wood.

Feasibility Study Report

40th Street and Osborn Road WQARF Registry Site
Phoenix, Arizona
Project # 14-2020-2037

REGISTERED GEOLOGIST
CERTIFICATE NO.
29374
JAMES N.
CLARKE
Date Signed 6-25-2021
ARIZONA U.S.A.

Prepared for:

ADEQ
Arizona Department
of Environmental Quality

Arizona Department of Environmental Quality
1110 West Washington Street, Phoenix, Arizona 85007

June 25, 2021

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June 25, 2021

Lisa Kowalczyk
Arizona Department of Environmental Quality
Remedial Projects Section, Remedial Projects Unit
1110 West Washington Street
Phoenix, Arizona 85007

Dear Ms. Kowalczyk:

Re: Feasibility Study Report
40th Street and Osborn Road WQARF Registry Site
Phoenix, Arizona

We certify that this document and attachments presented in this report are accurate and complete. This report was prepared by the staff of Wood Environment and Infrastructure Solutions, Inc. (Wood) under our supervision to ensure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who are directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate and complete.

If you have any questions or comments regarding this report, please contact Jim Clarke at (602) 733-6055.

Respectfully submitted,

Wood Environment & Infrastructure Solutions, Inc.	**Reviewed by:**
Registered Geologist Certificate No. 29374 JAMES N. CLARKE Date Signed 6-25-2021 Arizona U.S.A.	Registered Professional Engineer (Civil) Certificate No. 52733 DOUGLAS FISHER Date Signed 6-25-2021 Arizona U.S.A.
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Senior Associate Geologist	Senior Associate Engineer

c: Addressee

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List of Acronyms and Abbreviations

µg/L	Micrograms per liter
mg/L	milligrams per liter
48th & IS site	48th Street and Indian School Road WQARF site
A.A.C.	Arizona Administrative Code
A.R.S.	Arizona Revised Statutes
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
amsl	above mean sea level
AWQS(s)	Aquifer Water Quality Standard(s)
bgs	below ground surface
btoc	Below top of casing
cis-1,2-DCE	cis-1,2- dichloroethene
COC	contaminant of concern
COP	City of Phoenix
CSM	conceptual site model
DHE	Dehalococcoides Ethenogenes
DO	dissolved oxygen
Earth Tech	Earth Technologies, Inc
ECP	East Central Phoenix
ERD	enhanced reductive dechlorination
FOCIS™	Feedback Optimized Continuous Injection System™
FS	Feasibility Study
ft	feet
ft/ft	feet per foot
ft/yr	feet per year
gpm	gallons per minute
GWET	groundwater extraction and treatment
IDW	investigation derived waste
ISCO	in-situ chemical oxidation
ISCR	in-situ chemical reduction
LAU	Lower Alluvial Unit
lbs	pounds

List of Acronyms and Abbreviations (cont.)

LGAC	liquified granular activated carbon
LWUS	Land and Water Use Study
MAU	middle alluvial unit
MNA	monitored natural attenuation
O&M	operation & maintenance
OM&M	operation, maintenance, and monitoring
ORP	oxidation reduction potential
OU	Operable Unit
PCE	tetrachloroethene
PQGWWP	Poor Quality Groundwater Withdrawal Permit
PRB	permeable reactive barrier
Red ox	oxidation-reduction
remedial measures	remedial strategies and actions
RD	reductive dechlorination
RI	remedial investigation
ROs	remedial objectives
ROW	Right(s)-of-way
Site	40th Street and Osborn Road WQARF site
SRP	Salt River Project
TCE	trichloroethene
UAU	upper alluvial unit
VC	vinyl chloride
VOC	volatile organic compound
VPS(s)	vertical profile sample(s)
Wood	Wood Environment & Infrastructure Solutions, Inc.
WQARF	Water Quality Assurance Revolving Fund

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 40th Street and Osborn Road Water Quality Assurance Revolving Fund (WQARF) site (Site). The Site is located in Phoenix, Arizona (**Figure 1**) and covers an area of mixed commercial, educational and residential land use. There is a school associated with San Pablo Episcopal Church located at the northeast corner of 31st Street and Windsor Avenue. The Wood Environment & Infrastructure Solutions, Inc. (Wood) completed the work described in this report under Arizona Superfund Remedial Action Contract Purchase Order Number PO0000109764 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) as outlined in the Remedial Objectives Report (ADEQ, 2020a); and,
- Evaluate the identified remedies and recommend alternatives that comply with the requirements of Arizona Revised Statutes (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, Wood 2020a). This FS has been developed 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 (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.
- The alternative remedy evaluated is less aggressive than the reference remedy.

In accordance with A.A.C. R18-16-407(I), based on the evaluation of the reference remedy and the alternative remedy, 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.

2.0 Site 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 Remedial Investigation (RI) report (Wood 2020a) and the *BMW-20B, BMW-21B, BMW-22B Well Drilling and Groundwater Monitoring Technical Memorandum, East Central Phoenix 40th Street and Osborn Road Water Quality Assurance Revolving Fund Site, Phoenix, Arizona* dated June 26, 2020 (Wood, 2020b). This section also includes a description of the conceptual site model (CSM) for the Site.

2.1 Site Description and History

The Site is bounded by East Fairmount Avenue to the north, East Hubbell Street to the south, 42nd Street to the east and 25th Street to the west. The boundary line between the Site and the adjacent (east) 48th Street and Indian School Road WQARF site (herein referred to as the 48th & IS site) is currently 42nd Street (**Figure 1**). The Site is located in an area of mixed commercial, educational, and residential development.

The investigation began in 1983 when Salt River Project (SRP) collected groundwater samples from several wells that they were pumping in the Salt River Valley. This included SRP Well 17.9E-7.5N, which is located within the Site and west of the intersection of 40th Street and Osborn Road (**Figure 1**). PCE was detected at a concentration of 53 micrograms per liter (µg/L) in the sample collected from SRP Well 17.9E-7.5N, which is above the Aquifer Water Quality Standard (AWQS) of 5.0 µg/L. SRP took the well off-line in 1990, but continued operating the well periodically to collect water quality samples. The maximum PCE concentration of 210 µg/L was reported in the 1998 sample collected from SRP Well 17.9E-7.5N. PCE concentrations decreased to non-detect in the 2016 sample (ADEQ, 2020b).

Based on the results of the SRP well sampling, the East Central Phoenix (ECP) Study Area was established in 1988. The ECP Study Area was bounded by Camelback Road to the north, McDowell Road to the south, 50th Street to the east and 20th Street to the west and included the Site. The ECP Study Area has historically contained dry cleaning facilities, service stations, and printing shops, with some of the dry cleaners operating since 1962.

In 1997, ADEQ established the WQARF Registry, replacing the WQARF Priority List. In 1998, the ECP Study Area was divided into six individual WQARF Registry sites:

- 40th Street and Osborn Road (Site);
- 48th Street and Indian School Road;
- 40th Street and Indian School Road;
- 38th Street and Indian School Road;
- 32nd Street and Indian School Road; and,
- 24th Street and Grand Canal.

The Site was placed on the WQARF Registry List in May 2000 (ADEQ, 2000).

2.2 Physiographic Setting

A detailed description of the Site physiography is provided in the RI Report (Wood, 2020a). In summary, the Site is located within the eastern portion of West Salt River Valley sub-basin of the Phoenix Active Management Area (AMA), a broad, relatively level alluvial valley filled with layers of unconsolidated sand, gravel, silt, clay. The Site is located within the United States Geologic Survey Topographic 7.5 Minute Phoenix map, which shows a general topographic trend of decreasing elevations from the northeast to southwest. The ground surface slopes to the southwest and drops approximately 114 feet (ft) between wells BMW-04A (1,163.11 ft amsl) and BMW-16D (1,049.44 ft amsl) (**Figure 3**).

In 1993, the Arizona Department of Water Resources (ADWR) released the results of its modeling study of the Salt River Valley (Corkhill et al., 1993). For modeling purposes, the ADWR defined three hydrogeologic units in the basin-fill by differences in grain size that occur throughout most of the Phoenix Basin and are generally correlative with the hydrostratigraphic units defined by the United States Bureau of Reclamation in 1976. These include from the shallowest to deepest: the Upper Alluvial Unit (UAU), the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU). The UAU consists of unconsolidated sands and gravels deposited by flowing drainages and is the most permeable unit. The MAU and LAU are not present at the Site.

The Site has been assessed up to a depth of 300 ft below ground surface (bgs). The lithology below the Site consists predominantly of silt, clay, sand mixed with silt and/or clay, and gravel. The lithology at upgradient well BMW-02E and downgradient well BMW-16D is summarized on the following pages.

BMW-02E	
Depth (ft bgs)	**Summary Description**
0-67	sandy silt
67-75	clay with gravel
75-88	gravelly silt with sand
88-103	silt with sand
103-119	gravelly silt with sand
119-125	sandy silt with gravel
125-127	silt with gravel
127-130	silty gravel with sand
130-137	gravelly silt
137-154	silt with sand
155-157	gravelly silt with sand
157-174	sandy clay
174-187	sandy silt
187-197	clay with gravel
197-217	sandy silt with gravel
217-223	sandy clay with gravel
223-236	silty sand with gravel
236-243	sandy clay with gravel
243-248	clayey gravel with sand
248-276	sandy silt with gravel
276	bedrock – Upper Camels Head Formation

BMW-16D	
Depth (ft bgs)	**Summary Description**
0-25	silt with sand
25-44	sandy silt with gravel
44-73	silt with sand
73-95	silt with clay
95-107	clay with sand
107-127	silty gravel with sand
127-148	clay with sand
148-151	sandy silt with gravel
151-166	clay
166-172	clayey sand
172-187	Clay
187-202	clay with gravel
202-226	clayey sand with gravel
226-240	sandy clay with gravel
240-253	silty sand with gravel
253-265	sandy clay with gravel
265-276	clayey sand with gravel
276-279	silty sand with gravel
279-286	gravelly clay with sand
286-290	clayey sand with gravel

ft bgs – feet below ground surface

As indicated above, bedrock, identified as the Camels Head Formation, was encountered at a depth of 276 ft below top-of-casing (btoc) (923.53 ft amsl) at BMW-02E and at a depth of 285 ft btoc at BMW-10D (863.63 ft amsl). Bedrock was not encountered at monitoring wells BMW-14D and BMW-16D. Based on the lithology, the MAU and LAU are not considered to be present below the Site. Therefore, the UAU/Camels Head Formation contact drops approximately 60 ft in a southwesterly direction between BMW-02E and BMW-10D, which is a slope of approximately 0.007 ft per ft (ft/ft) (**Figure 3**).

The hydrostratigraphic units have been defined based on review and evaluation of data generated during groundwater assessments at the ECP WQARF sites. The hydrogeology has been investigated to a maximum depth of approximately 300 ft bgs within the UAU. The base of the UAU was encountered at BMW-02E, BMW-09D, BMW-10D, BMW-17D, BMW-18D, and BMW-19D. The UAU ranges from 276 ft thick at BMW-02E to greater than 300 ft thick at BWM-14D. The UAU consists of predominantly fine-grained sands, silts and silt with sand, to sandy silts with trace amounts of gravel. The groundwater surface lies within the UAU.

Monitoring well construction details for the Site are presented in **Table 1**. The monitoring wells are designated Zone A-D as follows based on depth and screened interval:

Zone	Well IDs	Screened Interval Range[1] (ft btoc)	Sample Depth Range[2] (ft btoc)
A	BMW-01A, BMW-02A, BMW-03A, BMW-04A, BMW-07A, BMW-10B[3], MW-1, MW-7, MW-8, MW-9, and MW-10	20-105 (across water table at all wells)	30-100
B	BMW-01B, BMW-02B, BMW-03B, BMW-04B, BMW-07B, and BMW-09C	70-120 (submerged at all wells)	70-115
C	BMW-02C	95-130 (submerged)	100-120
D	BMW-02E[4], BMW-09D, BMW-10D, BMW-11D, BMW-14D, BMW-16D, BMW-17D, BMW-18D, and BMW-19D	155-275 (submerged at all wells)	160-265

Notes:

1) Screened interval range is in feet below top-of-casing (ft btoc) and is obtained from **Table 1.** Depth-water ranges at the Site ranges from 39.10 ft btoc at BMW-03A to 82.90 ft btoc at BMW-16D
2) Sample depth range in in ft btoc and is obtained from **Table 3.**
3) BMW-10B is grouped as a Zone A well.
4) BMW-02E replaced the well that was supposed to be installed in BMW-02D. Therefore, it is grouped as a Zone D well.

Groundwater elevations in the UAU have been monitored since June 2003 (**Table 2**; **Appendix A** - hydrographs). Monitoring wells installed at the Site are screened across both shallow (water table) and deeper intervals within the UAU (**Figure 3** and **Table 1**). Groundwater elevations have generally declined since 2003. Depth to groundwater on May 13, 2020 ranged from 82.25 ft btoc (1,049.44 ft amsl) at BMW-04A to 37.26 ft btoc (1,163.11 ft amsl) at BMW-16D (**Table 2 and Figure 6**).

As shown by the groundwater elevation hydrographs in **Appendix A**, water levels have been historically declining. The longest record of water levels is available for BMW-01A, dating to June 13, 2003. Water level declines for select monitoring wells are provided as follows:

Well	Maximum GWE (ft AMSL)	Date	Current GWE (ft AMSL)	Date	Change since maximum GWE (ft)	Change Rate (ft/yr)
BMW-01A	1,166.30	06/13/03	1,152.69	9/21/20	-13.61	-0.80
BMW-02A	1,168.18	10/01/08	1,157.90	9/21/20	-10.28	-0.86
BMW-02B	1,168.83	6/3/08	1,157.85	9/21/20	-10.98	-0.84
BMW-02C	1,168.83[1]	6/3/08	1,157.82	9/21/20	-11.01	-0.85
BMW-02E	1,168.83[1]	6/3/08	1,157.53	9/21/20	-11.30	-0.87
BMW-03A	1,171.51	10/01/08	1,161.10	9/21/20	-10.41	-0.87
BMW-03B	1,171.46	10/08/08	1,161.10[2]	9/21/20	-10.36	-0.80
BMW-04A	1,168.05	02/27/14	1,162.92	9/21/20	-5.13	-0.79
BMW-04B	1,168.07	02/27/14	1,162.89	9/21/20	-5.18	-0.80
BMW-07A	1,155.34	8/24/2016	1,147.00	9/21/20	-8.34	-2.24
BMW-07B	1,155.26	8/24/2016	1,147.07	9/21/20	-8.19	-2.25
BMW-09D	1,119.41	11/30/18	1,117.96	9/21/20	-1.45	-0.73
BMW-10D	1,074.48	11/30/18	1,073.84	9/21/20	-0.64	-0.32
BMW-14D	1,055.99	5/13/20	1,055.52	9/21/20	-0.47	-1.42
BMW-16D	1049.44	5/13/20	1048.86	9/21/20	-0.58	-1.74

Notes:

AMSL – above mean sea level
Ft - feet
GWE – Groundwater elevation in feet above mean sea level (ft AMSL)
ft/yr – feet per year
feet above mean sea level (ft AMSL)
ft/yr – feet per year
1 – based on BMW-02B
2 – based on BMW-03A

The current (**Figure 4**) and historical direction of groundwater flow has been to the west-southwest with a current gradient of approximately 0.01 ft/ft. Vertical gradients between the shallow and deeper zones of the UAU monitored are generally negligible. The estimated horizontal hydraulic conductivity of the UAU is variable due to the heterogeneity of the UAU. Based on the results of groundwater modeling that has been performed at an upgradient wells (Fluid Solutions, 2000) and hydraulic parameter determinations of the lithologic logs from on-site wells, the horizontal hydraulic conductivity ranges from 5 to 15 ft/day. Assuming an effective porosity of 0.25, the current groundwater velocity ranges from 0.2 to 0.6 ft/day or 73 to 219 ft/year (ft/yr).

2.3 Nature and Extent of Contamination

The purpose of the RI was to determine the nature and extent of contamination. The RI also identified present and foreseeable land and water use that have been or could become impacted by the contamination associated. A summary of the RI findings is presented below (Wood, 2020a):

- The COC at the Site is dissolved PCE in the groundwater. The source of the PCE is currently unknown.

- Based on the October 2019 groundwater sampling event, the maximum concentration of PCE is 120 µg/L in samples BMW-02E-160 (1,039.63 ft amsl), BMW-02E-260 (939.63 ft amsl), and BMW-17D-140 (1,050.00 ft amsl).
- The vertical extent of groundwater impact has been characterized to bedrock.
- Groundwater flows in a southwesterly direction.
- Though PCE concentrations are slightly above the AWQS of 5.0 µg/L in groundwater samples collected from the furthest downgradient monitoring well BMW-16D, it has been determined that the downgradient extent of the PCE is adequately defined to complete the RI and FS.
- Additional details of land and water use within the Site are provided in the Remedial Investigation Report (Wood, 2020a).

Between April 2008 and May 2020, 18 monitoring wells were installed to characterize the areal and vertical extents of the PCE plume as follows:

- 5 Zone B wells – Site wells BMW-01B, BMW-02B, BMW-03B, BMW-04B, BMW-07B, and BMW-09C;
- 1 Zone C well - BMW-02C; and,
- 12 Zone D wells - BMW-02E, BMW-09D, BMW-10D, BMW-11D, BMW-14D, BMW-16D, BMW-17D, BMW-18D, BMW-19D, BMW-20, BMW-21D and BMW-22D.

The depth and sample intervals for each Zone are provided in the table in Section 2.2. Four borings identified as BMW-02D, BMW-08D, BMW-15D, and SMW-14B were also drilled with vertical profile samples (VPSs) collected at depths ranging from 40 ft bgs to 285 ft bgs, encompassing Zones A-D (**Table 4**).

Based on the results of the October 2019 groundwater monitoring event (Wood, 2020a) and the May 2020 monitoring well installation activities (Wood, 2020b), the aerial and vertical distributions of the dissolved PCE plume have interpreted as shown on **Figures 2-5**.

The Site PCE plume is described as follows (**Figures 2-5**):

- Extending from 112.5 ft bgs (1087.03 ft amsl) to 260 ft bgs (939.63 ft amsl) at BMW-02C/E (approximately 147.5 ft thick) at the upgradient end of the plume; and,
- Extending from 208 ft bgs (923.69 ft amsl) to approximately 245 ft bgs (886.69 (ft amsl) at BMW-16D (approximately 37 ft thick) at the downgradient end of the plume.

The entire plume is submerged below the water table and the decreasing thickness in the downgradient direction is controlled by the groundwater gradient and the underlying bedrock.

The September 2020 groundwater elevations are shown on **Figure 6**. The maximum PCE concentration reported was 120 µg/L in samples BMW-02E-160 (1,039.63 ft amsl), BMW-02E-260 (939.63 ft amsl), and BMW-17D-140 (1,050.00 ft amsl).

The BIOCHLOR Natural Attenuation Decision Support System, Version 2.2 (BIOCHLOR) was used to estimate the mass of dissolved PCE in the plume for the September 2020 groundwater sampling event. As shown on **Figures 2 and 3**, the PCE plume changes in width and thickness in the downgradient direction. Therefore, the PCE mass evaluation was performed on an area basis using the September 2020 PCE results. Average PCE concentrations for each well were input to the BIOCHLOR Model. The following provides the per area and total PCE mass/weight estimates for the September 2020 groundwater monitoring event.

Area	Wells and Average PCE Concentrations	Plume Water Volume (MGals)	PCE Mass (Kg)	PCE Weight (Lbs)
U[1]	BMW-02C/E (38 µg/L) Upgradient (55 µg/L)	44.30	9.9	21.83
1	BMW-02C/E (38 µg/L) BMW-17D (98 µg/L) BMW-22D (65 µg/L)	139.84	43.3	95.46
2	BMW-22D (65 µg/L) BMW-09C (18 µg/L)	31.84	7.1	15.65
3	BMW-09C (18 µg/L) BMW-18D (10 µg/L) BMW-10D (5 µg/L)	62.32	3.0	6.61
4	BMW-10D (5 µg/L)	10.52	0.7	1.54
5	BMW-14D (3.4 µg/L) BMW-16D (13 µg/L)	4.65	0.2	0.44
	Total	293.47	64.2	141.53

Notes:
MGals: million gallons
Kg: kilograms
Lbs: pounds
1. Area U is the area located upgradient of BMW-02

2.4 Risk Evaluation/Conceptual Site Model

2.4.1 Potential Receptors

Prior to performing the exposure pathway evaluation, potential receptors to COCs were identified. The Site boundary (**Figure 2**) includes an area encompassing residential, educational and commercial/industrial settings. As indicated in Section 1.0, there is a school associated with San Pablo Episcopal Church located at the northeast corner of 31st Street and Windsor Avenue. Potential receptors are identified as current and future residential individuals, student, education workers (teachers, maintenance, and administrative), commercial/industrial workers, and construction workers occupying areas within the boundary.

