AWQSs/MCLs;
- replacement of well RID-106 to achieve AWQSs/MCLs at RID-84 and to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.);
- replacing the existing pump (and perhaps motor) at well RID-114 to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.); and,
- providing for seasonal injection of unused reclaimed wastewater into well RID-84 (as a contingency measure, if needed).

Practicability

The Less Aggressive groundwater alternative remedy is practicable since it has been demonstrated that wellhead treatment systems can be readily installed at existing well sites.

[197] Model-projected hydrologic impacts associated with the proposed Reference Remedy are discussed in pages 21-23 of the *FS Model Report* in **Appendix F** and depicted in **Figures F-27 through F-31**.

Two (2) of the well sites proposed for treatment systems (RID-106 and RID-109) under this alternative remedy are small and would likely require acquisition of additional land from adjacent property owner(s). Also, drilling a replacement well at RID-106 may require a temporary access agreement from the adjacent property owner.

The Less Aggressive groundwater alternative remedy would be effective, in both the short- and long-term, at removing significant contaminant mass from the environment. Upon implementation of the Less Aggressive groundwater alternative remedy, treatment of groundwater at six (6) of the most highly contaminated RID wells will significantly reduce the transfer of contaminants from groundwater to air. Groundwater extraction and treatment, as part of the long-term groundwater remedy, will permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances in the regional aquifer.

In addition, enhancing extraction and contaminant capture at RID-106 through installation of a replacement well, could result in decreasing concentrations of VOCs in nearby well RID-84. Should enhanced capture at RID-106 fail to decrease contaminant concentrations in RID-84, the contingency strategy of seasonal injection into RID-84 could provide a practical and cost effective approach to reduce the impact of contaminants at RID-84 (which exceeds the AWQS/MCL for PCE, which might change based on EPA's recent[198] toxicity determination) and alleviate the need for installation of wellhead treatment.

The reliability of the Less Aggressive groundwater alternative remedy is robust. The proven design of the LGAC treatment systems, standard instrumentation and controls (with alarm interlocks), and the redundant lead-lag configuration makes these systems extremely reliable. The existing treatment systems were designed to minimize the frequency of system failures that could affect public health and, consistent with ADEQ requirements[199], have necessary safeguards to assure protection of public health against such failures. Subsequent treatment system installations will also be similarly designed and constructed.

Risk

The Less Aggressive groundwater alternative remedy would reduce the risk of imminent and substantial endangerment to public health and welfare and the environment by preventing uncontrolled releases of hazardous substances into the environment through the use of installed treatment systems at the six (6) most highly contaminated RID wells and by optimizing the pumping of RID wells to prevent plume migration and to contain the plume. The remedial strategies and remedial measures contained in the Less Aggressive groundwater alternative remedy would reduce the primary exposure pathways for COCs in groundwater, surface water,

[198] See footnote 29.
[199] *See* AAC R18-16-411.C

and air at the WVBA Site. Given that groundwater pumpage is the major outflow from the groundwater system, the Less Aggressive groundwater alternative remedy would substantially reduce the potential for exposed populations and environmental receptors to come in contact with COCs by the following mechanisms:

- Operational controls will be implemented to optimize pumping of RID wells in the WVBA Site to increase COC mass removal and enhance plume containment. Priority pumping of RID wells in the center of the plume will prevent contaminant migration to other threatened water provider wells (including RID, SRP, and City of Tolleson water supply wells) and the direct use of this water supply at wells that are peripheral to and downgradient of the current plume boundary.
- GAC treatment systems will be installed at the mostly highly contaminated RID wells within the plume and operational controls for blending with groundwater extracted at certain other less contaminated RID wells within the plume will be implemented to remove and reduce COCs from extracted groundwater to prevent the release of volatile chemicals into the environment above any applicable environmental or public health standards and therefore reduce the risk of imminent and substantial endangerment to public health and welfare from exposure to hazardous air pollutants by inhalation.
- Engineering controls will be implemented to restrict point source and fugitive emissions of COCs at well discharge structures and in open water conveyance laterals within the WVBA Site to eliminate incidental exposure risk to nearby residents and (unauthorized) public use of the RID water systems for swimming, bathing, and drinking.

The Less Aggressive groundwater alternative remedy would be operated until the contaminant concentrations in groundwater have been reduced to applicable AWQSs that are protective of human health and the environment. While the duration of groundwater remediation cannot be predicted with any certainty, the remedial strategies and remedial measures of the Less Aggressive groundwater alternative remedy would systematically remove COC mass and reduce residual COC concentrations in groundwater during implementation. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional. Further, the duration of the groundwater remedy will depend on other factors that are presently uncertain, including the presence of DNAPLs, changes in MCLs, and changes in aquifer conditions.

Based on existing contamination levels at the wells designated for treatment, the Less Aggressive groundwater alternative remedy would address and permanently remove approximately 77% of the total VOC mass impacting the RID well field each year and prevent the transfer of that contamination into local surface waters and the air. Fate and transport of contaminants would be controlled at the wells with treatment systems, with essentially all of the contaminants retained in the GAC. When the GAC becomes saturated, the spent GAC will be shipped to a permitted facility for destruction of the contaminants during the GAC regeneration process.

There will be no "duration of exposure" or "changes in risk over the life of the remediation" associated with the Less Aggressive groundwater alternative remedy since the remedial strategies and remedial measures would substantially limit the exposure route for contaminant impacts to environmental receptors from COC releases to groundwater, surface water, and air. As a result, there is no continuing endangerment to the public health and welfare or unacceptable impact on water use once the remedy is implemented. Priority pumping to contain the plume will protect additional groundwater supplies outside the plume from being polluted and will assure peripheral and downgradient wells that are threatened by the contaminant plume will remain available for unrestricted use for the long-term future. Installed GAC treatment systems at the most highly contaminated RID wells and blending of certain less contaminated RID wells will capture, remove and reduce target COCs to assure the wells and water supply are available for all beneficial uses and prevent these contaminants from discharging into local surface waters and the air above any applicable environmental or public health standards.

The residual risk in the aquifer is addressed by employing groundwater extraction and treatment as a principal element of the Less Aggressive groundwater alternative remedy to permanently and significantly reduce the toxicity, mobility, concentration and volume of the hazardous substances. Consistent with RID requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until AWQSs are attained and the groundwater supply is available for unrestricted use. The treatment systems are modular and can be relocated or replaced as needed to provide continued protection from residual contamination. Spent GAC media from the groundwater treatment process is sent to a permitted regeneration facility for permanent destruction of any residual contaminants.

Considering current and future land and resource use, this remedy will reduce the risk to public health in all use scenarios. Land use in the WVBA Site is currently a mixture of residential, commercial/industrial and agricultural. The trend, however, is a transition from agricultural land use towards increased residential, commercial and industrial development. This remedy would restore this contaminated groundwater resource to the quality required for future use as a source water for M&I use. All major water providers indicated support for restoration of the contaminated groundwater supply.

This remedy would substantially reduce the mass of hazardous substances released to local surface water and air and restore the quality of the water supply to below MCLs. Therefore, the Less Aggressive groundwater alternative remedy would reduce the risk to public health

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While the chemical toxicity of the contaminants remaining in the groundwater over the course of the remediation would not change, the concentrations in groundwater are expected to decline over time. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional.¶

regardless of future land or groundwater use. Reductions in contaminant releases to the environment would also be more protective of aquatic and terrestrial biota even though, as indicated in Section 2.2, the overall ecological risk associated with the target COCs is generally of low concern.

Cost

Estimated costs for the Less Aggressive groundwater alternative remedy are provided in **Table 7**. Capital costs are estimated to be $9.4 million with an estimated annual O&M cost of $2.0 million.[200] These costs include installation of infrastructure (including replacement of well RID-106 and re-equipping well RID-114) and the additional operational costs associated with recovering production capacity lost at each treated well due to increased head losses through treatment.

Uncertainties that could significantly impact the future cost of the Less Aggressive groundwater alternative remedy include the cost of consumables, primarily GAC, and, to a lesser extent, fluctuations in the cost of electricity. Additional uncertainty exists in the magnitude of the effect of enhanced capture from the RID-106 replacement well on well RID-84. Should the impact of enhanced capture at RID-106 fail to reduce contaminant concentrations at RID-84 to below AWQSs/MCLs, the contingency measure of seasonal injection at RID-84 would be deemed necessary and if that contingency were unsuccessful, wellhead treatment would be necessary.[201]

Benefit/Value

Groundwater extraction associated with the Less Aggressive groundwater alternative remedy would provide benefit to water providers within and adjacent to the WVBA Site whose wells are impacted or threatened by the contamination. Water impacted above AWQSs/MCLs could be remediated to allow the "maximum beneficial use of the waters of the state,"[202] while containment of the plume will ensure that well impacted below AWQSs/MCLs and wells threatened, but not impacted by COCs, including the RID, SRP, COP, APS and COT wells within

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[200] The estimated costs are strictly for design, construction, and O&M of the wellhead treatment system and other remedial measures described in Section 7.4.3. RID has incurred other notable costs that have gone into development of the RID response action, including legal, technical, and financial transaction costs, that are not included in the estimate of capital costs.

[201] Costs of potential actions for RID-84 injection or wellhead treatment contingencies are not included in this FS based on the presumption that expanded pumping and treatment at RID-106 and operational control of well pumping priorities will result in declining PCE concentration trend at RID-84 and/or the AWQS/MCL for PCE may increase based on EPA's recent toxicity determination resulting in no additional remedial actions costs for RID-84.

[202] See ARS § 49-282.06.A.2.

and adjacent to the WVBA Site, will produce water fit for their "current or reasonably foreseeable end uses."[203]

Groundwater treatment associated with the Less Aggressive groundwater alternative remedy provides a high degree of public protection against potential exposures to COCs by preventing uncontrolled emissions of hazardous substances into the environment at the most highly contaminated RID wells and eliminating public access to open laterals that transmit contaminated water. Treatment of the extracted groundwater would permanently remove a substantial mass of hazardous substances from extracted groundwater and prevent the transfer of that contamination into local surface waters and the air.

As stipulated in the WQARF process, this evaluation addresses the overall benefit and value to the public within and adjacent to the WVBA Site.[204] The public benefits from the remedial strategies and remedial measures contained in the Less Aggressive groundwater alternative remedy because they will reduce the concentration of contaminated groundwater and achieve the "maximum beneficial use of the waters of the state" that could be utilized by municipalities to spur local economic development. The public also would benefit from the Less Aggressive groundwater alternative remedy by remediating contamination in the regional aquifer and by lowering the risk to public health and welfare by providing a high degree of public protection against potential exposures to hazardous air pollutants, which should garner political and public acceptance.

