URS

PROPOSED REMEDIAL ACTION PLAN (PRAP)
7TH AVENUE AND BETHANY HOME ROAD WQARF SITE
PHOENIX, ARIZONA

Prepared by
ADEQ and URS Corporation

April 2015

Registered Professional Engineer (Chemical)
CERTIFICATE NO.
37331
JANET M.
WORKMAN
Date Signed 4-23-15
ARIZONA, USA
EXPIRES 03-31-2017

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS	
A.A.C.	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ARAR	Applicable or Relevant and Appropriate Requirement
A.R.S.	Arizona Revised Statute
AWQS	Aquifer Water Quality Standard
bgs	below ground surface
COC	contaminant of concern
COP	City of Phoenix
DCE	Dichloroethene
EPA	U.S. Environmental Protection Agency
ERA	Early Response Action
ERD	enhanced reductive dechlorination
FS	Feasibility Study
feet/day	feet per day
gal	gallon
GPM	gallon per minute
GWET	Groundwater Extraction and Treatment
ISCO	In Situ Chemical Oxidation
mg/kg	milligram per kilogram
O&M	Operation and Maintenance
PCE	tetrachloroethene
PRAP	Proposed Remedial Action Plan
psi	pounds per square inch
PVC	polyvinyl chloride
RO	Remedial Objective
ROI	radius of influence
SRP	Salt River Project
SVE	soil vapor extraction
TCE	trichloroethene
TOC	total organic carbon
µg/L	microgram per liter
URS	URS Corporation
VOC	volatile organic compound
WQARF	Water Quality Assurance Revolving Fund

1.0 INTRODUCTION

1.1 PURPOSE OF DOCUMENT

URS Corporation (URS) has been retained by the Arizona Department of Environmental Quality (ADEQ), to prepare this proposed remedial action plan (PRAP) for the 7th Avenue and Bethany Home Road Water Quality Assurance Revolving Fund (WQARF) Site (the Site), located in Phoenix, Arizona (see Figure 1). ADEQ is required under Arizona Revised Statute (A.R.S.) §49-287.04 to issue a PRAP for the proposed remedy of the plume to the public for review and comment. This PRAP was prepared in accordance with Arizona Administrative Code (A.A.C.) R18-16-408 and is based on information contained in the following documents:

- *Remedial Investigation Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (ADEQ, 2011)
- *Final Feasibility Study, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (Arcadis, 2012)
- *Enhanced Reductive Dechlorination Pilot Test Work Plan, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (Arcadis, 2013)
- *Enhanced Reductive Dechlorination Pilot Test Summary Report* (Arcadis, 2014)

The information contained in the PRAP is drawn from and, in many cases, quotes directly from the above-referenced remedial investigation and feasibility study (FS) reports without attribution other than that noted here. The detailed history of site investigations and Early Response Action (ERAs) completed at the Site are presented in the referenced documents and are not reiterated in detail here.

The purpose of the PRAP is to inform the public on the proposed remedy selected from the alternatives evaluation in the FS to address the groundwater plume and satisfy the cleanup goals that include site specific remedial objectives (ROs) provided in Appendix F of the *Remedial Investigation Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (ADEQ, 2011) and discussed in Section 5.0. The PRAP is part of the final remedy selection process under WQARF where public input is solicited on all alternatives and on the rationale for proposing the preferred remedy. New information that ADEQ receives during the public comment period could result in the selection of a final remedy that differs from the proposed remedy. Therefore the public is encouraged to review and comment on all the alternatives presented in this PRAP. Information on public participation activities associated with this PRAP is provided in Section 8.

1.2 SITE NAME AND LOCATION

As described in the Site Registry Report (ADEQ, 2004), the 7th Avenue and Bethany Home Road WQARF Site is located in the vicinity of the intersection of 7th Avenue and Bethany Home Road in Phoenix, Arizona. The current boundaries of the Site as stated on the ADEQ website (ADEQ, 2015) are W. Rose Lane to the north, Bethany Home Road to the south, N. 5th Avenue to the east, and N. 8th Avenue to the west (Figure 1).

Two properties have been identified as likely sources of the groundwater contamination within the Site: the Bayless Investment and Trading Company property, (Bayless property) located at 540 West Bethany Home Road, and the SCI Arizona Funeral Services property, (SCI property) located at 710 West Bethany Home Road.

The Bayless property (see Figure 2) is a 2.6-acre commercial property located at the northeast corner of 7th Avenue and Bethany Home Road located in Phoenix, Arizona which operated as a shopping center between 1952 and 1992. Businesses that occupied the shopping center included a grocery store, clothing store, bakery, beauty shop, barbershop, pharmacy, and a dry cleaner. The dry cleaner occupied one of the commercial spaces between 1952 and 1992. The grocery store was destroyed by fire in 1987, but the other businesses remained until 1992. The property was not located within the city limits when first developed, and was serviced by an on-site septic system. In 1960, the property was connected to the City of Phoenix (COP) sewer system, but the on-site septic tanks and cesspools remained in place. In 1993, all businesses were closed, and the shopping center was demolished in 1994. The septic tanks and cesspools have subsequently been removed.

The SCI property (see Figure 3) is located at 710 West Bethany Home Road, Phoenix, Arizona and consists of four separate parcels. Two of the parcels are of interest in this investigation. The Remedial Investigation Report (ADEQ, 2011) indicates that a dry cleaner operated on parcel 2 from the 1950's until the 1990's. Parcel 4 was occupied by a mortuary and parking lot and contained two surface drains. One drain led to a septic tank and one to a brick-lined seepage pit.

1.3 CONTAMINATED MEDIA

The contaminated medium associated with this PRAP is groundwater. The contaminants of concern (COCs) associated with the Site are tetrachloroethene (PCE), trichlorethene (TCE), and vinyl chloride. These contaminants are also collectively referred to as volatile organic compounds (VOCs) within this PRAP. An ERA completed at the Bayless property has addressed contamination in other media (i.e., soils).

2.0 SITE CHARACTERISTICS

2.1 NATURE AND EXTENT OF CONTAMINATION

Site investigations were conducted at the Bayless property that confirmed the presence of PCE and other VOCs in the soil and groundwater underlying the property. In addition, site investigations conducted at the SCI property indicated that chlorinated VOCs were present in both the underlying soils and groundwater. A detailed discussion pertaining to the distribution of contaminants associated with both properties is available in the Remedial Investigation Report (ADEQ, 2011) and summarized in the following sections.

2.1.1 Source of Release

The two properties identified as likely sources of the groundwater contamination associated with the 7th Avenue and Bethany Home Road WQARF Site include the Bayless property located at 540 West Bethany Home Road and the SCI property located at 710 West Bethany Home Road. On-Site septic tanks were identified as a potential PCE source, impacting two Salt River Project irrigation wells located within ½ mile of the Site. During a soil gas investigation conducted in 1999 by a consultant working for the Bayless property owner, excavation activities uncovered two separate septic tanks, three cesspools, and several runs of piping. A dried sludge sample collected from one of the septic tanks was analyzed for VOCs with a PCE concentration of 54 milligrams per kilogram (mg/kg). Subsequent samples collected from the cesspools revealed PCE concentrations ranging from non-detect to 2.1 mg/kg.

Investigations conducted in 1990 and 1991 in the vicinity of the SCI property identified a dry well, septic tank, and seepage pit. PCE and other VOCs were detected in soil vapor, soil, sludge, and dry well sediment.

2.1.2 Soil / Soil Vapor

As part of an ERA Investigation conducted in 2005, data were collected to characterize the source area of PCE contamination underlying the Bayless property. As a result of the ERA, the extent of the PCE contamination in the vadose zone was defined. Subsequently, a soil vapor extraction (SVE) system was installed at the site in the second quarter of 2005 and operated from June 2005 to April 2006 at which time a rebound test was conducted. The results of the rebound test indicated that the SVE system had adequately addressed the PCE contamination in the vadose zone as confirmed by the drilling and sampling of two verification borings which indicated that neither the regulatory limits for the Groundwater Protection Level of 0.8 mg/kg nor the Residential soil remediation level of 5.1 mg/kg were exceeded in any of the borehole samples. As a result of the SVE operations and soil verification sampling, the ADEQ granted the property owner a No Further Action determination for soil at the Bayless property in December 2008.

In 2008, six exploratory soil borings were drilled and two groundwater monitoring wells were installed as part of the ERA investigation at the SCI property. The exploratory boring locations were selected based on the known location of the former dry cleaner building, potential source areas including a dry well and former septic system and seepage pit, and known groundwater flow direction. Analytical results obtained during the investigation indicated that no constituent concentrations were detected in soil above regulatory standards and no further remediation of the vadose zone at the SCI property was deemed necessary.

2.1.3 Groundwater

Originally, COCs identified in groundwater underlying the 7th Avenue and Bethany Home Road WQARF Site included the following:

- Chloroform
- *cis*-1,2-Dichloroethene (DCE)
- *trans*-1,2-DCE
- Dichlorodifluoromethane
- TCE
- PCE
- Methyl-tert-butyl ether
- Vinyl chloride

Based on concentrations exceeding the Arizona Water Quality Standards (AWQSs), ADEQ has retained PCE, TCE, and vinyl chloride as the COCs in groundwater at the 7th Avenue and Bethany Home Road WQARF Site requiring active remediation. Historic groundwater concentrations are provided in Table 1. The impacted groundwater interval extends from a depth of approximately 80 feet below ground surface (bgs) to 110 feet bgs. The water table occurs at the upper portion of a fine-grained layer at a depth between 76 to 88 feet bgs.

For the Bayless property, the horizontal extent of PCE-impacted groundwater is largely defined by the existing groundwater monitoring wells MW-3, MW-4, MW-5, and MW-10. This has been supplemented by the two new wells (MW-3R and MW-14), in addition to the two injection wells (IW-1S and IW-1D) that were installed in support of a pilot test. Well MW-4 exhibits the highest PCE concentrations (i.e., up to 2,300 micrograms per liter [µg/L]) in the monitoring well network. The most current analytical result for Well MW-4 was 1,000 µg/L from the March 2014 groundwater monitoring event. Well MW-7 which is located farthest north of the Site (approximately 950 feet north of the Bayless property) has detectable concentrations of PCE, albeit at levels below regulatory concern, with the March 2014 result being 1.2 µg/L. The downgradient extent of the PCE plume that exceeds the 5 µg/L standard is estimated to reside between monitoring wells MW-10 and MW-7.

Well SRP13.1E-10.5N shown in Figure 1 has been sampled intermittently for VOCs since 1986. The PCE concentration has ranged from less than the detection limit to 5 µg/L, with an increasing trend observed from 2001 to 2012. The PCE result for the most recent groundwater sample collected on March 28, 2013 was 12 µg/L exceeding the 5 µg/L standard. The Salt River Project (SRP) well is located north of well MW-7; therefore, there is the potential for an unidentified preferential flow pathway to exist from the Site that may be impacting the SRP well. It is recommended that a nested groundwater monitoring well pair screened from 130 to 170 feet bgs and from 200 to 240 feet bgs be installed on W. Rose Lane in the vicinity of MW-7 to evaluate the PCE concentration with increasing depth at this location for performance monitoring of the remedy in the downgradient portion of the plume. Estimated costs for installation of a new nested groundwater monitoring well are provided in Section 6.5.

Groundwater samples collected in March 2014 from monitoring wells on the SCI property and immediately downgradient from the SCI property indicate PCE concentrations ranging from 9.2 µg/L to 170 µg/L (Arcadis, 2014c). The location with the highest PCE concentrations is MW-18, an off-site, downgradient well (Figure 4). The sample collected from offsite well MW-19, located north of MW-18, had a PCE concentration of 56 µg/L.

In March 2014, well MW-12 on the SCI property also had a TCE concentration of 13 µg/L, which exceeds the AWQS of 5 µg/L for TCE. Vinyl chloride was also detected in this well at a concentration of up to 1.5 µg/L, below the AWQS of 2 µg/L and *cis*-1,2-dichloroethene at a concentration of 18 µg/L, which is less than the AWQS of 70 µg/L. Other wells associated with the SCI property did not exhibit the PCE degradation products as were observed in MW-12.