Residential individuals include children and adults occupying residential locations within the Site boundary. A residential location is typically one where someone is present for an average of more than eight hours a day. It includes, but is not limited to, schools; dwellings; residences; correctional facilities; any other human activity areas of repeated, frequent use and/or chronic duration; and locations that typically house sensitive populations such as grade schools, hospitals, childcare centers, and nursing homes. Due to the depth of the dissolved phase PCE and that impacted groundwater is not being pumped in the area, the dissolved PCE in the groundwater does not currently pose a risk to residents.

Commercial/industrial workers include adults working at the businesses within the Site boundaries. Due to the depth of the dissolved phase PCE and that impacted groundwater is not being pumped in the area, the dissolved PCE groundwater does pose a risk to commercial/industrial workers in the area.

2.4.2 Ecological Risk Evaluation

As defined, an ecological receptor is "a specific ecological community, population, or individual organism, protected by federal or state laws and regulations, or a local population that provides an important natural or economic resource, function, and value" (A.A.C. R18-7-201). Wildlife or vegetation that is present in the study area is likely non-native to the area, is habituated to human presence, or has been maintained in a horticultural setting. Areas and land use within the boundary (**Figure 2**) do not contain suitable habitat for the five federally listed species. Due to the presence of COCs at depth, the urban character, and lack of ecological receptors within the boundary, an evaluation of ecological receptors is not warranted.

2.4.3 Human Risk Evaluation

An exposure or migration pathway is the route by which the potential hazard (identified COCs) migrates from the source (soil vapor, soil, surface water, or groundwater) to a receptor. Pathways can include:

- Inhalation of impacted vapors;
- Dermal contact with impacted soil, groundwater, or surface water; or
- Ingestion of impacted soil, groundwater, or surface water.

An exposure pathway is complete when all four of these components are present: 1) a source and mechanism of chemical release; 2) a retention or transport medium (pathway); 3) an exposure point (i.e., a setting where potential human contact with the chemical-affected medium or media occurs); and 4) a route of exposure at the exposure point (e.g., ingestion, dermal, inhalation). The land use at the Site is commercial/industrial, residential, and public open space. This exposure pathway evaluation, therefore, assesses potential pathways by which long-term commercial workers, short-term construction workers, visitors to the site and residents may be exposed to the COC, PCE.

The Exposure Pathway Model is provided as **Figure 7.** Impacted groundwater is currently not being used. Therefore, the exposure pathways for residential individuals, commercial/industrial workers, and construction workers were determined to be incomplete.

2.4.4 Conceptual Site Model

The dissolved PCE in the groundwater is a direct result of PCE releases to the subsurface. However, the source facility is unknown. A previously shallow, relatively horizontal PCE plume entered the zone of influence of SRP Well 17.9E-7.5N. The dissolved PCE plume was then drawn into the well. When pumping was discontinued in the mid-1980s, the dissolved PCE began to migrate downgradient with the ambient groundwater flow. Dissolved PCE has migrated approximately 13,000 feet down gradient. The dissolved PCE plume has been influenced by SRP well 17.9E-7.5N and has migrated approximately 10,660 ft from the SRP well to BMW-16D over a period of less than 35 years since the well was shut down, which is within the estimated groundwater flow velocity range.

3.0 Feasibility Study Scoping

This section summarizes the regulatory requirements presented in Arizona statute and rule, delineates the remediation area and presents the ROs identified by ADEQ (ADEQ, 2020a).

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. §49-282-06B, 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. §49-282-06C, 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 concluded that the groundwater was the only media with COC concentrations that exceeded a screening value or a regulatory standard. The remediation area is the main Site PCE plume depicted on **Figure 2** and the deep PCE plume depicted on **Figures 3-5.**

As of the October 2019 and May 2020 sampling events, the PCE plume is estimated to be at least 13,000 ft or 2.5 miles long and is and is a maximum of 960 ft wide. The vertical thickness of the submerged PCE slopes across the Site becoming thinner with distance, nearly 160 feet at well cluster BMW-02C/E to approximately 37 ft thick at BMW-16D.

3.3 Remedial Objectives

ROs have been developed as part of the RI process (ADEQ, 2020a). Pursuant to A.A.C. R18-16-406 (I), the ROs were based on field investigation results, the Land and Water use Study (LWUS) (Wood, 2020c), 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/Soil

The Site is located within a mixed residential and commercial area. The current City of Phoenix (COP) zoning maps indicate the Site is zoned as residential (multiple family residence, residential office, and single-family residence) and commercial (neighborhood retail, intermediate commercial, and restricted commercial). The COP indicated there are no current foreseeable plans to alter the current land use at or near the Site.

ROs for land use are typically established for those properties known to be contaminated with hazardous substances above a Soil Remediation Level or a risk-based level. A source facility for the PCE plume was not identified. Therefore, no soil nor vapor intrusion investigation was performed. No soil remedial objective is established for the Site (ADEQ, 2020a).

3.3.2 Remedial Objectives for Groundwater Use

The groundwater use portion of the LWUS Report is a summary of information gathered from the Arizona Department of Water Resources (ADWR), water providers, and municipalities. The water providers at the Site are the COP and SRP (Wood, 2020c).

The Site lies within the Phoenix Active Management Area (AMA), an area where groundwater use is controlled and regulated. The Phoenix AMA was created by the Arizona Groundwater Management Code passed in 1980 and covers approximately 5,646 square miles in central Arizona. All groundwater withdrawn from any AMA must occur under a groundwater right or permit, unless groundwater is being withdrawn from an exempt well.

ADWR records indicate there are fourteen (14) non-exempt and four (4) exempt water supply wells located within approximately one mile of the PCE plume boundary. The non-exempt wells include: (a) twelve (12) wells owned and operated by SRP; (b) one well owned by COP; and (c) one well owned by Maricopa County Flood Control District. According to ADWR, the COP owned well was used to fill the swimming pool at Perry Park; however, it is currently inactive. The well owned by Maricopa County was used for de-watering purposes. The intended use of the four exempt wells is domestic irrigation. There are no grandfathered rights in the vicinity of the PCE plume boundary. The COP and SRP have service area rights in the vicinity of the Site, however, only SRP is currently pumping groundwater in the vicinity of the PCE plume boundary. The current use of water is for irrigation water. The future use of groundwater includes irrigation and municipal (potable supply) (Wood, 2020c).

The groundwater is currently contaminated with PCE at concentrations that exceed the AWQS. Thus, the ROs for groundwater use are as follows (ADEQ, 2020a):

1.2.1.1 Irrigation Use

Protect against the loss or impairment of irrigation water threatened by the contaminants of concern within the Site. Where protection cannot be achieved in a reasonable, necessary, or cost-effective manner; restore, replace, or otherwise provide for irrigation water that is lost or impaired by the contaminants of concern at or origination from the 40th Street and Osborn Road WQARF Site. Action is needed for as long as necessary to ensure that, while the water exists and the resource remains available, the contamination associated with the Site does not prohibit or limit the designated use of groundwater within or outside the current site boundaries.

1.2.1.2 Potable Use

Protect against the loss or impairment of potable water threatened by the contaminants of concern at the Site. Where protection cannot be achieved in a reasonable, necessary, or cost-effective manner; restore, replace, or otherwise provide for potable water that is lost or impaired by the contaminants of concern at the Site. Action is needed for as long as necessary to ensure that, while the water exists and the resource remains available, the contamination associated with the Site does not prohibit or limit the designated use of groundwater.

3.3.3 Remedial Objectives for Surface Water Use

Current surface water use at the Site is irrigation from SRP canals. The water in the SRP canals is supplemented with groundwater pumped from SRP wells at the Site. The future use of the surface water in the SRP canals includes irrigation and drinking water. The current and future source of the water in the SRP canals originating from the Site is groundwater pumped by SRP wells. Thus, ROs for surface water use are not needed because the ROs for groundwater use for the water pumped into the canals are applicable (ADEQ, 2020a).

4.0 Identification and Screening of Remedial Measures and 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).

4.1 Remedial Measures/Strategies

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. The six remedial strategies to be developed are listed below. A strategy may incorporate more than one remediation technology or methodology, such as a plume remediation strategy that consists of a combination of pumping and treating in portions of an aquifer and monitored \natural attenuation for other portions of the aquifer. The basic remedial strategies are defined in A.R.S. § 49-282.06(B)4 and A.A.C. R18-16-407(F) are:

1. Plume remediation
2. Physical containment
3. Controlled migration
4. Source control
5. Monitoring
6. No action

4.1.1 Plume Remediation

Plume remediation is a strategy to achieve water quality standards for COCs in groundwater. This strategy typically involves groundwater extraction and treatment to achieve capture and removal of COCs from impacted groundwater but may also include in-situ treatment approaches. Plume remediation is applicable and will be retained for development of the reference remedy and alternate remedies.

4.1.2 Physical Containment

Physical containment is a strategy to hydraulically contain and limit the extent of contaminants within defined boundaries of the groundwater flow system. The containment strategy requires sufficient hydraulic control to prevent the migration of contaminants beyond the boundaries of the containment zone at concentrations exceeding AWQS. A containment strategy is generally coupled with plume remediation and treatment within the containment zone or other associated remedial actions such as injection and/or some form of physical barrier at the margins of the containment zone to restrict contaminant movement. Physical containment of the plume is verified by groundwater monitoring. Physical containment is not applicable at the Site due to the depth to the groundwater contamination and the thickness of the contamination.

4.1.3 Controlled Migration

Controlled migration is a strategy to control the direction or rate of migration, but not necessarily to contain migration of contaminants. This strategy, as with physical containment, requires some form of hydraulic control to influence the direction of contaminant movement, but does not necessarily achieve containment of the contaminants and prevent them from migrating beyond a specific defined boundary. Consistent with the discussion regarding the physical containment strategy in Section 4.1.2, a controlled migration strategy generally is coupled with plume remediation to influence the groundwater migration patterns through hydraulic control. Controlled migration of the plume is verified by groundwater monitoring. Controlled migration is applicable and will be retained for development of the reference remedy and alternate remedies.

4.1.4 Source Control

Source control is a strategy to eliminate or minimize a continuing source of contamination. As discussed previously, source control applies to facilities within the Site where releases of hazardous substances may have contributed to groundwater contamination. As noted in A.A.C. R18-16-407.F, "source control shall be considered as an element of the reference remedy and all alternative remedies, if applicable." Although source control is related and is a significant component of the Site, source control is not directly applicable to this FS, because the source of contamination is unknown.

4.1.5 Monitoring

Monitoring is a strategy to observe and evaluate contamination at a site through the collection of data. This strategy is typically employed as a remedial action in situations where there is no significant impairment or restriction to current or reasonably foreseeable future land and/or water uses caused by the contamination and where natural processes, such as biodegradation, sorption, or dispersion, are reasonably expected to reduce the concentration of contaminants over time. Monitoring is also an essential part of groundwater Pump and Treat (P&T) remedial actions for the purposes of assessing attenuation of contaminants (i.e., assessing trends in contaminant concentrations in certain wells/areas) and verifying hydraulic capture and plume containment within defined areas. Monitoring by itself is not a viable strategy for the reference and alternative remedies. However, continued monitoring will be an important aspect of any groundwater alternative remedies being considered to verify performance of the groundwater remedy and ensure that the Site groundwater ROs are met. Monitoring is applicable and will be retained for development of the reference remedy and alternate remedies.

4.1.6 No Action

No action is a strategy that consists of no action at a site. As with monitoring, this strategy is typically employed in situations where there is no significant impairment or restriction to current or reasonably foreseeable future land and/or water uses caused by the contamination. The remedial strategy of no action was considered in terms of the legal requirements for the reference and alternative remedies. The no action strategy does not assure the protection of public health and welfare and the environment from the contaminants impacting the groundwater above AWQSs. The no action strategy will not allow for the maximum beneficial use of the waters of the state and will not address the impacted and threatened water provider wells and therefore is not an option.

4.2 Screening of Groundwater Technologies

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 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 6**. The screening of technologies addresses only groundwater.

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. The following are conditions associated with the Site that limit the applicability/feasibility of remedial technologies:

- **Plume width.** The plume ranges in width from 900-960 ft.
- **Plume thickness at source.** The elevated dissolved PCE concentrations detected in groundwater samples collected from BMW-02C/02D and BMW-17D represent the source of dissolved PCE concentrations (**Figure 2**). However, the PCE concentrations in these wells above 5.0 µg/L extend from approximately 100 feet bgs to bedrock at approximately 260 feet bgs, which is a thickness of approximately 160 feet.
- **Plume length.** The overall plume length is approximately 13,000 feet or 2.46 miles. The PCE plume becomes deeper and thinner with decreasing concentrations in the downgradient (southwest) direction across the Site. At BMW-16D, the PCE plume extends from approximately 200 feet bgs to 250 feet bgs and is characterized by PCE concentrations ranging from 5.1 to 10 µg/L.

- **Plume submergence.** Depth to groundwater ranges from approximately 41 ft btoc at BMW-02C to approximately 83 ft btoc at BMW-16D. The upper vertical boundary of the PCE plume at BMW-02C is located approximately 60 ft below the water table. At BMW-16D, the upper boundary of the PCE plume is located approximately 117 ft below the water table.
- **Plume location.** The plume is located within a highly developed urbanized area that includes single and multi-family residences, an assisted living community/nursing home, commercial/retail properties, a City of Phoenix park, and City of Phoenix streets. This limits available locations to install remedial wells and the remediation system(s).

4.2.1 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) is an approach that involves monitoring volatile organic compounds (VOCs) and other parameters in groundwater to identify and track the decrease of contaminant concentrations over time. Processes that can decrease 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.

When sufficient biologically appealing organic carbon and hydrogen are available, bacteria will often deplete the supply of available electron acceptors. In this case, anaerobic, non-oxygen breathing, bacteria will utilize chlorinated solvents as electron acceptors, a process that is referred to as reductive dechlorination (RD). Reductive dechlorination is the principal biological process resulting in the degradation of chlorinated solvents in the subsurface. It is rare to find sufficient naturally occurring organic carbon to promote reductive dechlorination. Though the natural fraction of organic carbon in soil plays a role in RD, it is typically present at too low of levels in Arizona soils to promote RD. Therefore, the organic carbon typically originates from a fuel release (i.e., leaking underground storage tank), leachate from a landfill, or added as part of a remedial action. Reductive dechlorination (RD) is evaluated through observation of VOC daughter products, trends in VOC distributions, and trends in natural attenuation parameters. As shown in **Table 3**, the PCE RD daughter products TCE and c-1,2-DCE have not been historically detected at appreciable concentrations in groundwater samples. Therefore, the groundwater analytical data indicates that biologic degradation by reductive dechlorination is not a factor in MNA at the Site.

Simple one-dimensional numerical models such as BIOCHLOR can be used to obtain natural attenuation rates. These tools are used primarily to model MNA via biodegradation. However, because MNA via biodegradation is not occurring, the BIOCHLOR model can only be used, in a limited fashion, as a screening tool to predict future movement and concentrations of the PCE plume and not as a useful tool to measure natural attenuation. However, the BIOCHLOR model was used to estimate dissolved PCE mass within the plume.

With the exception of biodegradation indicators, the components required for retaining a MNA approach are present. The plume is stable, geochemical parameters at the site are not considered unsuitable for application of MNA, and no continuing source is identified. Based on the above, MNA consisting of physical processes that include advection and dispersion is retained for remedial alternative development, and as included in the remedial approaches described in Section 5.0, would meet the remedial objectives for the Site. Progress of an MNA remedy can be measured by the following:

- Monitoring to observe changes in concentration with time;

- Use of statistical trend analyses such as the Mann-Kendall statistic to evaluate concentration trends with time; and,
- Evaluation of changes in dissolved PCE mass with time.

4.2.2 Enhanced Reductive Dechlorination

Enhanced RD (ERD) is a remedial technology based on injecting substrate and/or nutrients and appropriate bacteria into groundwater to promote anaerobic biodegradation of VOCs. Under the right conditions, anaerobic RD can be a naturally occurring biodegradation process whereby microbes can degrade chlorinated VOCs in groundwater. However, the right conditions are typically not naturally present. Groundwater in Arizona is often aerobic, containing greater than 1.0 milligrams per liter (mg/L) of dissolved oxygen (DO). The DO must be decreased below 1.0 mg/L for anerobic conditions to be present. 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). Injected substrates can promote anaerobic biodegradation. The microbes use a primary substrate as a carbon and energy source. Some microbes produce enzymes and other compounds that degrade the target chlorinated compounds present in groundwater. Other microbes called halorespiring microbes breath the chlorinated VOCs, which are degraded internally by the microbes. A variety of compounds have been used as bio-stimulation amendments for ERD applications. Examples of substrates are sugars, alcohols (methanol, ethanol), lactate, and benzoate. If naturally occurring microbes become active after injection of a substrate, the reaction could stall at any of the below steps:

$$\text{PCE} \xrightarrow{H^{+}+e^{-}-Cl^{-}} \text{TCE} \xrightarrow{H^{+}+e^{-}-Cl^{-}} \text{c-1,2-DCE} \xrightarrow{H^{+}+e^{-}-Cl^{-}} \text{Vinyl Chloride} \xrightarrow{H^{+}+e^{-}-Cl^{-}} \text{Ethene}$$

If all the remaining residual PCE concentrations in the wells were converted to c-1,2-DCE and the reaction stalled, the AWQSs for PCE (5.0 µg/L) and TCE (5.0 µg/L) may be achieved. However, c-1,2-DCE (70 µg/L) may remain above the AWQS at BMW-02E and BMW-17D. However, if the reaction progressed to vinyl chloride (VC), which has an AWQS of 2.0 µg/L and is very mobile, VC would become a COC requiring remediation. As previously indicated, the only microbe identified to be capable of degrading PCE to ethene is Dehalococcoides Ethenogenes (DHE). This is a sulfate reducing microbe that is not commonly naturally occurring. Therefore, bio-augmentation is a subsequent step 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 substrate to the impacted areas and for microbes to contact the dissolved COC. Vertical ERD wells can be located along the plume in Phoenix street right-of-way (ROW). Manual injections of the substrate and microbial cultures will be required. However, due to the low PCE concentrations and dimensions of the plume, ERD is not considered to be practical for the dilute Site plume. Therefore, biological treatment via ERD was not retained as a viable technology for plume treatment.

4.2.3 Injected Liquified Granular Activated Carbon (LGAC)

This technology has recently been used considerably for source control and control migration of chlorinated COCs. The technology involves injecting LGAC into the subsurface. The two commonly used products are BOS 100 and Regenesis PlumeStop™. Both products contain LGAC that coat the sediments and "trap" the COCs by sorption. BOS 100 also contains metallic elemental iron to "treat" the chlorinated

COCs by chemical reduction. Therefore, BOS 100 removes the contaminants and provides both controlled migration and plume remediation. PlumeStop™ only "traps" the contaminants. AWQSs are achieved; however, the contaminants remain in the subsurface. Therefore, PlumeStop™ is considered a controlled migration technology. LGAC will achieve the ROs. BOS 100 was considered as a contingency remedial technology for the downgradient portion of the Site plume. A preliminary BOS 100 design was obtained from AST Environmental, the provider of BOS 100. The preliminary design involved drilling 20 injection points within a 100 ft line perpendicular to the plume. The initial boring is filled with bentonite chips. A direct push system is then used to pressure inject the BOS 100, forming a permeable reactive barrier (PRB). Assuming a treatment width of 800 ft, 160 injection points will be required. Based on the number of injection points required, this technology is not considered to be practicable in a developed urban setting and is not cost effective compared to other available remedial technologies. Therefore, LGAC injection was not retained for further evaluation as a remedial technology.