Based on the result of FS groundwater modeling, implementation of the Less Aggressive groundwater alternative remedy would not significantly alter future hydrologic or plume conditions in the WBVA Site or surrounding area, compared to the Baseline Scenario (continued current RID operations).[205] Overall, projected regional groundwater elevations, flow directions, and gradients for both simulations are similar. Proposed actions to prioritize and increase pumping at key RID wells as part of the Less Aggressive groundwater alternative remedy are projected to slightly improve hydraulic containment of the WVBA plume, particularly in the central and western portions of the WVBA. **Appendix F** includes a detailed summary of the model results.

The most pronounced differences in the projected local water table elevation and groundwater flow conditions are in the vicinity of RID-106, where the extent of capture is projected to expand as a result of increased pumping of a new replacement well at this site included in the Less Aggressive groundwater alternative remedy. It is particularly noteworthy that increased

[203] See ARS § 49-282.06.B.4.b.
[204] AAC R19-16-407.H.3.d
[205] Model-projected hydrologic impacts associated with the proposed Less Aggressive Remedy are discussed in pages 23-25 of the *FS Model Report* in **Appendix F** and depicted in **Figures F-32 through F-36**.

pumping at RID-106 is projected to capture a significantly larger region near the leading edge of the WVBA plume,[206] including contaminated groundwater in the vicinity of the Dolphin facility at 740 South 59th Avenue (**Figure 4** shows the historical impact of PCE release in this area). The model-projected increase in capture resulting from increased groundwater pumping at RID-106 would reduce the impact of PCE contamination from the Dolphin source area on RID-84 and potentially avoid the need for treatment at this well.

8.4.3 More Aggressive Groundwater Alternative Remedy

The More Aggressive groundwater alternative remedy includes:

- installation of two (2) additional wellhead treatment systems at RID-106 and RID-109 (in addition to the four (4) wellhead systems already in place at RID-89, RID-92, RID-95 and RID-114) to achieve AWQSs and MCLs;
- blending of six (6) other impacted wells such as RID-99, RID-100, RID-107, RID-110, RID-112 and RID-113 with treated, unimpacted or low-concentration contaminated groundwater to achieve AWQSs/MCLs;
- replacement of well RID-106 to enhance production capacity and increase contaminant mass removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.);
- replacing the existing pump (and perhaps motor) at well RID-114 to enhance production capacity and contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.); and,
- seasonal injection of unused reclaimed wastewater into as many as five (5) wells such as RID-84, RID-85, RID-90, RID-91, and RID-93 (which will operate as extraction/recovery wells during part of the year) to achieve AWQSs and MCLs at RID-84 and contain the plume from impacting other threatened water supply wells.

Practicability

The More Aggressive groundwater alternative remedy is practicable since it has been demonstrated that wellhead treatment systems can be readily installed at existing well sites. Two (2) of the wells sites proposed for wellhead treatment systems (RID-106 and RID-109) under this remedy are small and would likely require acquisition of additional land from

[206] *See* **Figures F-33 and F-34.**

adjacent property owner(s). Also, drilling a replacement well at RID-106 may require a temporary access agreement from the adjacent property owner.

Seasonal injection of unused reclaimed wastewater into existing RID wells will require some well modifications and associated infrastructure, including submersible booster pump (in the Main Canal) and delivery piping, downhole flow control valve, filtration, chlorination equipment and instrumentation and controls. While similar approaches have been successfully implemented, this aspect of the More Aggressive groundwater alternative remedy will increase the complexity and increase the uncertainty in terms of practicability.

The More Aggressive groundwater alternative remedy would be effective, in both the short- and long-term, at removing significant contaminant mass from the environment. Upon implementation of the More Aggressive groundwater alternative remedy, treatment of groundwater at six (6) of the most highly contaminated RID wells will significantly reduce the transfer of contaminants from groundwater to air. Groundwater extraction and treatment, as part of the long-term groundwater remedy, will permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances in the regional aquifer.

The effectiveness of the injection component, intended to induce a local groundwater mound to influence the hydraulic gradient in this region of the plume, is uncertain. The periodic nature of injection would likely mean that the groundwater mound would dissipate in times when injection is discontinued and the wells revert to groundwater extraction.

The reliability of the More Aggressive groundwater alternative remedy is robust with respect to the wellhead treatment elements. The proven design of the LGAC treatment systems, standard instrumentation and controls (with alarm interlocks), and the full redundancy provided by the lead-lag configuration makes these systems extremely reliable. The existing treatment systems were designed to minimize the frequency of system failures that could affect public health and, consistent with ADEQ requirements[207], have necessary safeguards to assure protection of public health against such failures. Subsequent treatment system installations will also be similarly designed and constructed.

The reliability of the injection component of the remedy, however, is less certain. Several factors could potentially reduce the reliability and/or effectiveness of this aspect of the remedy, including continued availability of excess reclaimed wastewater, well fouling/clogging during injection mode operation, and the transient effects of local groundwater mounding resulting from the periodic nature of the injection.

[207] *See* AAC R18-16-411.C

Risk

The More Aggressive groundwater alternative remedy would reduce the risk of imminent and substantial endangerment to public health and welfare and the environment by preventing uncontrolled releases of hazardous substances into the environment through the use of installed treatment systems at the six (6) most highly contaminated RID wells wells and by optimizing the pumping of RID wells to prevent plume migration and to contain the plume. The remedial strategies and remedial measures contained in the More Aggressive groundwater alternative remedy would reduce the primary exposure pathways for COCs in groundwater, surface water, and air at the WVBA Site. Given that groundwater pumpage is the major outflow from the groundwater system, the More Aggressive groundwater alternative remedy would substantially reduce the potential for exposed populations and environmental receptors to come in contact with COCs by the following mechanisms:

- Operational controls will be implemented to optimize pumping of RID wells in the WVBA Site to increase COC mass removal and enhance plume containment. Priority pumping of RID wells in the center of the plume will prevent contaminant migration to other threatened water provider wells (including RID, SRP, and City of Tolleson water supply wells) and the direct use of this water supply at wells that are peripheral to and downgradient of the current plume boundary.

- GAC treatment systems will be installed at the mostly highly contaminated RID wells within the plume and operational controls for blending with groundwater extracted at certain other less contaminated RID wells within the plume will be implemented to remove and reduce COCs from extracted groundwater to prevent the release of volatile chemicals into the environment above any applicable environmental or public health standards and therefore reduce the risk of imminent and substantial endangerment to public health and welfare from exposure to hazardous air pollutants by inhalation.

- Engineering controls will be implemented to restrict point source and fugitive emissions of COCs at well discharge structures and in open water conveyance laterals within the WVBA Site to eliminate incidental exposure risk to nearby residents and (unauthorized) public use of the RID water systems for swimming, bathing, and drinking.

The More Aggressive groundwater alternative remedy would be operated until the contaminant concentrations in groundwater have been reduced to applicable AWQSs that are protective of human health and the environment. While the duration of groundwater remediation cannot be predicted with any certainty, the remedial strategies and remedial measures of the More Aggressive groundwater alternative remedy would systematically remove COC mass and reduce residual COC concentrations in groundwater during implementation. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional. Further, the duration of the groundwater remedy will depend on other factors that are presently uncertain, including the presence of DNAPLs, changes in MCLs, and changes in aquifer conditions.

Based on existing contamination levels at the wells designated for treatment, the More Aggressive groundwater alternative remedy would address and permanently remove approximately 77% of the total VOC mass impacting the RID well field each year and prevent the transfer of that contamination into local surface waters and the air. Fate and transport of contaminants would be controlled at the wells with treatment systems, with essentially all of the contaminants retained in the GAC. When the GAC becomes saturated, the spent GAC will be shipped to a permitted regeneration facility for destruction of the contaminants during the GAC regeneration process.

There will be no "duration of exposure" or "changes in risk over the life of the remediation" associated with the More Aggressive groundwater alternative remedy since the remedial strategies and remedial measures would substantially limit the exposure route for contaminant impacts to environmental receptors from COC releases to groundwater, surface water, and air. As a result, there is no continuing endangerment to the public health and welfare or unacceptable impact on water use once the remedy is implemented. Priority pumping to contain the plume will protect additional groundwater supplies outside the plume from being polluted and will assure peripheral and downgradient wells that are threatened by the contaminant plume will remain available for unrestricted use for the long-term future. Installed GAC treatment systems at the most highly contaminated RID wells and blending of certain less contaminated RID wells will capture, remove and reduce target COCs to assure the wells and water supply are available for all beneficial uses and prevent these contaminants from discharging into local surface waters and the air above any applicable environmental or public health standards.

The residual risk in the aquifer is addressed by employing groundwater extraction and treatment as a principal element of the More Aggressive groundwater alternative remedy to permanently and significantly reduce the toxicity, mobility, concentration and volume of the hazardous substances. Consistent with RID requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until AWQSs are attained and the groundwater supply is available for unrestricted use. The treatment systems are modular and can be relocated or replaced as needed to provide continued protection from residual contamination. Spent GAC media from the groundwater treatment process is sent to a permitted regeneration facility for permanent destruction of any residual contaminants.

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While the chemical toxicity of the contaminants remaining in the groundwater over the course of the remediation would not change, the concentrations in groundwater are expected to decline over time. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional.¶

Considering current and future land and resource use, this remedy will reduce the risk to public health in all use scenarios. Land use in the WVBA Site is currently a mixture of residential, commercial/industrial and agricultural. The trend, however, is a transition from agricultural land use towards increased residential, commercial and industrial development. This remedy would restore this contaminated groundwater resource to the quality required for future use as a source water for potable M&I use. All major water providers indicated support for restoration of the contaminated groundwater supply.

This remedy would substantially reduce the mass of hazardous substances released to local surface water and air and restore the quality of the water supply to below MCLs. Therefore, the More Aggressive groundwater alternative remedy would reduce the risk to public health regardless of future land or groundwater use. Reductions in contaminant releases to the environment would also be more protective of aquatic and terrestrial biota even though, as indicated in Section 2.2, the overall ecological risk associated with the target COCs is generally of low concern.

Cost

Estimated costs for the More Aggressive groundwater alternative remedy are provided in **Table 7**. Capital costs are estimated to be $14.6 million with an estimated annual O&M cost of $2.2 million.[208] These costs include installation of infrastructure (including replacement of well RID-106 and re-equipping well RID-114) and the additional operational costs associated with recovering production capacity lost at each treated well due to increased head loss through treatment.

