Feasibility Study

Highway 260 and Johnson Lane
WQARF Registry Site

PINETOP-LAKESIDE, ARIZONA

Arizona Superfund Response Action Contract

Contract Number: ADEQ14-077538

Prepared for:

ADEQ
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CALIBRE

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FEASIBILITY STUDY

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CERTIFICATION

This report was prepared by the staff of CALIBRE Systems, Inc. All information, conclusions, and recommendations in this report have been prepared under the supervision of, and reviewed by, a Registered Professional Engineer.

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Table of Contents

List of Tables

List of Figures

Appendices

List of Acronyms

A.A.C.	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
A.R.S.	Arizona Revised Statutes
ASRAC	Arizona Superfund Remedial Action Contract
AWQS	Aquifer Water Quality Standard
Bgs	Below Ground Surface
CAB	Community Advisory Board
CI	Community Involvement
CIP	Community Involvement Plan
CSM	Conceptual Site Model
COC	Contaminant of Concern
ERD	Enhanced Reductive Dechlorination
FS	Feasibility Study
Ft	feet
GPLs	Groundwater Protection Limits
ISCO	In-situ chemical oxidation
ISCR	In-situ chemical reduction
LWUS	Land and Water Use Study
MNA	Monitored Natural Attenuation
$\mu g/m^3$	micrograms per cubic meter
µg/L	micrograms per liter
TCE	Trichloroethene
PCE	Tetrachloroethene
PRB	Permeable reactive barrier
RO	Remedial Objectives
RI	Remedial Investigation
SGSL	Soil Gas Screening Level
SRLs	Soil Remediation Levels Groundwater Protection Limits (GPLs)
RSL	Regional Screening Level
VOCs	Volatile organic compounds
WQARF	Water Quality Assurance Revolving Fund
ZVI	Zero valent Iron

1.0 INTRODUCTION

The purpose of this Feasibility Study (FS) report is to evaluate remedial alternatives and provide a recommendation for a preferred alternative for the Highway 260 and Johnson Lane Water Quality Assurance Revolving Fund (WQARF) site (Site). The Site is located in Pinetop-Lakeside, Arizona (see Figure 1-1) and covers an area of mixed commercial and residential land use. The Matrix-CALIBRE Team completed the work described in this report under Arizona Superfund Remedial Action Contract (ASRAC) Number ADEQ14-077538 with the Arizona Department of Environmental Quality (ADEQ).

1.1 Objectives and Scope of the Feasibility Study Report

The FS is a process used to:

- Identify remedial options and alternatives that will achieve the Site Remedial Objectives (ROs); and
- Evaluate the identified remedies and recommend alternatives that comply with the requirements of Arizona Revised Statutes[1] (A.R.S.) §49-282.06.

Based on the purpose and process noted above, this FS presents recommendations for a preferred remedy that:

- Assures the protection of public health, welfare, and the environment;
- To the extent practicable, provides for the control, management, or cleanup of hazardous substances so as to allow for the maximum beneficial use of waters of the state;
- Implements remedial actions which are reasonable, necessary, cost-effective, and technically feasible; and
- Addresses any well (used for municipal, domestic, industrial, irrigation or agricultural purposes) that could produce water that would not be fit for its current or reasonably foreseeable end use without treatment.

This FS report was developed based on data and information from the Remedial Investigation (RI, Pinyon Environmental 2019). The FS develops and presents a reference remedy and two alternative remedies, and evaluates the remedies to ensure that the remedies meet the following in accordance with Arizona Administrative Code[2] (A.A.C.) R18-16- 407(H):

- Achieves the ROs;
- Is consistent with water management plans and general land use plans; and
- Is evaluated with comparison criteria including practicability, risk, cost, and benefit.

One of the alternative remedies is less aggressive than the reference remedy and one is more aggressive as required by A.A.C. R18-16-407(E).

[1] *Arizona Revised Statutes §49: The Environment, 282: Water Quality Assurance Revolving Fund, 06: Remedial action criteria; rules*
[2] *Arizona Administrative Code Title 18: Environmental Quality, Chapter 16: Department of Environmental Quality WQARF Program, Article 4, 407: Feasibility Study*

In accordance with A.A.C. R18-16-407(I), based on the evaluation of the reference remedy and the alternative remedies, the proposed remedy is developed and described in this FS report. Additionally, this report describes the rationale for selecting the proposed remedy including the following:

- How the proposed remedy will achieve the ROs;
- How the comparison criteria were considered; and
- How the proposed remedy meets the requirements of A.R.S. §49-282.06.

1.2 Report Organization

This FS report has been prepared in accordance with the FS Work Plan (ADEQ 2019) and is organized as follows:

- Section 2: Site Background includes Site description, Conceptual Site Model (CSM) and problem statement defining the site conditions and media requiring remedial actions;

- Section 3: Feasibility Study Scoping presents the regulatory requirements of Arizona statutes and rules, delineation of the remediation areas, and the ROs established for the Site.

- Section 4: Identification and Screening of Remediation Technologies presents an evaluation and screening of remedial technologies applicable to contamination in soil and groundwater, and lists the specific technologies retained for developing the reference and alternative remedies;

- Section 5: Development of reference remedy and alternative remedies presents the evaluation process and development of a reference remedy, a more aggressive remedy, and a less aggressive remedy;

- Section 6: Comparison of reference remedy and alternative remedies presents a summary of the three remedial alternatives compared to each other based on practicability, risk, cost, and benefit, and includes a discussion of uncertainties associated with each remedy;

- Section 7: Proposed Remedy presents the proposed remedy and discusses how the remedy will meet the requirements of A.R.S. §49-282.06 and A.A.C. R18-16-407(I);

- Section 8: Community Involvement presents public participation opportunities; and

- Section 9: References provides a list of references cited in this FS report.

2.0 SITE HISTORY AND BACKGROUND

This section presents a summary of the Site history and description of physiographic setting, nature and extent of contamination and a risk evaluation. This summary is taken in large part from the RI report (Pinyon, 2019). This section also includes a description of the CSM for the Site and a problem statement based on the CSM.

2.1 Site History

Groundwater sampling in 2015 identified tetrachloroethene (PCE) and trichloroethene (TCE) in private wells on properties near the intersection of Highway 260 and Johnson Lane. PCE was detected at concentrations ranging from 47 to 59 micrograms per liter (µg/L) in private wells used for potable supply and irrigation. The Arizona Aquifer Water Quality Standard (AWQS) for PCE is 5.0 µg/L. TCE was detected below the AWQS of 5 µg/L. ADEQ recommended use of alternate bottled water for the impacted wells and initiated an Early Response Action in June 2018 that included providing treated drinking water to residents affected by contaminated wells.

On June 24, 2016 the Highway 260 and Johnson Lane site was placed on the WQARF Registry with an eligibility and evaluation score of 40 out of 120. ADEQ initiated a Remedial Investigation of the Site to determine the source and extent of contamination.

2.2 Site Background

The Site is located in Pinetop-Lakeside, Arizona. The Site is generally bounded by Rhoton Lane to the north, the western boundary of the Blue Ridge High School to the east, Burke Lane to the south, and Rainbow View Drive to the west (Figure 1-2).

The RI report was prepared in part to determine the nature and extent of contamination at the Site. The RI also identified present and reasonably foreseeable uses of land and waters of the state that have been impacted, or are threatened to be impacted, by the contamination. Based upon the data collected, the following represents the interpretations and conclusions presented in the RI.

Based on sampling conducted over several years, PCE has been identified as the contaminant of concern (COC) for the Site. The identified source of contamination is a former dry cleaner located on the Earl properties at the southeast corner of Highway 260 and Johnson Lane.

The extent of elevated PCE concentrations in soil vapor is limited to the source area and nearby properties located on the west side of Highway 260. The RI indicates that PCE concentrations in soil vapor to the west of the Earl properties appear to be the result of lateral migration of PCE through shallow, predominantly gravelly sand of the road base beneath and adjacent to Highway 260 (Figure 2-1). Another explanation for PCE concentrations in soil vapor on the west side of Highway 260 is migration of PCE either as pure product or at relatively high concentrations in groundwater, along a layer of basalt in the subsurface which is between 8 ft and 13 ft below ground surface (bgs) in the vicinity of the Earl property.

The extent of PCE impacts in groundwater above the AWQS is generally limited to the area northwest of the Earl properties, approximately 1,650 feet long and having a width of approximately 650 feet at its widest (Figure 2-2). PCE has been detected in groundwater from as deep as 310 feet within the plume. In general, groundwater appears to be the primary mode of transport for PCE at the Site. The current extent of impacts appears consistent with a general groundwater flow to the northwest.

The Site is located in a mixed commercial and residential area. Based on the land and water use study (LWUS), the Site spans across three zoning districts: light commercial, single family residential, and multiple family residential. The closest surface water bodies to the Site are Rainbow Lake, located approximately 1,200 feet from the down-gradient edge of the plume, and Billy Creek, a perennial stream located approximately 800 feet to the northeast. Surface water at Pinetop-Lakeside is used primarily for irrigation, livestock, domestic, tourism, and recreational purposes.

Nineteen private wells are located within potentially impacted areas in the vicinity of the Site. These wells are drilled into the Pinetop-Lakeside Aquifer. Private groundwater uses include irrigation, domestic household applications, and commercial production. The potential receptors most likely to be influenced by further down-gradient progress of releases from the facility are private well owners and users of Rainbow Lake.

2.3 Conceptual Site Model

The CSM for the Site includes the source (a release from a former dry cleaner on the Earl property), migration pathways in soil, soil vapor and groundwater, and potential routes of exposure to the relevant media. Groundwater at the Site contains PCE exceeding AWQS for potable use. The PCE plume is defined as the groundwater zone impacted by PCE at concentrations exceeding the AWQS. From the source area, the PCE plume migrates with groundwater flow to the northwest towards Rainbow Lake. The Site is underlain by a layer of vesicular basalt which may slow the vertical migration of PCE but empirical data demonstrates migration though it to groundwater. The local groundwater gradient is to the west/northwest and irrigation wells used by a plant nursery business are located about 500 feet down gradient from the source area. Surface water sampling from Rainbow Lake did not detect PCE in any samples.