Located approximately 1,350 feet north of the property, monitoring well MW-8 PCE concentration was below the laboratory reporting limit of 1.0 µg/L. The PCE in wells MW-18 and MW-19 both exceed the AWQS of 5 µg/L with concentrations of 170 µg/L and 56 µg/L, respectively. Because no other wells are located between these two wells and MW-8 located further upgradient, and because the western extent of the dissolved plume is not defined, it is recommended that up to three new groundwater monitoring wells be installed in the northwest section of the plume to refine the understanding of the extent of contamination and to monitor the effectiveness of the implemented remedy.

3.0 SCOPE AND ROLE OF REMEDIAL ACTION

3.1 OVERALL CLEANUP GOAL

The overall cleanup goal is to address the groundwater contamination plume associated with the 7th Avenue and Bethany Home Road WQARF Site. Specifically, the goals are:

- Satisfy the remedial objectives as discussed in Section 5.0
- In accordance with A.R.S. §49-282.06A:
  - ✓ Assure protection of public health and welfare and the environment;
  - ✓ Provide for, as practicable, the control, management or cleanup of the hazardous substances in order to allow for the maximum beneficial use of waters of the state; and,
  - ✓ Be reasonable, necessary, cost-effective, and technically feasible.

3.2 SCOPE OF GROUNDWATER PLUME REMEDIAL ACTION

The proposed remedy for the 7th Street and Bethany Home Road WQARF Site will be the final action to reduce the toxicity, mobility, and/or volume of PCE, TCE, and vinyl chloride found in the groundwater underlying the Site that will satisfy the cleanup goals presented in Section 3.1. The proposed remedy incorporates one or more remediation technologies or methodologies as provided in A.A.C. R18-16-407(F).

The remaining sections of this PRAP describe the risks associated with the contaminants of concern in groundwater, the ROs specific to addressing that contamination, and the remedial alternatives evaluation process that lead to the selection of the proposed remedy. Section 8 describes the avenues by which this PRAP will be issued for public comments.

4.0 NEED FOR REMEDIAL ACTION

The ADEQ has identified PCE, TCE, and vinyl chloride as the contaminants of concern in the groundwater underlying the Site. From the March 2014 sampling event, PCE concentrations ranged from non-detect to 1,000 µg/L encountered in the sample collected from monitoring well MW-4, exceeding the AWQS of 5 µg/L. The TCE concentrations in March 2014 ranged from non-detect to 13 µg/L, which also exceed the AWQS of 5 µg/L. Vinyl chloride concentrations did not exceed the AWQS of 2 µg/L in March 2014, but have been detected at concentrations of up to 3.7 µg/L within the last 5 years in the samples collected from well MW-12.

Although the COP does not currently extract water from the aquifer that has been impacted by chlorinated VOCs attributed to a release from the 7th Avenue and Bethany Home Road WQARF Site, degraded groundwater constitutes a vast reserve of water for use in meeting the COP's future water needs. The COP maintains wells for emergency use and future use in meeting service area water needs. These wells could be placed back in service, but would require wellhead treatment systems or approved blending programs should the groundwater contamination not be addressed. Given the current concentrations of chlorinated VOCs in the groundwater and the projected future needs for the COP, groundwater underlying the Site requires remediation to address the contamination.

In addition, SRP has two wells in the vicinity of the 7th Avenue and Bethany Home Road WQARF Site which are used to pump groundwater for agricultural purposes. Neither of the wells is located within the Site boundary. SRP well 12.5E-10N (55-608429) is located cross-gradient from the site with SRP well 13.1E-10.5N being located downgradient (see Figure 1). As discussed in Section 2.1.3, this downgradient well was sampled on March 28, 2013 yielding a PCE result for the groundwater sample of 12 µg/L exceeding the 5 µg/L standard. The SRP well is located north of well MW-7; therefore, there is the potential for an unidentified preferential pathway to exist from the Site that may be impacting the SRP well.

Based on the above, it is ADEQ's current judgment that the Proposed Remedy identified in this PRAP, or one of the other alternatives, is necessary to protect public health or welfare or the environment. In addition, it is necessary to be protective of the continued use of groundwater for agricultural purposes.

5.0 REMEDIAL OBJECTIVES

The *Final Remedial Objectives Report, 7th Avenue and Bethany Home Road WQARF Registry Site, Phoenix, Arizona* is provided in Appendix F of the *Remedial Investigation Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (ADEQ, 2011). Remedial objectives are established for current and reasonably foreseeable uses of land and waters of the State that have been or are threatened to be affected by a release of a hazardous substance.

5.1 REMEDIAL OBJECTIVES FOR LAND USE

The RO for current and future land use in the 7th Avenue and Bethany Home Road WQARF Site is as follows:

- Protect against possible exposure to hazardous substances from the release that could occur during typical industrial and residential uses.

5.2 REMEDIAL OBJECTIVES FOR GROUNDWATER USE

As discussed in Section 2.1.3, only TCE, PCE, and vinyl chloride are currently present at concentrations above their respective AWQS.

The groundwater uses identified in the vicinity of the 7th Avenue and Bethany Home Road WQARF site include municipal use, agricultural use, and private use (including domestic and irrigation). The ROs for current and future groundwater use in the 7th Avenue and Bethany Home Road WQARF Site are:

- To protect the supply of groundwater for municipal use and for the associated recharge capacity that is threatened by contamination emanating from the 7th Avenue and Bethany Home Road WQARF Site. To restore, replace or otherwise provide for the groundwater supply lost due to contamination associated with the 7th Avenue and Bethany Home Road WQARF Site. This action will be needed for as long as the need for the water exists, the source remains available, and the contamination associated with the 7th Avenue and Bethany Home Road WQARF Site prohibits or limits groundwater use.
- To protect the supply of groundwater for irrigation use and for the associated recharge capacity that is threatened by contamination emanating from the 7th Avenue and Bethany Home Road WQARF Site. To restore, replace or otherwise provide for the groundwater supply lost due to contamination associated with the 7th Avenue and Bethany Home Road WQARF Site. This action will be needed for as long as the need for the water exists, the

resource remains available, and the contamination associated with the 7th Avenue and Bethany Home Road WQARF site prohibits or limits groundwater use.

- To protect, restore, replace or otherwise provide a water supply for domestic and irrigation use by private well owners outside the current plume boundaries of the 7th Avenue and Bethany Home Road WQARF Site if the current use is impaired or lost due to contamination from the site. This action will be needed until municipal connections can be confirmed.

5.3 REMEDIAL OBJECTIVES FOR SURFACE WATER

ROs for current and future surface water use in the 7th Avenue and Bethany Home Road site are:

- To protect the supply of surface water for domestic and irrigation uses and for the associated recharge capacity that is threatened by contamination emanating from the 7th Avenue and Bethany Home Road WQARF Site. To restore, replace or otherwise provide for the surface water supply lost due to contamination associated with the 7th Avenue and Bethany Home Road WQARF Site. This action will be needed for as long as the need for the water exists, the resource remains available, and the contamination associated with the 7th Avenue and Bethany Home Road WQARF Site prohibits or limit surface water use.

5.4 BASIS FOR SELECTING CLEANUP LEVELS

The proposed remedy will reduce potential risk to human health and the environment by reducing the concentrations of groundwater contaminants of concern to the following target levels:

- PCE 5.0 µg/L
- TCE 5.0 µg/L
- Vinyl chloride 2.0 µg/L

Targets were selected that would reduce the risk associated with exposure to groundwater contaminants of concern to an acceptable level that will satisfy the overall clean up goals (Section 3.1) and the above ROs for groundwater use. The target levels for the contaminants of concern are based on the AWQSs, which are equivalent to the U.S. Environmental Protection Agency's (EPA's) Maximum Contaminant Levels established under the Safe Drinking Water Act.

6.0 EVALUATION OF REMEDIAL ALTERNATIVES

In accordance with the Remedy Selection Rule (A.A.C. R18-16-407), the FS was completed to identify three alternative remedies that are capable of achieving ROs. As documented in the *Final Feasibility Study, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (Arcadis, 2012), three alternatives were evaluated for remediation of the PCE impacted groundwater underlying the Site. These alternatives are as follows:

- Alternative 1- In-Situ Enhanced Reductive Dechlorination (ERD) with Monitored Natural Attenuation
- Alternative 2 – In-Situ Chemical Oxidation (ISCO) with Monitored Natural Attenuation
- Alternative 3 – Groundwater Extraction and Treatment (GWET) with Injection

Section 6.1 below presents the results of the comparative analysis of the three alternatives used in the FS. Section 6.2 presents the Proposed Remedy. Section 6.3 presents the results of an ERD pilot study conducted subsequent to completion of the FS Report and an evaluation of the pilot study results. Section 6.4 presents recommendations for a modified ERD design, and Section 6.5 re-evaluates costs to implement the modified design.

6.1 COMPARATIVE ANALYSIS

The comparison criteria used in the FS to evaluate each alternative and select a proposed remedy consisted of threshold criteria (overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements [ARARs]) and balancing criteria (long-term reliability and effectiveness; reduction of toxicity, mobility, or volume of waste; short-term effectiveness; implementability; and cost). The comparison of the three remedial alternatives to the evaluation criteria as presented in the FS Report are summarized in the table on the following page.

Evaluation Criteria	Component of Criterion	Alternative 1 – In-Situ Enhanced Reductive Dechlorination and Monitored Natural Attenuation	Alternative 2 – In-Situ Chemical Oxidation and Monitored Natural Attenuation	Alternative 3 – Groundwater Extraction and Aboveground Treatment and Re-Injection with Monitored Natural Attenuation
Threshold Criteria	Overall protection of human health and the environment	**Moderate to High.** ERD is protective of human health and the environment because COCs are biologically destroyed, hence removing the contamination. Treated groundwater requires some time to re-equilibrate to ambient conditions for secondary water quality objectives.	**Moderate to High.** ISCO is protective of human health and the environment because COCs are chemically destroyed, hence removing the contamination. Treated groundwater requires some time to re-equilibrate to ambient conditions for secondary water quality objectives.	**Moderate.** GWET is protective of human health and the environment because COCs are physically removed from the aquifer and the groundwater pumping maintains control of the plume. The effectiveness of GWET can be limited by matrix effects in the aquifer leading to an indeterminate operating timeframe.
	Compliance with ARARs	The ARARs would be met by all proposed alternatives.		
Balancing Criteria	Long-term reliability and effectiveness	**High.** The endpoint of ERD is achieving ROs in the aquifer as a result of destroying COCs. Therefore, there is no residual risk. The adequacy and reliability of ERD has been proven.	**High.** The endpoint of ISCO is achieving ROs in the aquifer as a result of destroying COCs. Therefore, there is no residual risk. The adequacy and reliability of ISCO has been proven.	**Moderate.** The endpoint of GWET is achieving ROs by physically removing COCs from the aquifer. This removal can be limited and therefore residual risk could remain in the aquifer to perpetuity.
	Reduction of toxicity, mobility, or volume of waste	**High.** ERD physically destroys COCs resulting in benign end products. All hazardous material is destroyed thereby permanently eliminating toxic mobility. ERD is an irreversible process.	**High.** ISCO physically destroys COCs resulting in benign end products. All hazardous material is destroyed thereby permanently eliminating toxic mobility. ISCO is an irreversible process.	**High.** GWET physically removes COCs. All hazardous material is eventually removed thereby permanently eliminating toxic mobility. GWET is an irreversible process.
	Short-term effectiveness	**Moderate.** ERD is a biological strategy and baseline data do not demonstrate a considerable degree of natural reductive dechlorination, which may lead to a lag phase. Implementation of ERD will not pose a significant threat to the community, workers, or the environment.	**Moderate to High.** ISCO is a chemical strategy and is expected to immediately reduce COCs. Implementation of ISCO will not pose a significant threat to the community or environment, but does pose a slight risk to workers.	**High.** GWET will initially extract all readily available and mobile COCs and impose hydraulic control of plume migration, thus demonstrating a high short-term effectiveness. Implementation of GWET will not pose a significant threat to the community, workers, or the environment.
	Implementability	**High.** Necessary equipment and labor is readily available. ERD is a proven technology that has the transparent performance metrics to gauge effectiveness. Injected reagent is typically edible, and approval by agencies can be readily obtained.	**Moderate to High.** Necessary equipment and labor is readily available. ISCO is a proven technology that has transparent performance metrics to gauge effectiveness. Injected reagent is typically regulated, though approval by agencies can be obtained.	**High.** Necessary equipment and labor is readily available. GWET is a proven technology that has transparent performance metrics to gauge effectiveness.
	Cost without contingency	Capital Cost: $971,300 Annual O&M Cost: $153,300 (Y1-Y5) $32,300 (Y6-Y10) $21,600 (Y11-Y15) Net Present Value: $1,837,000	Capital Cost: $1,391,800 Annual O&M Cost: $713,200 (Y1-Y5) $31,800 (Y6-Y10) $21,400 (Y11-Y15) Net Present Value: $3,680,000	Capital Cost: $682,900 Annual O&M Cost: $125,500 (Y1-Y5) $114,600 (Y6-Y10) $108,300 (Y10-Y15) Net Present Value: $1,986,000