Uncertainties that could impact the future cost of the More Aggressive groundwater alternative remedy include the cost of consumables, primarily GAC, and, to a lesser extent, fluctuations in the cost of electricity. Additional uncertainties exist in the long-term operation of the wells utilized for injection. There may be need to rehabilitate the wells to maintain acceptable injection rates or, worst case, re-drill the well, depending on casing condition. The potential plugging of well casing and formation material and loss of well efficiency associated with injection presents a potential future cost impact beyond what would be expected for normal use of wells for groundwater extraction.

[208] The estimated costs are strictly for design, construction, and O&M of the wellhead treatment system and other remedial measures described in Section 7.4.3. RID has incurred other notable costs that have gone into development of the RID response action, including legal, technical, and financial transaction costs, that are not included in the estimate of capital costs.

Benefit/Value

Groundwater extraction associated with the More Aggressive groundwater alternative remedy would provide benefit to water providers within and adjacent to the WVBA Site whose wells are impacted or threatened by the contamination. Water impacted above AWQSs/MCLs could be remediated to allow the "maximum beneficial use of the waters of the state,"[209] while containment of the plume will ensure that wells impacted below AWQSs/MCLS and wells threatened, but not impacted by COCs, including the RID, SRP, COP, APS and COT wells within and adjacent to the WVBA Site, will produce water fit for their "current or reasonably foreseeable end uses."[210]

Groundwater treatment associated with the More Aggressive groundwater alternative remedy provides a high degree of public protection against potential exposures to COCs by preventing uncontrolled emissions of hazardous substances into the environment at the most highly contaminated RID wells and eliminating public access to open laterals that transmit contaminated water. Treatment of the extracted groundwater would permanently remove a substantial mass of hazardous substances from extracted groundwater and prevent the transfer of that contamination into local surface waters and the air.

Groundwater recharge associated with the More Aggressive groundwater alternative remedy may potentially provide benefit by mitigating COC impacts at RID-84, RID-90, RID-91, and RID-93 by injecting seasonally-available effluent at and near these wells to limit, at least partially, plume impacts on these peripheral wells.

As stipulated in the WQARF process, this evaluation addresses the overall benefit and value to the public within and adjacent to the WVBA Site.[211] The public benefits from the remedial strategies and remedial measures contained in the More Aggressive groundwater alternative remedy because they will reduce the concentration of contaminated groundwater and achieve the "maximum beneficial use of the waters of the state" that could be utilized by municipalities to spur local economic development. The public also would benefit from the More Aggressive groundwater alternative remedy by remediating contamination in the regional aquifer and by lowering the risk to public health and welfare by providing a high degree of public protection against potential exposures to hazardous air pollutants, which should garner political and public acceptance.

Based on the result of FS groundwater modeling, implementation of the More Aggressive groundwater alternative remedy would not significantly alter future hydrologic or plume conditions in the WBVA Site or surrounding area, compared to the Baseline Scenario (continued

[209] See ARS § 49-282.06.A.2.
[210] See ARS § 49-282.06.B.4.b.
[211] AAC R19-16-407.H.3.d

current RID operations).[212] Overall, projected regional groundwater elevations, flow directions, and gradients for both simulations are similar. Proposed actions to prioritize and increase pumping at key RID wells in the More Aggressive groundwater alternative remedy are projected to slightly improve hydraulic containment of the WVBA plume, particularly in the central and western portions of the WVBA. **Appendix F** includes a detailed summary of the model results.

The most pronounced differences in the projected local water table elevation and groundwater flow conditions are in the vicinity of RID-106, where the extent of capture is projected to expand as a result of increased pumping of a new replacement well at this site included in the More Aggressive groundwater alternative remedy. It is particularly noteworthy that increased pumping at RID-106 is projected to capture a significantly larger region near the leading edge of the WVBA plume,[213] including contaminated groundwater in the vicinity of the Dolphin facility at 740 South 59th Avenue (**Figure 4** shows the historical impact of PCE release in this area). The model-projected increase in capture that results from increased groundwater pumping at RID-106 would reduce the impact of PCE contamination from the Dolphin source area on RID-84, and avoid the need for treatment at this well. Additionally, seasonal injection of effluent at selected wells on the southern periphery of the WVBA plume would recharge the UAU to a limited extent and result in higher groundwater elevations.

8.4.4 Most Aggressive Groundwater Alternative Remedy

The Most Aggressive groundwater alternative remedy includes:

- installation of nine (9) additional wellhead treatment systems at RID-84, RID-99, RID-100, RID-106, RID-107, RID-109, RID-110, RID-112 and RID-113 (in addition to the four (4) wellhead systems already in place at RID-89, RID-92, RID-95 and RID-114) to achieve AWQSs and MCLs;
- replacement of wells RID-92 and RID-106 to enhance production capacity and increase contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.);
- replacement of pump/motor at RID-84 and RID-114 to enhance production capacity and increase contaminant removal (and recover any reduction in the available supply of water caused by addressing impacted wells pursuant to ARS § 49-282.06.B.4.b.); and,
- expansion of the existing RID-92 wellhead treatment system (1 additional skid) to accommodate the increased well capacity.

[212] Model-projected hydrologic impacts associated with the proposed More Aggressive Remedy are discussed in pages 25-27 of the *FS Model Report* in **Appendix F** and depicted in **Figures F-37 through F-41**.
[213] *See* **Figures F-38 and F-39.**

Practicability

The Most Aggressive groundwater alternative remedy is practicable since it has been demonstrated that wellhead treatment systems can be readily installed at existing well sites. Several of the well sites proposed for treatment systems (RID-99, RID-100, RID-106, RID-107, RID-109, RID-110, RID-112, and RID-113) under this remedy, however, are small and would likely require acquisition of additional land from adjacent property owner(s). Similarly, drilling replacement wells at RID-92 and RID-106, and expanding the existing treatment capacity at RID-92, would also require acquisition of additional land as well as a temporary access agreement from the adjacent property owner.

The Most Aggressive groundwater alternative remedy would be effective, in both the short- and long-term, at removing significant contaminant mass from the environment. Upon implementation of the Most Aggressive groundwater alternative remedy, treatment of groundwater at the 13 most highly contaminated RID wells will significantly reduce the transfer of contaminants from groundwater to air. Groundwater extraction and treatment, as part of the long-term groundwater remedy, will permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances in the regional aquifer.

The reliability of the Most Aggressive groundwater alternative remedy is robust. The proven design of the LGAC treatment systems, standard instrumentation and controls (with alarm interlocks), and the full redundancy provided by the lead-lag configuration makes these systems extremely reliable. The existing treatment systems were designed to minimize the frequency of system failures that could affect public health and, consistent with ADEQ requirements[214], have necessary safeguards to assure protection of public health against such failures. Subsequent treatment system installations will also be similarly designed and constructed.

Risk

The Most Aggressive groundwater alternative remedy would reduce the risk of imminent and substantial endangerment to public health and welfare and the environment by preventing uncontrolled releases of hazardous substances into the environment through the use of installed treatment systems at the 13 most highly contaminated RID wells and by optimizing the pumping of RID wells to prevent plume migration and to contain the plume. The remedial strategies and remedial measures contained in the Most Aggressive groundwater alternative remedy would reduce the primary exposure pathways for COCs in groundwater, surface water, and air at the WVBA Site. Given that groundwater pumpage is the major outflow from the groundwater system, the Most Aggressive groundwater alternative remedy would substantially

[214] *See* AAC R18-16-411.C

reduce the potential for exposed populations and environmental receptors to come in contact with COCs by the following mechanisms:

- Operational controls will be implemented to optimize pumping of RID wells in the WVBA Site to increase COC mass removal and enhance plume containment. Priority pumping of RID wells in the center of the plume will prevent contaminant migration to other threatened water provider wells (including RID, SRP, and City of Tolleson water supply wells) and the direct use of this water supply at wells that are peripheral to and downgradient of the current plume boundary.

- GAC treatment systems will be installed at the mostly highly contaminated RID wells within the plume and operational controls for blending with groundwater extracted at certain other less contaminated RID wells within the plume will be implemented to remove and reduce COCs from extracted groundwater to prevent the release of volatile chemicals into the environment above any applicable environmental or public health standards and therefore reduce the risk of imminent and substantial endangerment to public health and welfare from exposure to hazardous air pollutants by inhalation.

- Engineering controls will be implemented to restrict point source and fugitive emissions of COCs at well discharge structures and in open water conveyance laterals within the WVBA Site to eliminate incidental exposure risk to nearby residents and (unauthorized) public use of the RID water systems for swimming, bathing, and drinking.

The Most Aggressive groundwater alternative remedy would be operated until the contaminant concentrations in groundwater have been reduced to applicable AWQSs that are protective of human health and the environment. While the duration of groundwater remediation cannot be predicted with any certainty, the remedial strategies and remedial measures of the Most Aggressive groundwater alternative remedy would systematically remove COC mass and reduce residual COC concentrations in groundwater during implementation. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional. Further, the duration of the groundwater remedy will depend on other factors that are presently uncertain, including the presence of DNAPLs, changes in MCLs, and changes in aquifer conditions.

Based on existing contamination levels at the wells designated for treatment, the Most Aggressive groundwater alternative remedy would address and permanently remove approximately 91% of the total VOC mass impacting the RID well field each year and prevent the transfer of that contamination into local surface waters and the air. Fate and transport of contaminants would be controlled at the wells with treatment systems, with essentially all of the contaminants removed by GAC. When the GAC becomes saturated, the spent GAC will be shipped to a permitted regeneration facility for destruction of the contaminants during the GAC regeneration process.

There will be no "duration of exposure" or "changes in risk over the life of the remediation" associated with the Most Aggressive groundwater alternative remedy since the remedial strategies and remedial measures would substantially limit the exposure route for contaminant impacts to environmental receptors from COC releases to groundwater, surface water, and air. As a result, there is no continuing endangerment to the public health and welfare or unacceptable impact on water use once the remedy is implemented. Priority pumping to contain the plume will protect additional groundwater supplies outside the plume from being polluted and will assure peripheral and downgradient wells that are threatened by the contaminant plume will remain available for unrestricted use for the long-term future. Installed GAC treatment systems at the most highly contaminated RID wells and blending of certain less contaminated RID wells will capture, remove and reduce target COCs to assure the wells and water supply are available for all beneficial uses and prevent these contaminants from discharging into local surface waters and the air above any applicable environmental or public health standards.