PCE in soil vapor extends off of the Earl property across Highway 260 to the west with the highest soil vapor levels detected about 200 feet from the source (on the west side of Highway 260). The existing soil vapor sampling data indicate an area of approximately 2 acres [about 400 feet (ft) long with a width of 270 ft] with soil vapor levels exceeding the worker soil gas screening level [(SGSL)[3], i.e., PCE above 1,567 micrograms per cubic meter, μg/m^3, for commercial/industrial building use]. Near the former dry cleaners, the highest soil vapor concentrations are from monitoring points SV-9 and SV-10 with PCE concentrations in the range of 10,000 to 35,000 μg/m^3. On the west side of Highway 260, about 200 ft west of the former dry cleaners, the highest soil vapor concentrations are from points SV-11, SV-18, DP-11, and SV-19C with PCE concentrations in the range of 19,000 to 44,000 μg/m^3. Indoor air samples were collected from the LLP property on the west side of Highway 260 and PCE was detected in each of the indoor air samples at concentrations ranging from 4.86 to 10.2 μg/m^3; all below EPA's indoor air regional screening levels[4] (RSLs) for workers (47 μg/m^3). Indoor air sampling was not completed at the former dry cleaners because the dry cleaning equipment remains in the structure and any indoor air concentrations would likely represent the prior PCE use in the building, not vapor intrusion.

[3] The SGSLs are derived using an attenuation factor (α) applied to EPA's regional screening levels (RSL) to represent the attenuation/dilution as vapors migrate into a building and mix with indoor air; SGSLs are not regulatory criteria but are intended to be used for screening. The PCE SGSL for residential use is 367 micrograms per cubic meter (μg/m^3) and the worker SGSL (commercial/industrial building use) for PCE is 1,567 μg/m^3.

[4] EPA has developed RSLs to evaluate the potential for chronic exposure to cause cancer; the screening levels are an estimated PCE concentration that would be expected to cause no more than one in a million excess cancer risk to persons exposed during their lifetime (a 10^{-6} risk).

2.4 Problem Statement

The Site contains PCE residues in soil vapor and groundwater. Groundwater at the Site contains PCE exceeding the AWQS (5.0 µg/L) covering approximately 20 acres (about 1,650 feet long with a width of 650 feet) and PCE has been detected at a depth of 310 ft bgs in a single well. The peak historical PCE concentrations detected in the groundwater plume have been in the range of 45-60 µg/L, more recently the highest PCE concentrations have been in the range of 10-15 µg/L. The existing soil vapor sampling data indicate an area of approximately 2 acres (about 400 ft long with a width of 270 ft) with soil vapor levels exceeding the worker SGSL, i.e., PCE above 1,567 µg/m^3, for commercial/ industrial building use. The SGSL's are screening levels and are not an enforceable standard.

Near the former dry cleaners, the highest soil vapor PCE concentrations are in the range of 10,000 to 35,000 µg/m^3. On the west side of Highway 260, about 200 ft west of the former dry cleaners, the highest soil vapor concentrations are PCE concentrations in the range of 19,000 to 44,000 µg/m^3. All measured indoor-air values were below the indoor air PCE RSL for workers (47 µg/m^3 and the RSL is a screening level). The PCE residues in soil vapor may represent a continuing source that prolongs the required duration of the groundwater remedy.

3.0 FEASIBILITY STUDY SCOPING

This section summarizes the regulatory requirements presented in Arizona statute and rule, delineates the remediation areas and presents the ROs identified by ADEQ (ADEQ, 2018).

3.1 Regulatory Requirements

The A.R.S. §49-282.06 requires that remedial actions shall:

1. Assure the protection of public health and welfare and the environment.
2. To the extent practicable, provide for the control, management or cleanup of the hazardous substances in order to allow the maximum beneficial use of the waters of the state.
3. Be reasonable, necessary, cost-effective and technically feasible.

Under A.R.S. § 49-282-06 B, the selected remedial action "shall address, at a minimum, any well that at the time of selection of the remedial action either supplies water for municipal, domestic, industrial, irrigation or agricultural uses or is part of a public water system if the well would now or in the reasonably foreseeable future produce water that would not be fit for its current or reasonably foreseeable end uses without treatment due to the release of hazardous substances. The specific measures to address any such well shall not reduce the supply of water available to the owner of the well."

Under A.R.S. Section 49-282-06 C, while selecting remedial actions, ADEQ shall consider:

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

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

3.2 Delineation of Remediation Areas

The RI report collected samples from soil, soil vapor, groundwater, surface water, and indoor air and compared the sample results to applicable regulatory standard to identify which media have been impacted by COCs.

The RI Report concluded that the groundwater was the only media with COC concentrations that exceeded a regulatory standard. PCE was detected in several monitoring wells at concentrations exceeding the AWQS of 5 µg/L. As indicated in Section 2, the extent of groundwater that exceeds the AWQS is an area of approximately 1,650 feet long by 650 feet wide covering an area of 20 acres. PCE has been detected from the water table, which is encountered at approximately 30 feet bgs, to a depth of 310 feet bgs in one well. This deepest well (ADEQ ID # 81400, see Figure 2-2) is used for irrigation supply and the PCE concentration is in a similar range to other shallower wells at depths of approximately 100 to 200 ft bgs. The PCE detected in this deepest well (# 81400) may potentially be the result of migration down the well bore hole.

PCE concentrations in groundwater, as monitored in November 2018, ranged from non-detect to 23.3 µg/L. PCE was detected in 12 of the 15 wells that were sampled during the November 2018 event. The wells were sampled most recently in April 2019 and PCE was detected in 10 of the 14 wells sampled. Concentrations of PCE in the plume have generally been steady or decreasing across most of the Site since monitoring began in 2015.

3.3 Remedial Objectives

ROs have been developed for the Site as part of the RI process. Pursuant to A.A.C. R18-16-406 (I), the ROs were based on field investigation results, the LWUS, the screening level risk evaluation, ADEQ input, and input from the community during the public comment period on the draft RO Report. ROs are used in this FS to identify appropriate remedial technologies in developing the remedial alternatives.

3.3.1 Remedial Objectives for Land Use

The Site is located in a mixed commercial and residential area. Based on the LWUS, the Site spans across three zoning districts: light commercial, single family residential, and multiple family residential. According to the LWUS, there are no immediate plans to change the land use or zoning for properties within the Site. Generally, commercial properties are concentrated near the southeastern portion of the Site while residential properties are concentrated near the northwestern portion of the Site.

In the RI, concentrations of PCE in soil vapor were converted to soil equivalents as per A.A.C. R18-7-203(C) to determine the concentration reasonably expected in the soil. The calculated concentrations were below the applicable Soil Remediation Levels (SRLs) or Groundwater Protection Limits (GPLs) and impacts in soil are not expected to have a direct impact to human health or the environment.

Based on these conditions an RO for soil is not required because impacts in soil are not expected to have a direct impact to human health or the environment.

3.3.2 Remedial Objectives for Surface Water

The Site is located near Rainbow Lake and the RI included surface water samples collected from Rainbow Lake. The surface water sampling in the RI did not identify any VOCs present above the analytical method detection limits (i.e., all samples were non-detect).

Based on these conditions an RO for surface water is not required because impacts in nearby surface water bodies are not expected to have a direct impact to human health or the environment.

3.3.3 Remedial Objectives for Groundwater Use

The groundwater use portion of the RI summarizes information gathered from the Arizona Department of Water Resources (ADWR), local water providers, and well owners. No municipal production wells are located within the Site.

According to the responses to the ADEQ questionnaires, Pinetop-Lakeside receives 100% of its water from wells that tap into the Pinetop-Lakeside and Coconino aquifers. Until the time of the Pinetop-Lakeside/Navaho County Water Resources Element of the Regional Plan, most wells tapped into the shallower Pinetop-Lakeside aquifer. The two main water providers for the area, Pinetop Water Community Facilities (which does not currently serve the Site) and Arizona Water Company, have wells drilled into the deeper Coconino aquifer, the primary source of groundwater for the area, which is not hydraulically connected to the Pinetop-Lakeside Aquifer. There are currently no municipal wells in the Site vicinity and no plans to install wells within the Site vicinity.

Nineteen private wells are located within potentially impacted areas in the vicinity of the Site. These wells are drilled into the shallower Pinetop-Lakeside Aquifer. Private groundwater uses include irrigation, domestic household applications, and commercial production. There are no plans to install additional wells or to change the use of wells within the Site vicinity.

During the most recent groundwater sampling event in April 2019, PCE was detected at or above the AWQS in five private wells and two monitoring wells. The private wells provide water for commercial irrigation and private domestic use. There are no plans to change the use of the impacted wells.

The ROs for groundwater at the Site are:

> *To restore, replace or otherwise provide for water for the designated use, lost or impaired by contamination associated with the Highway 260 and Johnson Lane WQARF site. This action will be needed as long as the need for the water exists, the resource remains available and the contamination associated with the Highway 260 and Johnson Lane WQARF site prohibits or limits the use of groundwater.*

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL MEASURES AND REMEDIAL STRATEGIES

This section presents the evaluation and screening of various remedial measures and strategies related to Site contamination and lists the applicable technologies retained for evaluation as part of the reference and alternative remedies pursuant to A.A.C. R18-16-407 (E) and (F).

Remedial measures are remediation technologies or methodologies that are screened based on anticipated removal or reduction of contaminants at the Site and the ability to achieve the ROs. Remedial strategies incorporate one or more remediation measures/technologies to achieve the RO. The basic remedial strategies summarized in A.A.C. R18-16-407 (F) are:

1. Plume remediation as a strategy to achieve AWQS for contaminants of concern throughout the site.
2. Physical containment as a strategy to contain contaminants within definite boundaries.
3. Controlled migration as a strategy to control the direction or rate of migration of contaminants.
4. Source control as a strategy to eliminate or mitigate a continuing source of contamination.
5. Monitoring as a strategy to observe and evaluate the contamination at the site through the collection of data.
6. No action as a strategy that consists of no action at a site.

For the basic remedial strategies listed above, listed items 2 and 6 (physical containment and no action) are unlikely to be applicable at this Site. The depth of contamination and existing development in the immediate area make physical containment too costly and/or infeasible. The no action strategy will not meet the ROs. The remaining remedial strategies (plume remediation, controlled migration, source control, and monitoring) are applicable and will be retained for development of the reference remedy and alternate remedies.