4.2.4 In-Situ Chemical Oxidation

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, catalyzed or activated hydrogen peroxide (HP), and ozone. The objective is to form strong oxidizing radicals that are capable of breaking the chemical bonds of the dissolved COCs. 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. 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. Pilot testing and/or bench testing is typically necessary to establish the injection spacing, rates, and oxidant dosing. ISCO is typically applicable and feasible for source control and remediation of plumes of limited extent. Due to the limitations caused by the Site plume dimensions, particularly the plume thickness at the source location, ISCO is not feasible. However, a continuous injection system can be applied as a controlled migration strategy for more manageable conditions found in the downgradient portions of the Site PCE plume.

As with LGAC, installation and operation of an ISCO system as a controlled migration technology is considered impracticable within a highly developed residential setting. Therefore, ISCO was not retained for alternative remedy development.

4.2.5 In-Situ Chemical Reduction

In situ chemical reduction (ISCR) is intended to reduce VOC concentrations by using materials such as zero-valent iron to degrade the VOCs. This technology is usually implemented in a PRB or funnel-and-gate configuration where the zero-valent iron can be installed perpendicular to the groundwater flow direction and the base of the barrier can be tied into a low permeability layer. Elemental iron or zero-valent iron was previously discussed and is included with the LGAC remedial technology and is therefore not retained as a remedial technology.

4.2.6 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 (GWET) removes and decreases contaminant mass from the aquifer but it is generally more effective in controlling or containing the downgradient migration of a 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. ADWR will require a Poor Quality Groundwater Withdrawal Permit (PQGWWP) for this activity. Discharge options with a beneficial re-use are strongly preferred due to the importance of water as a resource. However, ADWR charges fees for beneficial re-use of the water. Fees are not charged by ADWR for reinjection of treated water.

Groundwater extraction and treatment is typically inefficient at reducing contaminant mass because the concentrations in groundwater are low and it is expensive to install. However, considering the Site conditions, this is the only active remedial technology available to practicably and cost effectively achieve the remedial goals. The issues associated with GWET in a highly developed and urbanized setting are as follows:

- Property has to be retained for installation of extraction wells and treatment systems. This can be done via access agreement, lease, or purchase.
- The treated extracted water must be managed. The three options are re-injection, beneficial use such as irrigation or transfer to a canal system, or discharge to a sewer system.

If an existing pumping well can be equipped with wellhead treatment and treated water management infrastructure exists, the installation costs are greatly decreased. Re-injection is often the preferred method for treated water management; however, the treated water must be transported to an injection well gallery upgradient of the plume boundary. SRP has indicated they prefer transfer of the treated water to their canal system in the area.

Based on the evaluation of Site conditions, particularly the plume thickness at the source, this remedial technology can meet the Site ROs within a reasonable restoration time frame by itself, which as discussed in **Section 5.0** is expected to be within 22 years. It can also be an effective controlled migration approach. This FS includes GWET as one element of the remedy considered for the Site. Therefore, this remedial technology has been retained for further evaluation.

4.2.7 Summary of Screening and Technologies Retained

A summary of screening and specific technologies retained for developing the remedial alternatives is provided as **Table 4.**

5.0 Development of Reference Remedy and Alternative Remedies

The retained remedial technologies presented in **Section 4** are a combination of GWET and MNA, which based on the current Site conditions and urban setting are the best available technologies to practicably and cost effectively achieve the ROs. The recommended remedies including a reference remedy along with less aggressive and more aggressive alternative remedies have been developed, with all three including a combination of GWET and MNA. The reference remedy and alternate remedies consist of remedial strategies and actions (remedial measures) that will achieve ROs for the Site. Each remedy has been identified with consideration of the needs of the local water providers (SRP and COP).

Selected remedial measures are combined with the applicable strategies to develop the reference and alternate remedies. The reference and alternate remedies 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 5.0 µg/L (from the source to suitable downgradient boundaries) (**Figures 2 and 3**).

The reference remedy was developed based upon best engineering, geological, or hydrogeological judgment following engineering, geological, or hydrogeological standards of practice, considering the following:

- The information in the RI;
- The best available scientific information concerning available remedial technologies; and,
- Preliminary analysis of the comparison criteria and the ability of the reference remedy to comply with A.R.S. §49-282.06.

At a minimum, at least two alternative remedies are required to be developed for comparison with the reference remedy. At least one of the alternative remedies must employ a remedial strategy or combination of strategies that is more aggressive than the reference remedy, and at least one of the alternative remedies must employ a remedial strategy or combination of strategies that is less aggressive than the reference remedy. A more aggressive strategy is a strategy that requires fewer remedial measures to achieve remedial objectives, a strategy that achieves remedial objectives in a shorter period of time, or a strategy that is more certain in the long term and requires fewer contingencies. The reference and remedial alternatives include pumping of SRP well 17.9E-7.5N with wellhead treatment as either a contingency or the remedy (location shown on **Figure 2**). This is referred to as the SRP well GWET system. The Reference Remedy and More Aggressive Alternative Remedy include a second groundwater extraction well located at the intersection of the Grand Canal and Oak Street, referred to as the Grand Canal GWET system (location shown on **Figure 2**). In order to evaluate the proposed remedy, a capture zone analysis was prepared for SRP well 17.9E-7.5N.

The capture zone analysis was performed using a particle tracking simulation exercise. MODPATH was used for the pumping scenarios discussed below. MODPATH is a particle-tracking post-processing model that computes three-dimensional flow paths using output from groundwater flow simulations based on MODFLOW, the U.S. Geological Survey (USGS) finite-difference groundwater flow model. The program uses a semi-analytical particle-tracking scheme that allows an analytical expression of a particle's flow path to be obtained within each finite-difference grid cell. A particle's path is computed by tracking the particle from one cell to the next until it reaches a boundary, an internal sink/source, or satisfies another termination criterion. Data input to MODPATH consists of a combination of MODFLOW input data files, MODFLOW head and flow output files, and other input files specific to MODPATH. Output from MODPATH consists of several output files, including several particle coordinate output files intended to serve as input data for other programs that process, analyze, and display the results in various ways. The analysis is useful for visualizing the flow field and estimating capture zones of wells. The steps to this process can be summarized as follows:

- The user specifies hydraulic conductivity (horizontal and vertical) and sources/sinks. In transient simulations, also specify specific storage and stress periods.
- Run MODFLOW to calculate water table elevation everywhere.
- The user specifies porosity and the starting location of particles.
- Run MODPATH to calculate velocities, interpolate particle location, and output three-dimensional path lines.

Relevant characteristics of this groundwater model, derived from previous investigations of this Site and nearby sites are as follows:

- Single layer system, depth 300 ft.
- Calibrated flow direction is southwest.
- Advective flow is the sole transport mechanism.
- Constant head boundary conditions.
- Grid size is 100 ft x 100 ft.
- Homogeneous aquifer with horizontal and vertical hydraulic conductivities of 5 ft/day and 0.5 ft/day, respectively.
- Porosity = 0.25.
- Transient scenarios used 0.005 for the specific storage value.

The above aquifer parameters used for the following particle tracking scenarios are based on detailed lithologic logs of site-specific monitoring wells.

Figure 8 shows specified the surrounding modeling boundary conditions for the particle tracking simulations where the heads are set and remain constant based on recently measured water level elevations. Fluid is simulated as moving in or out of the groundwater at a rate sufficient to maintain the specified head for the different simulations.

Figure 9 shows the results of steady-state conditions that involves the forward particle tracking simulation for a pumping rate of 700 gpm at SRP Well 17.9 E-7.5N (SRP Well). Additionally, this model simulation indicates an average drawdown of approximately 35 feet and capture of the particles are lost between 1,200 to 1,300 feet downgradient of the SRP Well.

Figures 10 shows the results of transient state conditions that involves the forward particle tracking simulation for a pumping rate of 700 gpm at the SRP Well for a 10-year period. Like the previous steady-state scenario, drawdown is approximately 35 feet and capture are lost 1,200 to 1,300 downgradient of the SRP Well. However, this transient scenario indicates full capture of the upgradient particles within the 10-year period.

Figures 11 shows the results of transient state conditions that involves the forward particle tracking simulation for a pumping rate of 700 gpm at the SRP Well and a modeled extraction well completed approximately 2 miles southwest of the SRP Well pumping (identified as the Grand Canal GWET system) at 300 gpm for a 20-year period. Again, like the previous two scenarios, drawdown is approximately 35 feet at the SRP Well. Drawdown at the modeled extraction well is approximately 10 feet. This transient scenario indicates full capture of the upgradient particles within the 10-year period at the SRP Well and most of the particles downgradient of the SRP Well capture zone are either intercepted or captured at the modeled extraction well within a 17-year pumping period.

The reference and alternate 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 includes a group of similar and related remedial measures; therefore, the discussion of individual remedial measures is presented after the discussion of the remedial alternatives.

Components of the More Aggressive Alternative Remedy are included in the Reference Remedy and Less Aggressive Alternative Remedy, either as a part of the remedy or as a contingency. Therefore, the remedies are discussed in order from More Aggressive Alternative Remedy to Reference Remedy to Less Aggressive Alternative Remedy.

5.1 More Aggressive Alternative Remedy

This section describes the More Aggressive Alternative Remedy, which is multiple well GWET plus MNA. The more aggressive remedy involves installation of two GWET systems within two years of each other and concurrent operation, maintenance, and monitoring (OM&M) of the systems with the intent of decreasing the overall time to complete remediation.

The remedial strategies for the Reference Remedy from A.A.C. R18-16-407(F) are as follows:

- Source control for the area of BMW-02C/02E to eliminate or mitigate a continuing source of contamination;
- Controlled migration utilizing a downgradient GWET system;
- Plume remediation to achieve water quality standards for COCs in areas of highest contaminant concentrations;
- Monitoring to observe and evaluate the contamination through the collection of data; and,
- Contingency remedial measures to address potential uncertainties.

The remedy includes two GWET systems, one at SRP Well 17.9E-7.5N to remediate the upgradient portion of the PCE plume and a second downgradient GWET system to remediate the PCE plume downgradient of the SRP well.

5.1.1 SRP Well 17.9E-7.5N Wellhead Treatment (SRP Well GWET System)

SRP Well 17.9E-7.5N is an existing irrigation well located slightly outside the Site PCE plume and downgradient of the source that is located in the vicinity of BMW-02C/02E (**Figures 2 and 3**). As shown in **Table 3**, groundwater historically extracted from this well was reported with PCE concentrations above 5.0 µg/L ranging from 6.8 µg/L on August 8, 2010 to 210 µg/L on September 28, 1998. This demonstrates that operation of this well is able to locally change the ambient groundwater flow direction, thus capturing the dissolved PCE, which is confirmed by **Figures 8-11**. SRP took the well off-line in 1990, but continued operating the well periodically to collect water quality samples. When operating, SRP Well 17.9E-7.5N was located within the plume and was removing dissolved PCE. Since August 8, 2010 PCE concentrations in the extracted groundwater have been below 5.0 µg/L as groundwater flow shifted back to ambient conditions after the well was taken off-line.

According to ADWR records, SRP Well 17.9E-7.5N is 300 feet deep with an 18-inch steel casing that is screened from 100 to 300 ft bgs. The well is equipped with a pump that has a design capacity of 1,000 gallons per minute (gpm). However, based on pumping records reviewed in ADWR records, the average pumping rate was approximately 300 gpm. Due to the well and pump possibly not being in sufficient condition to serve as a GWET well, the cost estimate includes re-casing the well with a 14-inch diameter casing and installing a new submersible pump capable of 700 gpm.

The extracted groundwater will be treated using GAC. Based on the pump capacity and expected PCE concentrations, two 20,000 lb GAC vessels in series are planned. The treatment system is designed to handle a maximum flow rate of 700 gpm. The capital costs for the wellhead treatment system are for well improvements and purchase and installation of the GAC vessels. The estimated area required for the GAC vessels is approximately 32 ft x 14 ft. ADEQ will be responsible for OM&M for the wellhead treatment system. These costs include electrical costs and renting space for the treatment system if it is too large to be installed in the existing SRP well yard. Therefore, these costs have been included in the cost estimate for the remedy. Water samples will be collected monthly from the system to evaluate breakthrough of the GAC. Therefore, this will involve three samples per month analyzed for VOCs, one each from the influent and effluent for the lead GAC vessel and one from the effluent from the secondary GAC vessel. Total volume of water pumped will be measured each month.

The treated water will be discharged to the SRP Arizona Canal. This is considered a beneficial use by ADWR which requires a $3.00 per acre-foot (af) of water pumped. Assuming the system will be operated 24 hours per day and seven days per week (at least 95% runtime), approximately 1,130 af of water will be pumped, treated, and discharged. The estimated annual fee is $3,390.

The GWET system will continue to be operated until four consecutive semi-annual groundwater samples collected from BMW-02C/BMW-02E and from the discharge from the pumping well are reported with PCE below 5.0 µg/L. An additional two year rebound monitoring period (four additional sampling events) will be conducted to confirm completion GWET. Based on the particle tracking simulation and for cost estimation purposes, the O&M period is 10 years. Estimated GAC bed life is 12 months. Therefore, 10 GAC changeouts are estimated during the operation period. The cost estimate assumes the pump will have to be replaced every five years. Therefore, the cost estimate includes two pump replacements.

Based on the historic use and PCE concentrations, returning this well to service with wellhead treatment will provide the following:

- Pumping of SRP Well 17.9E-7.5N will increase the flow velocity upgradient of the well, thus decreasing the time to achieve the ROs.
- Restoration of a groundwater resource and asset for SRP.
- Decreased PCE concentrations downgradient of SRP Well 17.9E-7.5N, thus facilitating the MNA component of the remedy.
- Decreased remedy installation costs, specifically treated water management/infrastructure exist.

5.1.2 Downgradient Extraction Well

The more aggressive remedy includes installation of a supplemental extraction well downgradient of SRP well 17.9E-7.5N. This well will be installed within two years of the SRP GWET system and will be operated concurrently with the SRP GWET system with the intent of decreasing the overall time to complete remediation. Due to the highly developed and urbanized area, two locations were identified as follows:

1. Use of the COP production well located at Perry Park. According to ADWR records, the well address is 2626 North 32nd Street (northwest corner of 32nd Street and Virginia Avenue) and the registration number is 55-626525. According to available information in ADWR records, the installation date for this well is unknown. The well is 218 ft deep with a 20-inch casing and is equipped with a 270 gpm capacity pump. The water pumped from the well was used to fill the Perry Park swimming pool. This well and pump has not been used in several years. Therefore, the well must be retrofitted to be used as as the supplemental GWET well. The well must be deepened to 285 ft and a new casing will be required. The cost estimate assumes removal and disposal of the existing pump and video logging of the well. The preliminary design involves installation of a minimum 14-inch diameter casing with 140 feet of 0.02-inch slot (standard flow) casing with 3/16-inch wall thickness. For GWET operation, the well will be equipped with a new 300 gpm pump. Pumped water will be routed from the treatment system to the SRP Grand Canal along 31st to Oak Street and then along Oak Street to the Grand Canal. Total length of piping is one mile (5,280 ft). This is considered the shortest available route to the Grand Canal.

2. A vacant and undeveloped SRP easement for the Grand Canal located at the southeast corner of Oak Street and the Grand Canal. For design and cost purposes, the well will be drilled to 285 ft bgs using an air rotary method. A 10-inch diameter casing screened from 150-285 ft bgs will be installed. The well will be equipped with a submersible pump having a capacity of approximately 300 gpm. A power drop will be required to operate the pump. This location has a lower capital cost due to a long discharge pipe not being required (savings of approximately $1,000,000). However, system operation and maintenance will be required for an additional estimated five years.

Option 1 above is evaluated to be more expensive than Option 2 due to the capital cost to install the discharge pipe to the Grand Canal. However, the time to complete remediation for the area between the SRP well and the Perry Park well will be decreased. If the Grand Canal location is installed, capital costs will be lower; however, an additional five years of O&M will be required. The Grand Canal location does provide the added benefit of more effectively controlling migration of PCE downgradient of BMW-16D. Based on the above, Option 2 was selected for the remedy. The Grand Canal is referred to as the Grand Canal GWET system.

The extracted groundwater will be treated using GAC. Based on the pump capacity and expected PCE concentrations, two 10,000 lb GAC vessels in series are planned. The treatment system is designed to handle a maximum flow rate of 300 gpm. The capital costs for the wellhead treatment system are for well installation, purchase and installation of the GAC vessels, installation of the discharge pipe to the Grand Canal (less than 100 ft), and installation of a power drop. The estimated area required for the GAC vessels is approximately 20 ft x 10 ft. ADEQ will be responsible for OM&M for the wellhead treatment system. These costs include electrical costs, which have been included in the cost estimate for the remedy. Water samples will be collected monthly from the system to evaluate breakthrough of the GAC. Therefore, this will involve three samples per month analyzed for VOCs, one each from the influent and effluent for the lead GAC vessel and one from the effluent from the secondary GAC vessel. Total volume of water pumped will be measured each month.

The treated water will be discharged to the SRP Grand Canal. This is considered a beneficial use by ADWR which requires a $3.00 per af of water pumped. Assuming the system will be operated 24 hours per day and seven days per week, approximately 490 af of water will be pumped, treated, and discharged. The estimated annual fee is $1,470.

The GWET system will continue to be operated until four consecutive semi-annual groundwater samples collected from wells BMW-17D, BMW-22D, BMW-09D BMW-18D, BMW-19D, BMW-10D, BMW-14D, and BMW-16D and from the discharge from the pumping well are reported with PCE below 5.0 µg/L. An additional two year rebound monitoring period (four additional sampling events) will be conducted to confirm completion of GWET. Based on the particle tracking simulation, PCE concentrations may be decreased below 5.0 µg/L in these wells within 17 years considering concurrent operation with the SRP well 17.9E-7.5N GWET system. Estimated GAC bed life is 18 months. Therefore, 13 GAC changeouts are estimated during the operation period. The pump will be required to be changed approximately every five years. Therefore, three pump replacements are included in the cost estimate.

5.1.3 Monitoring

5.1.3.1 GWET Systems

Monitoring will be required to evaluate performance of the GWET system performance and achievement of the remedial goals. The monitoring will consist of the following:

- Monthly monitoring of GAC performance (assume six water samples collected per month analyzed for VOCs);
- For six months following startup of the SRP well 17.9N-7.5E GWET system, monthly measurement of water levels in wells BMW-01A, BMW-01B, BMW-02A, BMW-02B, BMW-02C, BMW-02E, BMW-03A, BMW-03B, BMW-04A, and BMW-04B to evaluate changes in water levels during system operation. This will be conducted during the first six months of operation. After this, water levels will be measured semi-annually as part of the regular monitoring program.
- For six months following startup of the Perry Park GWET system, monthly measurement of water levels in wells BMW-09D, BMW-10D, BMW-18D, and BMW-19D to evaluate changes in water levels during system operation. This will be conducted during the first six months of operation. After this, water levels will be measured semi-annually as part of the regular monitoring program.

The GWET systems will operate until four consecutive samples collected from surrounding monitoring wells and the discharge are reported with PCE concentrations below 5.0 µg/L. As indicated previously, the SRP well 17.9E-7.5N GWET system is expected to operate for 10 years and the Grand Canal GWET system is anticipated to operate for 17 years after system installation. Assuming the Grand Canal GWET system is started two years after the SRP well GWET system is started, these periods overlap.

5.1.3.2 Groundwater Monitoring/MNA Program

In addition to GWET system monitoring described in Section 5.1.3.1, groundwater monitoring will be used to evaluate performance of the more aggressive remedy and achievement of the remedial goals. Monitoring for the more aggressive remedy will involve semiannual groundwater elevation measurements and collection of groundwater samples. **Table 5** provides the groundwater monitoring program for cost estimation purposes. The well locations are shown on **Figure 1.**

Measurement of progress required for the more aggressive remedy to achieve the remedial goals will be performed using changes in PCE concentration with time, observation of changes in groundwater levels and groundwater flow direction, statistical trend analysis of data, and use evaluation of dissolved PCE mass change with time. Based on the estimated operation period of the Grand Canal GWET system, the estimated monitoring period is 21 years. As the remedy progresses, monitoring wells/sample intervals may be removed from the sampling program based on PCE concentrations, thus decreasing costs. Specifically, monitoring wells/sampling points will be removed from the sampling program if PCE concentrations are below 5.0 µg/L for four consecutive semi-annual groundwater sampling events and decreasing trends are indicated.

5.1.4 Contingencies

Contingencies for the more aggressive remedy are as follows:

- Installation of up to two downgradient monitoring wells should PCE concentrations increase in samples collected from BMW-16D.