The residual risk in the aquifer is addressed by employing groundwater extraction and treatment as a principal element of the Most Aggressive groundwater alternative remedy to permanently and significantly reduce the toxicity, mobility, concentration and volume of the hazardous substances. Consistent with RID requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until AWQSs are attained and the groundwater supply is available for unrestricted use. The treatment systems are modular and can be relocated or replaced as needed to provide continued protection from residual contamination. Spent GAC media from the groundwater treatment process is sent to a permitted regeneration facility for permanent destruction of any residual contaminants.

Considering current and future land and resource use, this remedy will reduce the risk to public health in all use scenarios. Land use in the WVBA Site is currently a mixture of residential, commercial/industrial and agricultural. The trend, however, is a transition from agricultural land use toward increased residential, commercial and industrial development. This remedy would restore this contaminated groundwater resource to the quality required for future use as a source water for potable M&I use. All major water providers indicated support for restoration of the contaminated groundwater supply.

This remedy would substantially reduce the mass of hazardous substances released to local surface water and air and restore the quality of the water supply to below MCLs. Therefore, the Most Aggressive groundwater alternative remedy would reduce the risk to public health regardless of future land or groundwater use. Reductions in contaminant releases to the environment would also be more protective of aquatic and terrestrial biota even though, as indicated in Section 2.2, the overall ecological risk associated with the target COCs is generally of low concern.

Deleted: While the chemical toxicity of the contaminants remaining in the groundwater over the course of the remediation would not change, the concentrations in groundwater are expected to decline over time. The rate of this decline is uncertain and will vary depending on the location within the aquifer and the proximity to continuing sources of contamination, either local or regional.

Cost

Estimated costs for the Most Aggressive groundwater alternative remedy are provided in **Table 7**. Capital costs are estimated to be $19.5 million with an estimated annual O&M cost of $4.2 million.[215] These costs include installation of infrastructure (including replacement of wells RID-92 and RID-106 and re-equipping wells RID-84 and RID-114) and the additional operational costs associated with recovering production capacity lost at each treated well due to increased head loss through treatment.

Uncertainties that could impact the future cost of the Most Aggressive groundwater alternative remedy include the cost of consumables, primarily GAC and, to a lesser extent, fluctuations in the cost of electricity.

Benefit/Value

Groundwater extraction associated with the Most Aggressive groundwater alternative remedy would provide benefit to water providers within and adjacent to the WVBA Site whose wells are impacted or threatened by the contamination. Water impacted above AWQSs/MCLs could be remediated to allow the "maximum beneficial use of the waters of the state,"[216] while containment of the plume will ensure that wells impacted below AWQSs/MCLs and wells threatened, but not impacted by COCs, including the RID, SRP, COP, APS and COT wells within and adjacent to the WVBA Site, will produce water fit for their "current or reasonably foreseeable end uses."[217]

Groundwater treatment associated with the Most Aggressive groundwater alternative remedy provides a high degree of public protection against potential exposures to COCs by preventing uncontrolled emissions of hazardous substances into the environment at the most highly contaminated RID wells and eliminating public access to open laterals that transmit contaminated water. Treatment of the extracted groundwater would permanently remove a substantial mass of hazardous substances from extracted groundwater and prevent the transfer of that contamination into local surface waters and the air.

As stipulated in the WQARF process, this evaluation addresses the overall benefit and value to the public within and adjacent to the WVBA Site.[218] The public benefits from the remedial

[215] The estimated costs are strictly for design, construction, and O&M of the wellhead treatment system and other remedial measures described in Section 7.4.3. RID has incurred other notable costs that have gone into development of the RID response action, including legal, technical, and financial transaction costs, that are not included in the estimate of capital costs.
[216] See ARS § 49-282.06.A.2.
[217] See ARS § 49-282.06.B.4.b.
[218] AAC R19-16-407.H.3.d

strategies and remedial measures contained in the Most Aggressive groundwater alternative remedy because they will reduce the concentration of contaminated groundwater and achieve the "maximum beneficial use of the waters of the state" that could be utilized by municipalities to spur local economic development. The public also would benefit from the Most Aggressive groundwater alternative remedy by remediating contamination in the regional aquifer and by lowering the risk to public health and welfare by providing a high degree of public protection against potential exposures to hazardous air pollutants, which should garner political and public acceptance.

Based on the result of FS groundwater modeling, implementation of the Most Aggressive groundwater alternative remedy would not significantly alter future hydrologic or plume condition in the WBVA Site or surrounding area, compared to the Baseline Scenario (continued current RID operations).[219] Overall, projected regional groundwater elevations, flow directions, and gradients for both simulations are similar. Proposed actions to prioritize and increase pumping at key RID wells in the Most Aggressive groundwater alternative remedy are projected to slightly improve hydraulic containment of the WVBA plume, particularly in the central and western portions of the WVBA. The most pronounced differences in projected local water table elevation and groundwater flow are in the vicinity of RID-92 and RID-106, where the extent of capture is projected to expand as a result of increased pumping of new replacement wells at these sites included in the Most Aggressive groundwater alternative remedy. **Appendix F** includes a detailed summary of the model results.

[219] Model-projected hydrologic impacts associated with the proposed Most Aggressive Remedy are discussed in pages 27-29 of the *FS Model Report* in **Appendix F** and depicted in **Figures F-42 through F-46**.

9.0 PROPOSED GROUNDWATER REMEDY

This section provides a comparative analysis of the four (4) groundwater alternative remedies, the rationale for selecting the proposed groundwater remedy for the WVBA Site, including how the proposed groundwater remedy achieves the WVBA Site groundwater ROs and meets the requirements of ARS § 49-282.06, considerations for public participation, and discussions addressing possible contingent remedial actions.

9.1 COMPARISON OF GROUNDWATER ALTERNATIVE REMEDIES

This section provides a comparison of the four (4) groundwater alternative remedies presented in this FS Report based on achievement of the WVBA Site groundwater ROs, consistency with water management plans, practicability, cost, risk and benefit/value. The purpose of this evaluation is to identify the advantages and disadvantages of each alternative relative to one another. This comparison is the basis for selection of the preferred remedy. A summary of the comparative analysis is presented in **Table 9**.

9.1.1 Achievement of ROs

As indicated in Section 8.3.1, all four (4) groundwater alternative remedies achieve the WVBA Site groundwater ROs for water use.

9.1.2 Consistency with Water Management Plans

As indicated in Section 8.3.2, all four (4) groundwater alternative remedies are consistent with water provider management plans and policies.

9.1.3 Practicability

Each of the four (4) groundwater alternative remedies presented in this FS Report is considered to be technically feasible and operationally practicable. While the Reference Remedy and all alternative remedies are generally practicable, they each involve differing levels of added infrastructure, as shown below, which differentiates them based on the associated level of effort of implementation.

Each of the proposed remedies presented in this FS Report is considered to be technically feasible and operationally practicable. While all alternatives are generally practicable, they each involve differing levels of added infrastructure, as shown below, which differentiates them based on the associated level of effort of implementation.

	Number of Existing Treatment Skids	Number of New Treatment Skids	Number of Replacement Wells	Number of Existing Wells Reconfigured as ASR Wells
Reference Remedy	9	12	2	0
Less Aggressive	9	5	1	0
More Aggressive	9	5	1	5
Most Aggressive	9	22	2	0

ASR = Aquifer Storage and Recovery

From an ease of implementation standpoint, the Less Aggressive groundwater alternative remedy is a significantly more viable option than the other groundwater alternative remedies in that it requires the installation of only two (2) additional wellhead treatment systems (a total of five [5] new treatment units) and a single replacement well. The Reference Remedy and More Aggressive groundwater alternative remedy are considered more challenging in implementation, primarily due to the added water treatment infrastructure and corresponding need to expand access and acquire land to facilitate the proposed remedial measures. The Most Aggressive groundwater alternative remedy is the least practicable of the groundwater alternative remedies evaluated due to the substantially greater requirements associated with access and land acquisition for installation of water treatment systems at nine (9) additional well sites.

9.1.4 Risk

All of the four (4) groundwater alternative remedies reduce the risk of imminent and substantial endangerment to public health and welfare and the environment by substantially reducing uncontrolled releases of hazardous substances into the environment through the priority pumping of RID wells and the use of installed treatment systems. By employing groundwater extraction and treatment as a principal element both to control plume migration and enhance containment of the regional plume and to permanently and significantly remove contaminants from extracted groundwater, all groundwater alternative remedies reduce the primary exposure pathways for COCs in groundwater, surface water, and air at the WVBA Site. All alternatives would prevent impacts to peripheral and downgradient wells and to additional groundwater supplies outside the plume, substantially reduce the mass of hazardous substances released to local surface water and air, and restore the quality of the water supply to below MCLs. The Most Aggressive groundwater alternative remedy, however, provides the highest level of risk reduction compared to the other remedies since it includes wellhead treatment on the largest number of impacted wells (all 13 wells exceeding AWQSs/MCLs), would remove the largest amount of contaminants from the environment, and does not rely on blending to achieve MCLs.

The Reference Remedy consists of wellhead treatment on nine (9) wells and both the Less Aggressive and the More Aggressive groundwater alternative remedies consist of wellhead treatment on six (6) wells. The relative differences in risk reduction, however, are not proportional since the six (6) wellhead treatment systems conceived in the Less and More Aggressive groundwater alternative remedies address the six (6) most highly contaminated wells in the WVBA Site and the additional wells treated in the Reference and Most Aggressive groundwater alternative remedies are considerably lower in contaminant concentration (as shown in **Table 2**).

In numerical terms, the amount of projected target COC mass removal associated with each of the proposed groundwater alternative remedies does not vary significantly, ranging from an estimated 77 to 91 percent of the total contaminant mass that is currently extracted by RID wells and released to the surface water and the air:

- the Reference Remedy removes approximately 83% of the total mass of VOCs estimated to be released into the surface water and the air each year;
- the Less Aggressive groundwater alternative remedy removes approximately 77% of the total mass of VOCs estimated to be released into the surface water and the air each year;
- the More Aggressive groundwater alternative remedy removes approximately 77% of the total mass of VOCs estimated to be released into the surface water and the air each year; and,
- the Most Aggressive groundwater alternative remedy removes approximately 91% of the total mass of VOCs estimated to be released into the surface water and the air each year.

Upon implementation, all groundwater alternative remedies would address the on-going and residual risk of groundwater contamination in the WVBA Site by permanently and significantly reducing the toxicity, mobility, concentration, and volume of the hazardous substances in groundwater and limiting the exposure route for contaminant impacts to environmental receptors. Consistent with water provider requirements and the established remedial objectives for municipal water use, groundwater extraction and treatment in the groundwater alternative remedies will be conducted until AWQSs are attained and the groundwater supply is available for unrestricted use.