4.1 Remedial Technologies Screening Criteria

Typically, appropriate remediation alternatives and technologies are screened using the following criteria:

- compatibility with current and reasonably foreseeable land use,
- treatment effectiveness for removal of the site COCs,
- regulatory requirements,
- constructability,
- operation and maintenance requirements,
- health and safety considerations,
- generation and management of waste products,
- flexibility/expandability, and
- cost.

The screening presented below does not explicitly evaluate each technology against each of these criteria, rather the intent is to identify fatal flaws or conversely, proven characteristics of technologies in order to develop and assemble the remedial alternatives that are described in Section 5. The screening of technologies is separated below into those that address vadose zone soil and those that address groundwater.

4.2 Screening of Technologies Applicable to Soil

The technologies that are described in this section are routinely used for sites with chlorinated solvents in vadose zone soil. The general approach, limitations and applicability to this Site are considered. Soil technologies are presented even though a soil RO has not been developed because reducing PCE concentrations in soil or soil vapor may decrease the timeframe required for groundwater remedies thereby decreasing lifecycle costs.

4.2.1 Excavation and Disposal of Contaminated Soil

This technology involves excavation and disposal of contaminated soil from the Site to eliminate material that is leading to ongoing groundwater contamination or acting as a source to soil vapor and potentially degrading indoor air quality. This technology is best suited where the area and depth of contaminated soil is relatively limited such that the volume of soil can be cost-effectively managed. Additionally, the soil to be removed must be readily accessible—not blocked by utilities, buildings, or transportation corridors. Finally, sites where excavation is typically selected are those where the concentrations are high and represent a significant ongoing source that is causing impacts to associated media such as groundwater, surface water, or indoor air. It is unclear whether any of these factors apply at the Site. The cost to excavate impacted soil is anticipated to be high relative to the benefit, and constructability issues associated with existing buildings and infrastructure that would make it difficult to access impacted soil make this technology unsuitable and it is therefore not retained for alternative development.

4.2.2 Soil Vapor Extraction

Soil Vapor Extraction or SVE is a proven technology for removing volatile organic compounds (VOCs) from the vadose zone. SVE involves installation of vertical, inclined, or horizontal wells above the water table in areas with elevated VOC concentrations and applying a vacuum to the wells using a blower. Flow through the subsurface draws contaminants into the wells and to the ground surface where the VOCs are removed from the vapor stream using a treatment system that typically consists of a water drop-out tank, a granular activated carbon unit, and various controls to operate the SVE system. SVE systems typically remove a relatively high quantity of VOCs early in system operation and the rate of mass removal declines rapidly based on the mass initially present in the vadose zone and the accessibility of the mass for removal by the SVE system. The latter is a function of the soil porosity, layering, presence of fractures; and spacing of the extraction wells relative to the location of the VOC mass. Additionally, if the integrity of the surface seal is poor, short-circuit flow paths can reduce system efficiency. This technology is generally cost-effective, straightforward to construct, operate and maintain. It is retained for alternative development.

4.3 Screening of Groundwater Technologies

The technologies that are described in this section are routinely used for sites with chlorinated solvents dissolved in groundwater. The general approach, limitations and applicability to the Site are considered.

4.3.1 Monitored Natural Attenuation

Monitored Natural Attenuation or MNA is an approach that involves monitoring VOCs and other parameters in groundwater to identify and track the reduction of contaminant concentrations over time. Processes that can reduce concentrations include dilution, dispersion, volatilization, and biological degradation. Documenting MNA typically includes measurement of various chemical and hydrogeological parameters to provide evidence that MNA is a protective remedy. MNA is usually combined with source control, or selected at sites where the source is substantially depleted. MNA is typically applicable to sites where the contaminant plume is stable or shrinking. MNA as a technology is retained for alternative development.

4.3.2 Enhanced Reductive Dechlorination

Enhanced Reductive Dechlorination or ERD is a remedial technology based on injecting substrate and/or nutrients and appropriate bacteria into groundwater to promote anaerobic biodegradation of VOCs. Anaerobic reductive dechlorination is a naturally occurring biodegradation process whereby microbes can degrade chlorinated VOCs in groundwater. The microbes use a primary substrate as a carbon and energy source, producing enzymes and other compounds that degrade the target chlorinated compounds present in groundwater. Most applications use a bio-stimulation substrate to provide a carbon source for driving the aquifer redox conditions lower and at the same time provide a fermentation substrate that releases hydrogen to serve as an electron donor (required for the dechlorination reactions). A variety of compounds have been used as bio-stimulation amendments for ERD applications. Bio-augmentation is a subsequent step, required for some but not all sites, during which a microbial mixture is injected into groundwater to initiate or accelerate key dechlorination steps. Depending on the contaminants present and the subsurface conditions, a variety of microbial cultures have been developed and are marketed by specialty vendors.

As with any in-situ technology, success depends on the ability to deliver the reagent to the impacted areas. ERD is only applicable to the saturated zone, and typically it must be combined with source zone treatment of any VOC residues in the vadose zone. However, with an effective ERD treatment zone in groundwater, the extent and duration of the vadose zone treatment may potentially be reduced because the rapid degradation of VOCs in groundwater is less sensitive to continuing contributions from the vadose zone.

ERD wells can be located at source areas or hotspots within a groundwater plume. In these configurations, ERD is implemented to maximize mass removal of COCs. An alternate configuration is to install ERD wells in a line perpendicular to the groundwater flow direction near the leading edge of the plume. In this configuration, the wells are sometimes called “bio-barrier wells” and the goal is to reduce COC concentrations to acceptable levels as groundwater is transported through the line of wells.

Biological treatment via ERD has been retained as a viable technology for plume treatment because it has been proven to be effective for enhancing and accelerating the reduction of PCE concentrations in groundwater at similar sites.

4.3.3 In-Situ Chemical Oxidation

This remedial technology, in-situ chemical oxidation or ISCO, involves chemical reactions that convert contaminants into less toxic or inert compounds. ISCO is implemented by injecting a chemical oxidant into groundwater via a series of injection wells (or other injection methods) to destroy or degrade organic compounds. Several different types of oxidants have been used successfully at chlorinated solvent sites including permanganate, persulfate, hydrogen peroxide and iron, and ozone. Site-specific aquifer oxidation-reduction (redox) conditions and parameters, hydraulic conductivity, along with oxidant-specific characteristics, need to be evaluated to determine the oxidant dosing and other critical design parameters. Pilot testing and/or bench testing is typically necessary to establish the injection spacing, rates, and oxidant dosing. Although targeted for destruction of dissolved VOCs in water, the oxidizing agent will also react with the soil matrix; therefore, the radius of influence from the injection points may be limited.

ISCO it is not considered a cost-effective or feasible technology for plume-wide treatment due to the depth and size of the plume, the relatively low concentrations detected, and the costs associated with overcoming the oxidant demand from the soil. However, there may be more limited areas where ISCO would be applicable and ISCO has been retained as a viable technology for hot-spot treatment in groundwater.

4.3.4 In-Situ Chemical Reduction

In situ chemical reduction (ISCR) is intended to reduce VOC concentrations by using materials such as zero-valent iron (ZVI) to degrade the VOCs. This technology is usually implemented in a permeable reactive barrier (PRB) or funnel-and-gate configuration where the ZVI can be installed perpendicular to the groundwater flow direction and the base of the barrier can be tied into a low permeability layer. Due to the apparent thickness of the plume and the logistical complications associated with excavation at the Site, this technology would be infeasible to implement at this Site. As such, this technology was not retained for further consideration.

4.3.5 Groundwater Extraction and Treatment

This remedial technology involves pumping contaminated groundwater from the plume and treating the groundwater ex-situ before discharge. Groundwater extraction and treatment removes and reduces contaminant mass from the aquifer but it is generally more effective in controlling or containing the down-gradient migration of the VOC plume. Contaminated groundwater can be treated by activated carbon, air stripping, oxidation, or by other means prior to discharge. Discharge options that may be considered include discharge to a sanitary sewer or a storm drain, a beneficial re-use such as irrigation supply, or reinjection into the aquifer at some location away from the plume. Discharge options with a beneficial re-use are strongly preferred due to the importance of water as a resource.

Groundwater extraction and treatment is typically inefficient at reducing contaminant mass because the concentrations in groundwater are low and it is expensive to operate. It is unlikely to meet the Site ROs within a reasonable restoration time frame by itself. However, it can be an effective plume containment approach. This FS includes groundwater extraction and treatment as one element of the long-term remedy considered for the Site, and this remedial technology has been retained for further evaluation.

4.3.6 Summary of Screening and Technologies Retained

Table 4-1 presents a summary of screening and specific technologies retained for developing the remedial alternatives.

Table 4-1 Summary of Technology Screening

Technology	Media	Comments	Retained?
Excavation and Disposal	Soil	Typically used when the volume of source material is limited, VOC concentrations are high, and surface conflicts with structures and infrastructure are minimal.	No
Soil Vapor Extraction	Soil	Typically used when VOC concentrations in soil or soil vapor are high and the area requiring treatment is moderately sized. Effectiveness of mass removal often declines rapidly over a few months or years.	Yes
Monitored Natural Attenuation	Groundwater	Typically used when source has been controlled, geochemical parameters and suitable, and plume is stable or shrinking.	Yes
Enhanced Reductive Dechlorination	Groundwater	Effective where in situ conditions can be manipulated to create reducing conditions and appropriate bacteria exist or can be introduced into groundwater.	Yes
In Situ Chemical Oxidation	Groundwater	Effective for limited volume, high VOC concentrations.	Yes
In Situ Chemical Reduction	Groundwater	Effective when groundwater flow can be directed through a treatment zone that is within depths of typical excavation equipment and structures or infrastructure do not interfere with implementation.	No
Groundwater Extraction and Treatment	Groundwater	Typically used for plume control rather than mass removal due to expense associated with long-term operations.	Yes

5.0 DEVELOPMENT OF REFERENCE REMEDY AND ALTERNATIVE REMEDIES

Based on the retained remedial technologies presented in Section 4, this section develops and presents the recommended Site remedies including a reference remedy along with alternative remedies (less aggressive and more aggressive remedies). The reference remedy and alternate remedies consist of remedial strategies and actions (remedial measures) to achieve ROs for the Site. The ROs established the in RI are presented in Section 3 and the range of remedial strategies considered, from A.A.C. R18-16-407(F), are summarized in Section 4.