5.1.5 Permits and Agreements

Permits and/or agreements would be necessary to authorize installation and operation of the More Aggressive Alternative Remedy, including:

- Pre-construction notifications (i.e., ADWR Notice of Intent to Drill) and postconstruction reporting (Driller's Reports) would be prepared for any new wells that are installed;

- Well construction and/or modification work must be conducted by an ADWR-licensed driller. New wells must comply with ADWR standards found in ARS §45-594, -595, -596 and -600 of the Groundwater Code;
- If the SRP well yard does not have sufficient space to install the wellhead treatment system; therefore, access to the adjacent church property will be required to install the wellhead treatment system;
- Special Use Permits for the COP to operate remediation systems (fees typically waived by COP when ADEQ is the applicant);
- An access agreement will have to be obtained from SRP to install and operate the Grand Canal GWET system;
- A poor quality groundwater withdrawal permit (PQGWWP) will be required from ADWR for pumping of the groundwater, which will include annual reporting; and,
- Well 17.9E-7.5N may not be used for remediation purposes and discharges from the contingent extraction well may not be discharged to the SRP canal system until SRP Board approval has been received and relevant agreements are in place.

5.1.6 Remedial Documents

The following remedial documents will be required and are included in the cost analysis:

- Remediation System Design;
- O&M Work Plan (requires public comment period);
- Remediation As-Built Installation Report;
- Monthly O&M Technical Memos providing GWET operation times, volumes of water pumped, results of GAC vessel sampling, and GAC changeout if performed;
- Annual Poor Quality Groundwater Withdrawal Report (due by March of each year); and,
- Annual Remedial Progress Report documenting GWET O&M and semi-annual groundwater monitoring results (submitted by June 30 of each year).

5.2 Reference Remedy

This section describes the Reference Remedy, which is GWET plus MNA.

The remedial strategies for the Reference Remedy from A.A.C. R18-16-407(F) are as follows:

- Source control for the area of BMW-02C/02E to eliminate or mitigate a continuing source of contamination;
- Plume remediation to achieve water quality standards for COCs in areas of highest contaminant concentrations;
- Monitoring to observe and evaluate the contamination at the Site through the collection of data; and,
- Contingency remedial measures to address potential uncertainties.

The Reference Remedy is the same as the more aggressive remedial alternative, with the exception that the Grand Canal GWET system is included as a contingency. This generally assumes the PCE plume downgradient of SRP well 17.9E-7.5N is currently in equilibrium and is stable. If PCE concentrations do not indicate a decreasing trend in the downgradient wells based on sampling events and/or modeling or the PCE concentrations are increasing in BMW-16D, the Grand Canal GWET system will be recommended to be installed and operated within seven years. The primary difference to the reference remedy is that the downgradient GWET system is installed at a later date than the more aggressive approach. The monitoring period for SRP well 17.9E-7.5N GWET system is 12 years. Modeling indicated that without a downgradient GWET system to control downgradient migration, PCE concentrations may increase to as high as 40 µg/L in the downgradient wells. After 100 years, PCE is modeled to be approximately 20 µg/L at BMW-16D. Therefore, it is estimated that a 110-year monitoring program will be required. Based on this, the contingency downgradient GWET system will be required.

For cost estimation purposes, the Grand Canal GWET system is installed seven years after the SRP well GWET system is started. Therefore, operation of the two systems will be concurrent for three years. O&M will be required for 17 years and monitoring will continue to year 26. The schedule for installation of the Grand Canal GWET system is flexible and can be installed at any time prior to Year 7. The benefit of this flexible installation schedule is a decrease in the O&M and monitoring time periods, thus decreasing costs.

5.3 Less Aggressive Alternative Remedy

This section describes the Less Aggressive Remedy, which is MNA. Though only requiring a single remedial measure, MNA is identified as the Less Aggressive Remedy because it does not require installation of a remediation system and is considered the longest-term remedy. The remedial strategies for the less aggressive remedy from A.A.C. R18-16-407(F) are:

- Plume remediation to achieve water quality standards for COCs in waters of the state throughout the Site;
- Monitoring to observe and evaluate the contamination at the Site through the collection of data; and,
- Contingency remedial measures to address potential uncertainties.

Considering planned future groundwater uses in the area, MNA will likely not be approved as a standalone remedy unless no other feasible remedial technologies are available based on Site limitations. Therefore, pumping of SRP well 17.9E-7.5N with wellhead treatment is included as a contingency, which is the same as the reference remedy.

5.3.1 Monitoring

Monitoring will be required to evaluate performance of the less aggressive remedy and achievement of the remedial goals. For cost estimation purposes, monitoring for the less aggressive remedy will involve semiannual groundwater elevation measurements of the same wells included in more aggressive remedy.

Measurement of progress and prediction of the time required for less aggressive remedy to achieve the remedial goals is the same as the more aggressive remedy. BIOCHLOR Natural Attenuation Decision Support System version 2.2 (BIOCHLOR) was used to screen PCE concentrations with time. The BIOCHLOR Model predicted that PCE will be at a concentration of approximately 20 µg/L at BMW-16D at 200 years. At 250 years, all monitoring points at the Site are shown as below 5.0 µg/L. However, PCE has migrated downgradient of BMW-16D. Therefore, implementation of contingency installation and operation of the SRP well 17.9E-7.5N GWET system will be required.

5.4 Discussion of Specific Remedial Measures

The evaluated Reference Remedy and More Aggressive Remedial Alternative include GWET utilizing wellhead treatment on SRP Well 17.9E-7.5N with installation and operation of a Grand Canal GWET system. MNA was evaluated as the Less Aggressive Remedy.

6.0 Detailed Comparison of The Reference Remedy and the Alternative Remedies

The following section compares the Reference Remedy and alternative remedies to criteria described in A.A.C R18-16-407H.3.

6.1 Comparison Criteria

In accordance with A.A.C R18-16-407E.3, the FS has been completed to identify a Reference Remedy and alternative remedies that are potentially capable of achieving ROs, and to evaluate the remedies based on the comparison criteria in order to select a remedy that complies with A.R.S §49-282.06. A.A.C R18-16-407H specifies that practicability, risks, costs, and benefits are the primary remedy evaluation criteria.

Practicability includes the assessment of feasibility, short- and long-term effectiveness, and the reliability of the remedial alternative. The risk criteria include assessment of the overall protectiveness of public health and the environment in terms of fate and transport of the COCs, current and future land and water uses, exposure pathways and durations of potential exposure, changes in risk during remediation, and residual risk at the end of remediation. The cost analysis includes capital, O&M, and life cycle costs. Evaluation of benefits includes the assessment of lowered risk, reduced COC concentration or volume, decrease in liability, and preservation of existing and future uses.

Table 4 presents an evaluation of the reference and alternative remedies for the Site with respect to the comparison criteria. The following subsections detail how the remedies perform against these criteria.

For cost analyses, the estimates are conceptual and assumed to have similar margins of error between +50 percent (%) and –30% (i.e., the actual costs are expected to be between 30% less than and 50% more than the estimated costs). Long term O&M and monitoring costs are based on an annual escalation rate of 3%. However, due to the contingencies, the costs will be further evaluated in the PRAP.

The remedies are presented in the following subsections in order from the less aggressive remedial alternative to the reference remedy to the more aggressive remedial alternative.

6.1.1 Less Aggressive Alternative Remedy

The practicability, risk, cost, and benefit of the Less Aggressive Remedy are discussed in the following subsections.

6.1.1.1 Practicability

The Less Aggressive Alternative Remedy for the Site plume consists of MNA. MNA is a known and effective remedy. Semiannual monitoring and progress measurement will assess effectiveness. Considered a long-term remedy for the Site. Provides less certainty than the Reference Remedy and More Aggressive Alternative Remedy; however, trend analysis and predictive modeling are intended to increase certainty. No significant technological or hydrogeological barriers to application are anticipated. This remedy is considered to be feasible. However, due to the estimated time period to achieve the ROs, implementation of the contingency remedial measures will be required to make this remedy practicable. This results in implementation of the Reference Remedy.

6.1.1.2 Protectiveness (Risk)

No aquatic or terrestrial biota are at risk from the impacts associated with the plume. Within the current plume boundaries, the Less Aggressive Alternative Remedy is protective of human health because groundwater within the PCE plume is not currently being used. However, PCE may migrate downgradient resulting in impacts to groundwater that is currently being or is planned to be used. Therefore, implementation of the contingency remedial measures will be required to make this remedy protective. This results in implementation of the Reference Remedy.

6.1.1.3 Cost

Costs for the Less Aggressive Alternative Remedy are presented in **Table 6** and detailed costs are presented in **Appendix B-1**. The two monitoring wells downgradient of BMW-16D are included in the cost as a capital cost. An estimated 250 years are estimated for the ROs to be achieved. However, by Year 65, the estimated cost for the Less Aggressive Remedy exceeds the estimated maximum cost (+50%) for the Reference Remedy. Due to the estimated time period for the ROs to be achieved, the estimated cost for the Less Aggressive Remedy is more than the estimated cost for the Reference and More Aggressive Remedies. The inclusion of the contingency remedial measure results in the Reference Remedy. Therefore, contingency costs have not been included in the cost analysis for the Less Aggressive Remedy. To provide the cost for the Less Aggressive Alternative Remedy, the time period provided in **Appendix B-1** is limited to a 65-year program. Based on a 65-year program, the total cost for the Less Aggressive Alternative Remedy is estimated at approximately $12,054,000, with a margin of error between $8,439,000 (-30%) and $18,081,000 (+50%).

6.1.1.4 Benefits

Under the current ambient groundwater flow velocity, the Less Aggressive Remedial Alternative provides less benefit than the Reference Remedy or More Aggressive Remedial Alternative due to the longer anticipated time to achieve the remedial goals. As stated previously, the contingency remedial measure for the Less Aggressive Remedial Alternative is required, thus resulting in the Reference Remedy.

6.1.2 Reference Remedy

The Reference Remedy is GWET via wellhead treatment at SRP Well 17.9E-7.5N with contingency installation and operation of the Grand Canal GWET system. The Reference Remedy is intended to achieve the remedial goal in a shorter time period than the Less Aggressive Remedy. It also offers a greater range for installation of the Grand Canal GWET system, between one and seven years of startup of the SRP well GWET system. The practicability, risk, cost, and benefits for implementation of the Reference Remedy are discussed in the following subsections.

6.1.2.1 Practicability

GWET is a well-established technology for remediation of PCE impacted groundwater, particularly when an existing production well is available for wellhead treatment. GWET is the only feasible and cost-effective remedial technology available that is shorter term than MNA. No significant technological or hydrogeological barriers to application are anticipated. The reference remedy is considered to be feasible and practical.

6.1.2.2 Protectiveness (Risk)

The Reference Remedy is considered protective of human health and the environment because groundwater within the plume area is remediated below the remediation goal, which allows future use of the groundwater. Also, the Reference Remedy also minimizes/eliminates downgradient migration of the PCE to potential downgradient groundwater uses.

6.1.2.3 Cost

Costs for the Reference Remedy are presented in **Table 4** and detailed costs are presented in **Appendix B-2**. Due to the timeframe, the estimated cost for the Reference Remedy is lower than the estimated cost for the Less Aggressive Remedial Alternative. Based on implementation of the Grand Canal GWET system seven years after startup of the SRP well GWET system and overall estimated 26-year time period to achieve the ROs, the cost for the Reference Remedy is higher than the estimated cost for the More Aggressive Remedial Alternative. However, the cost will decrease as the time period between startup of both GWET systems is decreased. Capital costs without contingencies are estimated to be approximately $1,173,000 and operation, maintenance, and monitoring (OM&M) costs are estimated to be approximately $5,858,000. These costs are based on the Grand Canal GWET system being installed and started during Year 7 of the remedy. These costs will decrease if the Grand Canal GWET system is installed and started within less than seven years. The total estimated cost for the Reference Remedy including contingencies is estimated at approximately $7,182,000, with a margin of error between $5,369,000 (-30%) and $11,474,000 (+50%).

6.1.2.4 Benefits

The Reference Remedy is the same as the More Aggressive Alternative Remedy; however, it provides a flexible schedule for installation and operation of the Grand Canal GWET system, within seven years of implementation of the remedy. This allows decreased costs if the Grand Canal GWET system is implemented between one and seven years of the SRP well GWET system. The overall benefit for this remedy is that SRP Well 17.9E-7.5N can be returned to service within a relatively short timeframe with minimal construction disturbance and an available groundwater resource is returned to use. Implementation of the Grand Canal GWET system is expected to decrease the time required to achieve the remedial goals, thus decreasing the overall cost.

6.1.3 More Aggressive Alternative Remedy

The More Aggressive Alternative Remedy is the same as the Reference Remedy. It is considered “more aggressive” because the Grand Canal GWET system is implemented within two years of startup of the SRP well GWET system. The estimated costs for the More Aggressive Alternative Remedy based on implementation of the Grand Canal GWET system within two years of implementation of the remedy are presented in **Table 4** and detailed costs are presented in **Appendix B-3**. The estimated cost for the More Aggressive Alternative Remedy is lower than the estimated cost for the Reference Remedy due to the shorter time period for OM&M and delisting/closure of the Site. Capital costs without contingencies are estimated to be approximately $1,001,000 and operation, maintenance, and monitoring (OM&M) costs are estimated to be approximately $4,930,000. These costs are based on the Grand Canal GWET system being installed and started during Year 2 of the remedy. The total estimated cost for the More Aggressive Remedy including contingencies is approximately $6,082,000, with a margin of error between $4,241,000 (-30%) and $9,075,000 (+50%).

The More Aggressive Alternative Remedy results in the benefit of decreasing the timeframe to delist/close the Site, thus decreasing cost. However, it requires that the Grand Canal GWET system be implemented within two years of the SRP well GWET system.

6.2 Comparison of Remedies

Comparison of the remedies is required under A.A.C R18 16-407(H). The three evaluated remedies are all capable of achieving the ROs for groundwater and result in plume remediation. The differences are the timeframe and cost required to achieve the ROs. However, the Less Aggressive Alternative Remedy without contingency is expected to result in downgradient migration of the PCE plume. **Table 4** presents a ranking of the comparison criteria for each of the remedies. Each remedy was ranked from zero to five, with five indicating the most relative benefit and zero indicating the least relative or no benefit. The following subsections describe the practicability, risk, cost, and benefits comparison for the remedies.

6.2.1 Practicability

There are four considerations for practicability as follows:

- Feasibility involves the ability to put the remedy in place;
- Short-term effectiveness represents how much the remedy removes the PCE and limits the potential for exposure in the short-term;
- Long-term effectiveness represents how much the remedy removes the PCE and limits the potential for exposure in the long-term; and,
- Reliability involves whether the technologies comprising the alternative are expected to perform reliably.

The three evaluated remedial alternatives were equally feasible and reliable and all received a score of 5. The Reference Remedy and More Aggressive Alternative Remedy each received a score of 5 for short/long term effectiveness. However, due to the estimated timeframe, the Less Aggressive Remedy received a score of 1 for short/long term effectiveness. The practicability scores for the evaluated remedial alternatives are; Reference – 15, More Aggressive – 15, and Less Aggressive – 11.

6.2.2 Protectiveness (Risk)

Due to the extent and low PCE concentrations, the Reference Remedy and More Aggressive Alternative Remedy are expected to achieve the remedial goals within 26 years, which is considered a reasonable timeframe, and control downgradient migration of the PCE plume. The Less Aggressive Alternative Remedy will require the most amount of time to achieve the remedial goal and may result in downgradient migration of PCE. The Reference Remedy and More Aggressive Alternative Remedy are considered more protective than the Less Aggressive Alternative Remedy due to the shorter time period to achieve the remedial goal. Therefore, the Reference Remedy and More Aggressive Alternative Remedy received a score of 5 and the Less Aggressive Alternative Remedy received a score of 1.

6.2.3 Cost

The three remedies have varying capital and O&M costs. Due to the timeframe required, the Less Aggressive Alternative Remedy will cost the most, exceeding the estimated maximum (+50%) cost of the Reference Remedy by Year 65. The More Aggressive Alternative Remedy is estimated to cost the least. However, the cost for the Reference Remedy is estimated to approach the cost for the More Aggressive Alternative Remedy as the period between implementation of the SRP well and Grand Canal GWET systems decreases.

6.2.4 Benefit

The Reference Remedy and More Aggressive Alternative Remedy are the same and have the benefit of achieving the ROs within and estimated 26 years. The More Aggressive Alternative Remedy is expected to achieve the ROs in less time, thus decreasing costs. However, the Reference Remedy provides an extended schedule for installation of the Grand Canal GWET system. The Reference Remedy and More Aggressive Remedy return SRP Well 17.9E-7.5N to service and restore the groundwater use within the Site. Due to the timeframe required, the Least Aggressive Alternative Remedy does not provide benefits.

7.0 Proposed Remedy

7.1 Process and Reason for Selection

As previously discussed, the available remedial technologies to achieve the groundwater ROs are limited due to the dimensions of the PCE plume, the hydrogeological and geochemical conditions at the Site, and the highly developed urbanized nature of the Site. The Reference Remedy and More Aggressive Alternative Remedy involve the same remedial measures and preliminary designs. The More Aggressive Alternative Remedy has the overall lowest cost. However, the Reference Remedy provides an extended schedule for installation of the Grand Canal GWET system, between one to seven years. Semiannual groundwater monitoring will be used to assess the PCE plume stability and monitor decreasing VOC concentrations at the Site. The Reference Remedy and More Aggressive Alternative Remedy scored the same (30 points) based on current conditions when ranking in accordance with the comparison criteria specified in A.A.C R18 16-407H.3.e (**Section 6**).

Based on the evaluation, the recommended remedy is the Reference Remedy. As the timeframe for installation of the Grand Canal GWET system decreases, overall estimated costs for the Reference Remedy will approach the overall estimated costs for the More Aggressive Alternative Remedy due to decreased OM&M time. This recommendation is based on what is the best combination of remedial effectiveness, practicability, cost, and benefit for restoration and use of groundwater resources.

7.2 Achievement of Remedial Objectives

The Reference Remedy for PCE in groundwater will achieve the ROs (**Section 3.3.2**). It will provide active remediation of the dissolved PCE plume and will result in achievement of the ROs within 26 years assuming that the Grand Canal GWET system is installed within seven years of implementation of the remedy. The remedy time period will decrease as the time to implement the Grand Canal GWET system is decreased.

7.3 Achievement of Remedial Action Criteria Pursuant to ARS §49-282.06

To meet the remedial action criteria listed in ARS §49-282.06, it is recommended that the Reference Remedy for PCE in groundwater be selected as the Final Remedy. The Reference Remedy will:

- Provide for adequate protection of public health and welfare and the environment;
- Provide a thorough and timely means for continued remediation and monitoring of the existing groundwater impacts, including evaluation of the progress of remediation over time;
- To the extent practicable, provide for the control, management, and cleanup of the dissolved PCE in the groundwater;
- Provide for the beneficial future use of the groundwater resource by SRP and possibly COP; and,
- Be reasonable, cost-effective, and technically feasible.

7.4 Consistency with Water Management and Land Use Plans

The Reference Remedy for groundwater is consistent with water management plans and general land use plans.

8.0 Community Involvement

ADEQ will issue a Notice to the Public announcing the availability of FS on ADEQ's website at www.azdeq.gov. The notice may be mailed to the Public Mailing List for the Site, water providers, the Community Advisory Board (CAB), and any other interested parties. ADEQ may also present a summary of this FS and the remedial alternatives in a CAB meeting. Interested parties can also review the FS and other site documents at the ADEQ Main Office located at 1110 West Washington Street, Phoenix, Arizona. With 24-hour notice, an appointment can be made to review related documentation.