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In addition, each of the remedies incorporates identical volatilization control measures to mitigate COC exposure pathways to the public. These measures, as described in Section 7, include elimination of point source emissions at wellhead and lateral discharges. These measures also include enclosing the few remaining open sections of the RID-92 lateral and the Salt Canal. Consequently, the small mass of VOCs that are not removed by direct remedial measures will pose a reduced risk to the public.

9.1.5 Cost

The estimated costs for the four (4) groundwater remedies evaluated are presented in **Table 7**. The Capital and O&M cost estimates, rounded to the nearest $100,000, are summarized as follows:

	Capital Expense	Annual O&M
Reference Remedy	$ 13,600,000	$ 3,000,000
Less Aggressive groundwater alternative remedy	**$ 9,400,000**	**$ 2,000,000**
More Aggressive groundwater alternative remedy	$ 14,600,000	$ 2,200,000
Most Aggressive groundwater alternative remedy	$ 19,500,000	$ 4,200,000

Projection of the 30-year and 50-year net present value costs (present worth) of the proposed groundwater alternative remedies are presented in **Table 8** and summarized below. These values (rounded to the nearest $100,000) assume that the capital and O&M costs indicated above would be incurred beginning in 2015 and annual cash flows for estimated O&M costs continue for the long-term future without adjustment for inflation. Periodic costs for equipment maintenance, repair, and/or replacement are accounted for as a recurring three (3) percent expense (based on equipment costs), included in the annual O&M cost roll-up.

	30-Year Present Worth	50-Year Present Worth
Reference Remedy	$ 73,300,000	$ 92,000,000
Less Aggressive groundwater alternative remedy	**$ 50,800,000**	**$ 63,800,000**
More Aggressive groundwater alternative remedy	$ 58,900,000	$ 72,700,000
Most Aggressive groundwater alternative remedy	$ 103,600,000	$ 130,000,000

The present worth calculations includes a three (3) percent discount rate applied to account for the time value of money. The use of this discount factor[220] is for comparative cost estimation purposes only and has not been analyzed in terms of whether this discount rate would satisfactorily establish the level of long-term funding necessary to fund future expenditures through established financial mechanisms such as a trust fund.

As evidenced by this cost summary, the Less Aggressive groundwater alternative remedy is considerably less expensive than the other groundwater alternative remedies in terms of capital expense, annual O&M and the resulting 30-year and 50-year present worth projections. In comparison to remedial actions underway at other WQARF and CERCLA sites in Phoenix and Tucson, the Less Aggressive groundwater alternative remedy is particularly cost effective (**Table 10**).

9.1.6 Benefit/Value

Each of the four (4) groundwater alternative remedies benefits the environment through elimination of significant point source emissions due to volatilization and removal of significant amounts of hazardous substances from the groundwater, surface waters and air in the WVBA Site. Each groundwater alternative remedy also will provide the benefit to water providers within and adjacent to the WVBA Site whose existing wells are impacted by groundwater contamination above AWQSs/MCLS of remediating the impacted water to allow the "maximum beneficial use of the waters of the state"[221] as a source of drinking water, which is a "reasonably foreseeable water end use" for all existing wells within the WVBA Site,[222] while containment of the plume will ensure that any other less impacted or threatened wells of the water providers within and adjacent to the WVBA Site, will produce water fit for their "current or reasonably foreseeable end uses" both now and in the reasonably foreseeable future.[223]

Compared to continuation of current RID operations, groundwater model projections indicate implementation of any of the remedial alternatives would result in localized and manageable changes in hydrologic conditions in the WVBA, but *would not cause significant additional water table decline or adverse movement of the WOC and M52 plumes*. These conclusions are

[220] A three (3) percent discount rate was used in lieu of the higher rate (e.g. 7%) specified by EPA guidance document (EPA, 2000) to reflect the currently lower productivity costs of capital. The 3% rate reflects an estimate of the private sector cost of capital for which the inflation premium has been removed. In contrast, based on economic assumptions included in the 2015 Federal Budget, the US Office of Management and Budget (OMB) currently uses a 1.9% real discount rate for discounting long-term constant-dollar cash flows, as indicated in the Memorandum from the Director of OMB re: 2014 Discount Rates for OMB Circular No. A-94 dated February 7, 2014. (Burwel, 2014)
[221] See ARS § 49-282.06.A.2.
[222] See ADEQ, *Final Remedial Objectives Report* (2012b)
[223] See ARS § 49-282.06.B.4.b.

consistent with the fundamental formulation criteria of the groundwater alternative remedies, which include reprioritized and increased pumping of key RID wells to enhance contaminant mass removal and hydraulic control of the plume where feasible, but do not include changes to the total amount of groundwater pumped by RID on an annual basis.

Although not significant at a regional scale, the reprioritized and increased pumping of RID wells associated with the groundwater alternative remedies are projected to locally improve hydraulic containment of the WVBA plume, particularly in the central and western portions of the Site. Importantly, the extent of capture is projected to expand where new wells are proposed and increased UAU pumping rates are expected, such as at RID-106 located near the leading edge of the plume.

In terms of overall value, the Less Aggressive groundwater alternative remedy provides the most practicable and lowest cost alternative that achieves an acceptable level of risk reduction while satisfying the WVBA Site groundwater RO of restoring the impacted groundwater for use as a source of drinking water.

9.2 CONCLUSION AND RATIONALE FOR SELECTION

Based on the results of detailed analysis that is set forth in this FS, the Less Aggressive groundwater alternative remedy is the proposed groundwater remedy for the WVBA WQARF Site. As specified in AAC R18-16-407.I, reasons for selecting the proposed remedy shall include: how the comparison criteria were considered, how the proposed remedy will achieve the WVBA Site groundwater ROs, and how the proposed remedy meets the requirements of ARS § 49-282.06, including specifically ARS § 49-282.06.B.4.b. Additionally, AAC R18-16-407.G, requires that the selected remedy address the needs of affected water providers.

9.2.1 Comparison Criteria

The evaluation criteria, including achievement of the WVBA Site groundwater ROs, consistency with water management plans, practicability, risk, cost and benefit/value, were considered for each of the four (4) groundwater alternative remedies and discussed in Section 8. The comparison of these criteria, as evaluated in relation to each other, was discussed in Section 9.1 and is summarized in **Table 9**.

9.2.2 Achievement of ROs

As noted before, the scope of this FS is to identify possible groundwater alternative remedies to address target COCs in groundwater within the WVBA Site, which also has been commingled with target COCs from adjacent regional groundwater contaminant sites. As such, this study is focused on groundwater contamination and addressing the impacts to water providers and protecting, at a minimum, all current and reasonably foreseeable water end uses as defined in the WVBA Site RO Report.[224] Previous analysis provided in Section 7 determined that all four (4) groundwater alternative remedies would meet the WVBA Site groundwater ROs for water use by addressing all impacted wells that are not suitable for current or reasonably foreseeable water end uses without treatment and ensuring that less impacted and threatened wells are suitable for current and reasonably foreseeable water end uses.

As shown in **Table 9**, all four (4) groundwater alternative remedies meet essential WQARF requirements established to assure the selected final groundwater remedy, at a minimum, meets ROs for all current and reasonably foreseeable water end uses within and outside the WVBA Site. The Most Aggressive groundwater alternative remedy proposes direct treatment at all thirteen (13) existing wells that are impacted above AWQSs and MCLs making those wells unfit to produce water for their current or reasonably foreseeable water end uses without treatment; however, the costs associated with this groundwater alternative remedy are the highest of all four (4) groundwater remedies. The Less Aggressive groundwater alternative remedy, which utilizes direct treatment at the six (6) most highly contaminated wells and addresses all of the other less impacted wells (albeit still above AWQSs/MCLs) through blending, distinguishes itself from other groundwater alternative remedies in this FS as the most effective combination of practicability, cost, and benefit for timely restoration of the groundwater resource and mitigation of environmental and public health impacts, while fully compliant with the groundwater ROs for the WVBA Site and applicable state law requirements.

With regard to land use and impacts, numerous facility investigations have been conducted throughout the WVBA Site over the past 25 years to characterize and remediate the impacts of hazardous substance releases. The scope of this FS, which is a regional groundwater remedy evaluation, does not include past or future work to address soil contamination at sources areas, nor the impacts, if any, on the loss or impairment to land uses. Instead, this FS assumes that the actions taken under ADEQ oversight have adequately addressed the known sources of hazardous substances impacting surface and subsurface soils and the potential this may have to cause a loss or impairment of land use. Further, should any additional information arise that identifies the need to address a presently unknown source of hazardous substances in surface or subsurface soil, it is assumed that ADEQ will assure that actions taken will not adversely impact or impair land uses in the WVBA Site.

[224] See ARS § 49-282.06.B.4.b.

9.2.3 Conformance With ARS § 49-282.06

As stated in ARS § 49-282.06.A., remedial actions shall:

1. Assure the protection of public health and welfare and the environment;
2. Provide for the control, management or cleanup of the hazardous substances in order to allow the maximum beneficial use of the [impacted] waters of the state; and,
3. Be reasonable, necessary, cost-effective and technically feasible.

As discussed in this FS Report, the proposed groundwater remedy, the Less Aggressive groundwater alternative remedy, meets all of these requirements. Treatment systems will remove the majority of hazardous substances from the environment, protecting public health and welfare, while providing for the control and cleanup necessary to allow "maximum beneficial use" as a drinking water source of the remediated water. The Less Aggressive groundwater alternative remedy also is reasonable, cost-effective and technically feasible as discussed in this FS Report.

In addition, ARS § 49-282.06.B.4.b. expressly requires that the selected remedial action for waters of the state "shall address, at a minimum, any well that at the time of selection of the remedial action either supplies water for municipal, domestic, industrial, irrigation or agricultural uses or is part of a public water system if the well would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end uses without treatment due to the release of hazardous substances." Likewise, ARS § 49-282.06.B.4.b. expressly requires that "specific measures to address any such well shall not reduce the supply of water available to the owner of the well." The Less Aggressive groundwater alternative remedy conforms to these requirements by ensuring all existing wells within the WVBA Site will produce water that is fit for its current and reasonably foreseeable end uses as determined in the groundwater ROs for the WVBA Site and restoring any reduction in the available supply of water caused by addressing any impacted wells.