Evaluation Criteria	Component of Criterion	Alternative 1 – In-Situ Enhanced Reductive Dechlorination and Monitored Natural Attenuation	Alternative 2 – In-Situ Chemical Oxidation and Monitored Natural Attenuation	Alternative 3 – Groundwater Extraction and Aboveground Treatment and Re-Injection with Monitored Natural Attenuation
Notes: Threshold Criteria: Relate directly to statutory findings and must be met. Primary Criteria: Key elements upon which evaluation of alternatives is completed. ARAR – Applicable or Relevant and Appropriate Requirements COCs – Contaminants of Concern ERD – Enhanced Reductive Dechlorination GWET – Groundwater Extraction and Treatment ISCO – In Situ Chemical Oxidation O&M – Operation and Maintenance ROs – Remedial Objectives				

6.2 PROPOSED REMEDY AND RATIONALE FOR SELECTION

The comparative costs for Alternatives 1, 2, and 3 as presented in the FS provide net present values for the three of $1.8M, $3.7M, and $2M, respectively. Based on a comparative analysis of the remedial alternatives, Alternative 1, in situ ERD with monitored natural attenuation, was selected as the appropriate remedy for the Site in the FS Report. The conceptual design for the selected remedy as presented in the FS Report is provided in Figure 4. Implementation of Alternative 1 was preferred over similarly priced Alternative 3, GWET with injection, because Alternative 1 provides a destructive pathway for contaminant removal and has a potential benefit of being completed before the anticipated remedial timeframe of 15 years. Alternative 3 requires achieving pore flushes alone to reduce COC concentrations, which does not provide a potential accelerated timeframe. Additionally, as extracted groundwater would be used for mixing the carbon source, an extraction-injection forced flushing component would be employed during ERD injection events for as long as the injection occurs. The difference in net present value of the costs between Alternatives 1 and 3 is the continuous operation of the GWET system for an indefinite period of time in Alternative 3 as compared to 5 years of injections with Alternative 1.

6.3 PILOT TEST STUDY

The pilot test study was performed in accordance with the *Enhanced Reductive Dechlorination Pilot Test Work Plan, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (ADEQ, 2013). Results of the pilot test study are provided in the *Enhanced Reductive Dechlorination Pilot Test Summary Report* (Arcadis, 2014a) and are supplemented by the "7th Avenue and Bethany Home Road WQARF Site Pilot Study Performance Monitoring Update" (Arcadis, 2014b). The report and update provide the results of the ERD pilot test activities conducted at the Site.

6.3.1 Pilot Test Procedures

Implementation of the pilot test study included the development of the well networks, injection of molasses solution as the carbon source, and performance monitoring. The well network consisted of the installation of two new injection wells (IW-1S and IW-1D), installation of two new groundwater monitoring wells (MW-3R and MW-14), and use of an existing monitoring well (MW-3). The new injection wells (IW-1S and IW-1D) were completed with 4-inch diameter schedule 40 polyvinyl chloride (PVC) blank casings to depths of approximately 80 feet bgs and 95 feet bgs, respectively. The wells were completed with 15 feet of 0.020-inch slotted stainless steel screen from approximately 80 to 95 feet bgs and 95 to 110 feet bgs, respectively. The two new monitoring wells (MW-3R and MW-14) were completed with 4-inch diameter PVC blank casings to approximately 80 feet bgs with 0.020-inch slotted PVC screen from approximately 80 to 110 feet bgs. The existing monitoring well, MW-3, is completed with 2-inch diameter PVC and is screened from approximately 68 feet bgs to 98 feet bgs. Locations are shown in Figure 2 which was extracted from the Arcadis Pilot Test Summary Report (Arcadis, 2014a).

The 2 percent by volume molasses solution was introduced as two injections. During the first injection, fluorescein dye tracer was added to the molasses solution to quantify the groundwater flow velocity. The work plan originally provided for a targeted radius of influence (ROI) of 20 feet. A field decision based on evaluation of lithology led to the reduction of the targeted ROI to 15 feet to reduce the labor cost associated with implementing the injection. Approximately 62,350 gallons (gal) of the 2 percent by volume molasses solution was injected into the aquifer over the two injection events.

For Injection Event #1, a total of 11,877 gal of molasses solution was injected into well IW-1S with an average injection pressure of 24 pounds per square inch (psi) with an average flow rate of 2.3 gallons per minute (gpm). Injection Well IW-1D received 10,928 gal at an injection pressure of 29 psi and flow rate of 1.9 gpm. For Injection Event #2, a total of 17,350 gal was injected into IW-1S at a pressure of 30 psi and rate of 0.9 gpm while IW-1D received 22,193 gal at a pressure of 30 psi and rate of 1.0 gpm. Injection Event #1 occurred over a period of approximately 10 days with Injection Event #2 occurring over a period of slightly less than 30 days.

Baseline VOC, total organic carbon (TOC), and fluorescein analytical data were obtained for the three monitoring wells and two injection wells on April 9, 2013. Injection Event #1 commenced on April 23, 2013 with injections occurring during daylight hours for a period of ten days with the last injection occurring on May 3, 2013. Injection Event #2 commenced on September 10, 2013 and was completed on October 9, 2013. Six separate groundwater monitoring events were conducted for VOCs with samples collected in August, October, December, January, February, and March. A seventh event was conducted in August 2014 with results provided in the Performance Monitoring Update (Arcadis, 2014b). The transformation pathway for reductive dechlorination of PCE is as follows:

PCE → TCE → *cis*-1,2-Dichloroethene → Vinyl Chloride → Ethene → Ethane

To note, 1,1-DCE can degrade to vinyl chloride in addition to *cis*-1,2-DCE, if present. It was not detected in any of the wells and should not contribute to the overall vinyl chloride results.

Table 2 summarizes the PCE, TCE, *cis*-1,2-DCE, vinyl chloride, ethene, and ethane results for the three monitoring wells (MW-3, MW-3R, and MW-14). For the two monitoring wells located in close proximity to the injection wells (MW-3 and MW-3R), PCE concentrations were initially elevated up to three orders of magnitude above the regulatory level of 5 µg/L, but declined over time to concentrations of less than the detection limit of 1 µg/L and below the regulatory level with the progression of the bioremediation process. TCE concentrations increased with the degradation of PCE then decreased as did the *cis*-1,2-DCE, vinyl chloride, and ethene. For monitoring well MW-14 which is located downgradient from the injection point, results are inconclusive which would be expected given the distance of about 65 feet between the injection wells and MW-14 and the anticipated ROI of 15 feet.

The methane concentrations for the two groundwater monitoring wells, MW-3 and MW-3R, located in close proximity to the injection wells demonstrated an excellent increase to levels (i.e., methane concentrations greater than 5,000 µg/L) indicating that methanogenic conditions that are conducive to reductive dechlorination exist. Concentrations increased to 7,000 µg/L for the sample collected from 85 feet within MW-3 and to 10,000 µg/L for the sample collected from 85 feet within MW-3R by the first monitoring event conducted on August 1, 2013. The concentrations increased then remained at levels that are indicative of conditions continuing to support on-going remediation of the impacted groundwater. As with the VOC concentrations, methane concentrations for well MW-14 demonstrate that reductive conditions are not present.

The TOC results are indicative as to whether a sufficient biomass has been established to sustain reductive conditions that are conducive to enhanced reductive dechlorination. The TOC concentrations initially decreased over time following Injection Event #1, increased after Injection Event #2 then proceeded to decrease. The half-life of TOC in the aquifer was calculated to be approximately 23 days. This half-life was attributed to microbial utilization and not “washout”, as the fluorescein concentrations did not change.

As discussed in the Performance Monitoring Update (Arcadis, 2014b), the results from the fluorescein dye tracer test indicate that the average groundwater velocity at the Site is between 0.1 and 0.2 feet per day (feet/day). The data from the August 2014 sampling effort indicate that the leading edge of the tracer pulse may be arriving at well MW-14. As additional monitoring data are collected from the three monitoring wells, including downgradient well MW-14, the groundwater velocity estimate can be refined.

6.3.2 Pilot Test Evaluation

Injection wells IW-1S and IW-1D were installed approximately 12.5 feet and 17.5 feet east of existing monitoring well MW-3, respectively. Newly installed monitoring well MW-3R was installed approximately 15 feet north (downgradient) of the two new injection wells. The new monitoring well MW-14 was installed approximately 50 feet downgradient of well MW-3R.

The VOC results for the monitoring wells MW-3 and MW-3R demonstrate that the targeted ROI of 15 feet was achieved for the pilot test. Based on the promising results of the pilot test, an ROI of 15 feet would be appropriate for full scale implementation; however, because other wells were not spaced at additional distances (e.g., 20 feet, 25 feet, etc.), it can only be estimated as to what the actual ROI may be and hence the actual number of injection wells that may be needed to adequately treat the contaminated groundwater.

Results for monitoring well MW-14 which is located approximately 65 feet downgradient from the injection wells had not shown any microbial influence as of the August 2014 monitoring event. Based upon the available fluorescein tracer data for well MW-14, the groundwater associated with the injection wells at the time of the injections may not have yet reached MW-14. Once the injection pulse is shown to have encroached upon well MW-14, additional monitoring data may aid in refining the ROI estimate and ultimately the determination of the appropriate number of injection wells. However, given the estimated half-life of TOC in the aquifer of 23 days, it is highly unlikely if any microbial influence will be seen at this well given that the injections occurred over a year prior to the August 2014 monitoring effort.

The preliminary design presented in the Feasibility Study Report (Arcadis, 2012) provides for two sets of six nested wells installed along two transects, one running east-west at the approximate location of the former buildings on the Site, and one running east-west parallel to W. Berridge Lane located downgradient to the north (see Figure 4 extracted from the Feasibility Study Report [Arcadis, 2012]). The proposed transects are approximately 200 feet long with the nested injection wells spaced 40 feet apart. This preliminary design is assumed to have been based on the planned ROI of 20 feet. If the ROI of 15 feet as demonstrated by the pilot test is used, the number of nested injection wells required for each transect of 200 feet will need to be increased to eight.

Regarding the proposed location of the northern transect at W. Berridge Lane approximately 500 feet from the southern transect, the PCE result for monitoring well MW-10 located at W. Berridge Lane immediately adjacent to the proposed transect is reported in the Feasibility Study Report (Arcadis, 2012) was 320 µg/L, indicating that the plume has already reached this area and has likely passed it. The PCE result for monitoring well MW-7 which is located on W. Rose Lane approximately 600 feet to the north of W. Berridge Lane was 2.5 µg/L indicating that PCE has migrated that far and the actual edge of the PCE plume with concentrations exceeding the regulatory level of 5 µg/L resides somewhere in between the two streets.

6.4 RECOMMENDATIONS

For ERD to occur, the constituents (i.e., PCE) must be dissolved and be available in the aqueous phase. Enhanced dissolution is the process by which the amount of PCE released into the aqueous phase is increased over ambient dissolution rates. Electron donor (i.e., molasses solution) injections enhance dissolution of PCE by (1) increasing the apparent solubility of PCE in aqueous solution and (2) encouraging bacterial degradation of PCE (and subsequent degradation products) in solution, thus increasing the concentration difference and driving more PCE into solution. The amount of enhanced dissolution and the efficiency of the ERD reactions in groundwater are evaluated by examining changes in the relative concentrations of PCE and reductive degradation products (i.e., TCE, *cis*-1,2-DCE, vinyl chloride, and ethane). Elevated concentrations of PCE and/or total ethenes after injections demonstrate dissolution of PCE into the groundwater. High concentrations of ethane relative to PCE, TCE, *cis*-1,2-DCE, and vinyl chloride approximately a month after injections indicate that ERD reactions are efficiently dechlorinating PCE and subsequent degradation products to nontoxic degradation products (i.e., ethane). If proper conditions are maintained, then the dechlorination of PCE proceeds all the way to ethane.