As noted in Section 4, physical containment and no action are unlikely to be applicable at this Site and the other remedial strategies from A.A.C. R18-16-407(F) (i.e., plume remediation, controlled migration, source control, and monitoring) are used to develop the reference remedy and alternate remedies. For the vadose zone, potential remedies consider current and future land use and/or impacts to groundwater. For groundwater, each remedy has been identified with consideration of the needs of the local water provider (Arizona Water Company) and existing private water supply wells used by local businesses and residents.

Selected remedial measures are combined with the applicable strategies to develop the reference remedy and alternative remedies. For this Site, the reference remedy and each alternative remedy include contingent remedial measures. The contingent remedial measures are included to address the existing uncertainties regarding certain Site conditions, the achievement of ROs, or uncertain timeframes in which ROs will be achieved. Where remedial measures are necessary to achieve ROs, the remedial measures will be required as long as necessary to ensure the continued achievement of those objectives. The areas where remedial alternatives need to address environmental impacts include the plume area which is above the PCE AWQS of 5 µg/L (from the source to suitable down gradient boundaries) and may also consider areas where elevated levels of PCE in soil vapor are reported in the RI. The down gradient area with elevated levels of PCE in soil vapor is primarily on the west side of Highway 260. This down gradient area is not the initial source for the plume (i.e., it is not the point of release from the dry cleaner operations) but it currently represents the area with the highest PCE concentrations detected in soil vapor. The PCE inventory in this zone may be sufficiently high that it warrants remedial measures for control; this is a remaining data gap from the RI and the remedial alternatives listed below have been developed to address it.

The reference remedy and the alternative remedies are presented in the following sections. Discussion of the remedies includes a discussion of the associated remedial measures and remedial strategies pursuant to A.A.C. R18-16- 407(E). The remedial alternatives presented include a group of similar and related remedial measures; therefore, the discussion of individual remedial measures is presented after the discussion of the remedial alternatives.

5.1 Reference Remedy

This section describes the reference remedy. The remedial strategies from A.A.C. R18-16-407(F) included are monitoring, controlled migration, plume remediation, and source control. The remedial measures/technologies include in the reference remedy are:

- MNA for the groundwater plume, which would include monitoring COCs and other relevant indicator parameters to document the VOC plume stability and verify existing removal/ degradation conditions are suitable to meet the project ROs within a reasonable restoration timeframe. An existing and ongoing removal process is the groundwater extraction from the nursery in the central area of the VOC plume. The operational needs and groundwater extraction rates by the nursery may change in the future. The MNA element of the remedy includes monitoring that will be used to evaluate future conditions/changes to the plume.
- SVE treatment of the area with elevated soil vapor concentrations, this element of the reference remedy is proposed in two phases. The first phase would consist of a short-term SVE pilot test using a mobile equipment system (trailer-based). The estimated duration of the pilot test is two months. An objective of the pilot test is to evaluate and demonstrate PCE mass removal from the vadose zone.
- Continued point-of-use treatment for existing potable supply wells.
- As a contingency, if the pilot test demonstrates effective mass removal, the SVE system would be expanded in a second phase to treat a larger area. Soil vapor with elevated PCE concentrations are present on both the east and west sides of Highway 260 and under the highway. The shallow basalt unit was encountered at approximately 8 ft bgs in MW-2 on the east side of the highway and at 13 ft bgs in MW-1 on the west side of the highway. These shallow depths limit the radius of influence of vertical SVE wells. Consequently, horizontal wells installed with a directional drilling rig are a more effective means of removing soil vapors from a larger area, including the area under the highway. Coordination with property owners on both sides of the highway, coordination with the Arizona Department of Transportation and location of all utilities are pre-requisites to implementing this contingent portion of the remedy.
- A contingency for expanding the point-of-use treatment to other nearby potable, private-use supply wells. This contingency would be implemented if future monitoring data indicate water quality standards for the intended use are, or may be, exceeded. Periodic monitoring of these three wells would be included in the MNA element of the remedy.
- A contingency for installing up to three additional monitoring wells is also included in the reference remedy. This contingency would be implemented if monitoring indicated that additional wells were needed to evaluate the plume conditions. This contingency may be implemented if the VOC plume changes significantly and/or access to selected key monitoring wells change in the future.

5.2 Less Aggressive Remedy

This section describes the less aggressive Remedy. The remedial strategies included are monitoring, controlled migration, and plume remediation. The remedial measures/technologies included in this less aggressive remedy are:

- MNA for the groundwater plume, as described above in the reference remedy and including the existing removal processes via groundwater extraction from the nursery.
- Continued point-of-use treatment for existing potable supply wells.

- Contingency for expanding the point-of-use treatment at up to three other nearby potable, private-use supply wells if future monitoring data indicate water quality standards for the intended use are, or may be, exceeded.
- Contingency for installing up to three additional monitoring wells. This contingency would be implemented if monitoring indicated that additional wells were needed to evaluate the plume conditions.

5.3 More Aggressive Remedy

This section describes the more aggressive remedy. The remedial strategies included are monitoring, controlled migration, plume remediation, and source control. The remedial measures/technologies included in this more aggressive remedy are:

- MNA for the groundwater plume, as described above in the reference remedy and including the existing removal processes via groundwater extraction from the nursery.
- Continued point-of-use treatment for existing potable supply wells.
- SVE treatment of the area with elevated concentrations of PCE in soil vapor, as described in the reference remedy, including the contingency to expand the SVE operations to a Phase 2 treatment area.
- This more aggressive remedy includes in-situ treatment of groundwater. At present, there is no location where in-situ treatment is necessary or appropriate because the PCE concentrations are relatively low. If, however, the PCE concentrations increased over time, after the SVE system had been operation and allowed to provide source control, an in-situ remedy might be appropriate. The most likely technology for this contingent in-situ treatment would be enhanced reductive dechlorination (ERD), which would include injecting substrate and bacteria into one or more wells at or up gradient of the groundwater area with the highest PCE concentrations. This element of the remedy would not be implemented for approximately two years after the SVE remedy was terminated to give that element of the remedy time to show improvements in groundwater via source control. For costing purposes, it is assumed that three injection wells would be installed and substrate would be injected in the wells three times per year for three years. Groundwater samples would be collected from those wells and other nearby wells to evaluate the performance of the remedy.
- Contingency for expanding the point-of-use treatment to other nearby potable, private-use supply wells if future monitoring data indicate water quality standards for the intended use are, or may be, exceeded.
- Contingency for installing up to three additional monitoring wells. This contingency would be implemented if monitoring indicated that additional wells were needed to evaluate the plume conditions.

5.4 Discussion of Specific Remedial Measures

Concentrations of PCE have generally been steady or decreasing across most of the Site since monitoring began in 2015. Based on these conditions, plus the relatively low PCE concentrations observed in groundwater, a combination of MNA and other measures/technologies are proposed as the reference remedy and the alternate remedies. The MNA element of the remedy includes monitoring of selected Site wells on a periodic basis for the duration of the remedial action. The expected life-cycle of

MNA operation is uncertain because the duration of existing data is too short to make a projection regarding attenuation rates and the estimated timeframe to meet the AWQS. The operating duration of MNA as the sole remedy is assumed to be 25 years for purpose of developing the FS cost estimate. The FS cost estimate for the less aggressive remedy includes 25 year of monitoring; the reference remedy, including additional remedial measures (as a contingency), is based on 20 years of monitoring; and the more aggressive remedy is based on 15 years of monitoring. The timeframe for restoration is an estimate and the actual timeframe may be longer and is unlikely to be much shorter.

The continued point-of-use treatment for existing potable supply wells is an important element of the remedy. Existing private water supply wells are impacted, or near the VOC plume, and this treatment element is required to meet the ROs. This treatment element will be required as long as the existing wells are used for potable use and impacts exceed the AWQS. A contingency is included for expanding the point-of-use treatment recognizing the plume boundaries may change and/or use of existing wells within the existing boundary may change.

SVE is proposed for PCE mass removal from vadose zone soil which would be implemented in the hot-spot area on the both sides of Highway 260 where the PCE concentrations in soil vapor are highest. SVE is a presumptive remedy for removal of VOCs from moderately permeable soils. As presently conceived a short-term SVE pilot test would be implemented to evaluate the need and relative benefits of SVE operations. The SVE operations described herein may not be required to meet and fulfill the ROs but it is anticipated that SVE operations could reduce the project lifecycle costs.

Source area treatment of groundwater is included as an element of the more aggressive remedy. The most likely option if this action was deemed necessary or warranted would be ERD treatment including injecting substrate and dechlorinating bacteria into one or more wells in the area(s) with the highest COC concentrations. It would also include monitoring COCs and other indicator parameters. This type of a contingency would be considered to assist, or accelerate the timeframe to closure, with MNA as the primary groundwater remedy.

6.0 DETAILED COMPARISON OF THE REFERENCE REMEDY AND THE ALTERNATIVE REMEDIES

This section compares the three alternatives described in the previous section using the evaluation criteria listed in the A.A.C. 18-16 407(H). That section provides the comparative evaluation criteria required in the FS including:

1) A demonstration that the remedial alternative will achieve the remedial objectives.
2) An evaluation of consistency with the water management plans of affected water providers and the general land use plans of local governments with land use jurisdiction.
3) An evaluation of the comparison criteria including:
    a. An evaluation of the practicability of the alternative, including its feasibility, short and long-term effectiveness, and reliability, considering site-specific conditions, characteristics of the contamination resulting from the release, performance capabilities of available technologies, and institutional considerations.

b. An evaluation of risk, including the overall protectiveness of public health and aquatic and terrestrial biota under reasonably foreseeable use scenarios and end uses of water. This evaluation shall address:
    i. Fate and transport of contaminants and concentrations and toxicity over the life of the remediation;
    ii. Current and future land and resource use;
    iii. Exposure pathways, duration of exposure, and changes in risk over the life of the remediation;
    iv. Protection of public health and aquatic and terrestrial biota while implementing the remedial action and after the remedial action; and
    v. Residual risk in the aquifer at the end of remediation.

c. An evaluation of the cost of the remedial alternative, including the expenses and losses including capital, operating, maintenance, and life cycle costs. The cost analysis may include the analysis of uncertainties that may impact the cost of a remedial alternative, analysis of projected water uses and costs associated with use-based treatment, other use impairment costs of water not remediated to water quality standards, and the cost of measures such as alternative water supply or treatment. Transactional costs necessary to implement the remedial alternative, including the transactional costs of establishing long-term financial mechanisms, such as trust funds, for funding of an alternative remedy, shall be included in the cost estimate.

d. An evaluation of the benefit, or value, of the remediation. This analysis includes factors such as:
    i. Lowered risk to human and aquatic and terrestrial biota;
    ii. Reduced concentration and reduced volume of contaminated water;
    iii. Decreased liability; acceptance by the public;
    iv. Aesthetics; preservation of existing uses;
    v. Enhancement of future uses; and
    vi. Improvements to local economies.
    e. A discussion of the comparison criteria, as evaluated in relation to each other.