9.2.4 Consistency With Water Provider Needs And Plans

Previous analysis provided in Sections 7 and 8 determined that all four (4) groundwater alternative remedies were consistent with affected water provider needs and management plans. As shown in **Table 9**, all four (4) groundwater remedies meet essential WQARF requirements that have been established to assure the selected groundwater remedy meets the water management needs of affected water providers. The Most Aggressive groundwater alternative remedy, at a substantial cost, fully addresses RID's needs to directly treat all impacted wells having COCs in excess of AWQSs/MCLs and addresses the needs of all water providers (RID, SRP, COP, APS and COT) by ensuring that any impacted or threatened existing well within and adjacent to the WVBA Site will now and in the reasonable foreseeable future (i.e. at least over the next 100 years) produce water fit for its "current or reasonably foreseeable end uses" for all water providers pursuant to ARS § 49-282.06.B.4.b. The Less Aggressive groundwater alternative remedy, however, is adequate to meet the needs of all of the water providers and distinguishes itself from the other groundwater remedies in this FS as the most effective combination of practicability, cost, and benefit for timely restoration of the groundwater resource and mitigation of environmental and public health impacts, while fully compliant with the groundwater ROs for the WVBA Site and applicable state law requirements.

9.2.5 Consistency with Land Use Plans

As mentioned in the discussion of land use ROs, the source area work that has been or may be conducted to address facility-specific releases of hazardous substances is independent of and outside the scope of this FS. With respect to the proposed groundwater remedy, the actions necessary to implement the Less Aggressive groundwater alternative remedy will have minimal impact on land use in the WVBA Site.

The remedial measures for the Less Aggressive groundwater alternative remedy listed in Section 7.5.3 all involve enhanced water infrastructure at RID well sites and within the RID water distribution system. However, there are two (2) locations at RID-106 and RID-109 where it will be necessary to acquire land to build out the remedy components. Review of aerial photographs indicates there is vacant or undeveloped land adjacent to these well sites, the surrounding land use is commercial and industrial private property, and the planned remedial measures are consistent with existing land uses.

9.3 COMMUNITY INVOLVEMENT

Public participation and community relations activities associated with the groundwater remedy selection process will follow community involvement requirements of AAC R18-16-404 and the *Community Involvement Plan for West Van Buren WQARF Site, Phoenix, Arizona* (ADEQ, 2011a). Consistent with this Community Involvement Plan, ADEQ will lead the public outreach and coordinate public communication and comments. Specific community involvement activities may include the preparation and distribution of public notices describing the availability of the FS Report for public review and participation in public meetings to discuss the report.

In order to broaden communication outreach and enhance transparency, RID will continue to deliver messages and information, in coordination with ADEQ, through the various communications channels and platforms developed for the Early Response Action. These channels and platforms include one-on-one briefings with interested individuals, group presentations, electronic and print media, and web-based communications.

9.4 CONTINGENCIES

As discussed in Section 7.4.7, the Less Aggressive groundwater alternative remedy is subject to uncertainties that may require contingency actions. The COP owns four (4) shallow production wells within the WVBA Site. Although the City has indicated it does not intend to use the wells and the wells are currently capped and out of service, the City has an established right to withdraw groundwater at these wells. Should the City require the wells for some non-potable use[225] in the future, then it will be necessary to evaluate potential remedial measures and take appropriate actions to address the water provider needs.

With respect to uncertainties associated with implementation of the remedial measures for the Less Aggressive groundwater alternative remedy, this action requires additional land in the vicinity of RID-106 and RID-109 to install wellhead treatment systems, and in the case of RID-106, to drill a replacement well. Review of aerial photographs of these locations indicates there is vacant or undeveloped land adjacent to the wells. From a planning perspective, it appears reasonable to assume that sufficient land can be acquired for the planned remedial measures. Should any constraints arise that limit land access or acquisition, further action may be necessary by ADEQ or RID to acquire the necessary land by eminent domain.

The Less Aggressive groundwater alternative remedy indirectly addresses groundwater contamination at well RID-84, which currently has PCE contamination in excess of MCLs/AWQSs, by expanded pumping and treatment of RID-106 and prioritized pumping of wells in this area as a means to limit PCE contamination at RID-84. Although projected groundwater modeling simulations provide reason to believe that this approach will effectively address the RID-84 impact, it is not assured this action will achieve MCLs/AWQSs at RID-84 or the timeframe it may require. Once actions to increase production capacity at RID-106 are completed, RID will monitor water quality and groundwater conditions throughout the leading edge of the plume to determine the effectiveness of this approach in limiting contamination at RID-84. If, after three (3) years, PCE concentrations are not declining at RID-84, and/or there has been no change in the AWQS/MCL for PCE based on EPA's recent toxicity information,[226] contingent actions may be necessary. With ADEQ approval, RID would take subsequent action at RID-84 to reconfigure the well to enable injection of water from the adjacent RID Main Canal, to further mitigate COC impacts, consistent with the approach described in **Appendix G**. In the

[225] As noted previously, COP operates under a set of long-standing policies, including specific city council direction, which discourages or outright prohibits the introduction of contaminated groundwater through a treatment plant directly into the potable distribution system (see **Appendix E**).
[226] See footnote 29 regarding EPA's recent changes to the risk factor for PCE.

unlikely event that this subsequent contingency action is unsuccessful, wellhead treatment may be necessary.

Beyond these specific concerns, there are other broad-based uncertainties that may pose a potential impact to the outcome of the proposed groundwater remedial action. These uncertainties include:

- The extent to which the Less Aggressive groundwater alternative remedy is able to provide physical containment of the plume, to reduce contamination at impacted wells that are currently below AWQSs/MCLs and prevent threatened wells from becoming impacted in the future; and,
- The potential action by EPA to lower the MCL for TCE, thereby lowering the treatment goals associated with this remedial action.

With respect to plume containment, the Less Aggressive groundwater alternative remedy would include on-going monitoring of groundwater elevations and water quality to determine whether groundwater extraction in the WVBA Site is effective in physically containing the plume and preventing it from migrating to impacted wells that are not currently impacted above AWQSs/MCLs or to threatened wells that are not currently impacted by COCs. Although not considered likely, should future monitoring data indicate that RID, SRP, COP or COT wells outside of the plume show increasing COC impacts, contingent actions may be necessary to more fully contain the contaminant plume.

Finally, there is uncertainty regarding whether and the extent to which the MCL for TCE may be reduced, through pending action by EPA. If this change occurs, there may be need to treat additional wells since the target for blending (the MCL) is now 5 µg/L for TCE and the revised MCL could be substantially lower. Concentrations in individual wells also will change with time. Routine monitoring of water quality within the RID well field and water system will be conducted to track trends and assure blended water supplies meet target water quality. Adjustments to the remedy could be warranted based on the results of system monitoring. The modular nature of the wellhead treatment systems will facilitate relocation of treatment systems should contaminant distribution change significantly.

9.5 PROPOSED REMEDY BENCHMARKING

Groundwater contamination encompassing the WVBA Site and upgradient M52 Site and WCP Area sites is the largest groundwater contaminant plume in Arizona. This plume is one of three mega-sites in Arizona that also includes the NIBW CERCLA Site in Scottsdale and the Tucson International Airport Area (TIAA) CERCLA Site in Tucson. At the NIBW and TIAA sites and M52 portion of the large commingled plume impacting the WVBA Site, groundwater remedies were implemented in previous decades, in the period 1992 to 2001. A summary of the costs and key operating metrics associated with the large-scale groundwater P&T systems at these three (3) sites is provided in **Table 10**, along with the associated information for the proposed WVBA Site groundwater alternative remedy.

As evident in this summary, the proposed groundwater alternative remedy for the WVBA Site, the Less Aggressive groundwater alternative remedy, is notably more cost effective than other selected groundwater remedies at the three (3) largest Arizona groundwater cleanup actions. In particular:

- The projected capital cost[227] of the Less Aggressive groundwater alternative remedy is substantially less than costs incurred to design and build all other regional groundwater remedies. For example the projected capital costs of the Less Aggressive groundwater alternative remedy is significantly less than the costs for the M52 OU2 groundwater remedy, even though that remedy was completed 13 years ago and is capable of treating only 40% of the design capacity of the proposed WVBA Site remedy. When capital costs are compared in terms of present worth measured in 2014 dollars, the Less Aggressive groundwater alternative remedy is nearly three (3) to ten (10) times more cost effective (remedial action cost per gpm of treatment capacity) than the other selected groundwater remedies. The proposed Less Aggressive groundwater alternative remedy provides substantial cost savings through the extensive use of existing infrastructure.

- The projected O&M costs[228] of the Less Aggressive groundwater alternative remedy, are less than the reported O&M costs of all other regional groundwater remedies when calculated based on the annual O&M expenses per pound of VOC mass removed or thousand gallons of groundwater treated. The expected O&M costs of the Less Aggressive groundwater alternative remedy are projected, based on these metrics, to range from around 20% to over an order of magnitude more cost effective than the other operating groundwater remedies.

Upon implementation, the Less Aggressive groundwater alternative remedy would become the single largest groundwater remedial action in Arizona. In this regard, the Less Aggressive

[227] Projected capital and O&M costs of the proposed Less Aggressive Remedy are reasonably well understood and defined. In contrast to usual FS cost estimates which typically range from +50% to -30% (EPA, 2000), the information gained from implementation of the RID-95 Wellhead Pilot Initiative (Synergy, 2012b) provides the basis to estimate remedial action costs more precisely and consistent with the expected cost accuracy (+15% to -10%) of the remedial design activity.
[228] *Ibid.*

groundwater alternative remedy is expected to pump and treat nearly 12,000 gpm[229] of contaminated water, on average, and remove 2,500 pounds of target COCs annually.[230] Moreover, the blending of other impacted wells with treated water provides remediation of up to 26,800 gpm of contaminated water supply. In comparison, remedial actions associated with regional groundwater cleanup at the other sites reported the following results in 2013:

- NIBW Site – combined extraction of 7,627 gpm of contaminated groundwater and removal of 1,405 pounds of TCE (the principal COC) at the Central Groundwater Treatment Facility and Miller Road Treatment Facility.
- M52 Site – combined extraction of 2,134 gpm of contaminated groundwater and removal of 1,300 pounds of VOCs at the OU1 and OU2 treatment plants.
- TIAA Site – extraction of 2,511 gpm of contaminated groundwater and removal of 107 pounds of TCE (the principal COC) at the Tucson Airport Remediation Project facility.

Finally, it is important to note that the selection of LGAC treatment technology as part of the proposed WVBA Site groundwater remedy is consistent with and conforms to remedial measures adopted at other Arizona WQARF and CERCLA sites. In fact, recent groundwater remedial actions implemented at the following sites have all selected LGAC for groundwater treatment:

- WOC WQARF Site
- PGA-North CERCLA Site
- Payson WQARF Site
- 56th Street and Earll Drive WQARF Site
- NIBW CERCLA Site – GAC Treatment Facility

LGAC was selected as the preferred groundwater treatment technology at these sites even though the end use varied from drinking water (NIBW and Payson), irrigation (WOC, PGA-North, and 56th Street and Earll), and injection (PGA-North). LGAC in a lead/lag configuration provides redundant treatment to ensure reliable and fail-safe operation while providing a high degree of public protection against potential VOC air emissions.