9.0 References

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Tables

TABLE 1
WELL CONSTRUCTION DATA
FEASIBILITY STUDY REPORT - 40TH STREET AND OSBORN ROAD WATER QUALITY ASSURANCE REVOLVING FUND SITE

ECP SUB AREA	WELL ID	ADWR REGISTRATION NUMBER (55-)	DATE COMPLETED	DRILLING METHOD	BORING DIAMETER (INCHES)	BORING DEPTH (FEET BGBS)	CASING MATERIAL/ DIAMETER/ SLOT SIZE (INCHES)	PERFORATED INTERNAL (FEET BGS)	SAND PACK INTERVAL (FEET BGS)	FILTER PACK MATERIAL	BENTONITE SEAL (FEET BGS)	TOP OF CASING ELEVATION (1) (FEET ASML)	GROUND SURFACE ELEVATION (1) (FEET ASML)	LOCATION COORDINATES (2)	
														LATITUDE (DEG)	LONGITUDE (DEG)
40osb	SRP17.9E-7.5N	617857	5/1/1965	Cable Tool	NR	300	Steel / 18 / Perforated	100.0 - 300.0	48.0 - 300.0	Gravel	NR	NR	1193	NR	NR
40osb	BMW-01A	598109	6/2/2003	Hollow Stem Auger	10	91	PVC / 4 / 0.020	20 - 60	15 - 63	#10-20 Sand	11 - 15 63 - 91	1193.20	1194.38	33.4877	-111.9961
40osb	BMW-01B	909970	12/4/2008	Hollow Stem Auger	8	100	PVC / 2 / 0.020	70 - 100	65 - 100	#10-20 Sand	59 - 65	1193.59	1194.34	33.4878	-111.9961
40osb	BMW-02A*	908743	4/18/2008	Sonic	10	61	PVC / 2 / 0.020	20 - 60	15 - 61	8/12 Sand	10 - 15	1199.66	1200.06	33.4901	-111.9946
40osb	BMW-02B*	908743	4/18/2008	Sonic	10	100	PVC / 2 / 0.020	70 - 100	65 - 100	8/12 Sand	10 - 15 61 - 65	1199.60	1200.06	33.4901	-111.9946
40osb	BMW-02C	917659	3/18/2015	Sonic	8.25 7.125	139.8 140.6	PVC / 4 / 0.020	109.5 - 139.5	106.7 - 140.6	#10-20 Sand	101.6 - 106.7	1199.53	1199.99	33.4901	-111.9946
40osb	BMW-02E	922509	4/10/2019	Sonic	9	280	PVC / 4 / 0.020	155 - 265	153 - 269	#10-20 Sand	147 - 153	1199.63	1199.97	33.4901	-111.9947
40osb	BMW-03A*	908744	5/16/2008	Hollow Stem Auger	10	60.5	PVC / 2 / 0.020	20 - 60	15 - 60.5	8/12 Sand	10 - 15	1201.09	1201.32	33.4895	-111.9929
40osb	BMW-03B*	908744	5/16/2008	Hollow Stem Auger	10	98.3	PVC / 2 / 0.020	70 - 100	65 - 101	8/12 Sand	10 - 15 61 - 65	1201.12	1201.32	33.4895	-111.9929
40osb	BMW-04B	916201	1/3/2014	Sonic	8.625 6.0	120.0 121.7	PVC / 4 / 0.020	78.8 - 118.8	75.4 - 121.7	#10-20 Sand	71.6 - 75.4	1200.32	1200.90	33.4888	-111.9920
40osb	BMW-04A	916200	1/4/2014	Sonic	8.625 6.0	70.0 71.1	PVC / 4 / 0.020	30.0 - 70.0	27.0 - 71.1	#10-20 Sand	23.5 - 27.0	1200.37	1200.86	33.4888	-111.9920
40osb	BMW-07A	916198	12/29/2013	Sonic	8.625 6.0	70.0 74.0	PVC / 4 / 0.020	29.6 - 69.6	26.0 - 70.0	#10-20 Sand	23.0 - 26.0	1189.22	1189.74	33.2034	-111.9982
40osb	BMW-07B	916199	12/28/2013	Sonic	8.625 6.0	115.0 116.0	PVC / 4 / 0.020	85.0 - 115.0	80.0 - 116.0	#10-20 Sand	70.0 - 80.0	1189.20	1189.72	33.4868	-111.9982
40osb	BMW-09C	922867	9/29/2019	Sonic	9.0	135.0	PVC / 4 / 0.020	95.0 - 130.0	93.0 - 130.0	#10-20 Sand	90.5 - 93.0	1170.54	1170.84	33.4823	-112.0069
40osb	BMW-09D	921211	4/2/2018	Sonic	8.25 6.125	234.5 288.0	PVC / 4 / 0.020	180.7 - 230.7	176.5 - 234	#10-20 Sand	170.5 - 176.5	1170.44	1170.77	33.4823	-112.0069
40osb	BMW-10D	921212	4/25/2018	Sonic	8.25 6.125	233.0 293.0	PVC / 4 / 0.020	230.6 - 280.6	227.5 - 280.6	#10-20 Sand	221.5 - 227.5	1148.63	1149.67	33.4765	-112.0339
40osb	BMW-11D	921213	5/9/2018	Sonic	8.25 6.125	233.0 241.0	PVC / 4 / 0.020	151.0 - 211.0	148.0 - 214.0	#10-20 Sand	140.0 - 148.0	1180.11	1180.61	33.4828	-111.9998
40osb	BMW-14D	922019	10/31/2018	Sonic	9.0	300.0	PVC / 4 / 0.020	225.0 - 275.0	223.0 - 277.0	#10-20 Sand	221.0 - 223.0	1135.93	1136.31	33.4730	-112.0239
40osb	BMW-16D	922021	4/19/2019	Sonic	9.0	290.0	PVC / 4 / 0.020	205.0 - 275.0	203.0 - 278.0	#10-20 Sand	198.3 - 203.0	1131.69	1132.28	33.3717	-112.0263
40osb	BMW-17D	922346	8/27/2019	Sonic	9.0	267.0	PVC / 4 / 0.020	135.0 - 245.0	133.0 - 247.0	#10-20 Sand	130.0 - 133.0	1185.97	1186.37	33.4874	-112.0020
40osb	BMW-18D	922865	9/13/2019	Sonic	9.0	274.0	PVC / 4 / 0.020	215.0 - 265.0	213.0 - 267.0	#10-20 Sand	210.0 - 213.0	1157.00	1157.33	33.4795	-112.0151
40osb	BMW-19D	922866	8/27/2019	Sonic	9.0	267.0	PVC / 4 / 0.020	202.0-252.0	197.0 - 252.0	#10-20 Sand	194.0 - 197.0	1152.04	1152.44	33.3750	-112.1187
40osb	BMW-20D	923910	3/24/2020	Sonic	9.0	247.0	PVC / 4 / 0.020	135.0 - 245.0	133.0 - 245.0	#10-20 Sand	125.0 - 133.0	1192.44	1192.76	33.4904	-112.0021
40osb	BMW-21D	923912	4/1/2020	Sonic	9.0	233.0	PVC / 4 / 0.020	180.0 - 230.0	178.0 - 230.0	#10-20 Sand	170.0 - 178.0	1176.02	1176.35	33.4863	-112.0079
40osb	BMW-22D	923911	4/9/2020	Sonic	9.0	235.0	PVC / 4 / 0.020	130.0 - 230.0	128.0 - 230.0	#10-20 Sand	117.0 - 128.0	1176.67	1176.97	33.4841	-112.0050

NOTES:

* wells installed within the same borehole
(1) NAVD88
(2) GRID, NAD83, Arizona Central 202
40osb East Cental Phoenix Water Quality Assurance Revolving Fund Site - 40th Street and Osborn Road Site
ADWR Arizona Department of Water Resources
FEET BGS feet below ground surface
FEET AMSL feet above mean sea level
NR Not Reported
Sonic Rotosonic drilling method
SRP Salt River Project

TABLE 2. OCTOBER 2020 -SEPTEMBER 2021 WATER LEVEL DATA, ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well I.D	ADEQ Number	ADWR Number	Date	Measuring Point Elevation (ft. AMSL)[1]	Depth to Groundwater (ft. BMP)[2]	Groundwater Elevation (ft. AMSL)[1]	Change Since Previous (ft.)	Comments
BMW-01A	62104	55-598109	10/15/2019	1193.20	39.93	1153.27	0.22	
			5/12/2020	1193.20	40.5	1152.70	-0.57	
			9/21/2020	1193.20	40.51	1152.69	-0.01	
BMW-01B	77128	55-909970	10/15/2019	1193.59	NM	NM	NM	Inaccessible
			5/12/2020	1193.59	40.16	1153.43	NM	
			9/21/2020	1193.59	40.21	1153.38	-0.05	
BMW-02A	71384	55-908743	10/15/2019	1199.66	40.90	1158.76	0.38	
			5/13/2020	1199.66	41.71	1157.95	-0.81	
			9/21/2020	1199.66	41.76	1157.90	-0.05	
BMW-02B	71385	55-908743	10/15/2019	1199.60	40.89	1158.71	0.36	
			5/13/2020	1199.60	41.67	1157.93	-0.78	
			9/21/2020	1199.60	41.75	1157.85	-0.08	
BMW-02C	80535	55-817659	10/15/2019	1199.53	40.27	1159.26	0.94	
			5/13/2020	1199.53	41.63	1157.90	-1.36	
			9/21/2020	1199.53	41.71	1157.82	-0.08	
BMW-02E	81753	55-922509	10/15/2019	1199.63	41.38	1158.25	0.22	
			5/13/2020	1199.63	42.05	1157.58	-0.67	
			9/21/2020	1199.63	42.10	1157.53	-0.05	
BMW-03A	71386	55-908744	10/15/2019	1201.09	39.10	1161.99	0.32	
			5/13/2020	1201.09	39.78	1161.31	-0.68	
			9/21/2020	1201.09	39.99	1161.10	-0.21	

TABLE 2. OCTOBER 2020 -SEPTEMBER 2021 WATER LEVEL DATA, ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well I.D	ADEQ Number	ADWR Number	Date	Measuring Point Elevation (ft. AMSL)[1]	Depth to Groundwater (ft. BMP)[2]	Groundwater Elevation (ft. AMSL)[1]	Change Since Previous (ft.)	Comments
BMW-03B	71387	55-908744	10/15/2019	1201.12	39.10	1162.02	0.32	
			5/13/2020	1201.12	39.78	1161.34	-0.68	
			9/21/2020	1201.12	44.04	1157.08	-4.26	Anomalous reading
BMW-04A	79627	55-916200	10/15/2019	1200.37	36.69	1163.68	NM	
			5/13/2020	1200.37	37.26	1163.11	-0.57	
			9/21/2020	1200.37	37.45	1162.92	-0.19	
BMW-04B	79628	55-916201	10/15/2019	1200.32	36.62	1163.70	NM	
			5/14/2020	1200.32	37.30	1163.02	-0.68	Vehicle over well 5/13
			9/21/2020	1200.32	37.43	1162.89	-0.13	
BMW-07A	79643	55-916198	10/15/2019	1189.22	41.69	1147.53	0.02	
			5/13/2020	1189.22	42.21	1147.01	-0.52	
			9/21/2020	1189.22	42.22	1147.00	-0.01	
BMW-07B	79644	55-916199	10/15/2019	1189.20	41.63	1147.57	0.02	
			5/13/2020	1189.20	42.31	1146.89	-0.68	
			9/21/2020	1189.20	42.13	1147.07	0.18	
BMW-09C	81747	55-922867	10/15/2019	1170.54	51.03	1119.51		First Water Level
			5/13/2020	1170.54	52.41	1118.13	-1.38	
			9/21/2020	1170.54	52.41	1118.13	0.00	
BMW-09D	81660	55-921211	10/15/2019	1170.44	52.27	1118.17	-0.26	
			5/13/2020	1170.44	52.56	1117.88	-0.29	
			9/21/2020	1170.44	52.48	1117.96	0.08	
BMW-10B	81748	55-922868	10/15/2019	1149.25	76.16	1073.09		First Water Level
			5/13/2020	1149.25	76.42	1072.83	-0.26	
			9/21/2020	1149.25	76.23	1073.02	0.19	

TABLE 2. OCTOBER 2020 -SEPTEMBER 2021 WATER LEVEL DATA, ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well I.D	ADEQ Number	ADWR Number	Date	Measuring Point Elevation (ft. AMSL)[1]	Depth to Groundwater (ft. BMP)[2]	Groundwater Elevation (ft. AMSL)[1]	Change Since Previous (ft.)	Comments
BMW-10D	81661	55-921212	10/15/2019	1148.63	74.73	1073.90	0.24	
			5/13/2020	1148.63	74.68	1073.95	0.05	
			9/21/2020	1148.63	74.79	1073.84	-0.11	
BMW-11D	81662	55-921213	10/15/2019	1180.11	43.92	1136.19	-0.13	
			5/13/2020	1180.11	44.21	1135.90	-0.29	
			9/21/2020	1180.11	44.26	1135.85	-0.05	
BMW-14D	81663	55-922019	10/15/2019	1135.93	80.45	1055.48	0.16	
			5/13/2020	1135.93	79.94	1055.99	0.51	
			9/21/2020	1135.93	80.41	1055.52	-0.47	
BMW-16D	81754	55-922021	10/15/2019	1131.69	82.90	1048.79	0.05	
			5/13/2020	1131.69	82.25	1049.44	0.65	
			9/21/2020	1131.69	82.83	1048.86	-0.58	
BMW-17D	81746	55-922346	10/15/2019	1185.97	46.12	1139.85		First Water Level
			5/13/2020	1185.97	46.64	1139.33	-0.52	
			9/21/2020	1185.97	46.57	1139.40	0.07	
BMW-18D	81749	55-922865	10/15/2019	1157.00	69.34	1087.66		First Water Level
			5/13/2020	1157.00	69.48	1087.52	-0.14	
			9/21/2020	1157.00	69.41	1087.59	0.07	
BMW-19D	81750	55-922866	10/15/2019	1152.04	70.85	1081.19		First Water Level
			5/13/2020	1152.04	71.04	1081.00	-0.19	
			9/21/2020	1152.04	70.91	1081.13	0.13	
BMW-20D	81924	55-923910	5/13/2020	1192.44	49.02	1143.42		First Water Level
			9/21/2020	1192.44	48.86	1143.58	0.16	
BMW-21D	81925	55-923912	5/13/2020	1176.02	51.98	1124.04		First Water Level
			9/21/2020	1176.02	51.75	1124.27	0.23	

TABLE 2. OCTOBER 2020 -SEPTEMBER 2021 WATER LEVEL DATA, ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well I.D	ADEQ Number	ADWR Number	Date	Measuring Point Elevation (ft. AMSL)[1]	Depth to Groundwater (ft. BMP)[2]	Groundwater Elevation (ft. AMSL)[1]	Change Since Previous (ft.)	Comments
BMW-22D	81926	55-923911	5/13/2020	1176.67	50.09	1126.58		First Water Level
			9/21/2020	1176.67	50.04	1126.63	0.05	
MW-7*	60962	55-583961	10/15/2019	1156.75	68.59	1088.16	-0.11	
			5/13/2020	1156.75	NM	NM	NM	Flooded w/bugs
			9/21/2020	1156.75	69.70	1087.05	NM	
MW-8*	81755	55-205093	10/15/2019	1157.28	66.80	1090.48	0.18	
			5/13/2020	1157.28	67.18	1090.10	-0.38	
			9/21/2020	1157.28	67.00	1090.28	0.18	
MW-9*	81756	55-205094	10/15/2019	1156.28	66.70	1089.58	0.17	
			5/13/2020	1156.28	67.08	1089.20	-0.38	
			9/21/2020	1156.28	66.83	1089.45	0.25	
MW-10*	81757	55-205095	10/15/2019	1152.84	70.91	1081.93	0.26	
			5/13/2020	1152.84	71.14	1081.70	-0.23	
			9/21/2020	1152.84	71.05	1081.79	0.09	

Notes:

1. Feet above mean sea level (ft AMSL)
2. Feet below measuring point (ft BMP)

NM - not measured.

* indicates monitoring well associated with Former Mobil Station #18KDP, 3141 East Thomas Road, Phoenix, Arizona, LUST file number 3004.