To determine whether anaerobic conditions are conducive to the ERD of PCE and its degradation products, additional monitoring of key indicators is recommended. Proper conditions are defined by the absence of sulfate, the presence of ferrous iron, the active production of methane, and the absence of nitrate. Methanogenic conditions, defined as the production of methane concentrations greater than 5,000 μg/L, are consistent with conditions favorable for ERD to occur. Conditions favorable for methanogenesis are indicated by low sulfate (< 5 mg/L) and elevated ferrous iron. Elevated alkalinity (measured as calcium carbonate) concentrations are also an indicator as to whether bioactivity is taking place. It is recommended that monthly field measurements for sulfate, ferrous iron, and alkalinity be implemented to verify that field conditions are and remain at levels supportive of on-going ERD operations. The results of these tests can also be used to determine when additional injections may be necessary to ensure that the bioactivity remains at optimum levels. The frequency of these measurements can be reduced once a reliable trend can be established.

It is also important to measure pH as optimal microbial activity for ERD occurs under neutral pH conditions (pH between 6 to 8 units) with the microbial community being negatively impacted when the pH drops below 5.5. Changes in groundwater pH are moderated or buffered by (1) the presence of carbonate materials and (2) the respiration of the microbial community producing carbon dioxide that dissolves in the groundwater. If the pH decreases during the course of the groundwater treatment process, it may become necessary to add amendments to further buffer the groundwater. It has been shown that introducing sodium lactate provides a buffering capacity helping to maintain the optimum pH range while introducing a secondary carbon source to the groundwater in addition to the molasses solution.

As discussed above, the estimated number of nested injection wells was based on the estimated ROI of 20 feet. Given that the pilot test proved an efficacy of a 15 foot ROI, an additional four nested injection wells (two per transect) may be necessary to ensure that impacted groundwater is properly treated. Also, the existing plume extends downgradient of the proposed location of the northern transect of injection wells. The lateral extent of the PCE contamination is also not completely defined. The location of this transect, as well as the relative length and potentially number of related injection wells needs to be revisited to ensure that the downgradient migration of PCE is mitigated.

Based on the results from the fluorescein dye tracer test indicating that the average groundwater velocity at the Site is between 0.1 and 0.2 feet/day, five years of injections may not be adequate to address the groundwater contamination. The apparent distance between the proposed locations of the southern and northern transects as shown in Figure 4 is approximately 500 feet. Assuming an average groundwater velocity of 0.15 feet/day, the contaminated groundwater currently located near the southern transect would take approximately 9 years to reach the northern transect. Given the presumed half-life of 23 days for TOC in the aquifer, the contaminated groundwater outside of the ROI affected by the injections at the southern transect would largely be untreated and take 9 years to reach the northern transect without any contaminant retardation, which is unlikely.

In summary, the remedy selected in the Feasibility Study Report (Arcadis, 2012) of ERD with monitored natural attenuation is technically feasible. The following enhancements will ensure the efficiency with which the implemented remedy operates:

- Implement performance monitoring in addition to field monitoring parameters to ensure that optimal aquifer conditions are maintained to support enhanced reductive dechlorination. This performance monitoring will include measurements of sulfate, alkalinity, and ferrous iron concentrations in addition to pH level.
- Use sodium lactate along with molasses, if necessary, to maintain pH levels in the optimum range.
- Include two additional nested well locations per transect (i.e., four additional injection screens per transect) to account for the reduction in ROI from 20 feet to 15 feet.
- The well exhibiting the highest PCE concentrations (MW-4; 2,300 µg/L in 2012) is downgradient and likely outside the ROI of the on-site injection transect. Assuming a

groundwater velocity of 0.15 feet/day and no contaminant retardation, the time required for the contaminant to move downgradient from the proposed location of the southern transect to the off-Site injection transect located to the north (500 feet) is estimated to be close to 9 years. Given that the feasibility study recommends injections for a period of 5 years, the most contamination portion of the plume may not be treated by enhanced reductive dechlorination. Therefore it is recommended that:

  - ➢ the on-Site treatment transect be moved north near well MW-4 along with continued use of the two injection wells installed within the source area as part of the pilot test (see Figure 5); and
  - ➢ the injections be extended to at least a 9-year period from the currently recommended 5-year period (this decision may be deferred to the first periodic review). If the on-Site treatment transect is moved north near well MW-4 as recommended, the distance to the northern transect will be reduced to approximately 375 feet resulting in a reduction of the injection period from 9 years to a minimum of 7 years.

- Continue monitoring of well MW-7 on W. Rose Lane for increasing concentrations of PCE. Should concentrations increase, a simple groundwater model will be developed to evaluate whether monitored natural attenuation will adequately address the portion of the plume north of W. Berridge Lane. An additional transect of injection wells may be warranted at a downgradient location.
- Install a single nested injection well on the SCI property. Based on the March 2014 analytical data, the location proposed in the Feasibility Study Report (Arcadis, 2012) to address the residual underlying groundwater contamination is located upgradient of the higher concentrations indicating that the contamination has migrated as would be expected. Therefore, it is recommended that the injection well be relocated in the vicinity of MW-18 which exhibited the highest PCE concentrations in the vicinity of the SCI property.
- Although available data indicate complete degradation of PCE to ethene without *cis*-1,2-DCE or vinyl chloride accumulation, provide for a contingency to inject dehalococcoides should vinyl chloride accumulation become evident.

In addition, as discussed in Section 2.1.3, a new nested groundwater monitoring well should be installed in the vicinity of MW-7 to evaluate the PCE concentration with increasing depth for performance monitoring of the remedy in the downgradient portion of the plume. In addition, three new groundwater monitoring wells should be installed cross-gradient and downgradient of well MW-19 to refine the understanding of the nature and extent of the plume in that area and to provide for monitoring of the effectiveness of the implemented remedy. Proposed locations of these new groundwater monitoring wells are provided in Figure 6. Contamination will be evaluated during drilling of the new groundwater monitoring wells. Groundwater samples will be collected prior to well completion and development and submitted for laboratory analysis with results due within 48 hours of collection. If evidence of PCE is present in the collected groundwater sample, the well will be completed, developed, and subsequently incorporated into the monitoring network. If evidence of PCE is not present, the well will be abandoned in accordance with Arizona Department of Water Resources requirements.

6.5 COST EVALUATION

The Feasibility Study Report (Arcadis, 2012) provided a cost estimate for the ERD remedy in Table 2 of the report. The costs were broken into two broad categories, including (1) capital investment for ERD and (2) operation and maintenance costs for ERD.

6.5.1 ERD Capital Costs

The capital investment for ERD costs included the following:

- Administrative/Regulatory Interface for ERD
- Mobilization/Demobilization
- Injection and Monitoring Well Installation
- Injection Treatment System
- Personnel Oversight Costs
- Treatability Pilot Testing
- As-Built and Pilot Test Reporting
- Project Management and Administrative

The costs associated with treatability pilot testing and as-built and pilot test reporting have already been expended and will not be further evaluated. Neither the administrative/regulatory interface costs nor the injection treatment system costs are anticipated to be influenced by any of the recommended changes and likewise will not be further evaluated.

For mobilization/demobilization, two separate mobilization/demobilization efforts are planned with the southern-most transect of injection wells to be installed initially and the northern transect to be installed at a future date. Based on this plan, the mobilization/demobilization costs were doubled to account for the two separate events. The costs for the resulting mobilization/demobilization efforts will increase from $45,000 to $90,000.

The injection well and monitoring well installation costs will increase because of the recommended increase in the number of injection wells from 13 nested well pairs (26 wells) to 17 nested well pairs (34 wells). The FS estimate provided a cost of $7,500 per well for the 26 wells plus five new monitoring wells. Based on a revised cost of $9,000 per well, the cost for a total of 31 wells x $9,000 = $279,000. Increasing the number of nested well pairs will result in an increase to 39 x $9,000 = $351,000. Similarly, the drilling oversight costs were increased from 15.5 days to 39 days or $15,500 to $39,000 based on the provided rate of $1,000 per day. The overall cost increase resulting from the additional injection wells and increased oversight will be $142,000.

Assuming that the additional wells will increase injection treatment system installation time, personnel oversight costs are assumed to be increased by four days; therefore, the time required for on-site resident construction engineer and the truck/health and safety monitoring equipment/expendables that comprise the costs would increase from 50 to 54 days at $1,350 per day, or an overall increase of $5,400.

The project management and administrative costs are based on a straight percentage of 10% of the capital costs; therefore, if capital costs increase, the project management and administrative costs will also increase. The overall increase to capital investment costs for ERD will be represented by the increased costs for mobilization/demobilization, injection and monitoring well installation, personnel oversight costs, and project management/administrative costs, less the costs associated with the pilot testing, resulting in a total increase in capital cost of $85,140 as compared to the capital cost presented in the FS.

6.5.2 ERD Operation and Maintenance Costs

The operation and maintenance costs for ERD included the following"

- Quarterly Monitoring for Years 1 through 5
- Semi-Annual Monitoring for Years 6 through 10
- Annual Monitoring for Years 11 through 15
- Annual Operation and Maintenance for Years 1 through 5
- Project Management and Administrative Costs

Provided that the on-Site transect is moved closer to well MW-4 as recommended resulting in a 7-year injection timeframe, quarterly monitoring would be required for Years 1 through 7 rather than Years 1 through 5. It is assumed that semi-annual monitoring would be required for a 5-year period following completion of injection activities, with annual monitoring being performed for the final three years of the total 15-year remediation period.

The annual operation and maintenance cost included the acquisition of the carbon substrate, as well as the injection labor and related miscellaneous operations and maintenance expenses. The carbon substrate annual cost was calculated by the following equation:

$$Cost = \left[\frac{(\pi\ x\ r^2\ x\ h\ x\ \theta\ x\ 7.48\ x\ \%\ x\ N\ x\ I\ x\ 11.8)}{2000}\right]\ x\ 300$$

Where: π = 3.141592
r = radius of influence
h = the injection thickness (assumed to be height of the screen, or 15 feet)
θ = mobile porosity (assumed to be between 10 and 20 percent at the site)
% = percent of molasses in solution
N = number of injection wells
I = number of injections during the year
11.8 = density of molasses
2000 = conversion from pounds to tons
300 = cost per ton for molasses

For the carbon substrate cost estimate provided in Table 2 of the FS Report (Arcadis, 2012), the following values were used to determine the annual cost:

- Radius of influence = 20 feet
- Injection thickness = 15 feet
- Mobile porosity = 0.10
- Percent of molasses in solution = 1 percent
- Number of injection wells = 36
- Number of injections during the year = 4

This resulted in an annual cost of $40,000 for the carbon substrate. There are two notable differences between the values used for calculating the annual cost and the proposed remedy. One is that the actual number of injection wells proposed in the feasibility study is 26. Second is the percent of molasses was 2 percent. These values result in a revised annual cost for the carbon substrate of $60,000. Promulgating this change throughout the net present value calculation for the alternative as presented in the FS results in a cost of $1,977,000 as compared to the cost of $1,837,000 provided in Table 2 of the Feasibility Study Report (Arcadis, 2012) taking into account the revised costs for well installation of $9,000 per well versus $7,500 per well listed in the report.

Following the carbon substrate injection as per the recommendation, the following values are used to determine the annual cost:

- Radius of influence = 15 feet
- Injection thickness = 15 feet
- Mobile porosity = 0.10
- Percent of molasses in solution = 2 percent
- Number of injection wells = 34
- Number of injections during the year = 4

This results in an annual cost of $40,000, which would be applied for a minimum duration of 7 years as opposed to 5 years as proposed in the feasibility study. The injection labor and miscellaneous operations and maintenance expenses are anticipated to be similar to those provided in the feasibility study report. In addition, the annual monitoring and reporting costs have been re-evaluated to reflect an increased number of monitoring wells within the monitoring network (22 versus 16) and increased labor to conduct the sampling activities. The annual cost has been increased from $38,800 to $46,600 for quarterly monitoring, from $26,900 to $29,300 for semi-annual monitoring, and adjusted from $21,000 to $20,700 for annual monitoring. Project management costs have also been adjusted to reflect ten percent of the O&M and monitoring costs.