6.1 Evaluation of the Reference Remedy

6.1.1 Achieving Remedial Objectives

The reference remedy is anticipated to achieve remedial objectives for groundwater, which are "to restore, replace or otherwise provide for water for the designated use…." in the following ways. First, existing actions have been implemented to restore water for residents with water supply wells by providing point-of-use treatment within the plume footprint and the reference remedy will continue this action until other elements of the remedy have had time to work. The MNA portion of the remedy will restore groundwater over a period of several years. The required duration for MNA is not predictable because the existing sampling has not been conducted long enough to establish trends. Implementing

SVE in and near the former source area will reduce additional inputs of PCE to groundwater, which would likely decrease the duration of the groundwater remedy.

6.1.2 Impacts on Water Management Plans or Land Use Plans

The reference remedy is not anticipated to have any adverse impact on local water management plans or land use planning. Neither the Pinetop-Lakeside General Plan nor the Pinetop-Lakeside Navajo County Regional Plan have land use considerations that seem to conflict with the reference remedy (Pinetop-Lakeside 2015, BRW, 2004). Any new water supply wells are expected to be drilled into the Coconio aquifer, which underlies the Pinetop-Lakeside surficial aquifer in the area. Once PCE concentrations are below AWQS, groundwater will be suitable to use for any purpose, which would have a positive effect on water management, because there would be no restrictions.

6.1.3 Practicability Evaluation

The reference remedy is anticipated to be practicable to implement at the Site in the short-term and straightforward to operate and maintain in the long term. Short-term considerations are related to logistics and property access associated with installing an SVE system to treat soil vapors near the former source area. Specific requirements would be obtaining property access agreements, utility clearance and coordinating with any utility services required. The SVE system would require periodic inspections, sampling, and maintenance. SVE systems are generally reliable and a telemetry system would be included to notify operators if a maintenance visit was required. PCE, the contaminant of concern at the Site is a common chemical in groundwater at many sites and does not pose any unusual challenges for remedial actions.

6.1.4 Risk Evaluation

The reference remedy is anticipated to provide a positive effect on the overall protectiveness of public health, aquatic and terrestrial biota during and after implementation. Currently, the public is protected by providing point-of-use treatment to the nearby landowners who rely on shallow groundwater wells that are impacted by the Site. That protection will continue as long as necessary. Additional risk reduction will be achieved over several years when the MNA remedy is in place and the SVE system is intended to shorten the duration of the time required for MNA. There are no known or anticipated risks to aquatic or terrestrial biota because the PCE impacts are confined to groundwater, which is inaccessible to biota. There are no currently planned changes to land use that would amplify the existing risks at the Site. One possible change could be a different land use on the Earl Property.

The public can be protected while implementing the SVE portion of the remedy using standard construction safety practices including signage and fencing. While the SVE system is operating, public safety would be maintained by storing the equipment in a locked trailer or within a locked fence. There are no specific impacts to biota envisioned with the type of remedial actions in the reference remedy.

After the remedy is completed, it is anticipated that PCE concentrations will be less than the AWQS of 5 µg/L, such that the residual risk associated with the site will have been effectively minimized.

6.1.5 Cost Evaluation

The cost of the reference remedy including short-term capital costs, ongoing operation and maintenance costs is estimated to be $895,000. The reference remedy also includes contingencies to provide an expanded SVE system, additional point-of-use treatment for up to three residences, and installation of up to three wells for plume monitoring, at a cost of approximately $627,000 for the three contingent elements. The total cost of the reference remedy, including the contingent elements is $1,522,000. Table 6-1 summarizes the relative cost comparison for the three alternatives considered. Other transactional costs such as funding mechanisms as described in A.A.C. 18-16 407 are not anticipated to impact the cost of the reference remedy. A detailed cost breakdown for the reference remedy is presented in Appendix A, Table A-1.

Table 6-1. Summary of Costs for Remedial Alternatives

Alternative	Base Cost	Contingent Elements	Total Cost	Restoration Timeframe[2]
Reference Remedy (MNA, SVE, point-of-use treatment)	$895,000	$626,000	$1,522,000	20 Years
Less Aggressive Remedial Alternative (MNA, point-of-use treatment)	$936,000	$264,000	$1,200,000	25 Years
More Aggressive Remedial Alternative (MNA, SVE, point-of-use treatment, in situ groundwater treatment)	$1,026,000	$601,000	$1,627,000	15 years

Notes:
1. All costs are estimates and should not be interpreted as final construction, or project bid costs. Costs are in present dollars (2019) and do not include inflation. All costs include a 15% markup for project indirect costs (reporting/design/project oversight) and a 20% contingency
2. The timeframe for restoration is an estimate based on limited data, actual timeframes may be longer and are unlikely to be shorter.

6.1.6 Benefit Evaluation

The reference remedy is anticipated to provide benefits to the community as it is implemented by reducing risk associated with consumption of contaminated groundwater. Although this risk is effectively managed by point-of-use treatment, the need for such treatment will be eliminated after the MNA remedy is complete. At that point in time, PCE concentrations will be below AWQS and the volume of contaminated water will be essentially eliminated.

It is anticipated that the public will accept the reference remedy although there may be concerns associated with short-term construction related disruptions. The reference remedy is not anticipated to provide significant aesthetic enhancements, changes in future land use, or improvement to the local economy.

6.2 Evaluation of the Less Aggressive Remedy

This section evaluates the less aggressive remedy, focusing on elements where the evaluation differs from the reference remedy.

The less aggressive remedy is anticipated to achieve remedial objectives at the Site but it may take longer than the reference remedy because it does not include the SVE element for source control (a contingent element of the reference remedy). For evaluation purposes, it is assumed that monitoring would be required for up to 25 years. The impacts on water plans, practicability, risk, and benefits are expected to be very similar to the reference remedy. In comparison to the reference remedy, this less aggressive remedy represents higher potential risk because PCE vapors and groundwater exceeding the AWQS will remain in place for a longer period of time. The cost of the less aggressive remedy is estimated to be $936,000 for the primary elements, $264,000 for the contingent elements, for a total of $1,200,000 (see Table 6-1 for the relative cost comparison of the three alternatives considered). A detailed cost breakdown for the less aggressive remedy is presented in Appendix A, Table A-2.

6.3 Evaluation of the More Aggressive Remedy

This section evaluates the more aggressive remedy, focusing on elements where the evaluation differs from the reference remedy.

The more aggressive remedy is anticipated to achieve remedial objectives at the Site and would likely take a shorter timeframe than the reference remedy because it includes ERD as an active measure for groundwater. For evaluation purposes, it is assumed that the MNA monitoring would be required for up to 15 years with the inclusion of more aggressive remedial actions. The impacts on water plans, risk, and benefits are expected to be very similar to the reference remedy. The practicability of the more aggressive remedy is lower than the reference remedy because the present data have not identified higher concentrations areas where it would be applied and injecting treatment reagents cannot be applied in areas where they might negatively impact existing groundwater users. The cost of the more aggressive remedy is estimated to be $1,026,000 for the primary elements, $601,000 for the contingent elements, for a total of $1,627,000 (see Table 6-1 for the relative cost comparison of the three alternatives considered). A detailed cost breakdown for the more aggressive remedy is presented in Appendix A, Table A-3.

6.4 Comparison of the Remedial Alternatives

Many elements of the three alternatives are identical, however, it is anticipated that the duration of the remedies, although difficult to predict without more monitoring data, would vary. Table 6-2 provides a summary of the comparative analysis.

Table 6-2 Summary of Comparison of Reference Remedy and Alternative Remedies

Remedial Alternative	Will Achieve Site ROs?	Consistent with Water Management Plans?	Practicability	Risk/ Overall protectiveness	Cost (includes contingencies)	Benefit	Public Acceptance
Reference Remedy MNA, Point-of-use treatment , contingency for SVE pilot/implementation, contingency for expanding the Point-of-use treatment	Yes	Yes	High, conventional proven technologies, need property access	Protective	$1,522,000	High with targeted mass removal from source, lowered risk	Yes (Anticipated)
Less Aggressive Remedy MNA, Point-of-use treatment, contingency for expanding the Point-of-use Treatment	Yes	Yes	High, conventional proven technology	Protective, but duration is expected to be longer than reference remedy	$1,200,000	Medium, lowered risk	Yes (Anticipated)
More Aggressive Remedy MNA, Point-of-use treatment , SVE pilot/implementation, plus in-situ ERD treatment of groundwater	Yes	Yes	Medium, conventional proven technologies, need property access	Protective, anticipated shorter duration than reference remedy	$1,627,000	High with targeted mass removal from source, lowered risk	Yes (Anticipated)

All the alternatives are considered practicable, but the More Aggressive Remedy is ranked lower in terms of practicability because it is less certain how or where the in situ treatment would be applied.