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6]				Comments/Other VOCs detected[7]
					PCE	TCE	c-1,2-DCE	Chloroform	
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-01A	1193.20	41	1152.20	10/16/2019	<2.0	<2.0	<2.0	4.5	Changed due to lower water level
		41	1152.20	9/24/2020	<0.50	<0.50	<0.50	5.1	
				Δ Last	NC	NC	NC	0.6	
		57.3	1135.90	10/16/2019	<2.0	<2.0	<2.0	6.4	
				9/24/2020	<0.50	<0.50	<0.50	8.9	
				Δ Last	NC	NC	NC	2.5	
BMW-01B	1193.59	72.5	1121.09	10/16/2019	NS	NS	NS	NS	Inaccessible
				9/24/2020	<0.50	<0.50	<0.50	0.69	
				Δ Last	NC	NC	NC	NC	
		96.3	1097.29	10/16/2019	NS	NS	NS	NS	Inaccessible
				9/24/2020	<0.50	<0.50	<0.50	0.9	
				Δ Last	NC	NC	NC	NC	
BMW-02A	1199.66	57.4	1142.26	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				10/16/2019(D)	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
BMW-02B	1199.60	84.7	1114.90	10/16/2019	<2.0	<2.0	<2.0	3.8	
				9/24/2020	<0.50	<0.50	<0.50	1.9	
				Δ Last	NC	NC	NC	-1.9	
		90.7	1108.90	10/16/2019	<2.0	<2.0	<2.0	3.0	
				9/24/2020	0.55	<0.50	<0.50	2.0	
				Δ Last	NC	NC	NC	-1.0	
		96.8	1102.80	10/16/2019	<2.0	<2.0	<2.0	3.9	
				9/24/2020	<0.50	<0.50	<0.50	1.8	
				Δ Last	NC	NC	NC	-2.1	
BMW-02C	1199.53	112.5	1087.03	10/16/2019	**24**	<2.0	<2.0	<2.0	
				9/24/2020	**15**	<0.50	<0.50	<0.50	
				9/24/2020(D)	**22**	<0.50	<0.50	<0.50	
				Δ Last	-9	NC	NC	NC	
		118.5	1081.03	10/16/2019	**19**	<2.0	<2.0	<2.0	
				9/24/2020	**9.6**	<0.50	<0.50	0.89	
				Δ Last	-9.4	NC	NC	NC	
		124.5	1075.03	10/16/2019	**15**	<2.0	<2.0	<2.0	
				9/24/2020	**9.5**	<0.50	<0.50	0.89	
				Δ Last	-5.5	NC	NC	NC	
		130.5	1069.03	10/16/2019	**11**	<2.0	<2.0	<2.0	
				9/24/2020	**9.6**	<0.50	<0.50	1.2	
				Δ Last	-1.4	NC	NC	NC	
		136.5	1063.03	10/16/2019	**15**	<2.0	<2.0	<2.0	
				9/24/2020	**8.4**	<0.50	<0.50	1.2	
				Δ Last	-6.6	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6]				Comments/Other VOCs detected[7]
					PCE	TCE	c-1,2-DCE	Chloroform	
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-02E	1199.63	160.0	1039.63	10/16/2019	**120**	2.0	<2.0	<2.0	
				9/24/2020	**100**	1.9	<2.0	0.57	
				Δ Last	-20	-0.1	NC	NC	
		180.0	1019.63	10/16/2019	**100**	<2.0	<2.0	<2.0	
				9/24/2020	**51**	0.72	<0.50	0.54	
				Δ Last	-49	NC	NC	NC	
		200.0	999.63	10/16/2019	**89**	<2.0	<2.0	<2.0	
				9/24/2020	**51**	0.89	<0.50	<0.50	
				Δ Last	-38	NC	NC	NC	
		220.0	979.63	10/16/2019	**93**	<2.0	<2.0	<2.0	
				9/24/2020	**55**	0.84	<0.50	0.50	
				Δ Last	-38	NC	NC	NC	
		240.0	959.63	10/16/2019	**100**	<2.0	<2.0	<2.0	
				9/24/2020	**52**	0.94	<0.50	<0.50	
				Δ Last	-48	NC	NC	NC	
		260.0	939.63	10/16/2019	**120**	<2.0	<2.0	<2.0	
				9/24/2020	**54**	0.98	<0.50	<0.50	
				9/24/2020(D)	**45**	0.95	<0.50	<0.50	
				Δ Last	-66	NC	NC	NC	
BMW-03A	1201.09	58	1143.09	8/24/2016	<1.0	<1.0	<1.0	<1.0	
				12/4/2018	<2.0	<2.0	<2.0	<2.0	
				10/16/2019	<2.0	<2.0	<2.0	<2.0	
				10/16/2019(D)	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
BMW-03B	1201.12	95.5	1105.62	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	0.87	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
BMW-04A	1200.37	35.5	1164.87	8/24/2016	<1.0	<1.0	<1.0	<1.0	
		36.5	1163.87	12/4/2018	<2.0	<2.0	<2.0	<2.0	Changed due to lower water level
				10/16/2019	<2.0	<2.0	<2.0	<2.0	
		45	1155.37	9/24/2020	<0.50	<0.50	<0.50	<0.50	Changed due to lower water level
				Δ Last	NC	NC	NC	NC	
		51.4	1148.97	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				Δ Last	NC	NC	NC	NC	
		67.2	1133.17	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				10/16/2019(D)	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6]				Comments/Other VOCs detected[7]
					PCE	TCE	c-1,2-DCE	Chloroform	
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-04B	1200.32	81.2	1119.12	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
		98.3	1102.02	10/16/2019	<2.0	<2.0	<2.0	<2.0	MTBE (94) -1.1 µg/L
				9/24/2020	<0.50	<0.50	<0.50	<0.50	MTBE (94) -1.4µg/L
				Δ Last	NC	NC	NC	NC	
		115.4	1084.92	10/16/2019	<2.0	<2.0	<2.0	<2.0	MTBE (94) -1.2 µg/L
				9/24/2020	<0.50	<0.50	<0.50	<0.50	MTBE (94) -1.4 µg/L
				Δ Last	NC	NC	NC	NC	
BMW-07A	1214.27	42.5	1171.77	10/16/2019	<2.0	<2.0	<2.0	<2.0	Changed due to lower water level
		43	1171.27	9/24/2020	<0.50	<0.50	<0.50	<0.50	Changed due to lower water level
				Δ Last	NC	NC	NC	NC	
BMW-07B	1214.50	87.5	1127.00	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	0.70	<0.50	<0.50	0.72	
				Δ Last	NC	NC	NC	NC	
		111.5	1103.00	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	0.76	<0.50	<0.50	0.67	
				Δ Last	NC	NC	NC	NC	
BMW-09C	1170.44	100	1070.44	10/16/2019	3.4	<2.0	<2.0	<2.0	
				9/25/2020	2.6	<0.50	<0.50	0.75	
				Δ Last	-0.8	NC	NC	NC	
		120	1050.44	10/16/2019	3.2	<2.0	<2.0	<2.0	
				9/25/2020	3.5	<0.50	<0.50	1.1	
				Δ Last	0.3	NC	NC	NC	
BMW-09D	1170.44	185	985.44	10/16/2019	**11**	<2.0	<2.0	<2.0	
				9/25/2020	**21**	<0.50	<0.50	<0.50	
				Δ Last	10	NC	NC	NC	
		205	965.44	10/16/2019	**14**	<2.0	<2.0	<2.0	
				9/25/2020	**16**	<0.50	<0.50	<0.50	
				9/25/2020 (D)	**19**	<0.50	<0.50	<0.50	
				Δ Last	2	NC	NC	NC	
		225	945.44	12/4/2018	**19**	<2.0	<2.0	<2.0	
				10/16/2019	**8.4**	<2.0	<2.0	<2.0	
				10/16/2019 (D)	**12**	<2.0	<2.0	<2.0	
				9/25/2020	**17**	<0.50	<0.50	<0.50	
				Δ Last	8.6	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6] PCE	TCE	c-1,2-DCE	Chloroform	Comments/Other VOCs detected[7]
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-10D	1148.63	235	913.63	10/16/2019	2.0	<2.0	<2.0	<2.0	
				9/25/2020	**5.1**	<0.50	<0.50	<0.50	
				Δ Last	3.1	NC	NC	NC	
		255	893.63	10/16/2019	3.0	<2.0	<2.0	<2.0	
				9/25/2020	4.4	<0.50	<0.50	<0.50	
				Δ Last	1.4	NC	NC	NC	
		275	873.63	10/16/2019	4.6	<2.0	<2.0	<2.0	
				9/25/2020	4.9	<0.50	<0.50	<0.50	
				Δ Last	0.3	NC	NC	NC	
BMW-11D	1180.11	156	1024.11	10/16/2019	2.3	<2.0	<2.0	<2.0	
				9/24/2020	1.9	0.68	<0.50	<0.50	
				Δ Last	-0.4	NC	NC	NC	
		176	1004.11	10/16/2019	2.0	<2.0	<2.0	<2.0	
				9/24/2020	2.3	0.50	<0.50	<0.50	
				Δ Last	0.3	NC	NC	NC	
		196	984.11	10/16/2019	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	1.7	0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
BMW-14D	1135.93	225	910.93	10/15/2019	**5.9**	<2.0	<2.0	<2.0	
				9/25/2020	1.3	<0.50	<0.50	1.3	Toluene (1000)-0.95 µg/L
				Δ Last	-4.6	NC	NC	NC	
		245	890.93	10/15/2019	<2.0	<2.0	<2.0	<2.0	
				9/25/2020	1.5	<0.50	<0.50	1.4	Toluene (1000)-1.2 µg/L
				Δ Last	NC	NC	NC	NC	
		265	870.93	10/15/2019	<2.0	<2.0	<2.0	<2.0	
				9/25/2020	**7.4**	<0.50	<0.50	0.76	
				Δ Last	NC	NC	NC	NC	
BMW-16D	1131.69	208	923.69	10/15/2019	**5.1**	<2.0	<2.0	<2.0	
				9/25/2020	**12**	<0.50	<0.50	0.51	
				Δ Last	6.9	NC	NC	NC	
		228	903.69	10/15/2019	**10**	<2.0	<2.0	<2.0	
				9/25/2020	**11**	<0.50	<0.50	<0.50	
				9/25/20 (D)	**12**	<0.50	<0.50	0.50	
				Δ Last	1	NC	NC	NC	
		245	886.69	10/15/2019	**8.3**	<2.0	<2.0	<2.0	
				9/25/2020	**13**	<0.50	<0.50	0.53	
				Δ Last	4.7	NC	NC	NC	
		265	866.69	10/15/2019	4.0	<2.0	<2.0	<2.0	
				9/25/2020	**13**	<0.50	<0.50	<0.50	
				Δ Last	9.0	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6]				Comments/Other VOCs detected[7]
					PCE	TCE	c-1,2-DCE	Chloroform	
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-17D	1190.00	140	1050.00	10/16/2019	**120**	2.1	<2.0	<2.0	
				9/24/2020	**130**	2.4	<0.50	<0.50	
				Δ Last	10.0	0.3	NC	NC	
		160	1030.00	10/16/2019	**110**	<2.0	<2.0	<2.0	
				9/24/2020	**120**	2.2	<0.50	<0.50	
				Δ Last	10.0	NC	NC	NC	
		180	1010.00	10/16/2019	**110**	2.0	<2.0	<2.0	
				9/24/2020	**91**	1.8	<0.50	<0.50	
				9/24/2020 (D)	**110**	1.9	<0.50	<0.50	
				Δ Last	-19.0	NC	NC	NC	
		210	980.00	10/16/2019	**100**	<2.0	<2.0	<2.0	
				9/24/2020	**76**	1.6	<0.50	<0.50	
				Δ Last	-24.0	NC	NC	NC	
		235	955.00	10/16/2019	**81**	<2.0	<2.0	<2.0	
				9/24/2020	**75**	1.9	<0.50	<0.50	
				Δ Last	-6.0	NC	NC	NC	
BMW-18D	1158.00	220	938.00	10/16/2019	4.8	<2.0	<2.0	<2.0	CDS (NE)-7.3 μg/L, Toluene (1000)-42 μg/L
				9/25/2020	**16**	<0.50	<0.50	0.54	Toluene (1000)-6.3 μg/L
				Δ Last	11.2	NC	NC	NC	
		240	918.00	10/16/2019	**5.3**	<2.0	<2.0	<2.0	CDS (NE)-6.6 μg/L, Toluene (1000)-37 μg/L
				10/16/2019 (D)	**8.8**	<2.0	<2.0	<2.0	Toluene (1000)-9.4 μg/L
				9/25/2020	**5.7**	<0.50	<0.50	<0.50	Toluene (1000)-20 μg/L, MTBE (94)-1.5 μg/L, acetone (NE)-33 μg/L
				9/25/2020 (D)	**9.7**	<0.50	<0.50	<0.50	Toluene (1000)-13 μg/L, MTBE (94)-0.56 μg/L
				Δ Last	0.4	NC	NC	NC	
		260	898.00	10/16/2019	3.9	<2.0	<2.0	<2.0	CDS (NE)-8.8 μg/L, Toluene (1000)-39 μg/L
				9/25/2020	**5.1**	<0.50	<0.50	<0.50	Toluene (1000)-21 μg/L, MTBE (94)-1.0 μg/L, acetone (NE)-15 μg/L
				Δ Last	1.2	NC	NC	NC	
BMW-19D	1153.00	205	948.00	10/15/2019	<2.0	<2.0	<2.0	<2.0	CDS (NE)-6.8 μg/L, Toluene (1000)-23 μg/L
				9/25/2020	4.0	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	
		225	928.00	10/15/2019	2.6	<2.0	<2.0	<2.0	Toluene (1000)-12 μg/L
				9/25/2020	**5.1**	<0.50	<0.50	<0.50	
				Δ Last	2.5	NC	NC	NC	
		245	908.00	10/15/2019	<2.0	<2.0	<2.0	<2.0	CDS (NE)-9.0 μg/L, Toluene (1000)-28 μg/L
				9/25/2020	3.4	<0.50	<0.50	<0.50	
				Δ Last	NC	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6] PCE	TCE	c-1,2-DCE	Chloroform	Comments/Other VOCs detected[7]
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-20D	1192.44	140	1052.44	5/15/2020	<2.0	<2.0	<2.0	<2.0	1,2,4-TMB (NE) - 2.8 µg/L, CDS (NE) - 6.4 µg/L, Toluene (1000) - 6.3 µg/L
				9/24/2020	<0.50	<0.50	<0.50	0.81	Toluene (1000) - 0.73 µg/L
				Δ Last	NC	NC	NC	NC	
		160	1032.44	5/15/2020	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	0.91	
				Δ Last	NC	NC	NC	NC	
		180	1012.44	5/15/2020	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	0.81	
				Δ Last	NC	NC	NC	NC	
		210	982.44	5/15/2020	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	1.1	
				Δ Last	NC	NC	NC	NC	
		230	962.44	5/15/2020	<2.0	<2.0	<2.0	<2.0	
				9/24/2020	<0.50	<0.50	<0.50	<0.50	1,2,4-TMB (NE) - 0.75 µg/L, Toluene (1000) - 2.3 µg/L, Xylene (10,000) - 2.2 µg/L
				Δ Last	NC	NC	NC	NC	
BMW-21D	1176.02	190	986.02	5/15/2020	<2.0	<2.0	<2.0	<2.0	MTBE (94) - 2.7 µg/L
				9/25/2020	<0.50	<0.50	<0.50	0.65	MTBE (94) - 1.3 µg/L
				Δ Last	NC	NC	NC	NC	
		210	966.02	5/15/2020	<2.0	<2.0	<2.0	<2.0	MTBE (94) - 2.5 µg/L
				9/25/2020	<0.50	<0.50	<0.50	0.85	
				Δ Last	NC	NC	NC	NC	
		225	951.02	5/15/2020	<2.0	<2.0	<2.0	<2.0	MTBE (94) - 2.4 µg/L
				9/25/2020	<0.50	<0.50	<0.50	0.53	MTBE (94) - 1.9 µg/L
				Δ Last	NC	NC	NC	NC	

Table 3
PCE, TCE, c-1,2-DCE, and CHLOROFORM ANALYTICAL RESULTS, OCTOBER 2019 -SEPTEMBER 2020
ECP 40th STREET AND OSBORN ROAD WQARF SITE

Well Name	MP Elevation (ft AMSL)[1]	Depth Sampled (ft BMP)[2]	Sample Elevation (ft AMSL)[3]	Sample Date	Results[4-6] PCE	TCE	c-1,2-DCE	Chloroform	Comments/Other VOCs detected[7]
				Aquifer Water Quality Standard	5.0	5.0	5.0	100	
BMW-22D	1176.67	132	1044.67	5/15/2020	**98**	4.8	<2.0	<2.0	
				5/15/2020 (D)	**110**	**5.2**	<2.0	<2.0	
				9/24/2020	**50**	3.1	<0.50	<0.50	
				9/24/2020 (D)	**66**	3.4	<0.50	0.65	
				Δ Last	-48.0	-1.7	NC	NC	
		160	1016.67	9/24/2020	**92**	4.2	<0.50	0.66	
		180	996.67	5/15/2020	**110**	5.0	<2.0	<2.0	
				9/24/2020	**64**	3.3	<0.50	0.61	
				Δ Last	-46.0	-1.7	NC	NC	
		210	966.67	5/15/2020	**94**	4.7	<2.0	<2.0	
				9/24/2020	**88**	4.2	<0.50	0.66	
				Δ Last	-6.0	-0.5	NC	NC	
		225	951.67	5/15/2020	**52**	3.3	<2.0	<2.0	
				9/24/2020	**33**	2.3	<0.50	0.51	
				Δ Last	-19.0	-1.0	NC	NC	

Notes:
1. Measuring point (MP) elevation in feet above mean sea level (ft AMSL)
2. Sample Depth - feet below MP (ft BMP)
3. Sample elevation in feet above mean sea level (ft AMSL)
4. Volatile organic compound (VOC) concentrations reported in micrograms per liter (ug/L). DCE - dichloroethene, PCE -tetrachloroethene, TCE - trichloroethene, 1,2,4-TMB - 1,2,4-trimethylbenzene, CDS - carbon disulfide, MTBE - methyl-
5. (D) denotes duplicate result
6. Δ denotes change since last and baseline sampling events for ISCO treatment zone wells. NC denotes no change.
7. The AWQS or remedial goal for other detected VOCs are shown in ().
* micropurge sample analyzed by non-compliance screening method. NA - not analyzed.

Table 4. Summary of Remedial Technology Screening and Retainage
40th Street and Osborn Road WQARF Site

Technology	Media	Comments	Retained?
MNA	Groundwater	Typically used when source has been controlled, geochemical parameters are suitable, and plume is stable or shrinking. With the exception of biodegradation indicators, these components are present.	Yes
ERD	Groundwater	Effective where in situ conditions can be manipulated to create reducing conditions and appropriate bacteria exist or can be introduced into groundwater.	No
Injected LGAC	Groundwater	Effective as a source control and controlled migration technology. Requires multiple injection points. Is not practicable in a residential setting.	No
ISCO	Groundwater	Effective as a source control and controlled migration technology. Requires multiple injection points. Is not be practicable in a residential setting.	No
ISCR	Groundwater	Effective when groundwater flow can be directed through a treatment zone that is within depths of typical excavation/drilling equipment and structures or infrastructure do not interfere with implementation.	No
GWET	Groundwater	Typically used for plume control rather than mass removal due to expense associated with long-term operations.	Yes

Table 5. Groundwater Monitoring Program 40th Street & Osborn Road WQARF Site.							
Wells Used for Water Level Measurements							
BMW-01B, BMW-02B, BMW-02C, BMW-03B, BMW-04B, BMW-05B, BMW-06B, BMW-07B, BMW-09C, BMW-09D, BMW-10D, BMW-11D, BMW-14D, BMW-16D, BMW-17D, BMW-19D, BMW-20D, BMW-21D, and BMW-22D							
Wells Used for Sampling and Sample Depths							
Well Identification	**Screened Interval (ft bgs)**	**Sample ID**					
		S1	**S2**	**S3**	**S4**	**S5**	**S6**
		Sample Depths (ft bgs)(A)					
BMW-01A	20-60	41	57.3				
BMW-01B	70-100	72.5	96.3				
BMW-02A	20-60	57.4					
BMW-02B	70-100	84.7	90.7	96.8			
BMW-02C	109.5-139.5	112.5	118.5	124.5	130.5	136.5	
BMW-02E	155-265	160	180	200	220	240	260
BMW-03A	20-60	58					
BMW-03B	70-100	95.5					
BMW-04A	30-70	45	67.2				
BMW-04B	78.8-118.8	81.2	98.3	115.4			
BMW-07A	29.6-69.6	43					
BMW-07B	85-115	87.5	111.5				
BMW-09C	95-130	100	120				
BMW-09D	180-230	185	205	225			
BMW-10D	230-280	235	255	275			
BMW-11D	151-211	156	176	196			
BMW-14D	225-227	225	245	265			
BMW-16D	205-275	208	228	245	265		
BMW-17D	155-265	140	160	180	210	235	
BMW-18D	235-285	220	240	260			
BMW-19D	235-285	240	260	280			
BMW-20D	135-245	140	160	180	210	230	
BMW-21D	180-230	190	210	225			
BMW-22D	130-230	132	160	180	210	225	
Total		24	20	15	6	5	1

(A) Sample depths are from shallow to deeper

ft bgs – feet below ground surface

Table 6 - Remedy Evaluation
Feasibility Study Report
40th Street and Osborn Road WQARF Site
Phoenix, Arizona