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229 As indicated in **Table 10**, the projected average annual pumping rate of 11,758 gpm for the Less Aggressive groundwater alternative remedy is derived from assigned pumping used in FS Model simulations, further discussed in **Appendix F**.

230 As indicated in **Table 10**, the estimated VOC mass removal is for the TCE, PCE, and 1,1-DCE only and based on projected pumping rates and 2013 water quality data from the impacted wells. The annual amount of VOC mass removal is likely to decline over time with continued remedy pumping.

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10.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 1997. **Toxicological Profile for Tetrachloroethylene**, U.S. Department of Health and Human Services, Public Health Service, originally published September 1997 and last updated March 2011.

AMEC Geomatrix, Inc. (AMEC), 2008. **GORE™-Survey Report, Prudential Overall Supply, ADEQ West Van Buren WQARF Site, 5102 West Roosevelt Street, Phoenix, Arizona**, July 25.

ADEQ, 1989. **Memorandum from David Hawkins to Lowell Carty, Project Manager for EW WQARF Site, re: "List of facilities to be evaluated in the East Washington Study Area"**, December 28.

_______, 1990. **Memorandum from Michael Leach, ADEQ Hydrologist, to Tom Curry, ADEQ WQARF Coordination Unit, re: "Van Buren Tank Farm – Final Summary Site Assessment Report"**, February 26.

_______, 1994a. **Memorandum from Keith Ross, ADEQ Hydrologist, to Linda Burgess, ADEQ Project Manager, re: "Phoenix Sky Harbor WQARF Phase II Study Results"**, January 5.

_______, 1994b. **Memorandum from Jeff Kulon, ADEQ Project Manager, to Al Brown, ADEQ Manager, re: "Sky Harbor/East Washington WQARF Sites"**, August 18.

_______, 2005. **Remedial Objectives Report, West Central Phoenix – West Osborn Complex, Phoenix, Arizona**, May 2005.

_______, 2006a. **Fact Sheet – West Van Buren Water Quality Assurance Revolving Fund Site**, February.

_______, 2006b. **Final Remedial Investigation Report, WCP East Grand Avenue WQARF Site, Phoenix, Arizona, 2-15**, June.

_______, 2007. **Letter from ADEQ Waste Programs Director to EPA Region 9 Superfund Director**, November 14.

_______, 2009. **Agreement to Conduct Work between Arizona Department of Environmental Quality and Roosevelt Irrigation District**, October 8.

______, 2010a. **Conditional Approval of a Water Quality Assurance Fund (WQARF) Early Response Action (ERA) Work Plan for the West Van Buren Registry Site**, June 24.

______, 2010b. **Letter from Henry Darwin, ADEQ Deputy Director, to David Armstrong, attorney for SRP, re: ADEQ Response to Request for Interim Decision**, October 13.

______, 2010c. **Review of Well Investigation Work Plan, Roosevelt Irrigation District, Early Response Action, West Van Buren Area, Water Quality Assurance Revolving Fund Site**, December 16.

______, 2011a. **Community Involvement Plan, West Van Buren Site Water Quality Assurance Revolving Fund (WQARF) Site, Phoenix, Arizona**, ADEQ Document No. EQR 10-01, December.

______, 2011b. **2011 Sitewide Five-Year Review Report, Motorola 52nd Street Superfund Site, Phoenix, Arizona**, prepared by ADEQ in collaboration with U.S. Environmental Protection Agency and URS Corporation, September.

______, 2011c. **REISSUANCE, Review of Well Investigation Work Plan, Roosevelt Irrigation District, Early Response Action, West Van Buren Area, Water Quality Assurance Revolving Fund Site**, February 9.

______, 2011d. **Well Investigation Work Plans letter from Synergy dated May 9, 2011, West Van Buren Area, Water Quality Assurance Revolving Fund Registry Site**, July 7.

______, 2011e. **Review of RID-95 Wellhead Pilot Treatment System Proposal Work Plan, West Van Buren Water Quality Assurance Revolving Fund Registry Site**, September 2.

______, 2012a. **Re: Groundwater Modeling Work Plan for Wellhead Pilot Treatment Systems, Roosevelt Irrigation District Early Response Action, West Van Buren Area, Water Quality Assurance Revolving Fund Site, October 27, 2011**, April 19.

______, 2012b. **Remedial Objectives Report, West Van Buren Area WQARF Registry Site, Phoenix, Arizona**, August 8.

______, 2013a. **Conditional Approval of RID's Modified Early Response Action Work Plan, West Van Buren WQARF Registry Site, Phoenix, Arizona**, February 1.

______, 2013b. **Approval of Draft Work Plan for Feasibility Study Groundwater Modeling dated October 3, 2013**, November 27.

______, 2014a. **Agreement to Conduct Work between Arizona Department of Environmental Quality and Roosevelt Irrigation District** (Amended), February 27.

______, 2014b. **ADEQ File Request**, email from Scott Clink, ADEQ Records Administrative Services Officer to Stuart Kimball, June 2.

Arizona Department of Health Services, 1992. **Health Risk Assessment**, (reference to this report originated from the WVBA Site RI Report prepared by Terranext).

Arizona Department of Water Resources, 2013. **Review of RID-SRP Agreements**, letter from Andrew Craddock, Manager of ADWR's Recharge, Assured & Adequate Water Supply Program to Donovan Neese, RID Superintendent, October 21.

Bartlett, R. Douglas, Mercer, James, and Suriano, Thomas R., 2006. **Regional Groundwater Flow and Solvent Groundwater Contamination in Central Phoenix, How to Create a 15-Mile Long Plume in Only 30 Years**, abstract and presentation given at the Arizona Hydrological Society Symposium, September 14.

Basin & Hydrogeologists, 2010. **Roosevelt Irrigation District (RID) Early Response Action Implementation Plan and Groundwater Response Action Plan for West Van Buren Water Quality Assurance Revolving Fund (WQARF) Site – Reference to Draft Plans Prepared by RID, Dated September 25, 2009 and October 5, 2009**, January 4.

BE&K/Terranext, 2001. **Roosevelt Irrigation District, Canal Characterization Report, West Van Buren WQARF Area, Phoenix, Arizona,** February 8.

Brown, James G., and Pool, D.R. 1989. **Hydrogeology of the Western Part of the Salt River Valley Area, Maricopa County, Arizona**, U. S. Geological Survey Water-Resources Investigations Report 88-4202.

Burwel, S.M., 2014. **Memorandum for the Heads of Departments and Agencies: 2014 Discount Rates for OMB Circular No. A-94**, February 7.

Camp, Dresser & McKee, Earth Technology Corporation, 1989. **Facility Prescreening Results**, November 7.

City of Phoenix, 1992. **Work Plan for the Phase II WQARF Study of Phoenix Sky Harbor International Airport, 1-3**, City of Phoenix, September.

______, 2010a. **Suggested Remedial Objectives for the West Van Buren WQARF Site**, letter from Philip McNeeley of COP to Julie Riemenschneider of ADEQ, January 7.

______, 2010b. **City of Phoenix Comments on West Van Buren ("WVB") WQARF Site, Roosevelt Irrigation District ("RID") Early Response Action Work Plan**, letter from Thomas Buschatzke of COP to Jennifer Thies of ADEQ, April 21.

______, 2011. **2011 Water Resources Plan**, City of Phoenix Water Services Department.

______, 2012. **Letter from Philip McNeely, Manager of City of Phoenix Office of Environmental Programs to Henry Darwin, ADEQ Director, re: RID's Modified ERA for WVBA Site**, December 3.

City of Tolleson, 2013. **2012 Water Quality Report**, May.

Clear Creek Associates, 2013. **Operable Unit No 1 Effectiveness Report, 2012 Operations at 52nd Street Superfund Site**, prepared for Freescale Semiconductor, March 2013.

Cohen, R. and Mercer, J., 1993. **DNAPL Site Evaluation**, U.S. Environmental Protection Agency Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, EPA/600/R-93/022, February 1993.

Conestoga-Rovers & Associates, 2013. **Effectiveness Report – 2012. 20th Street Groundwater Treatment Facility, 52nd Street Superfund Site, Operable Unit 2 Area, Phoenix, Arizona**, March 2013.

Corkhill, F., Corell, S., Hill, B., and Carr, D., 1993. **A Regional Groundwater Flow Model of the Salt River Valley – Phase II Phoenix Active Management Area, Hydrogeologic Framework and Basic Data Report**, Arizona Department of Water Resources Modeling Report No. 09.

Doherty, J., 2010a. **PEST, Model-Independent Parameter Estimation – User Manual (5th ed., with slight additions)**, Brisbane, Queensland, Australia, Watermark Numerical Computing.

______, 2010b. **Addendum to the PEST Manual**, Brisbane, Queensland, Australia, Watermark Numerical Computing.

Dolphin, 2010. **Early Response Action Proposed by Roosevelt Irrigation District for the West Van Buren Water Quality Assurance Revolving Fund (WQARF) Site**, letter from Pete Polson of Dolphin, Inc. to Jennifer Thies of ADEQ, April 22.

Environmental Protection Agency (EPA), 1979. **Water-related Environmental Fate of 129 Priority Pollutants**.

______, 1981. **Aquatic Fate Process Data of Organic Priority Pollutants**, Washington, D.C., EPA-440/4-81-014.

______, 1992. **Estimating Potential for Occurrence of DNAPL at Superfund Sites**, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, EPA/600/R-93/022, January 1992.

______, 1993. ***Evaluation of the Likelihood of DNAPL Presence at NPL Sites, National Results***, Office of Solid Waste and Emergency Response, EPA 540R-93-073, September 1993.

______, 1998. **Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, 3, 23-26**.

______, 1999. **EPA Superfund Explanation of Significant Differences (ESD#1) to July 1994 Record of Decision, Operable Unit Two, East Phoenix Groundwater Containment, Motorola 52nd Street Superfund Site, Phoenix, Arizona**, EPA/ESD/R09-99/054, September 10, 1999.

______, 2000. **A Guide to Developing and Documenting Cost Estimates During the Feasibility Study**, U.S. Army Corps of Engineers and EPA Office of Emergency and Remedial Response, EPA 540-R-00-002, July.