The cost estimates presented in the FS did not account for the cost of conducting remedy effectiveness evaluation and reporting for the three remedies considered. Over the estimated 15-year life of the ERD remedy, three effectiveness evaluations will be performed (at 5-year intervals) at an estimated cost of $8,500 each. Promulgating these costs through the net present value calculation with the assumptions discussed above pertaining to the durations for quarterly, semi-annual, and annual monitoring, yields a revised net present value of $2,130,000 for the ERD remedy as compared to the net present value of $1,837,000 as provided in the Feasibility Study Report (Arcadis, 2012) and the revised net present value of $1,977,000 as discussed above.

With respect to comparison to the net present value costs for the GWET alternative, the revised net present value of $2,130,000 for ERD exceeds the GWET net present value cost provided in the Feasibility Study Report (Arcadis, 2012) of $1,986,000. However, it should be noted that the GWET cost did not provide for an aquifer test which should be performed to evaluate some of the uncertainties associated with the alternative, most notably determining the rate of removal and whether extraction can adequately influence the diffusion of contaminants from immobile porosity to mobile porosity to achieve the cleanup goals within the 15 year timeframe used for the cost determination. Assuming the aquifer testing and test reporting costs would be similar to those determined for the ERD pilot test, and accounting for increased project management, the net present value cost for GWET would increase by $126,500 to $2,112,000. With the added cost of effectiveness evaluations, which were not considered in the FS, the present value cost of GWET would be essentially equal to the cost of ERD. Furthermore, if GWET could not adequately influence the rate of removal, the remediation timeframe could increase substantially approaching 30 years as determined for ambient flushing, with costs increasing accordingly.

6.5.3 ERD Close-Out Costs

The FS did not consider the cost of site close-out at the conclusion of the remedy implementation and after ROs have been achieved. Site close-out activities will consist of well abandonment of injection and monitoring wells, demolition of the injection equipment and appurtenances, and preparation of site close-out documents. The total cost of site close-out is estimated to be $142,600.

6.5.4 ERD Total and Net Present Value Costs

The total cost of the remedy and total net present value of the remedy with and without site close-out activities is summarized below.

	Total Cost	Net Present Value (7% Interest and 3% Inflation)
Cost of Remedy Excluding Site Close-Out	$2,363,000	$2,130,000
Cost of Remedy Including Site Close-Out	$2,506,000	$2,208,000

Table 3 provides three versions of the cost estimate for comparison:

- the cost estimate presented in the FS;
- a revised version of the FS cost estimate that incorporates corrections to the annual carbon substrate costs and adjustments to the cost of well installation; and
- the estimated cost for the Proposed Remedy as presented in this PRAP which incorporates the recommended ERD design presented in Figure 5, the proposed monitoring well installations presented in Figure 6, modifies the monitoring costs based on a larger monitoring well network, incorporates effectiveness evaluations, and incorporates site close-out activities.

7.0 PROPOSED REMEDY

7.1 PROPOSED REMEDY AND RATIONALE FOR SELECTION

The Proposed Remedy consists of Alternative 1 - ERD implemented according to the modified design presented in Figure 5 and as described in Sections 6.4 and 6.5 with the following contingencies:

- Use of sodium lactate with molasses, if necessary to maintain pH levels in the optimum range for reductive dechlorination
- Introduction of dehalococcoides should vinyl chloride accumulation become evident
- In the event of increasing concentrations at MW-7, develop a groundwater model to evaluate whether MNA is adequately addressing the portion of the plume north of Berridge Lane. An additional transect of injection wells may be warranted at a downgradient location.

The modified Alternative 1 provides a destructive pathway for contaminant removal and has a potential benefit of being completed before the anticipated remedial timeframe of 15 years. The recommendation to implement the Proposed Remedy is based on what is considered to be the best combination of remedial effectiveness, practicability, cost, and benefit for restoration and use of the groundwater resource. The Proposed Remedy will:

- Achieve the goals presented in Section 3.1, including achieving the RO's described in Section 5.0,
- Be consistent with water management plans, and
- Be consistent with general land use planning.

7.2 ACHIEVEMENT OF REMEDIAL OBJECTIVES

The Proposed Remedy with contingencies achieves the cleanup goals for the Site as described in Section 3.1 and the ROs as discussed in Section 5.0. Implementation of the Proposed Remedy will presumably remediate the groundwater underlying the 7th Avenue and Bethany Home Road WQARF Site over time, ultimately to attain applicable AWQSs for the contaminants of concern at the Site.

The Proposed Remedy will address groundwater remediation for the aquifer underlying the Site. This remedy is designed to achieve the remedial action criteria pursuant to A.R.S. §40-282.06, including the following:

- Assures the protection of public health, welfare, and the environment.
- Provides a thorough and timely means to actively remediate the chlorinated VOC-impacted groundwater underlying the Site.
- Provides a thorough and timely means for continued monitoring of the existing groundwater contamination within and residual groundwater contamination downgradient of the Site, including the progress of monitored natural attenuation remediation over time.
- To the extent practicable, provides for the control, management, and cleanup of the contaminants of concern in the groundwater.
- Is reasonable, necessary, cost-effective, and technically feasible.

7.3 CONSISTENCY WITH WATER MANAGEMENT PLANS

As discussed in Section 5.2, addressing groundwater contamination associated with the 7th Avenue and Bethany Home Road WQARF Site is necessary to ensure the municipal, agricultural, private use of the groundwater. Regarding the COP's access to groundwater required for the benefit of the municipality, the disconnection and/or abandonment of the COP's production wells due to water quality concerns and aging equipment has left the COP capable of only meeting 10 to 15 percent of its peak demand with groundwater. The COP has identified a need to substantially rebuild its well capacity for drought redundancy, operating flexibility, and system emergencies. In correspondence and discussions with the ADEQ and the EPA, the COP has emphasized that the Central Phoenix Aquifer is an important future water supply that the COP will need to be able to access.

The Proposed Remedy, which is believed to be consistent with the COP's latest published *2011 Water Resources Plan* (COP, 2011) and is consistent with the Site ROs (Section 5.0), provides an opportunity for a solution that ensures part of the COP's well capacity, particularly in the Central Phoenix Area.

The Proposed Remedy is also consistent with SRP's use of the groundwater resource to supplement surface water for irrigation purposes.

7.4 CONSISTENCY WITH GENERAL LAND USE PLANNING

As discussed in the RO Report provided in Appendix F of the *Remedial Investigation Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona* (ADEQ, 2011), there is little acreage available to be developed in the future. The area near the site is not expected to experience significant increases in either employment or residential growth. The zoning pattern in the Site area has long been established, and there are no foreseeable changes in the future. The

Proposed Remedy is considered to be consistent with Current and Future Land Use and provides for adequate protection of public health and welfare and the environment

7.5 LEAD AGENCY STATEMENT FOR REMEDY SELECTION

Based on information currently available, the ADEQ believes the Proposed Remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The ADEQ expects the Proposed Remedy to satisfy the remedial action criteria pursuant to A.R.S. §49-282.06 and the ROs as described in Sections 3.1 and 5.0.

8.0 COMMUNITY PARTICIPATION

8.1 PUBLIC COMMENT PERIOD OF PRAP

The public comment period will be 30 days. ADEQ will accept written comments on this PRAP that are postmarked within the comment period and submitted to:

Arizona Department of Environmental Quality
ATTN: Scott Goodwin, Project Manager
1110 West Washington Street
Phoenix, Arizona 85007

8.2 ADMINISTRATIVE RECORD

The PRAP and RI/FS reports are available for review online at:

http://www.azdeq.gov/environ/waste/sps/7th_Bethany.html

Hard copies are available at:

ADEQ Records Center
1110 W. Washington St.
Phoenix, AZ
(602) 771-4380 or (800) 234-5677, Ext. 6027714380

Please call for hours of operation and to schedule an appointment.

8.3 OTHER CONTACT INFORMATION

Name/Title/Address	Phone/Fax	E-mail
Scott Goodwin, ADEQ Project Manager	(602) 771-4452 (602) 771-4138 fax	goodwin.scott@azdeq.gov
Caroline Oppleman, ADEQ Community Involvement Coordinator	(602) 771-6890 (602) 771-4236 fax	oppleman.caroline@azdeq.gov

9.0 REFERENCES

ADEQ, 2004. "Site Registry Report (Final) Water Quality Assurance Revolving Fund (WQARF) Site, 7th Avenue and Bethany Home Road, Phoenix, Maricopa County, Arizona." August.

ADEQ, 2011. *Remedial Investigation Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona*. April.

ADEQ, 2015. http://www.azdeq.gov/environ/waste/sps/7th_Bethany_ Home_ Road.html, reviewed on April 20, 2015.

ADWR, 2007. "East Valley Water Forum Scenarios for the East Salt River Valley Sub-basin. An Application of the Regional Groundwater Flow Model of the Salt River Valley, Arizona. Hipke, W. Modeling Report No. 17." April.

Arcadis, 2012. *Final Feasibility Study, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona.* November.

Arcadis, 2013. *Enhanced Reductive Dechlorination Pilot Test Work Plan, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona.* February.

Arcadis, 2014a. *Enhanced Reductive Dechlorination Pilot Test Summary Report, 7th Avenue and Bethany Home Road WQARF Site, Phoenix, Arizona.* May.

Arcadis, 2014b. "7th Avenue and Bethany Home Road WQARF Site Pilot Study Performance Monitoring Update." Transmittal letter dated August 29, 2014.

Arcadis, 2014c. "7th Avenue and Bethany Home Road WQARF Site 2014 Groundwater Monitoring." Transmittal letter dated June 27, 2014.

COP, 2011. 2011 Water Resource Plan. City of Phoenix Water Services Department.

COP, 2012. "City of Phoenix – Schedule F-1 Amendment to 2011 & 2012 Annual Water Withdrawal and Use Reports (56-002030)." Transmittal letter dated April 23, 2013.

Corkhill, E.F., S. Corell, B.M. Hill, and D.A. Carr, 1993. *A Regional Groundwater Flow Model of the Salt River Valley - Phase I.* Arizona Department of Resources Modeling Report No. 6.

EPA, 2004. *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings.* February.

Malcolm Pirnie, 2005a. *Final Work Plan, ERA Investigation. 7th Avenue and Bethany Home Road WQARF Site.* June.

Malcolm Pirnie 2005b. *Early Response Action Evaluation Report. 7th Avenue and Bethany Home Road WQARF Site*. June.

Reynolds, S.G. and R.D. Bartlett, 2002. "Subsurface Geology of the Easternmost Phoenix Basin: Implications for Groundwater Flow." Arizona Geological Survey Contributed Report CR-02-A.

USGS, 1995. *Ground Water Atlas of the United States – Arizona, Colorado, New Mexico, Utah.* Available on-line at http://pubs.usgs.gov/ha/ha730/gwa.html.