7.0 PROPOSED REMEDY

The proposed remedy is recommended as a modification of the reference remedy (one element, the SVE pilot test is moved to a contingency). The proposed remedy meets the requirements of A.R.S. §49-282.06 and A.A.C. R18-16-407(I) as summarized below. The remedial measures/technologies included in the proposed remedy are:

- MNA for the groundwater plume, which would include monitoring COCs and other relevant indicator parameters to document the VOC plume stability and verify existing removal/degradation conditions. The MNA element of the remedy includes monitoring that will be used to evaluate future conditions/changes to the plume.
- Continued point-of-use treatment for existing potable supply wells.
- As a contingency, SVE treatment of the area with elevated soil vapor concentrations. This contingent element of the recommended remedy is proposed in two phases. The first phase would consist of a short-term SVE pilot test using a mobile equipment system (trailer-based). If the SVE pilot test demonstrates effective mass removal, the SVE system would be expanded in a second phase to treat a larger area. This contingency would be implemented if deemed necessary based on future monitoring results. Soil vapor with elevated PCE concentrations is present on both the east and west sides of Highway 260.
- A contingency for expanding the point-of-use treatment to other nearby potable, private-use supply wells. This contingency would be implemented if future monitoring data indicate water quality standards for the intended use are, or may be, exceeded.
- A contingency for installing up to three additional monitoring wells. This contingency may be implemented if the VOC plume changes significantly and/or access to selected key monitoring wells change in the future.

7.1 Achieving Remedial Objectives

The proposed remedy is anticipated to achieve remedial objectives for groundwater, which are to “to restore, replace or otherwise provide for water for the designated use….” by providing affected residents with point-of-use treatment; the MNA portion of the remedy will restore groundwater over a period of several years; if the SVE contingency is implemented in and near the former source area, it will reduce additional inputs of PCE to groundwater, which will decrease the duration of the groundwater remedy.

7.2 Impacts on Water Management Plans or Land Use Plans

The proposed remedy is not anticipated to have adverse impact on local water management plans or land use planning. Once PCE concentrations are below AWQS, groundwater will be suitable to use for any purpose, which would have a positive effect on water management, because there would be no restrictions.

7.3 Practicability Evaluation

The proposed remedy is anticipated to be practicable to implement at the Site in the short-term and straightforward to operate and maintain in the long term. Short-term considerations are related to logistics and property access associated with installing an SVE system to treat soil vapors near the former source area. In the long term, the SVE system would require periodic inspections, sampling, and maintenance.

7.4 Risk Evaluation

The proposed remedy is anticipated to provide a positive effect on the overall protectiveness of public health, aquatic and terrestrial biota during and after implementation. Currently, the public is protected by providing point-of-use treatment to the nearby landowners who rely on shallow groundwater wells that are impacted by the Site. Additional risk reduction will be achieved over several years when the MNA remedy is in place and if the SVE contingency is implemented, the SVE system will the duration of the time required for MNA.

If the SVE contingency is implemented, the public can be protected while implementing this portion of the remedy using standard construction safety practices including signage and fencing. If implemented, public safety would be maintained by storing the equipment in a locked trailer or within a locked fence. There are no specific impacts to biota envisioned with the type of remedial actions in the proposed remedy.

After the remedy is completed, it is anticipated that PCE concentrations will be less than the AWQS of 5 µg/L, such that the residual risk associated with the site will have been effectively minimized.

7.5 Cost Evaluation

The cost of the proposed remedy including short-term capital costs, ongoing operation and maintenance costs is estimated to be $748,000. The SVE contingency is included to reduce uncertainty in the estimated restoration timeframe; as noted in Sections 5 and 6, the number of years of MNA required is an estimate and the actual number of years may be longer. This contingency is included to address the requirements under A.A.C. R18-16-407(H)3(c) to consider uncertainties in the cost analysis that may impact life-cycle cost of remedial alternatives. The decision to implement this SVE contingency will be based on analysis of future groundwater monitoring results. The SVE contingency would be implemented to reduce uncertainty in the clean-up time and corresponding costs. The proposed remedy also includes contingencies to provide additional point-of-use treatment for up to three residences, and installation of up to three wells for plume monitoring, at a cost of approximately $774,000 for the contingent elements. The total cost of the proposed remedy is $1,522,000. Other transactional costs such as funding mechanisms as described in A.A.C. 18-16 407 are not anticipated to impact the cost of the proposed remedy. A detailed cost breakdown for the proposed remedy is presented in Appendix A, Table A-4.

7.6 Benefit Evaluation

The proposed remedy is anticipated to provide benefits to the community as it is implemented by reducing risk associated with consumption of contaminated groundwater. Although this risk is effectively managed by point-of-use treatment, the need for such treatment will be eliminated after the MNA remedy is complete. At that point in time, PCE concentrations will be below AWQS and the volume of contaminated water essentially eliminated. The SVE contingency is included to reduce uncertainty in the estimated restoration timeframe and to provide an added benefit by accelerating Site restoration.

The public acceptance of the proposed remedy will be addressed through community involvement. The proposed remedy is not anticipated to provide significant aesthetic enhancements, changes in future land use, or improvement to the local economy. There may be potential concerns associated with short-term construction related disruptions for contingent elements (i.e., construction related to a SVE pilot test and expanded SVE operations).

8.0 COMMUNITY INVOLVEMENT

ADEQ has implemented multiple community involvement (CI) steps to date and will continue to do so in the future. Existing CI steps have included:

- Public notice regarding availability of the WQARF Registry listing for the Site
- Developing a Community Involvement Plan (CIP)
- Establishing a Community Advisory Board (CAB)
- Public notice and comments on the Draft RI Report
- Public notice regarding availability of the RO Report
- Public notice regarding availability of the FS Work Plan
- Public notice regarding availability of the Final RI Report

ADEQ will issue a Notice to the Public announcing availability of FS Report on ADEQ's website at www.azdeq.gov. The notice may be mailed to the Public Mailing List for the site, water providers, the CAB, and any other interested parties.

9.0 REFERENCES

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Figures

ADEQ Arizona Department of Environmental Quality

Matrix DESIGN GROUP

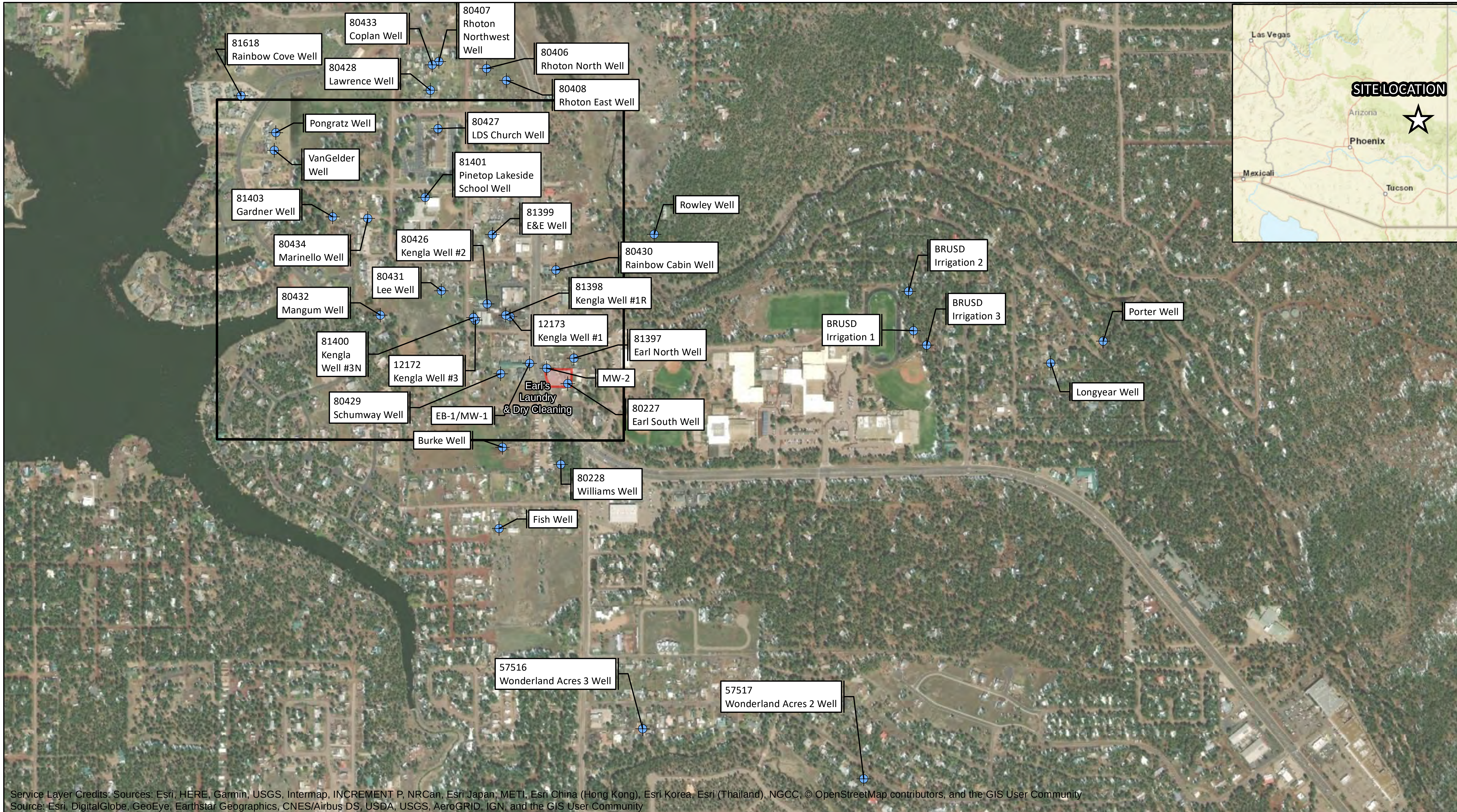
CALIBRE

LEGEND

0 12.5 25 50 Miles

N

Figure 1-1 Site Location
Highway 260 and Johnson Lane WQARF Site



ADEQ Arizona Department of Environmental Quality

Matrix DESIGN GROUP

CALIBRE

LEGEND

N

ADEQ Well ID (if available)
Common Well Name

WQARF Site Boundary

Source Area

0 250 500 1,000 Feet

Figure 1-2 Groundwater Monitoring Well Locations
Highway 260 and Johnson Lane WQARF Site

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CALIBRE

LEGEND

N

Source Area

Soil Vapor Sample Point PCE (ug/m3)