______, 2001. **Memorandum to EPA Regional Counsel from Directors of the EPA Office of Site Remediation Enforcement and the EPA Office of Regulatory Enforcement, and Chief of EPA Environmental Enforcement Section**, January 18.

______, 2002. **Toxicology Review of 1,1-Dichloroethylene, In Support of Summary Information on the Integrated Risk Information System,** EPA/635/R02/002, June.

______, 2009a. **Administrative Settlement Agreement and Order of Consent for Remedial Investigation and Feasibility Study, Motorola 52nd Street Superfund Site Operable Unit 3**, **Findings of Fact,** USEPA Region 9, Docket No. 2008-17, August 2009.

______, 2009b. ***DNAPL Remediation: Selected Projects Where Regulatory Closure Goals Have Been Achieved***, Office of Solid Waste and Emergency Response, EPA 542/R-09/008, August 2009.

______, 2010. **OU3 Administrative Settlement Agreement and Order on Consent for Remedial Investigation and Feasibility Study and Statement of Work**, September 8.

______, 2011. **Toxicology Review of Trichloroethylene, In Support of Summary Information on the Integrated Risk Information System, EPA/635/R-09/011F**, September.

______, 2012. **Toxicology Review of Tetrachloroethylene, In Support of Summary Information on the Integrated Risk Information System, EPA/635/R-08/011F**, February.

______, 2014. **TSCA Work Plan Chemical Risk Assessment, Trichloroethylene: Degreasing, Spot Cleaning and Arts & Crafts Uses; CASRN: 79-01-6**, EPA Document 740-R1-4002, Office of Chemical Safety and Pollution Prevention, June.

ERM, 2010. **Final OU3 Phase III Groundwater Remedial Investigation and Feasibility Study Work Plan, 52nd Street Superfund Site Operable Unit 3 Study Area, Phoenix, Arizona,** prepared by Environmental Resource Management on behalf of the Motorola 52nd Street Superfund Site Operable Unit 3 Work Group, August.

Gallagher & Kennedy (G&K), 2010. **Detailed Response to ADEQ Comments on the Roosevelt Irrigation District Early Response Action "Well Investigation Work Plan"**, November 15.

GeoTrans, 2004. **Remedial Investigation Report, West Osborn Complex, West Osborn Road, Phoenix, Arizona**, prepared by GeoTrans Inc. for United Industrial Corporation, July 22.

______, 2012a. **Final Feasibility Study Report for the Shallow Groundwater Subsystem, West Osborn Complex WQARF Site, Phoenix, Arizona**, January 17.

______, 2012b. **Final Feasibility Study Report for the Lower Sand and Gravel Subunit, West Osborn Complex WQARF Site, Phoenix, Arizona**, May 16.

Hafner, H.R., and O'Brien, T.E., 2006. **Analysis of Air Toxics Collected as Part of the Joint Air Toxics Assessment Project, Final Report**, STI-905039.03-3016-FR, December.

Honeywell, 2003. **Additional Site Characterization Work Plan**, April.

______, 2010. **West Van Buren WQARF Site, Roosevelt Irrigation District Proposal for Early Response Action**, letter from Karen Gaylord, Honeywell counsel, to Jennifer Thies of ADEQ, April 22.

HydroGeoLogic, 1996. **MODFLOW-SURFACT:** version 3.0, HydroGeoLogic Inc., Herndon, VA.
______, 2002. **Final Industrial Survey No, 2 for the West Van Buren WQARF Registry Site**, June 13.

HydroSystems, 2014. **West Van Buren Area Aquifer Storage & Recovery Well Feasibility Report**, April.

Kulon, Jeffrey P., Ross, Keith A., Olm, Richard C., 1994. **Stepping Out of the Pump and Treat Rut: Phoenix Plume Management Strategy,** paper presented at the Seventh Annual Symposium of the Arizona Hydrological Society, Scottsdale, Arizona, September 22-23.

Lesage, S., Jackson, R.E., Priddle, M.W., & Riemann P.G., 1990. **Occurrence and Fate of Organic Solvent Residues in Anoxic Groundwater at the Gloucester Landfill, Canada, 24 Environmental Science and Technology, 559, 564**, 1990.

M&A, 2010a. **Work Plan, Roosevelt Irrigation District Early Response Action, West Van Buren Water Quality Assurance Revolving Fund Site**, February 3.

______, 2010b. **Well Investigation Work Plan, West Van Buren Area, Phoenix, Arizona**, prepared for Gallagher & Kennedy, P.A. and Roosevelt Irrigation District, August 9.

______, 2010c. **Phase 1 Well Investigation Work Plan, West Van Buren Area, Phoenix, Arizona**, prepared for Gallagher & Kennedy, P.A. and Roosevelt Irrigation District, November 24.

______, 2011a. **Investigations at Well RID-95, Roosevelt Irrigation District Early Response Action, West Van Buren Area Water Quality Assurance Revolving Fund Site**, July 25.

______, 2011b. **Groundwater Modeling Work Plan for Wellhead Pilot Treatment Systems, Roosevelt Irrigation District Early Response Action, West Van Buren Area Water Quality Assurance Revolving Fund Site**, October 27.

______, 2011c. **Groundwater Modeling Work Plan for Wellhead Pilot Treatment Systems, Roosevelt Irrigation District Early Response Action, West Van Buren Area Water Quality Assurance Revolving Fund Site**, October 27.

______, 2012. **Technical Memorandum (revised), Investigations at Well RID-95, Roosevelt Irrigation District, Early Response Action, West Van Buren Area Water Quality Assurance Revolving Fund Site**, revised report prepared by Montgomery & Associates for Roosevelt Irrigation District, January 11.

______, 2013. **Draft Work Plan for Feasibility Study Groundwater Modeling**, October 3.

National Research Council, 2013. **Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites**, the National Academies Press, Washington, DC.

National Toxicology Program, 2014**. Report on Carcinogens, Monograph on Trichloroethylene, Peer Review Draft**, Division of the National Toxicology Program, National Institute of Environmental Health Services, U.S. Department of Health and Human Services, June 27.

Pankow, James F., and Cherry, John, A. 1996. **Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation**, Waterloo Press, 1996.

Reynolds, S.J., and Bartlett, R.D., 2002. **Subsurface Geology of Easternmost Phoenix Basin, Arizona: Implications for Groundwater Flow**, Arizona Geological Society Contributed Report CR-02-A, August.

Salt River Project (SRP), 2009. **West Van Buren WQARF Site, Roosevelt Irrigation District's Proposed Early Response Plan**, letter from W.R. Powell of SRP to Julie Riemenschneider of ADEQ, December 4.

Synergy, 2011a. **Early Response Action - Public Health Exposure Assessment and Mitigation Work Plan, West Van Buren Area Water Quality Assurance Revolving Fund Site**, June 16.

______, 2011b. **RID-95 Wellhead Pilot Treatment System Proposal, West Van Buren Area Water Quality Assurance Revolving Fund Site**, August 18.

______, 2011c. **Early Response Action - Public Health Exposure Assessment and Mitigation Summary Report, West Van Buren Area Water Quality Assurance Revolving Fund Site**, September 16.

______, 2012a. **1-Month Technology/Design Demonstration Report: RID-95 Pilot System, West Van Buren Area Water Quality Assurance Revolving Fund Site**, May 8.

______, 2012b. **Long-Term Operational Assessment Report, RID-95 Wellhead Pilot Treatment Systems, West Van Buren WQARF Registry Site, Phoenix, Arizona**, April 5.

______, 2012c. **Follow-Up on Phase 1 Groundwater Modeling and Modified ERA Proposal**, July 24.

______, 2012d. **Modified Early Response Action Work Plan, West Van Buren WQARF Registry Site, Phoenix, Arizona**, October 19.

______, 2013a. **Feasibility Study Work Plan, West Van Buren WQARF Registry Site, Phoenix, Arizona**, June 21.

______, 2013b. **Technical Memorandum, Investigations at Well RID-92**, prepared by Synergy Environmental for Arizona Department of Environmental Quality, June 21.

______, 2013c. **Technical Memorandum, Installation of and Investigations at Well RID-111R**, prepared by Synergy Environmental for Arizona Department of Environmental Quality, June 21.

______, 2013d. **Operation & Maintenance Plan, RID Wellhead Treatment Systems, West Van Buren Area WQARF Site, Phoenix, Arizona**, October 2.

______, 2014. **Roosevelt Irrigation District Well Investigations, West Van Buren Area WQARF Registry Site** letter to ADEQ, March 5.

Terranext, 2008. **Draft Remedial Investigation Report, West Van Buren WQARF Registry Site, Phoenix, AZ**, prepared for ADEQ, October.

______, 2012. **Remedial Investigation Report, West Van Buren WQARF Registry Site, Phoenix, AZ**, prepared for ADEQ, August.

______, 2013. **First Quarter 2013 Water-Quality Report, West Van Buren Area (WVBA) Water Quality Assurance Revolving Fund (WQARF) Registry Site, Phoenix, Arizona**, Prepared for Arizona Department of Environmental Quality, July.

Thomas, R.G., 1982. **Volatilization from Water, Handbook of Chemical Physical Property Estimation Methods: Environmental Behavior of Environmental Compounds**, Lyman, W.J., Reehl, W.F., and Rosenblatt, D.H. (editors), McGraw Hill Book Company, New York.

Trach, Robert J., 1996. **Ultraviolet/Oxidation Treatment**, prepared for Ground-water Remediation Technologies Analysis Center, November.

Univar, USA, Inc. 2008. **Univar USA Inc.'s Comments, Draft Remedial Investigation Report, West Van Buren Area WQARF Site, Phoenix, AZ,** letter from Michael Gaudette of Univar to Jennifer Thies of ADEQ, December 29, 2008.

URS Corporation, 2011. **2011 Sitewide Five-Year Review Report, Motorola 52nd Street Superfund Site, Phoenix, Arizona**, prepared in conjunction with Arizona Department of Environmental Quality and U.S. Environmental Protection Agency, September 30.

______, 2013a. **Final Proposed Remedial Action Plan (PRAP), Shallow Groundwater System, West Osborn Complex Registry WQARF Site, Phoenix, Arizona**, June.

______, 2013b. **Final Proposed Remedial Action Plan (PRAP), Lower Sand and Gravel Subunit, West Osborn Complex Registry WQARF Site, Phoenix, Arizona**, June.

Weston, 2000. **Central Phoenix Plume Model**, prepared by Roy F. Weston on behalf of ADEQ.

______, 2001. **Central Phoenix Plume Model, Phase III: Groundwater Flow Model, Final, 1996-1998 Validation Simulations**, prepared for ADEQ, February 12.