FIGURES

Figure 1
Site Map with City of Phoenix Well, SRP Wells, and Estimated Plume Boundary
7th Ave & Bethany Home Rd WQARF Site

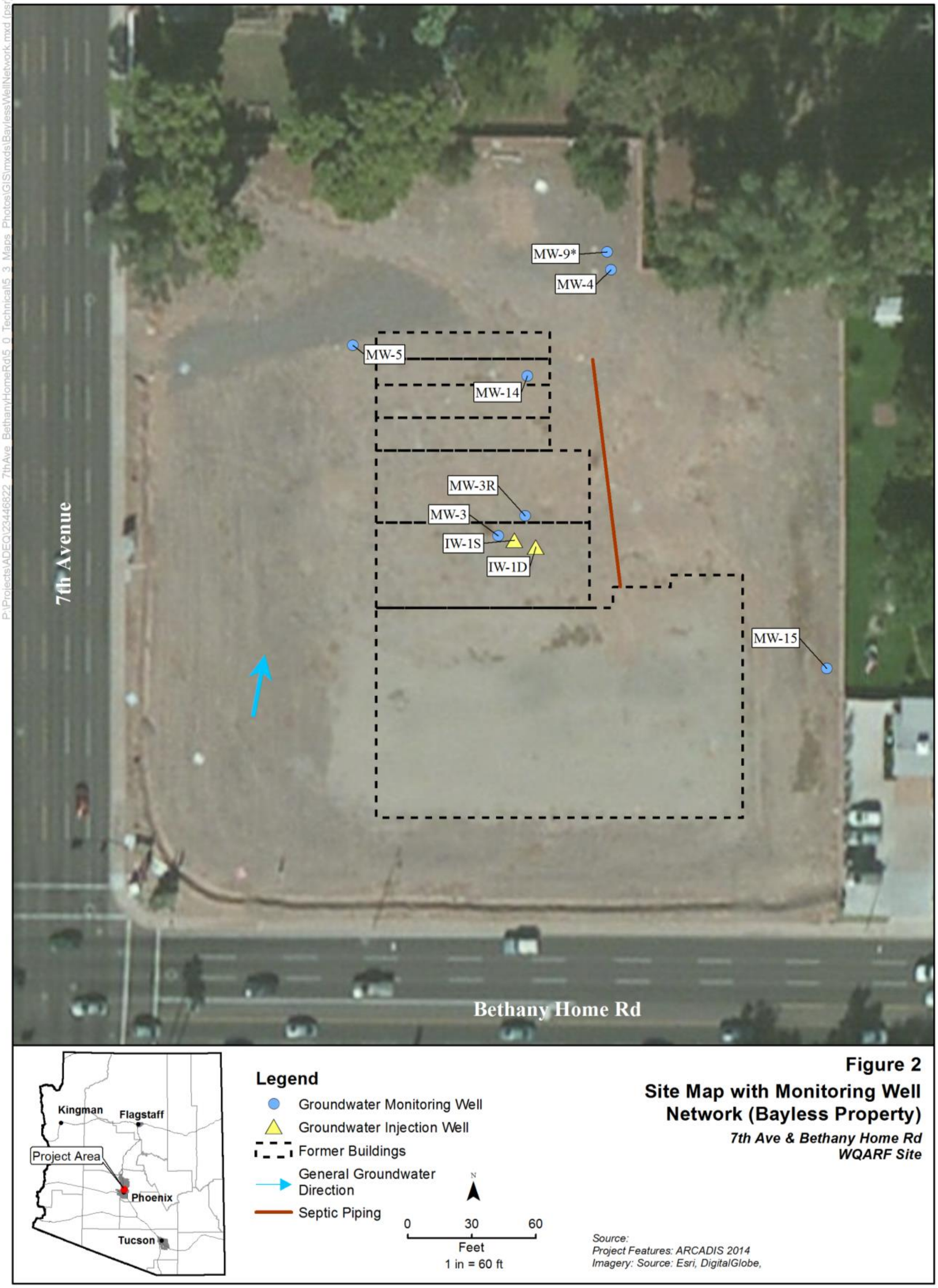


Figure 2

Site Map with Monitoring Well Network (Bayless Property)

7th Ave & Bethany Home Rd
WQARF Site

Legend

- Property Boundary
- Monitor Well
- Former Seepage Pit
- Former Septic Tank
- Dry Well
- Former Septic System Area
- Limits of Excavation
- Parcel
- Former Tank Pit

N

0 50 100
Feet
1 in = 100 ft

Figure 3
Site Map with Monitoring Well Network (SCI Property)
7th Ave & Bethany Home Rd WQARF Site

Source:
Project Features: ARCADIS 2014
Imagery: © 2015 Microsoft Corporation

Legend

- ▲ Proposed Nested Injection Well
- Monitor Well
- Proposed Injection Transect
- March 2014 Groundwater Elevation Contours (ft amsl)
- Former Buildings
- General Groundwater Direction

MW-3
1075.20
250 µg/L

Monitor Well Name
March 2014 Groundwater Elevation (ft amsl)
PCE Concentration (µg/L)
0.00 = Not Sampled (NS)

N

0 250 500
Feet
1 in = 250 ft

Figure 4

Proposed Design for Alternative 1: In Situ Enhanced Reductive Dechlorination with Monitored Natural Attenuation

7th Ave & Bethany Home Rd
WQARF Site

Source:
Project Features: ARCADIS 2014
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX,

Figure 5

Recommended Design for Alternative 1: In Situ Enhanced Reductive Dechlorination with Monitored Natural Attenuation

7th Ave & Bethany Home Rd
WQARF Site

Legend

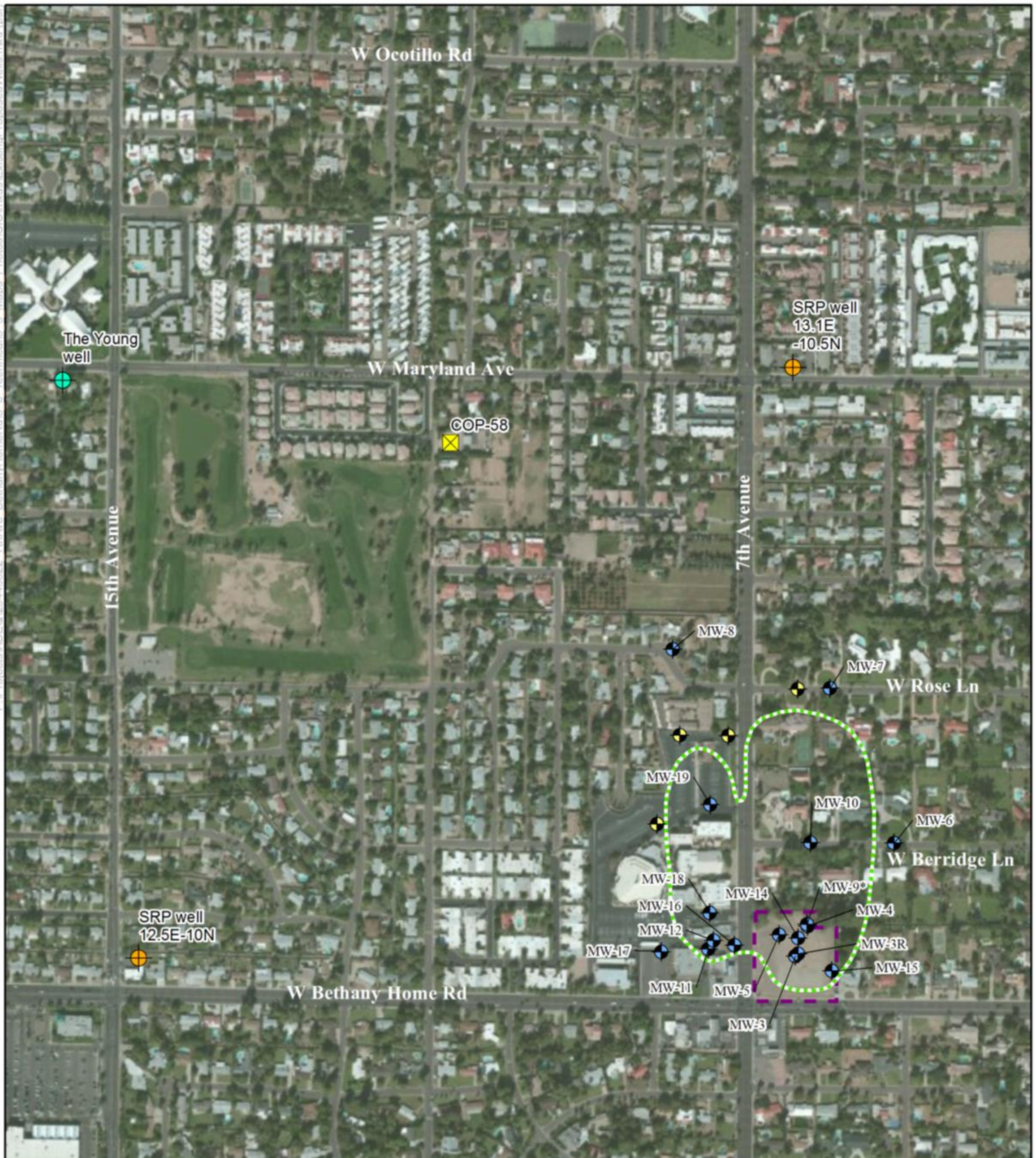
- Proposed Nested Injection Well
- Monitor Well
- Injection Well
- Proposed Injection Transect
- March 2014 Groundwater Elevation Contours (ft amsl)
- Former Buildings
- General Groundwater Direction

MW-3 1075.20 250 µg/L	Monitor Well Name March 2014 Groundwater Elevation (ft amsl) PCE Concentration (µg/L) 0.00 = Not Sampled (NS)

N

0 250 500
Feet
1 in = 250 ft

Source:
Project Features: ARCADIS 2014
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX,



Legend

- Existing Monitor Well
- Proposed Monitor Well
- SRP Well
- Private Well
- City of Phoenix Well 58 (55-626549)
- Estimated Plume Boundary
- Site Boundary

N

0 300 600
Feet
1 in = 600 ft

Source:
Project Features: ARCADIS 2014
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar

Figure 6
Site Map with Existing and Proposed Wells, and Estimated Plume Boundary
7th Ave & Bethany Home Rd
WQARF Site

TABLES

Table 1. Historic Groundwater Monitoring Analytical Data

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
BAYLESS PROPERTY										
MW-3	3/20/2014	< 0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 5.0
	4/9/2013	**2.0**	< 0.5	< 0.5	**2.5**	**550**	< 0.5	< 0.5	< 0.5	< 0.5
	1/18/2012	**3.5**	< 0.5	**0.70**	**1.5**	**250**	< 0.5	< 0.5	< 0.5	< 0.5
	9/29/2010	**4.1**	< 0.5	**1.1**	**1.7**	**210**	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/2008	**1.5**	< 0.5	**1.0**	**0.70**	**81**	< 0.5	< 0.5	< 0.5	< 0.5
	8/28/2008	**2.7**	< 0.5	**1.2**	**1.3**	**200**	< 0.5	< 0.5	< 0.5	< 0.5
	4/15/2008	< 0.5	< 0.5	< 0.5	< 0.5	**410**	< 0.5	< 0.5	< 0.5	< 0.5
	1/31/2008	< 4.0	< 1.0	< 5.0	**1.4**	**260**	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**300**	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	**350**	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**400**	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	**380**	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	**270**	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	< 5.0	**2.4**	**770**	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	**5.4**	< 2.0	< 5.0	**3.2**	**1000**	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	< 5.0	**2.0**	**650**	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	< 5.0	**2.4**	**730**	< 2.0	< 2.0	< 2.0	< 0.5
	8/5/2005	< 5.0	< 2.0	< 5.0	**2.6**	**950**	< 2.0	< 2.0	< 2.0	< 0.5
	5/19/2005	< 5.0	< 2.0	< 5.0	**2.8**	**970**	< 2.0	< 2.0	< 2.0	< 0.5
	2/17/2005	**5.5**	< 2.0	**5.0**	**3.5**	**990**	< 2.0	< 2.0	< 2.0	< 0.5
	11/18/2004	**10**	< 2.0	**6.0**	**4.9**	**1600**	< 2.0	< 2.0	< 2.0	< 0.5
MW-4	3/20/2014	< 0.5	<1.0	**3.0**	**2.3**	**1000**	<1.0	<1.0	<1.0	< 5.0
	4/10/2013	**3.3**	**0.54**	**5.5**	**3.2**	**1400**	<0.5	<0.5	<0.5	**0.58**

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
	1/25/2012	< 0.5	**0.88**	**4.4**	**6.6**	**2300**	<0.5	<0.5	<0.5	<0.5
	9/30/2010	**1.4**	<0.5	**2.3**	**1.2**	**320**	<0.5	<0.5	<0.5	<0.5
	11/11/2008	**2.7**	< 0.5	**2.5**	**1.6**	**600**	< 0.5	< 0.5	< 0.5	< 0.5
	8/28/2008	**2.2**	< 0.5	**2.5**	**1.7**	**720**	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	**820**	< 0.5	< 0.5	< 0.5	< 0.5
	1/31/2008	< 4.0	< 1.0	< 5.0	**2.3**	**1000**	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	**2.3**	**920**	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	**5.5**	**2.3**	**810**	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	**5.2**	**2.0**	**970**	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	**5.5**	**2.5**	**1000**	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	**7.0**	**2.2**	**1000**	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	**7.3**	**2.0**	**1100**	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	< 5.0	< 2.0	**13**	**2.2**	**750**	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	**14**	**2.6**	**1200**	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	**15**	**2.2**	**1200**	< 2.0	< 2.0	< 2.0	< 0.5
	8/5/2005	< 5.0	< 2.0	**13**	**2.7**	**1600**	< 2.0	< 2.0	< 2.0	< 0.5
	5/19/2005	< 5.0	< 2.0	**19**	**2.9**	**1400**	< 2.0	< 2.0	< 2.0	< 0.5
	2/17/2005	< 5.0	< 2.0	**17**	< 2.0	**830**	< 2.0	< 2.0	< 2.0	< 0.5
	11/18/2004	**7.1**	**2.3**	**25**	**4.9**	**2200**	< 2.0	< 2.0	< 2.0	< 0.5
MW-5	3/20/2014	<0.50	<1.0	<1.0	<1.0	**41**	<1.0	<1.0	<1.0	< 5.0
	4/10/2013	<0.50	<0.5	<0.5	**0.50**	**65**	<0.5	<0.5	<0.5	<0.5
	1/18/2012	<0.50	<0.5	<0.5	<0.5	**38**	<0.5	<0.5	<0.5	<0.5
	9/30/2010	<0.50	<0.5	<0.5	<0.5	**25**	<0.5	<0.5	<0.5	<0.5
	11/11/2008	**0.53**	< 0.5	< 0.5	< 0.5	**42**	< 0.5	< 0.5	< 0.5	< 0.5
	8/28/2008	**0.52**	< 0.5	< 0.5	< 0.5	**53**	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/2008	**0.80**	**0.61**	< 0.5	< 0.5	**70**	< 0.5	< 0.5	< 0.5	< 0.5