10,000 ug/m3 PCE

1,000 ug/m3 PCE

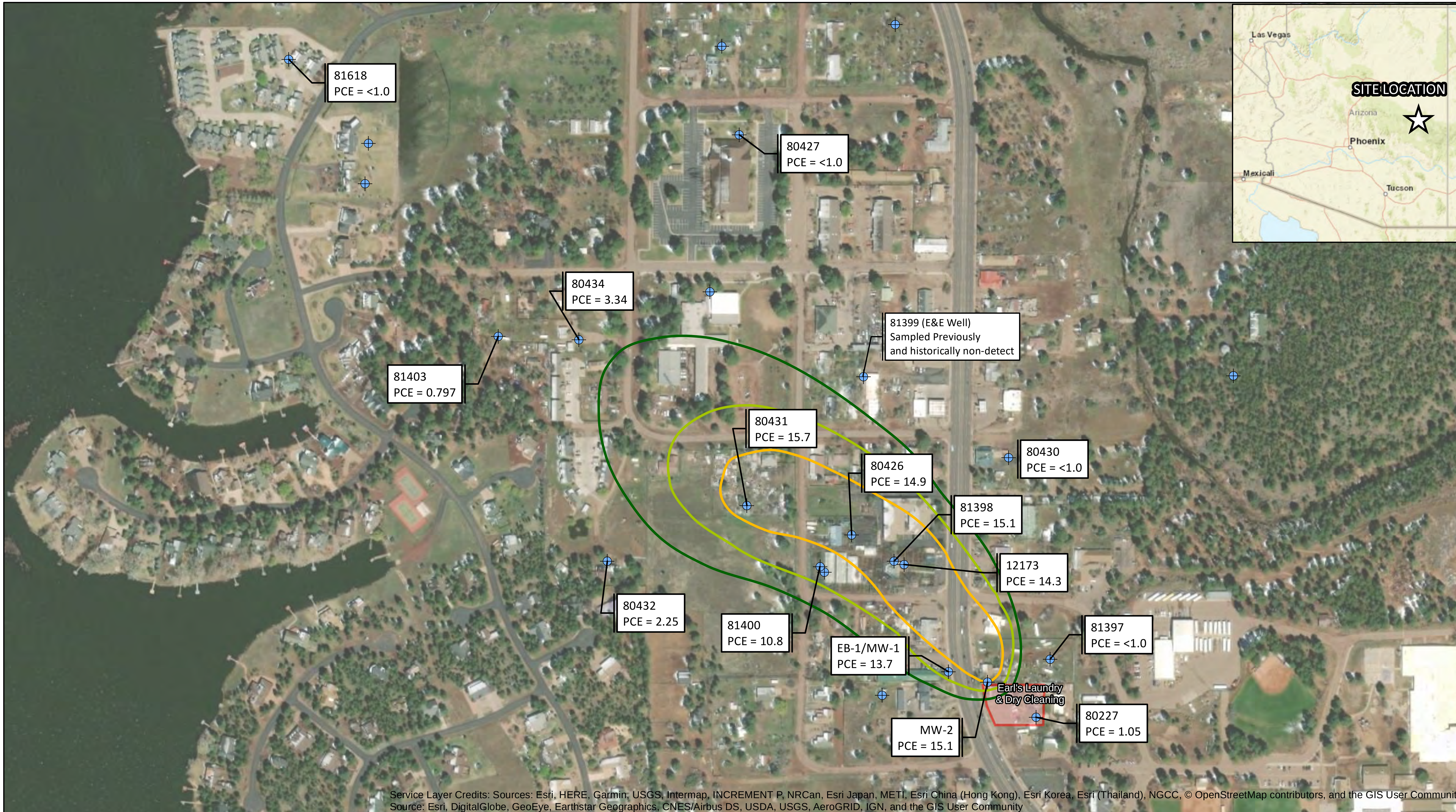
Approximate area with VOCs above specified concentration.

0 50 100 200 Feet

*Sample points SV-2, SV-9, SV-11, SV-16, and SV-18 had two samples collected. First sample result listed is from field lab analysis. Second sample result labeled confirmation sample was analyzed by a laboratory off-site.

Figure 2-1 - PCE Soil Vapor Monitoring Results 2017

Highway 260 and Johnson Lane WQARF Site



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Matrix DESIGN GROUP

CALIBRE

LEGEND

N

0 125 250 500 Feet

Well ID
PCE (ug/L)

PCE Contours
- 5 ug/L
- 10 ug/L
- 15 ug/L

Source Area

Figure 2-2 - PCE Groundwater Monitoring Results
April 2019
Highway 260 and Johnson Lane WQARF Site

Appendix A Detailed Cost Estimates

Table A-1 Reference Remedy—Monitored Natural Attenuation with SVE and point-of-use-treatment

	Quantity	Unit	Unit Cost [1]	Cost [2]	Detail
LONG TERM MONITORING COSTS (MNA)					
Monitoring Well Sampling (Years 0-20)	20	Event	$23,000	$460,000	Monitoring 20 wells to be completed 1/ yr for 20 years. Includes labor, equipment, and laboratory analysis & reporting
5-year PSR review	4	Event	$12,000	$48,000	PSR report once every 5 years
Subtotal:				**$508,000**	
SVE system- Phase 1 Pilot Test					
Phase 1 SVE Pilot Test- Setup	1	LS	$91,000	$91,000	Includes equipment delivery, installation, drilling SVE three wells, carbon vessels, delivery
SVE Pilot Test Operations (2-months)	2	mo	$8,000	$16,000	SVE operations and monitoring (labor, monitoring/lab, electrical)
Subtotal:				**$107,000**	
Point-of-use treatment at private residences					
GAC Changeout	12	Events	$450	$5,400	Assumes routine operation with periodic carbon changes in each household for years 0-20 years. It is assumed that the GAC will last 5 years at each household.
Sampling and consultation with residents	20	yr	$1,440	$29,000	Assumes periodic sampling and reporting to each household for years 0-20 years.
Subtotal:				**$34,000**	
Subtotal prior to INDIRECT COSTS & Contingency				**$649,000**	
INDIRECT COSTS					
Reporting/Design/Project Oversight[3]	1	LS	$97,350	$97,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the project period.
Alternative Subtotal (including IDCs)				**$746,000**	
Contingency (20 Percent) [4]				**$149,000**	Appropriate FS contingency for planning
SUBTOTAL prior to Contingent Elements				**$895,000**	

CONTINGENT ELEMENTS (Phase 2 SVE, Point of Use Carbon, Monitoring Wells)

Contingency for Phase 2 SVE Operations					
Construction of Expanded SVE system	1	ea	$164,000	$164,000	Includes directional drilling 3 horizontal wells under the highway
Operation and Maintenance of SVE system, 12-months,	12	mo	$7,000	$84,000	Assumes routine operation and maintenance (including carbon & electricity use) for 12 months operation after construction
Closure and demobe	1	ea	$24,000	$24,000	Demobilize equipment, spent carbon disposal, decommissioning of wells.
Subtotal:				**$272,000**	
Contingency for 3 Additional Point-of-Use Carbon Units					
Purchase and Install 3 additional GAC Units	3	ea	$1,000	$3,000	
GAC Changeout	12	Events	$450	$5,400	Assumes routine operation with periodic carbon changes in each household for years 0-20 years
Sampling and consultation with residents	20	yr	$1,440	$29,000	Assumes periodic sampling and reporting to each household for 0-20 years
Subtotal:				**$37,000**	
Contingency for 3 Additional Monitoring Wells					
Install wells with oversight	3	ea	$34,333	$103,000	Permitting, drilling, oversight, waste management
Sample wells annually	20	yr	$2,100	$42,000	Assumes sampling and reporting for years 0-20
Subtotal:				**$145,000**	
Subtotal of Contingent Elements prior to IDCs and Contingency				**$454,000**	
INDIRECT COSTS on Contingent Elements					
Reporting/Design/Project Oversight[3]	1	LS	$68,100	$68,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the project period.
Contingent Elements Cost (Including IDCs)				**$522,000**	
Contingency (20 Percent) [4]				**$105,000**	Appropriate contingency for feasibility-level planning.
SUBTOTAL COST OF CONTINGENT ELEMENTS				**$627,000**	
TOTAL COST OF ALTERNATIVE WITH CONTINGENT ELEMENTS				**$1,522,000**	Reference Remedy

Notes:

1 All cost values are estimates and should not be interpreted as final project costs. Costs are in present dollar and do not include inflation costs.

2 Total values are rounded up to the nearest $1,000.

3 Anticipated indirect costs are assumed as 15% of the estimated remediation cost.

4 A 20% Contingency is appropriate for feasibility-level planning and will be reduced during the remedial design phase of the project.

Abbreviations:

IDC	Indirect Cost
LS	Lump Sum
YR	Year

Table A-2 Less Aggressive Remedy—Monitored Natural Attenuation and point-of-use-treatment

	Quantity	Unit	Unit Cost [1]	Cost [2]	Detail
LONG TERM MONITORING COSTS (MNA)					
Monitoring Well Sampling (Years 0-25)	25	Event	$23,000	$575,000	Monitoring 20 wells to be completed 1/ yr for 25 years. Includes labor, equipment, and laboratory analysis & reporting
5-year PSR review	5	Event	$12,000	$60,000	PSR report once every 5 years
Subtotal:				**$635,000**	
Point-of-use treatment at private residences					
GAC Changeout	15	Events	$450	$6,750	Assumes routine operation with periodic carbon changes in each household for years 0-25 years. It is assumed that the GAC will last 5 years at each household.
Sampling and consultation with residents	25	yr	$1,440	$36,000	Assumes periodic sampling and reporting to each household for years 0-25 years.
Subtotal:				**$43,000**	
Subtotal prior to INDIRECT COSTS and Contingency				**$678,000**	
INDIRECT COSTS					
Reporting/Design/Project Oversight[3]	1	LS	$101,700	$102,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the 25-year project period.
Alternative Subtotal (including IDCs)				**$780,000**	
Contingency (20 Percent) [4]				**$156,000**	Appropriate FS contingency for planning
SUBTOTAL prior to Contingent Elements				**$936,000**	

CONTINGENT ELEMENTS (Point of Use Carbon, Monitoring Wells)

Contingency for 3 Additional Point-of-Use Carbon Units					
Purchase and Install 3 additional GAC Units	3	ea	$1,000	$3,000	
GAC Changeout	15	Events	$450	$6,750	Assumes routine operation with periodic carbon changes in each household for years 0-25 years
Sampling and consultation with residents	25	yr	$1,440	$36,000	Assumes periodic sampling and reporting to each household for years 0-25
Subtotal:				**$46,000**	
Contingency for 3 Additional Monitoring Wells					
Install wells with oversight	3	ea	$34,333	$103,000	
Sample wells annually	20	yr	$2,100	$42,000	
Subtotal:				**$145,000**	
Subtotal of Contingent Elements prior to IDCs and Contingency				**$191,000**	
INDIRECT COSTS on Contingent Elements					
Reporting/Design/Project Oversight[3]	1	LS	$28,650	$29,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over theproject period.
Contingent Elements Cost (Incluuding IDCs)				**$220,000**	
Contingency (20 Percent)[4]				**$44,000**	Appropriate contingency for feasibility-level planning.
SUBTOTAL COST OF CONTINGENT ELEMENTS				**$264,000**	
TOTAL COST OF ALTERNATIVE WITH CONTINGENT ELEMENTS				**$1,200,000**	Less Aggressive Remedy

Notes:

1 All cost values are estimates and should not be interpreted as final project costs. Costs are in present dollar and do not include inflation costs.