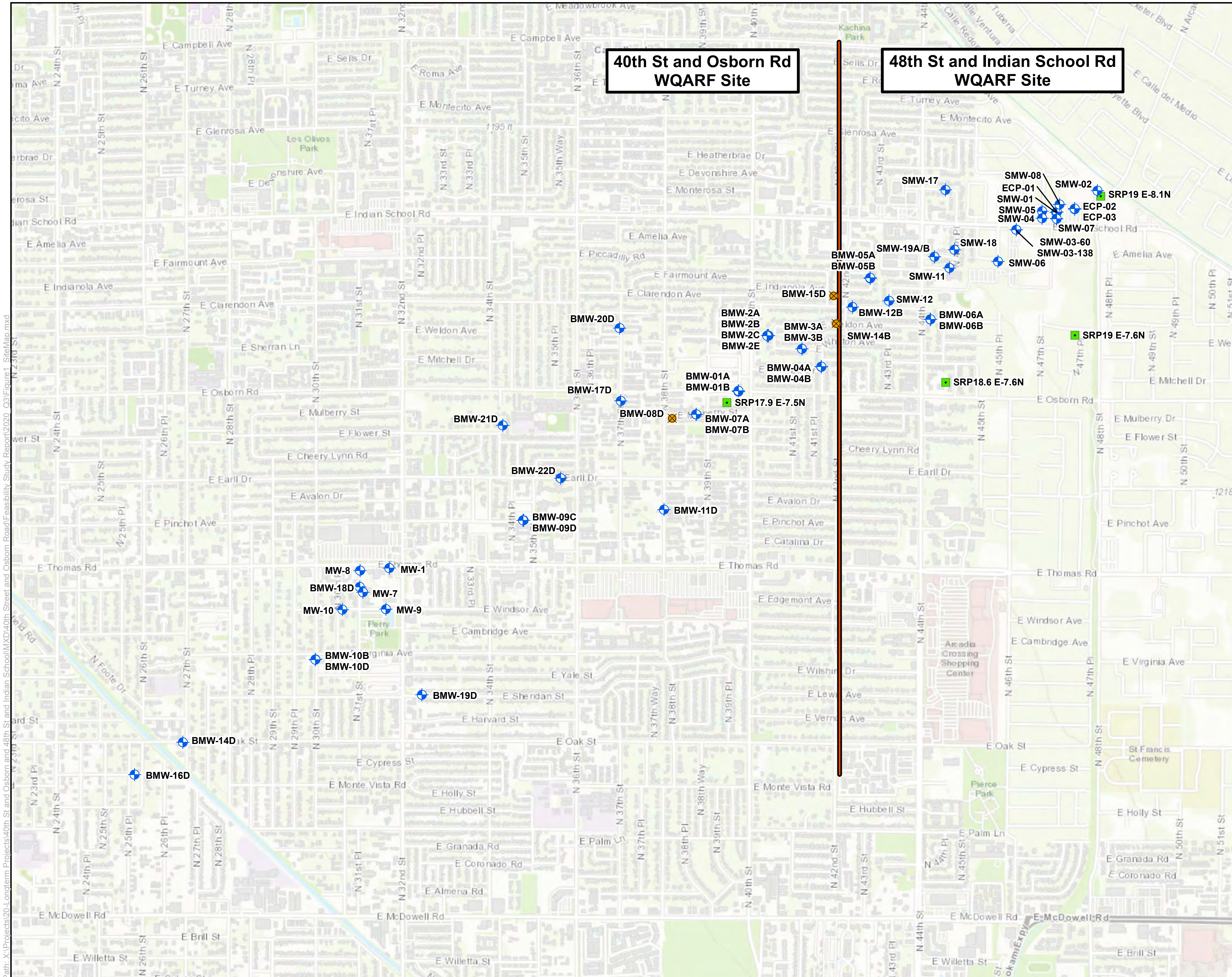
Remedial Alternative	Groundwater	Will Alternative Meet Remedial Objectives?	Practicability			Protectiveness (Risk)	Benefits	Regulatory/Public Acceptance	Estimated Cost (w/o Contingency)	Estimated Contingency Costs	Total Remedy Estimated Cost Including Contingency			Cost Score	Total Score
			Feasibility	Short/Long Term Effectiveness	Reliability						Total Cost	(-30%)	(+50%)		
Reference Remedy	**SRP Well GWET System plus Contingency Grand Canal GWET System. Grand Canal GWET system installed within first 7 years of remedy.**	Yes	GWET using a combination of wellhead treatment at the SRP well and the contingency Grand Canal system is a well documented remedy for PCE plumes. Considering the dimensions of the plume, it is the most feasible remedy. **Score = 5**	OU-1 - GWET using a combination of wellhead treatment at the SRP well and the contingency Grand Canal system is expected to be effective in the short term and long term. **Score = 5**	The remedial measures are known and reliable remediation technologies. **Score = 5**	The Reference Remedy is protective, in that it will decrease PCE concentrations to below cleanup goals and continues to monitor and evaluate Site contamination through the collection of data. **Score = 5**	The overall benefit is that SRP Well 17.9E-7.5N is returned to service and a groundwater resource is returned to use. Remedy is expected to contain further downgradient migration of the PCE plume. Flexible schedule for installation of the Grand Canal system between Years 1-7 of the remedy provides a funding benefit to ADEQ **Score = 5**	Likely.	**$7,031,000**	**$151,000**	**$7,182,000**	**$5,369,000**	**$11,474,000**	**5**	**30**
More Aggressive Remedy	**SRP Well GWET System plus Grand Canal GWET System. Grand Canal GWET system installed Year 2 of remedy.**	Yes	GWET using a combination of wellhead treatment at the SRP well and the contingency Grand Canal system is a well documented remedy for PCE plumes. Considering the dimensions of the plume, it is the most feasible remedy. **Score = 5**	OU-1 - GWET using a combination of wellhead treatment at the SRP well and the Grand Canal system is expected to be effective in the short term and long term. **Score = 5**	The remedial measures are known and reliable remediation technologies. **Score = 5**	The More Aggressive Remedy is protective, in that it will decrease PCE concentrations to below cleanup goals and continues to monitor and evaluate Site contamination through the collection of data. **Score = 5**	The overall benefit is that SRP Well 17.9E-7.5N is returned to service and a groundwater resource is returned to use. Remedy is expected to contain further downgradient migration of the PCE plume. **Score = 5**	Likely.	**$5,931,000**	**$151,000**	**$6,082,000**	**$4,241,000**	**$9,075,000**	**5**	**30**
Less Aggressive Remedy	**Semiannual Monitoring of Groundwater Well Network for Up to 250 Years**	Yes	Monitoring is very feasible as groundwater monitoring is currently conducted at the site. Monitoring of the current well network is feasible considering the current conditions of the plume. **Score = 5**	Monitoring is a known and effective remedy given the condition of the plume; semiannual monitoring will assess effectiveness. Considered a long-term remedy for the Site without implementation of contingency, which results in the Reference Remedy. **Score = 1**	Monitoring is a known and reliable remediation technology. **Score = 5**	The Less Aggressive Remedy is protective, in that it continues to monitor and evaluate Site contamination through the collection of data. However, PCE plume is estimated to migrate downgradient within the term of the remedy without contingency. Implementation of contingency results in the Reference Remedy. **Score = 1**	Under the current conditions, provides less benefit than the Reference or More Aggressive Alternative Remedies for the Site because it will take the longest period of time to remediate groundwater impacts. Plume also migrates downgradient without implementation of contingency. Implementation of the contingency results in the Reference Remedy. **Score = 1**	Moderately unlikely	**>$12,054,000 (cost capped at 65 years due to total cost exceeds maximum [+50%] cost for Reference Remedy**	**Contingency results in Reference Remedy, costs not included.**	**>$12,054,000**	**>$8,439,000**	**>$18,081,000**	**1**	**13**

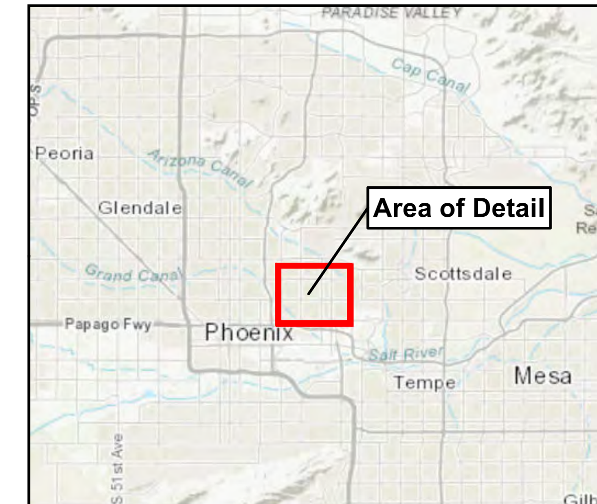
Abbreviations:
WQARF = Water Quality Assurance Revolving Fund
ISCO - In-situ Chemical Oxidation
GWET - Groundwater Extraction and Treatment
O&M - Operation and Maintenance
PCE = Tetrachloroethene
O&M = operations and maintenance
% = percent
$ = United States dollars

Scoring:
Scores ranged from zero to five, with five indicating the most relative benefit and zero indicating the least relative or no benefit.

Notes:
Costs are rounded off to the nearest thousand
Costs are based on 2020 dollar values
Costs for O&M and contingencies include an assumed 3% annual escalation

Figures





Area of Detail

Legend

- Groundwater Monitoring Well
- SRP Production Well
- Boring Location - Abandoned

Notes:

BMW-14D	Groundwater Monitoring Well Identification
SRP	Salt River Project
WQARF	Water Quality Assurance Revolving Fund

0 750 1,500 Feet

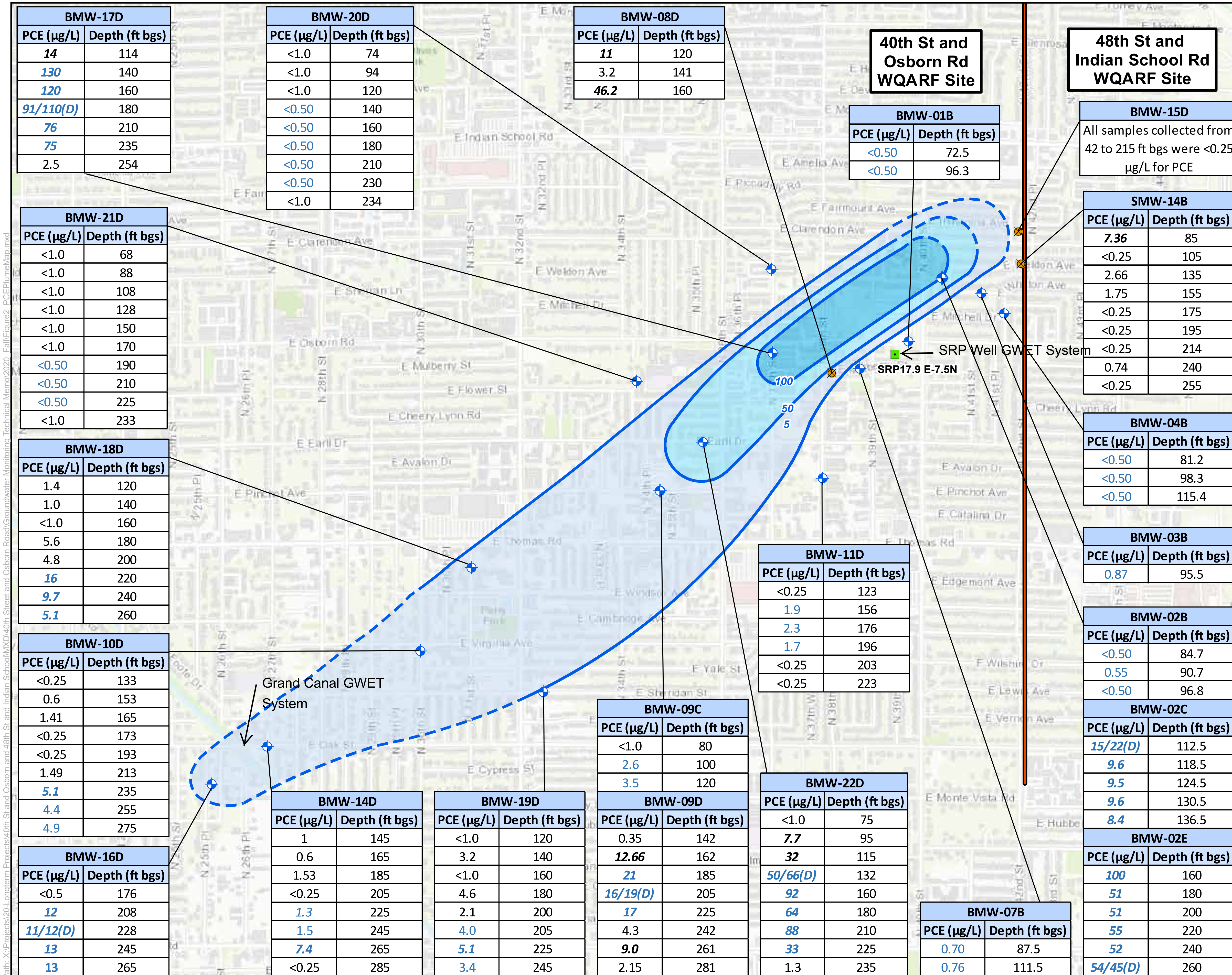
N

Feasibility Study Report
ECP 40th St & Osborn Rd WQARF Site
Phoenix, Arizona

FIGURE 1 — **Site Map**

Job No.	14-2020-2037
PM:	JC
Date:	11/18/2020
Scale:	1"= 1500'

wood.



BMW-17D

PCE (µg/L)	Depth (ft bgs)
14	114
130	140
120	160
91/110(D)	180
76	210
75	235
2.5	254

BMW-20D

PCE (µg/L)	Depth (ft bgs)
<1.0	74
<1.0	94
<1.0	120
<0.50	140
<0.50	160
<0.50	180
<0.50	210
<0.50	230
<1.0	234

BMW-08D

PCE (µg/L)	Depth (ft bgs)
11	120
3.2	141
46.2	160

BMW-01B

PCE (µg/L)	Depth (ft bgs)
<0.50	72.5
<0.50	96.3

BMW-15D

All samples collected from 42 to 215 ft bgs were <0.25 µg/L for PCE

SMW-14B

PCE (µg/L)	Depth (ft bgs)
7.36	85
<0.25	105
2.66	135
1.75	155
<0.25	175
<0.25	195
<0.25	214
0.74	240
<0.25	255

BMW-21D

PCE (µg/L)	Depth (ft bgs)
<1.0	68
<1.0	88
<1.0	108
<1.0	128
<1.0	150
<1.0	170
<0.50	190
<0.50	210
<0.50	225
<1.0	233

BMW-18D

PCE (µg/L)	Depth (ft bgs)
1.4	120
1.0	140
<1.0	160
5.6	180
4.8	200
16	220
9.7	240
5.1	260

BMW-10D

PCE (µg/L)	Depth (ft bgs)
<0.25	133
0.6	153
1.41	165
<0.25	173
<0.25	193
1.49	213
5.1	235
4.4	255
4.9	275

BMW-16D

PCE (µg/L)	Depth (ft bgs)
<0.5	176
12	208
11/12(D)	228
13	245
13	265

BMW-14D

PCE (µg/L)	Depth (ft bgs)
1	145
0.6	165
1.53	185
<0.25	205
1.3	225
1.5	245
7.4	265
<0.25	285

BMW-19D

PCE (µg/L)	Depth (ft bgs)
<1.0	120
3.2	140
<1.0	160
4.6	180
2.1	200
4.0	205
5.1	225
3.4	245

BMW-09C

PCE (µg/L)	Depth (ft bgs)
<1.0	80
2.6	100
3.5	120

BMW-09D

PCE (µg/L)	Depth (ft bgs)
0.35	142
12.66	162
21	185
16/19(D)	205
17	225
4.3	242
9.0	261
2.15	281

BMW-11D

PCE (µg/L)	Depth (ft bgs)
<0.25	123
1.9	156
2.3	176
1.7	196
<0.25	203
<0.25	223

BMW-22D

PCE (µg/L)	Depth (ft bgs)
<1.0	75
7.7	95
32	115
50/66(D)	132
92	160
64	180
88	210
33	225
1.3	235

BMW-07B

PCE (µg/L)	Depth (ft bgs)
0.70	87.5
0.76	111.5

BMW-04B

PCE (µg/L)	Depth (ft bgs)
<0.50	81.2
<0.50	98.3
<0.50	115.4

BMW-03B

PCE (µg/L)	Depth (ft bgs)
0.87	95.5

BMW-02B

PCE (µg/L)	Depth (ft bgs)
<0.50	84.7
0.55	90.7
<0.50	96.8

BMW-02C

PCE (µg/L)	Depth (ft bgs)
15/22(D)	112.5
9.6	118.5
9.5	124.5
9.6	130.5
8.4	136.5

BMW-02E

PCE (µg/L)	Depth (ft bgs)
100	160
51	180
51	200
55	220
52	240
54/45(D)	260

Area of Detail

Legend

- Groundwater Monitoring Well
- SRP Production Well
- Boring Location - Abandoned

Approximate Distribution of PCE (Dash Where Inferred)

- Above 100 µg/L
- Above 50 µg/L
- Above 5 µg/L

Notes:

BMW-14D	Groundwater Monitoring Well Identification
1.53	Results that are black are vertical profile sample results
1.3	Results that are blue are from September 2020
7.4	Results that are ***bolded and italicized*** exceed the Aquifer Water Quality Standard of 5 µg/L
16/19(D)	Duplicate sample
µg/L	Microgram per liter
ft	Feet
amsl	Above Mean Sea Level
bgs	Below Ground Surface
PCE	Tetrachloroethene
WQARF	Water Quality Assurance Revolving Fund

0 650 1,300 Feet

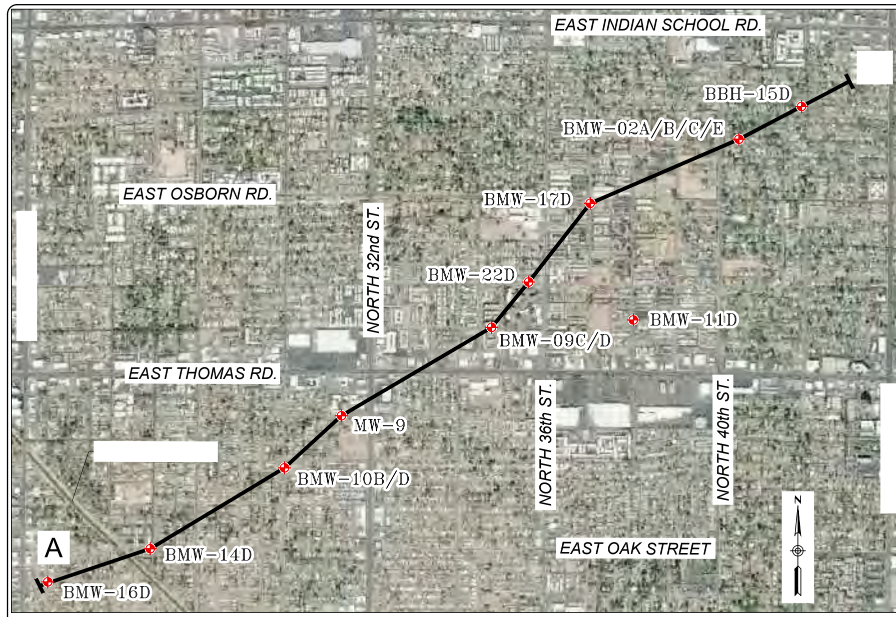
N

Feasibility Study Report
ECP 40th St & Osborn Rd WQARF Site
Phoenix, Arizona

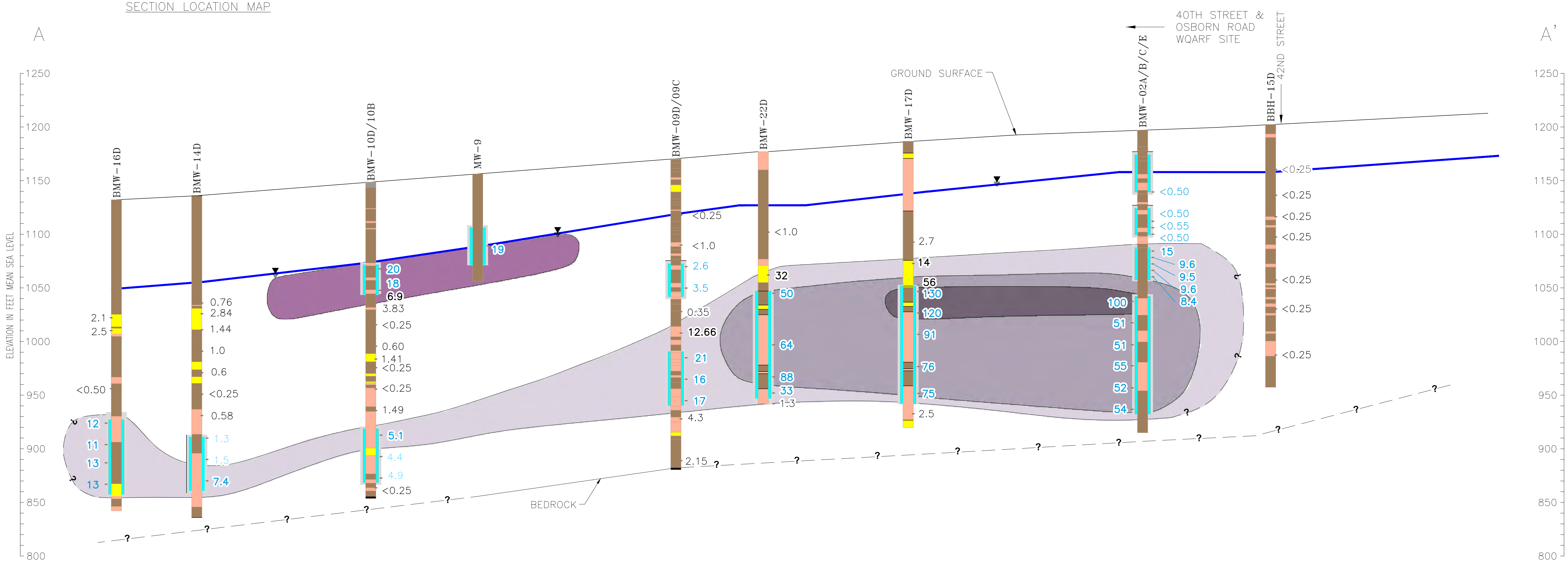
FIGURE 2 — **Site PCE Plume Map**

Job No. 14-2020-2037
PM: JC
Date: 10/29/2020
Scale: 1"= 1300'

wood.



SECTION LOCATION MAP

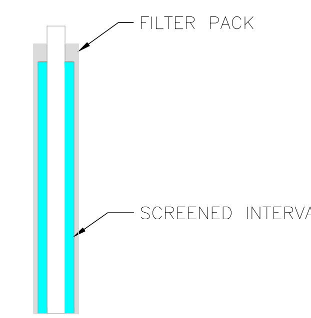


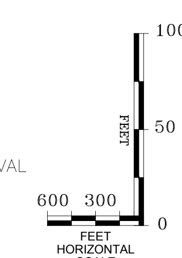
EXPLANATION

- BORING LOCATION
- GROUNDWATER WELL LOCATION
- DEPTH-DISCRETE GROUNDWATER SAMPLE (e.g. SIMULPROBE/HYDROPUNCH OR HYDROPUNCH SAMPLER)
- 3.6 CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GRAB GROUNDWATER SAMPLE IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEDES 5.0 ug/l
- 3.6 SEPTEMBER 2020 CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GROUNDWATER IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEEDS 5.0 ug/l
- WATER LEVEL ELEVATION MEASURED ON SEPTEMBER 21, 2020
- ? ? WHERE INFERRED

BOREHOLE LITHOLOGY

- SILTY OR CLAYEY SAND AND GRAVEL; AND SAND MIXTURES
- PREDOMINANTLY SAND OR GRAVEL
- PREDOMINANTLY SILT AND CLAY
- SITE PCE PLUME >5.0 ug/L
- SITE PCE PLUME >50 ug/L
- SITE PCE PLUME >100 ug/L
- OFF-SITE SHALLOW PCE PLUME >5.0 ug/L





REVISIONS:

Environment & Infrastructure Solutions, Inc.
4600 E. WASHINGTON STREET, SUITE 600
PHOENIX, ARIZONA 85034
PHONE: 602-733-6000
FAX: 602-733-6100

wood.