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	**62**	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**57**	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	**60**	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**54**	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	**77**	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	**86**	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	< 5.0	< 2.0	**60**	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	< 5.0	< 2.0	< 5.0	< 2.0	**90**	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	< 5.0	< 2.0	**51**	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	< 5.0	< 2.0	**72**	< 2.0	< 2.0	< 2.0	< 0.5
	8/5/2005	< 5.0	< 2.0	< 5.0	< 2.0	**110**	< 2.0	< 2.0	< 2.0	< 0.5
	5/19/2005	< 5.0	< 2.0	< 5.0	< 2.0	**180**	< 2.0	< 2.0	< 2.0	< 0.5
	2/17/2005	< 5.0	< 2.0	< 5.0	< 2.0	**140**	< 2.0	< 2.0	< 2.0	< 0.5
	11/18/2004	< 5.0	< 2.0	< 5.0	< 2.0	**140**	< 2.0	< 2.0	< 2.0	< 0.5
MW-6	3/18/2014	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 5.0
	4/12/2013	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	1/18/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	9/29/2010	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	11/11/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**0.63**
	8/28/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**0.56**
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**0.78**
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	NS	NS	NS	NS	NS	NS	NS	NS	NS
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
MW-7	5/19/2014	< 0.5	<1.0	<1.0	<1.0	**1.2**	<1.0	<1.0	<1.0	< 5.0
	4/10/2013	< 0.5	< 0.5	< 0.5	< 0.5	**1.8**	< 0.5	< 0.5	< 0.5	**0.51**
	1/17/2012	< 0.5	< 0.5	< 0.5	< 0.5	**2.5**	< 0.5	< 0.5	< 0.5	**0.55**
	3/4/2011	< 0.5	< 0.5	< 0.5	< 0.5	**2.5**	< 0.5	< 0.5	< 0.5	< 0.5
	9/29/2010	< 0.5	< 0.5	< 0.5	< 0.5	**2.1**	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	8/28/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
MW-8	3/18/2014	< 0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 5.0
	1/17/2012	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**1.6**
	3/4/2011	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**1.4**

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
	9/30/2010	< 0.5	< 0.5	< 0.5	< 0.5	<0.5	< 0.5	< 0.5	< 0.5	**1.4**
	11/11/2008	< 0.5	< 0.5	< 0.5	< 0.5	**0.61**	< 0.5	< 0.5	< 0.5	**1.1**
	8/28/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**1.1**
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	**1.2**
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.0**
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/24/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	6/15/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	1/31/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	10/13/2005	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
MW-9	3/19/2014	< 0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 5.0
	1/18/2012	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	9/30/2010	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	11/11/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	8/28/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	2/21/2007	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5
	11/20/2006	< 5.0	< 2.0	< 5.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 0.5

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
MW-10	5/19/2014	<0.5	<1.0	<1.0	<1.0	**380**	<1.0	<1.0	<1.0	< 5.0
	4/12/2013	<0.5	<0.5	**0.73**	**1.1**	**410**	<0.5	<0.5	<0.5	<0.5
	1/18/2012	<0.5	<0.5	<0.5	**0.53**	**320**	<0.5	<0.5	<0.5	<0.5
	9/30/2010	<0.5	<0.5	<0.5	<0.5	**130**	<0.5	<0.5	<0.5	<0.5
	11/11/2008	< 0.5	< 0.5	< 0.5	**0.64**	**140**	< 0.5	< 0.5	< 0.5	**0.84**
	8/28/2008	< 0.5	< 0.5	< 0.5	**0.50**	**170**	< 0.5	< 0.5	< 0.5	**0.76**
	4/16/2008	< 0.5	< 0.5	< 0.5	< 0.5	**110**	< 0.5	< 0.5	< 0.5	**0.66**
	1/31/2008	< 4.0	< 1.0	< 5.0	< 1.0	**130**	< 1.0	< 1.0	< 1.0	< 0.5
	11/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**150**	< 2.0	< 2.0	< 2.0	< 0.5
	8/14/2007	< 5.0	< 2.0	< 5.0	< 2.0	**150**	< 2.0	< 2.0	< 2.0	< 0.5
	5/16/2007	< 5.0	< 2.0	< 5.0	< 2.0	**94**	< 2.0	< 2.0	< 2.0	< 0.5
MW-3R	3/20/2014	< 0.5	<1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 5.0
	4/9/2013	**0.98**	< 0.5	< 0.5	**1.2**	**230**	< 0.5	< 0.5	< 0.5	< 0.5
MW-14	3/20/2014	< 0.5	<1.0	< 1.0	**2.0**	**670**	< 1.0	< 1.0	< 1.0	< 5.0
	4/9/2013	**1.2**	< 0.5	< 0.5	**1.4**	**310**	< 0.5	< 0.5	< 0.5	< 0.5
MW-15	3/19/2014	< 0.5	**2.5**	**1.5**	<1.0	**47**	<1.0	<1.0	<1.0	< 5.0
	4/9/2013	**0.79**	**4.3**	**2.6**	< 0.5	**28**	< 0.5	< 0.5	< 0.5	**0.89**
MW-19	3/18/2014	< 0.5	<1.0	<1.0	<1.0	**56**	<1.0	<1.0	<1.0	< 5.0
	4/12/2013	< 0.5	< 0.5	< 0.5	< 0.5	**28**	< 0.5	< 0.5	< 0.5	**1.4**
SCI PROPERTY										
MW-11	3/19/2014	< 0.5	<1.0	<1.0	<1.0	**9.2**	<1.0	<1.0	<1.0	< 5.0
	4/11/2013	< 0.5	< 0.5	< 0.5	< 0.5	**6.2**	< 0.5	< 0.5	< 0.5	**2.8**
	1/17/2012	< 0.5	< 0.5	< 0.5	< 0.5	**13**	< 0.5	< 0.5	< 0.5	**3.0**
	9/29/2010	< 0.5	< 0.5	< 0.5	< 0.5	**1.4**	< 0.5	< 0.5	< 0.5	**1.6**
	11/11/2008	< 0.5	< 0.5	< 0.5	< 0.5	**5.2**	< 0.5	< 0.5	< 0.5	**3.2**
	8/28/2008	< 0.5	< 0.5	< 0.5	< 0.5	**4.9**	< 0.5	< 0.5	< 0.5	**3.1**

Sample ID	Date Collected	CFC-12 (µg/L)	1,2-DCA (µg/L)	MTBE (µg/L)	TCE (µg/L)	PCE (µg/L)	tDCE (µg/L)	VC (µg/L)	cDCE (µg/L)	Chloroform (µg/L)
	4/17/2008	< 0.5	< 0.5	< 0.5	< 0.5	**8.5**	< 0.5	< 0.5	< 0.5	**4.4**
MW-12	3/19/2014	< 0.5	<1.0	<1.0	**13**	**12**	**1.0**	**1.5**	**18**	< 5.0
	4/11/2013	< 0.5	< 0.5	< 0.5	**18**	**13**	**1.7**	**2.3**	**31**	**0.62**
	1/17/2012	< 0.5	< 0.5	< 0.5	**18**	**13**	**2.4**	**2.5**	**31**	**0.54**
	9/29/2010	< 0.5	< 0.5	< 0.5	**29**	**17**	**2.4**	**3.7**	**46**	<0.5
	11/11/2008	< 0.5	< 0.5	< 0.5	**32**	**25**	**4.5**	**2.7**	**44**	**0.65**
	8/28/2008	< 0.5	< 0.5	< 0.5	**26**	**14**	**3.2**	**2.7**	**23**	< 0.5
	4/17/2008	< 0.5	< 0.5	< 0.5	**27**	**24**	**2.9**	**2.6**	**33**	**0.76**
MW-16	41716	< 0.5	<1.0	<1.0	<1.0	**26**	<1.0	<1.0	<1.0	**6.6**
	41376	< 0.5	< 0.5	< 0.5	< 0.5	**6.3**	< 0.5	< 0.5	< 0.5	**3.0**
MW-17	3/18/2014	< 0.5	< 0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 5.0
	4/12/2013	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
MW-18	3/18/2014	< 0.5	<1.0	<1.0	<1.0	**170**	<1.0	<1.0	<1.0	< 5.0
	4/12/2013	< 0.5	< 0.5	< 0.5	< 0.5	**120**	< 0.5	< 0.5	< 0.5	**1.9**
	AWQS	NE	5	NE	5	5	100	2	70	NE

NOTES:

(1) Quality Assurance Sample

(2) Sample DUP is a blind duplicate of MW-17.

(3) Sample DUP is a blind duplicate of MW-4.

(4) Sample DUP01 is a blind duplicate of MW-14.

CFC 12 = Dichlorodifluoromethane

1,2-DCA = 1,2- Dichloroethane

NS = Not Sampled, due to pump malfunction

.

MTBE = Methyl-Tert-Butyl-Ether

TCE = Trichloroethene

PCE = Tetrachloroethene

µg/L = micrograms per liter

AWQS = Aquifer Water Quality Standard

NE = Not Established

Table 2. Groundwater Monitoring Analytical Data for the Pilot Test Wells

Well	Sample Date	Sample Depth (ft)	Concentration (µg/L)						
			PCE	TCE	*cis*-1,2-DCE	Vinyl Chloride	Ethene	Ethane	Methane
MW-3	4/9/2013	95	550	2.5	< 1.0	< 1.0	0.47	0.016	0.29
	8/1/2013	85	170	8.4	61	< 1.0	0.022	0.011	7,000
	8/1/2013	90	430	14	45	< 1.0	0.19	0.056	9,600
	8/1/2013	95	350	28	57	< 1.0	0.23	0.065	9,200
	10/30/2013	85	2.9	< 1.0	63	16	0.42	0.034	12,000
	10/30/2013	90	2.4	< 1.0	64	19	0.67	0.030	12,000
	12/16/2013	85	< 1.0	< 1.0	8.7	5.6	3.1	0.015	12,000
	12/16/2013	90	< 1.0	< 1.0	9.2	6.0	3.4	0.029	14,000
	1/27/2014	85	< 1.0	< 1.0	7.9	4.5	4.5	0.091	13,000
	2/17/2014	90	< 1.0	< 1.0	7.9	4.2	3.3	0.120	14,000
	2/19/2014	91	< 1.0	< 1.0	8.7	5.5	7.3	0.14	16,000
	3/20/2014	90	< 1.0	< 1.0	6.6	3.2	2.5	0.10	19,000
	8/6/2014	90	< 1.0	< 1.0	3.1	1.6	1.2	0.22	13,000
MW-3R	4/9/2013	96	230	1.2	< 1.0	< 1.0	1.3	0.66	4.9
	8/1/2013	85	3,100	48	36	12	11	0.13	10,000
	8/1/2013	95	3,700	52	39	14	15	0.20	13,000
	8/1/2013	105	3,500	52	39	14	15	0.092	13,000
	10/30/2013	85	2.7	2.4	120	96	14	6.1	14,000
	10/30/2013	95	1.1	2.3	110	95	12	4.6	11,000
	10/30/2013	105	< 1.0	1.5	100	99	18	6.0	14,000
	12/16/2013	85	< 1.0	< 1.0	8.1	6.1	11	0.99	15.000
	12/16/2013	95	< 1.0	< 1.0	8.3	6.3	11	1.3	19,000
	12/16/2013	105	< 1.0	< 1.0	6.1	4.5	7.4	1.0	16,000
	1/27/2014	85	< 1.0	< 1.0	7.6	3.0	5.2	0.20	11,000
	1/27/2014	95	< 1.0	< 1.0	7.4	3.0	6.0	0.36	17,000
	1/27/2014	105	< 1.0	< 1.0	5.9	2.9	6.2	0.36	24,000