2 Total values are rounded up to the nearest $1,000.

3 Anticipated indirect costs are assumed as 15% of the estimated remediation cost.

4 A 20% Contingency is appropriate for feasibility-level planning and will be reduced during the remedial design phase of the project.

Abbreviations:

IDC Indirect Cost
LS Lump Sum
YR Year

Table A-3 More Aggressive Remedy—Monitored Natural Attenuation, SVE, ERD, and Point-of-Use-Treatment

	Quantity	Unit	Unit Cost [1]	Cost [2]	Detail
LONG TERM MONITORING COSTS (MNA)					
Monitoring Well Sampling (Years 0-15)	15	Event	$23,000	$345,000	Monitoring 20 wells to be completed 1/ yr for 15 years. Includes labor, equipment, and laboratory analysis & reporting
5-year PSR review	3	Event	$12,000	$36,000	PSR report once every 5 years
Subtotal:				**$381,000**	
SVE system- Phase 1 Pilot Test					
Phase 1 SVE Pilot Test- Setup	1	LS	$91,000	$91,000	Includes equipment delivery, installation, drilling SVE three wells, carbon vessels, delivery
SVE Pilot Test Operations (2-months)	2	mo	$8,000	$16,000	SVE operations and monitoring (labor, monitoring/lab, electrical)
Subtotal:				**$107,000**	
ERD Treatment					
Install wells with oversight	3	ea	$34,333	$103,000	
Census testing and microbe Injection	1	ea	$2,700	$2,700	One time at each well
ERD Injections	9	Events	$13,685	$123,161	3 events per year for 3 years
Subtotal:				**$229,000**	
Point-of-use treatment at private residences					
GAC Changeout	9	Events	$450	$4,050	Assumes routine operation with periodic carbon changes in each household for years 0-15 years. It is assumed that the GAC will last 5 years at each household.
Sampling and consultation with residents	15	yr	$1,440	$22,000	Assumes periodic sampling and reporting to each household for years 0-15 years.
Subtotal:				**$26,000**	
Subtotal prior to INDIRECT COSTS and Contingency				**$743,000**	
INDIRECT COSTS					
Reporting/Design/Project Oversight[3]	1	LS	$111,450	$112,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the 15-year project period.
Alternative Subtotal (including IDCs)				**$855,000**	
Contingency (20 Percent) [4]				**$171,000**	Appropriate FS contingency for planning
SUBTOTAL prior to Contingent Elements				**$1,026,000**	

CONTINGENT ELEMENTS (Phase 2 SVE, Point of Use Carbon, Monitoring Wells)

Contingency for Phase 2 SVE Operations					
Construction of Expanded SVE system	1	ea	$164,000	$164,000	Includes directional drilling 3 horizontal wells under the highway
Operation and Maintenance of SVE system, 12-months,	12	mo	$7,000	$84,000	Assumes routine operation and maintenance (including carbon & electricity use) for 12 months operation after construction
Closure and Demobe	1	ea	$24,000	$24,000	Demobilize equipment, spent carbon disposal, decommissioning of wells.
Subtotal:				**$272,000**	
Contingency for 3 Additional Point-of-Use Carbon Units					
Purchase and Install 3 additional GAC Units	3	ea	$1,000	$3,000	
GAC Changeout	9	Events	$450	$4,050	Assumes routine operation with periodic carbon changes in each household for years 0-15 years
Sampling and consultation with residents	15	yr	$1,440	$22,000	Assumes periodic sampling and reporting to each household for years 0-15 years
Subtotal:				**$29,000**	
Contingency for 3 Additional Monitoring Wells					
Install wells with oversight	3	ea	$34,333	$103,000	
Sample wells annually	15	yr	$2,100	$31,500	
Subtotal:				**$135,000**	
Subtotal of Contingent Elements prior to IDCs and Contingency				**$436,000**	
INDIRECT COSTS on Contingent Elements					
Reporting/Design/Project Oversight[3]	1	LS	$65,400	$65,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the 15-year project period.
Contingent Elements Cost (Incluuding IDCs)				**$501,000**	
Contingency (20 Percent)[4]				**$100,000**	Appropriate contingency for feasibility-level planning.
SUBTOTAL COST OF CONTINGENT ELEMENTS				**$601,000**	
TOTAL COST OF ALTERNATIVE WITH CONTINGENT ELEMENTS				**$1,627,000**	More Aggressive Remedy

Notes:

1 All cost values are estimates and should not be interpreted as final project costs. Costs are in present dollar and do not include inflation costs.

2 Total values are rounded up to the nearest $1,000.

3 Anticipated indirect costs are assumed as 15% of the estimated remediation cost.

4 A 20% Contingency is appropriate for feasibility-level planning and will be reduced during the remedial design phase of the project.

Abbreviations:

IDC	Indirect Cost
LS	Lump Sum
YR	Year

Table A-4 Proposed Remedy—Monitored Natural Attenuation, SVE, and Point-of-Use-Treatment

	Quantity	Unit	Unit Cost [1]	Cost [2]	Detail
LONG TERM MONITORING COSTS (MNA)					
Monitoring Well Sampling (Years 0-20)	20	Event	$23,000	$460,000	Monitoring 20 wells to be completed 1/ yr for 20 years. Includes labor, equipment, and laboratory analysis & reporting
5-year PSR review	4	Event	$12,000	$48,000	PSR report once every 5 years
Subtotal:				**$508,000**	
Point-of-use treatment at private residences					
GAC Change out	12	Events	$450	$5,400	Assumes routine operation with periodic carbon changes in each household for years 0-20 years. It is assumed that the GAC will last 5 years at each household.
Sampling and consultation with residents	20	yr	$1,440	$29,000	Assumes periodic sampling and reporting to each household for years 0-20 years.
Subtotal:				**$34,000**	
Subtotal prior to INDIRECT COSTS and Contingency				**$542,000**	
INDIRECT COSTS					
Reporting/Design/Project Oversight[3]	1	LS	$81,300	$81,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the 20-year project period.
Alternative Subtotal (including IDCs)				**$623,000**	
Contingency (20 Percent) [4]				**$125,000**	Appropriate FS contingency for planning
SUBTOTAL prior to Contingent Elements				**$748,000**	

CONTINGENT ELEMENTS (Phase 1&2 SVE, Point of Use Carbon, Monitoring Wells)

	Quantity	Unit	Unit Cost	Cost	Detail
Contingency for SVE system- Phase 1 Pilot Test					
Phase 1 SVE Pilot Test- Setup	1	LS	$91,000	$91,000	Includes equipment delivery, installation, drilling SVE three wells, carbon vessels, delivery
SVE Pilot Test Operations (2-months)	2	mo	$8,000	$16,000	SVE operations and monitoring (labor, monitoring/lab, electrical)
Subtotal:				**$107,000**	

Contingency for Phase 2 SVE Operations					
Construction of Expanded SVE system	1	ea	$164,000	$164,000	Includes directional drilling 3 horizontal wells under the highway
Operation and Maintenance of SVE system, 12-months,	12	mo	$7,000	$84,000	Assumes routine operation and maintenance (including carbon & electricity use) for 12 months operation after construction
Closure and Demobe	1	ea	$24,000	$24,000	Demobilize equipment, spent carbon disposal, decommissioning of wells.
Subtotal:				**$272,000**	
Contingency for 3 Additional Point-of-Use Carbon Units					
Purchase and Install 3 additional GAC Units	3	ea	$1,000	$3,000	
GAC Change out	12	Events	$450	$5,400	Assumes routine operation with periodic carbon changes in each household for years 0-20 years
Sampling and consultation with residents	20	yr	$1,440	$29,000	Assumes periodic sampling and reporting to each household for years 0-20 years
Subtotal:				**$37,000**	
Contingency for 3 Additional Monitoring Wells					
Install wells with oversight	3	ea	$34,333	$103,000	
Sample wells annually	20	yr	$2,100	$42,000	
Subtotal:				**$145,000**	
Subtotal of Contingent Elements prior to IDCs and Contingency				**$561,000**	
INDIRECT COSTS on Contingent Elements					
Reporting/Design/Project Oversight[3]	1	LS	$84,150	$84,000	Assumes 15% of overall cost for project oversight, management, permits, work plans, regulatory interaction, etc., over the 15-year project period.
Contingent Elements Cost (Including IDCs)				**$645,000**	
Contingency (20 Percent) [4]				**$129,000**	Appropriate contingency for feasibility-level planning.
SUBTOTAL COST OF CONTINGENT ELEMENTS				**$774,000**	
TOTAL COST OF ALTERNATIVE WITH CONTINGENT ELEMENTS				**$1,522,000**	Recommended Remedy

Notes:

1 All cost values are estimates and should not be interpreted as final project costs. Costs are in present dollar and do not include inflation costs.

2 Total values are rounded up to the nearest $1,000.

3 Anticipated indirect costs are assumed as 15% of the estimated remediation cost.

4 A 20% Contingency is appropriate for feasibility-level planning and will be reduced during the remedial design phase of the project.

Abbreviations:

IDC	Indirect Cost
LS	Lump Sum
YR	Year