Well	Sample Date	Sample Depth (ft)	Concentration (µg/L)						
			PCE	TCE	*cis*-1,2-DCE	Vinyl Chloride	Ethene	Ethane	Methane
	2/19/2014	95	< 1.0	< 1.0	3.7	2.6	8.3	0.20	17,000
	3/20/2014	95	< 1.0	1.0	7.7	5.5	4.6	0.22	15,000
	8/6/2014	105	< 1.0	< 1.0	< 1.0	< 1.0	1.2	1.50	20,000
MW-14	4/9/2013	98	310	1.4	ND	ND	1.6	0.83	2.4
	8/1/2013	85	92	< 1.0	< 1.0	< 1.0	0.53	0.13	1.9
	8/1/2013	95	100	< 1.0	< 1.0	< 1.0	0.67	0.087	2.4
	8/1/2013	105	87	< 1.0	< 1.0	< 1.0	0.84	0.15	2.5
	10/30/2013	85	49	< 1.0	< 1.0	< 1.0	1.0	0.065	1.1
	10/30/2013	95	170	1.3	< 1.0	< 1.0	0.38	0.044	1.3
	10/30/2013	105	59	< 1.0	< 1.0	< 1.0	0.38	0.032	1.3
	12/16/2013	85	110	< 1.0	< 1.0	< 1.0	0.30	0.037	8.2
	12/16/2013	95	110	< 1.0	< 1.0	< 1.0	0.15	0.022	6.5
	12/16/2013	105	54	< 1.0	< 1.0	< 1.0	0.27	0.027	4.1
	1/27/2014	85	200	1.3	< 1.0	< 1.0	0.20	0.014	2.9
	1/27/2014	95	410	1.7	< 1.0	< 1.0	0.091	0.031	2.0
	1/27/2014	105	28	< 1.0	< 1.0	< 1.0	0.24	0.030	7.3
	2/19/2014	95	390	1.9	< 1.0	< 1.0	0.48	0.040	4.3
	3/20/2014	95	500	< 5.0	< 5.0	< 5.0	0.42	0.028	5.5
	8/6/2014	95	250	< 10.0	< 10.0	< 10.0	0.092	0.011	7.7

cis-1,2-DCE = *cis*-1,2-dichloroethene
ft = feet
PCE = tetrachloroethene
TCE = trichloroethene
µg/L = microgram per liter

Table 3. Enhanced Reductive Dechlorination Cost Estimate

Task Description	Unit	FS Original Unit Cost	FS Original Quantity	FS Original Cost	FS Adjusted Unit Cost	FS Adjusted Quantity	FS Adjusted Cost	PRAP Unit Cost	PRAP Quantity	PRAP Total
Capital Investment for Enhanced Reductive Dechlorination										
Administrative/Regulatory Interface for ERD				**$200,000**			**$200,000**			**$200,000**
RDI/RD work plans, design, specifications, and documents	LS	$200,000	1	$200,000	$200,000	1	$200,000	$200,000	1	$200,000
Mobilization/Demobilization				**$45,000**			**$45,000**			**$90,000**
Site survey/Utility Mark Out	LS	$10,000	1	$10,000	$10,000	1	$10,000	$10,000	2	$20,000
Equipment & Manpower Mobilization/Demobilization	LS	$10,000	1	$10,000	$10,000	1	$10,000	$10,000	2	$20,000
Subcontractor/Equipment/Materials Procurement	LS	$25,000	1	$25,000	$25,000	1	$25,000	$25,000	2	$50,000
Injection and Monitoring Well Installation				**$248,000**			**$294,500**			**$390,000**
Injection Well Installation: 34 stainless steel wells (17 nested well pairs), screened 15 feet. **New Monitoring Wells:** 5 PVC construction. Drilling, materials, per diem, decontamination, permits, IDW management, drums included.	LS	$7,500	31	$232,500	$9,000	31	$279,000	$9,000	39	$351,000
Drilling oversight (one staff professional)	Day	$1,000	15.5	$15,500	$1,000	15.5	$15,500	$1,000	39	$39,000
Injection Treatment System				**$322,500**			**$322,500**			**$207,500**
Trenching, piping, backfill, resurfacing	LF	$55	1,000	$55,000	$55	1,000	$55,000	$55	1,000	$55,000
Instrumentation and Piping Conveyance	LS	$25,000	1	$25,000	$25,000	1	$25,000	$25,000	1	$25,000
Equalization Tank	LS	$7,500	1	$7,500	$7,500	1	$7,500	$7,500	1	$7,500
Reagent Feed System/Tanks/Pumps/Filters	LS	$20,000	1	$20,000	$20,000	1	$20,000	$20,000	1	$20,000
Static Mixers	LS	$5,000	2	$10,000	$5,000	2	$10,000	$5,000	2	$10,000
Control Panel/Telemetry	LS	$50,000	1	$50,000	$50,000	1	$50,000	$50,000	1	$50,000
Building, piping, valves, fittings, other misc. equipment	LS	$10,000	1	$10,000	$10,000	1	$10,000	$10,000	1	$10,000
Electrical Install and Start Up	LS	$30,000	1	$30,000	$30,000	1	$30,000	$30,000	1	$30,000
Treatability Pilot Testing	LS	$115,000	1	$115,000	$115,000	1	$115,000	$0	0	$0
Personnel Oversight Costs				**$67,500**			**$67,500**			**$72,900**
On-site resident construction engineer	Day	$1,000	50	$50,000	$1,000	50	$50,000	$1,000	54	$54,000
Truck, Health & Safety Monitoring Equipment, Expendables	Day	$350	50	$17,500	$350	50	$17,500	$350	54	$18,900
Project Management and Administrative				**$88,300**			**$92,950**			**$96,040**
Project Management and Administrative (10% of capital cost)	LS	$88,300	1	$88,300	$92,950	1	$92,950	$96,040	1	$96,040
Project Management Subtotal				**$88,300**			**$92,950**			**$96,040**
Total Capital Investment for In Situ Groundwater Treatment				**$971,300**			**$1,022,450**			**$1,056,440**

Operation and Maintenance Costs for ERD										
Task Description	**Unit**	**FS Original Unit Cost**	**FS Original Quantity**	**FS Original Cost**	**FS Adjusted Unit Cost**	**FS Adjusted Quantity**	**FS Adjusted Cost**	**PRAP Unit Cost**	**PRAP Quantity**	**PRAP Total**
Annual Performance Monitoring Program Costs										
Quarterly Monitoring (costs below include 4 full rounds of sampling including duplicates at 10% and one field blank per event)										
Labor & Materials ($1,600 for two persons)	Day	$2,000	1	$2,000	$2,000	1	$2,000	$1,600	3	$4,800
Laboratory Sampling Costs	sample	$200	16	$3,200	$200	16	$3,200	$130	25	$3,250
Groundwater Sampling Kit, Truck, Expendables	Day	$750	1	$750	$750	1	$750	$200	3	$600
Monitoring Cost Per Event				**$5,950**			**$5,950**		-	**$8,650**
Annual Report/Regulatory Interfacing	LS	$15,000	1	$15,000	$15,000	1	$15,000	$12,000	1	$12,000
Annual Monitoring/Reporting Subtotal - Years 1-5 or Years 1-7				**$38,800**			**$38,800**			**$46,600**
SemiAnnual Monitoring (costs below include 2 full rounds of sampling including duplicates at 10% and one field blank per event)										
Labor & Materials ($1,600 for two persons)	Day	$2,000	1	$2,000	$2,000	1	$2,000	$1,600	3	$4,800
Laboratory Sampling Costs	sample	$200	16	$3,200	$200	16	$3,200	$130	25	$3,250
Groundwater Sampling Kit, Truck, Expendables	Day	$750	1	$750	$750	1	$750	$200	3	$600
Monitoring Cost Per Event				**$5,950**			**$5,950**		-	**$8,650**
Annual Report/Regulatory Interfacing	LS	$15,000	1	$15,000	$15,000	1	$15,000	$12,000	1	$12,000
Annual Monitoring/Reporting Subtotal - Years 5-10 or Years 8-12				**$26,900**			**$26,900**			**$29,300**
Annual Monitoring (costs below include 1 full round of sampling of 22 wells including two duplicates and one field blank per year).										
Labor & Materials ($1,600 for two persons)	Day	$2,000	1	$2,000	$2,000	1	$2,000	$1,600	3	$4,800
Laboratory Sampling Costs	sample	$200	16	$3,200	$200	16	$3,200	$130	25	$3,250
Groundwater Sampling Kit, Truck, Expendables	Day	$750	1	$750	$750	1	$750	$200	3	$600
Monitoring Cost Per Event				**$5,950**			**$5,950**		-	**$8,650**
Annual Report/Regulatory Interfacing	LS	$15,000	1	$15,000	$15,000	1	$15,000	$12,000	1	$12,000
Annual Monitoring/Reporting Subtotal - Years 10-15 or Years 13-15				**$21,000**			**$21,000**			**$20,700**
Annual Operation and Maintenance										
Carbon Substrate (includes shipping)	LS	$40,000	1	$40,000	$60,000	1	$60,000	$40,000	1	$40,000
Injection Labor, Miscellaneous O&M Expenses:	LS	$50,000	1	$50,000	$50,000	1	$50,000	$50,000	1	$50,000
Subtotal Annual O&M				**$90,000**			**$110,000**			**$90,000**
Remedy Effectiveness Reporting - Every 5 Years										
Remedy Effectiveness Report - Year 5	LS			$0			$0	$8,500	1	$8,500
Remedy Effectiveness Report - Year 10	LS			$0			$0	$8,500	1	$8,500
Remedy Effectiveness Report - Year 15	LS			$0			$0	$8,500	1	$8,500

Task Description	Unit	FS Original Unit Cost	FS Original Quantity	FS Original Cost	FS Adjusted Unit Cost	FS Adjusted Quantity	FS Adjusted Cost	PRAP Unit Cost	PRAP Quantity	PRAP Total
Project Management and Administrative										
Project Management and Administrative Years 1 - 5 or Years 1 - 7	LS	$24,500	1	$24,500	$24,500	1	$24,500	$13,700	1	$13,700
Project Management and Administrative - Years 6 - 10 or Years 8 - 12	LS	$5,400	1	$5,400	$5,400	1	$5,400	$2,900	1	$2,900
Project Management and Administrative Years 10 - 15 or Years 13 - 15	LS	$600	1	$600	$600	1	$600	$2,100	1	$2,100
Site Closure Cost										
Task Description	**Unit**	**FS Original Unit Cost**	**FS Original Quantity**	**FS OriginalCost**	**FS Adjusted Unit Cost**	**FS Adjusted Quantity**	**FS Adjusted Cost**	**PRAP Unit Cost**	**PRAP Quantity**	**PRAP Total**
Well Abandonment inc. Permitting, Surface Restoration	LS			$0			$0	$89,100	1	$89,100
Remediation System Demolition, Site Restoration	LS			$0			$0	$20,000	1	$20,000
Personnel Oversight Costs	Day			$0			$0	$1,000	12	$12,000
Site Closeout Documents	LS			$0			$0	$8,500	1	$8,500
Project Management and Administrative (10% of closure cost)	LS			$0			$0	$12,960	1	$12,960
Subtotal Closure Cost				**$0**			**$0**			**$142,600**
Total Cost of Remedy Excluding Site Close-Out				**$2,007,000**			**$2,158,000**			**$2,363,000**
Present Worth of Remedy Excluding Site Close-Out (7% Interest Rate, 3% Inflation)				**$1,837,000**			**$1,977,000**			**$2,130,000**
Total Project Cost Including Site-Close-Out				**-**			**-**			**$2,506,000**
Present Worth of Total Project Cost Including Site Close-Out (7% Interest Rate, 3% Inflation)				**-**			**-**			**$2,208,000**

Notes:
Total Annual and Capital Costs have been rounded to the nearest $100.
LS = Lump Sum
Table content and format modified/adopted from Final Feasibility Study, 7th Ave and Bethany Home Road WQARF Site, Phoenix, AZ. (Arcadis, 2012)