Cross - Section A-A'
Feasibility Study Report

PROJECT: 40th Street and Osborn Road WQARF Site Phoenix, Arizona

DESIGNED BY:
DRAWN BY:
CHECKED BY:

PROJECT NO. 14-2020-2037

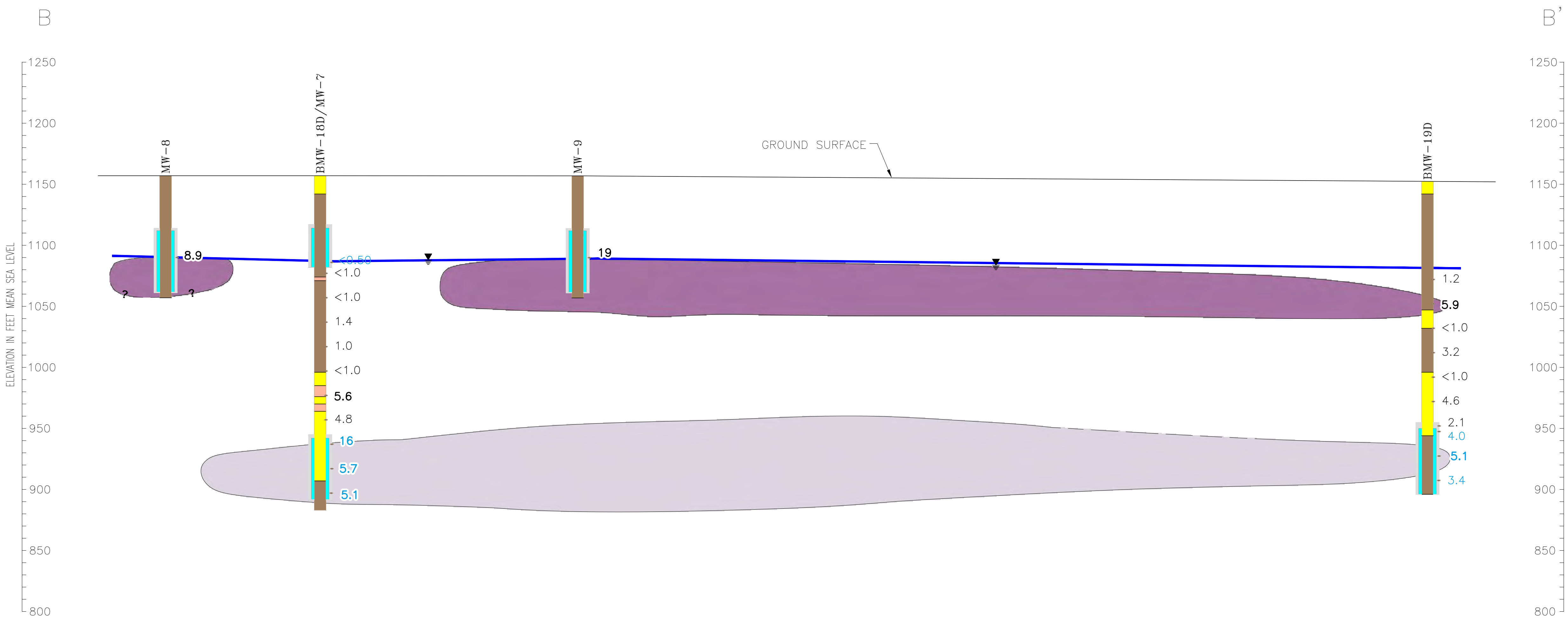
DRAWING NAME

3

SHEET NO.

File: G:\Environmental-Development\2020 Projects\14-2020-2037 FY 2021 40th & Osborn WQARF TO #1\14 CAD\DWG\1420202009_40th_St_Cross-section_Figure1.dwg

SECTION LOCATION MAP

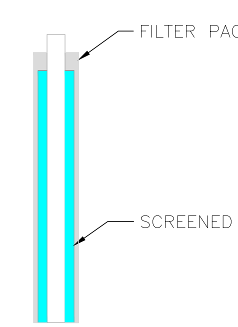


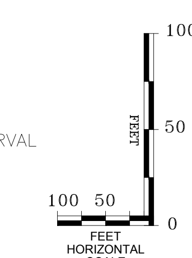
EXPLANATION

●	BORING LOCATION
◆	GROUNDWATER WELL LOCATION
•	DEPTH-DISCRETE GROUNDWATER SAMPLE (e.g. SIMULPROBE/HYDROPUNCH OR HYDROPUNCH SAMPLER)
3.6	CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GRAB GROUNDWATER SAMPLE IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEDES 5.0 ug/l
3.6	SEPTEMBER CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GROUNDWATER IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEEDS 5.0 ug/l
ND	NON-DETECTION
	WATER LEVEL ELEVATION MEASURED ON SEPTEMBER 21, 2020
— ? — — ? —	WHERE INFERRED

BOREHOLE LITHOLOGY

	SILTY OR CLAYEY SAND AND GRAVEL; AND SAND MIXTURES
	PREDOMINANTLY SAND OR GRAVEL
	PREDOMINANTLY SILT AND CLAY
	SITE PCE PLUME >5.0 ug/L
	OFF-SITE SHALLOW PCE PLUME >5.0 ug/L





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REVISIONS:

wood.
Environment & Infrastructure Solutions, Inc.
4600 E. WASHINGTON STREET, SUITE 600
PHOENIX, ARIZONA 85034
PHONE: 602-733-6000
FAX: 602-733-6100

Cross - Section B-B'
Feasibility Study Report

PROJECT: 40th Street and Osborn Road WQARF Site Phoenix, Arizona

DESIGNED BY:
DRAWN BY:
CHECKED BY:

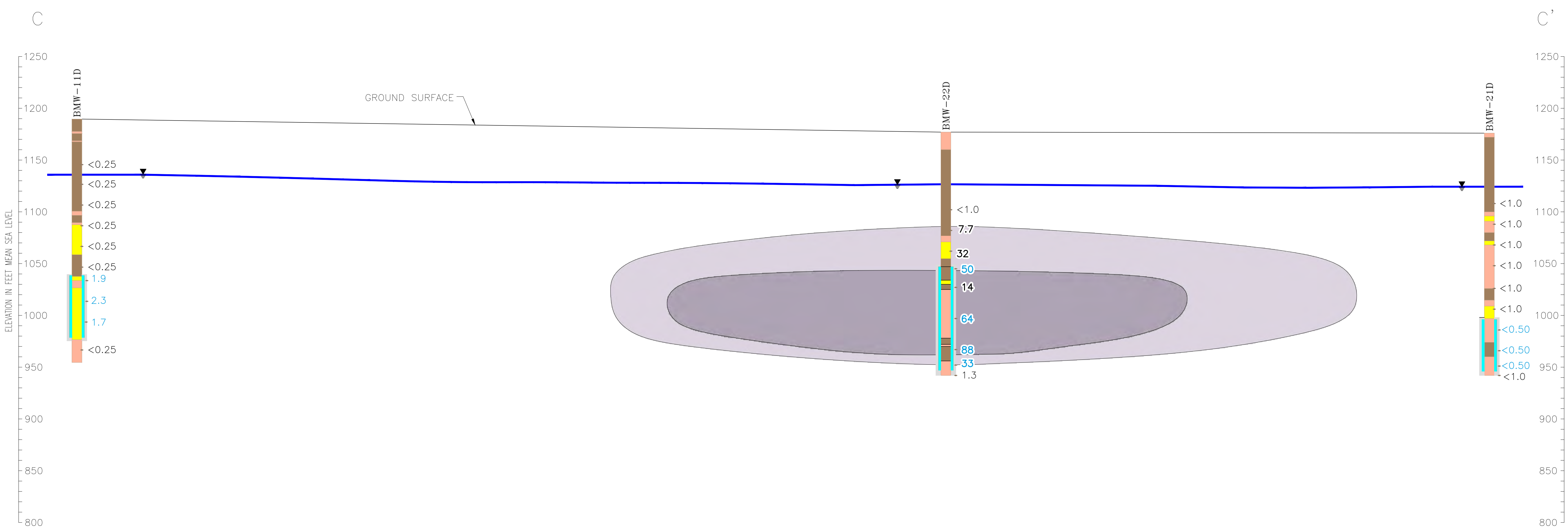
PROJECT NO. 14-2020-2037

DRAWING NAME

4

SHEET NO.

SECTION LOCATION MAP

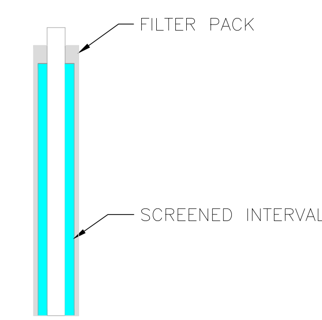


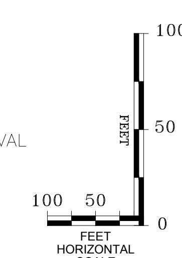
EXPLANATION

- BORING LOCATION
- GROUNDWATER WELL LOCATION
- DEPTH-DISCRETE GROUNDWATER SAMPLE (e.g. SIMULPROBE/HYDROPUNCH OR HYDROPUNCH SAMPLER)
- 3.6 — CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GRAB GROUNDWATER SAMPLE IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEDES 5.0 ug/l
- 3.6 — SEPTEMBER 2020 CONCENTRATION OF TETRACHLOROETHYLENE (PCE) DETECTED IN GROUNDWATER IN MICROGRAMS PER LITER (ug/l), BOLD IF EXCEEDS 5.0 ug/l
- ND — NON-DETECTION
- WATER LEVEL ELEVATION MEASURED ON SEPTEMBER 21, 2020
- — ? — ? — WHERE INFERRED

BOREHOLE LITHOLOGY

- SILTY OR CLAYEY SAND AND GRAVEL; AND SAND MIXTURES
- PREDOMINANTLY SAND OR GRAVEL
- PREDOMINANTLY SILT AND CLAY
- SITE PCE PLUME >5.0 ug/L
- SITE PCE PLUME >50 ug/L





REVISIONS:

Environment & Infrastructure Solutions, Inc.
4600 E. WASHINGTON STREET, SUITE 600
PHOENIX, ARIZONA 85034
PHONE: 602-733-6000
FAX: 602-733-6100

wood.

Cross - Section C-C'
Feasibility Study Report

PROJECT:
40th Street and Osborn Road
WQARF Site Phoenix, Arizona

DESIGNED BY:
DRAWN BY:
CHECKED BY:

PROJECT NO.
14-2020-2037

DRAWING NAME
5
SHEET NO.

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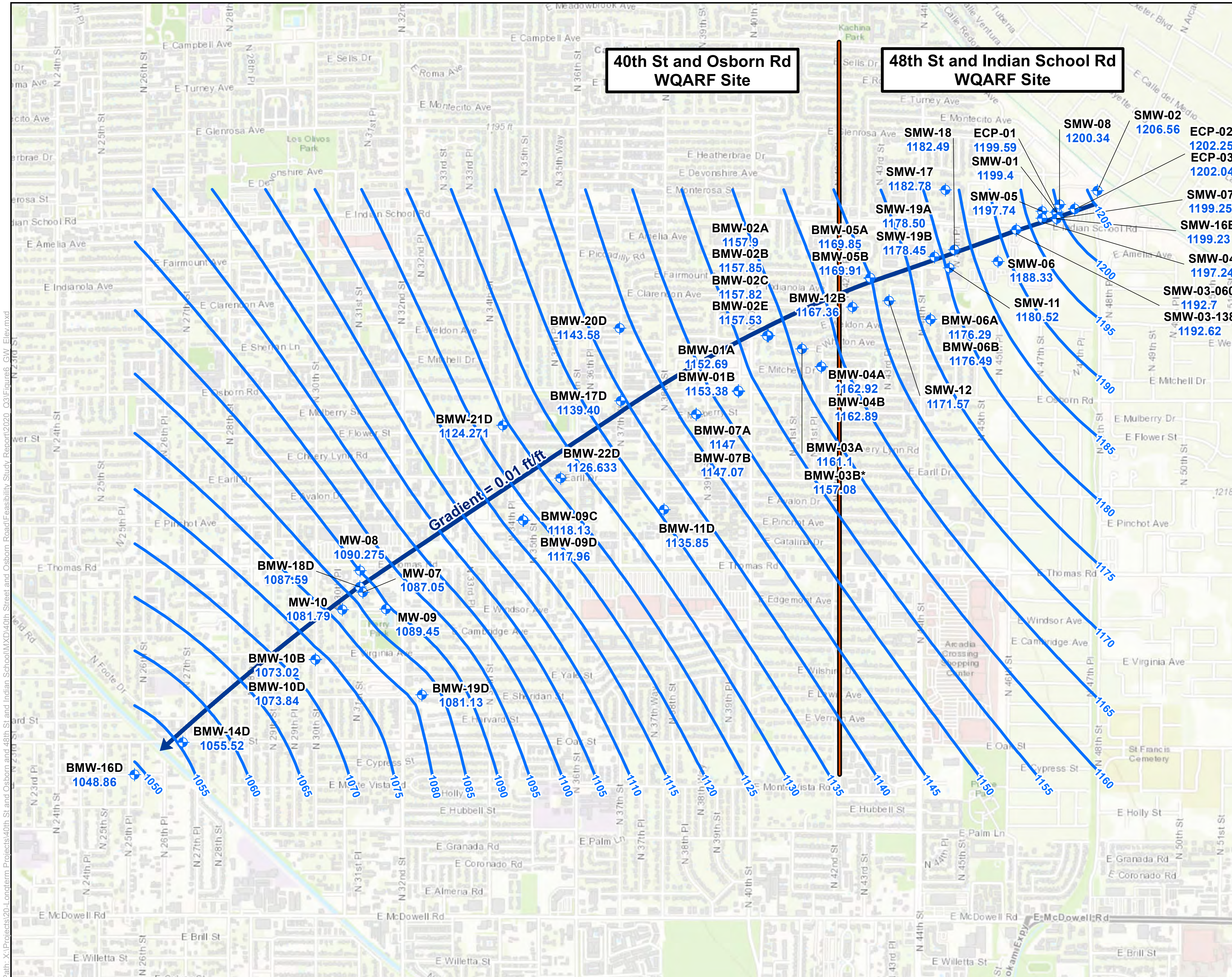
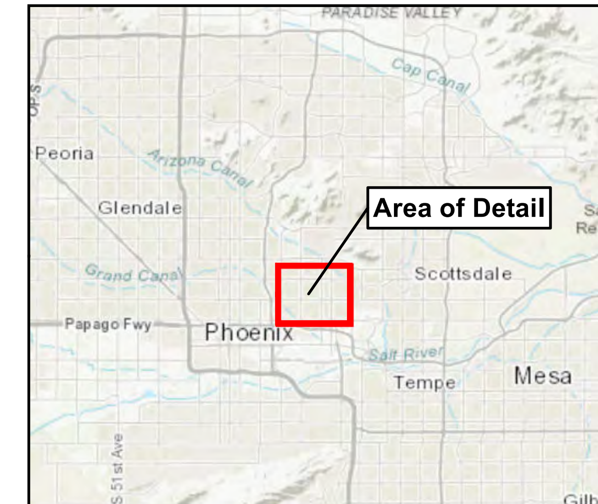




Area of Detail

Legend

- Wells
- Groundwater Elevation Contour (ft amsl)
- Groundwater Flow Direction

Notes:

BMW-11D	Groundwater Monitoring Well Identification
1136.19	Groundwater Elevation (ft amsl)
*	Groundwater elevation value excluded from contouring
ft	Feet
amsl	Above Mean Sea Level
WQARF	Water Quality Assurance Revolving Fund

0 750 1,500 Feet

N

Feasibility Study Report
ECP 40th St & Osborn Rd WQARF Site
Phoenix, Arizona

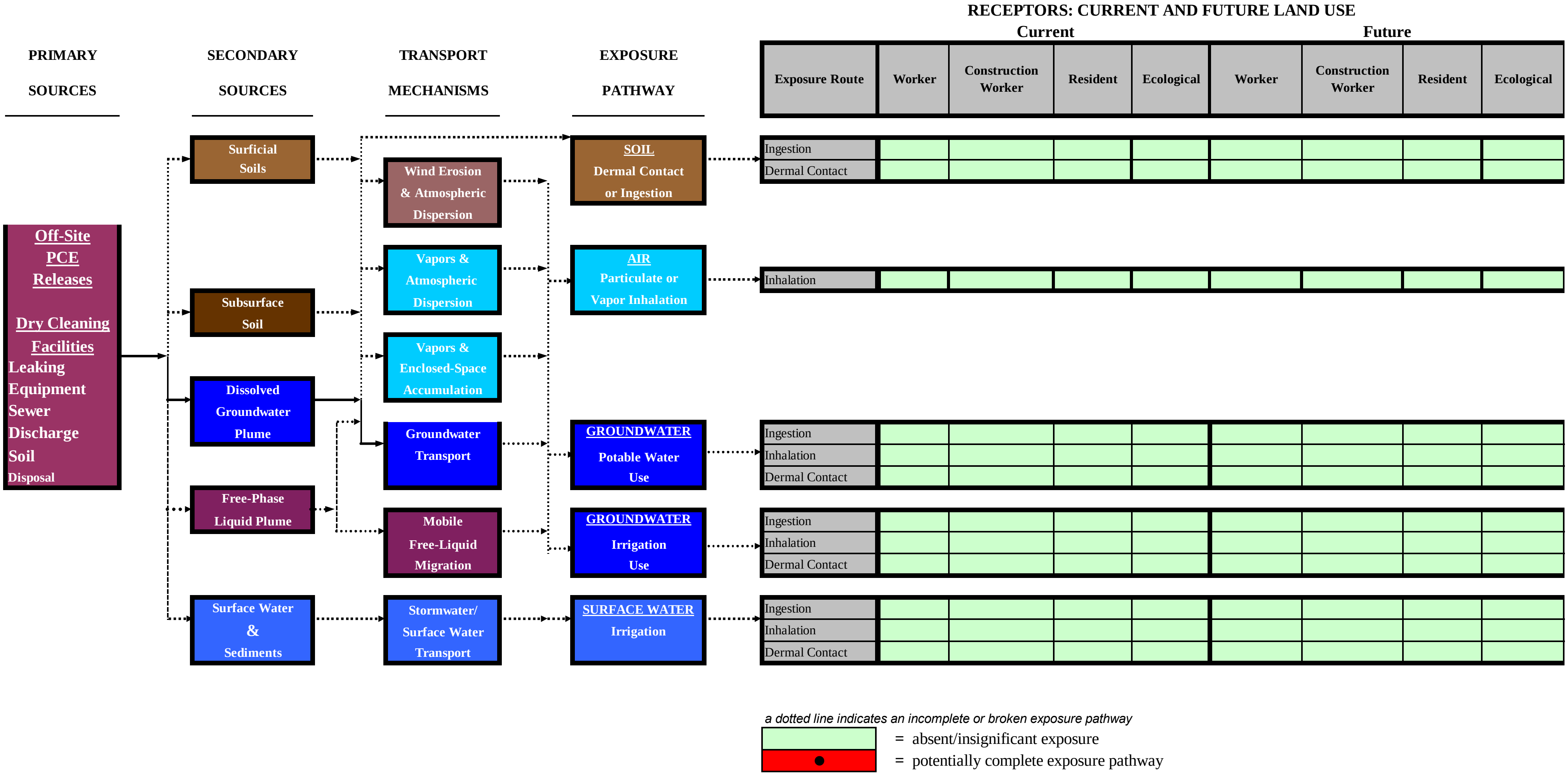
FIGURE 6

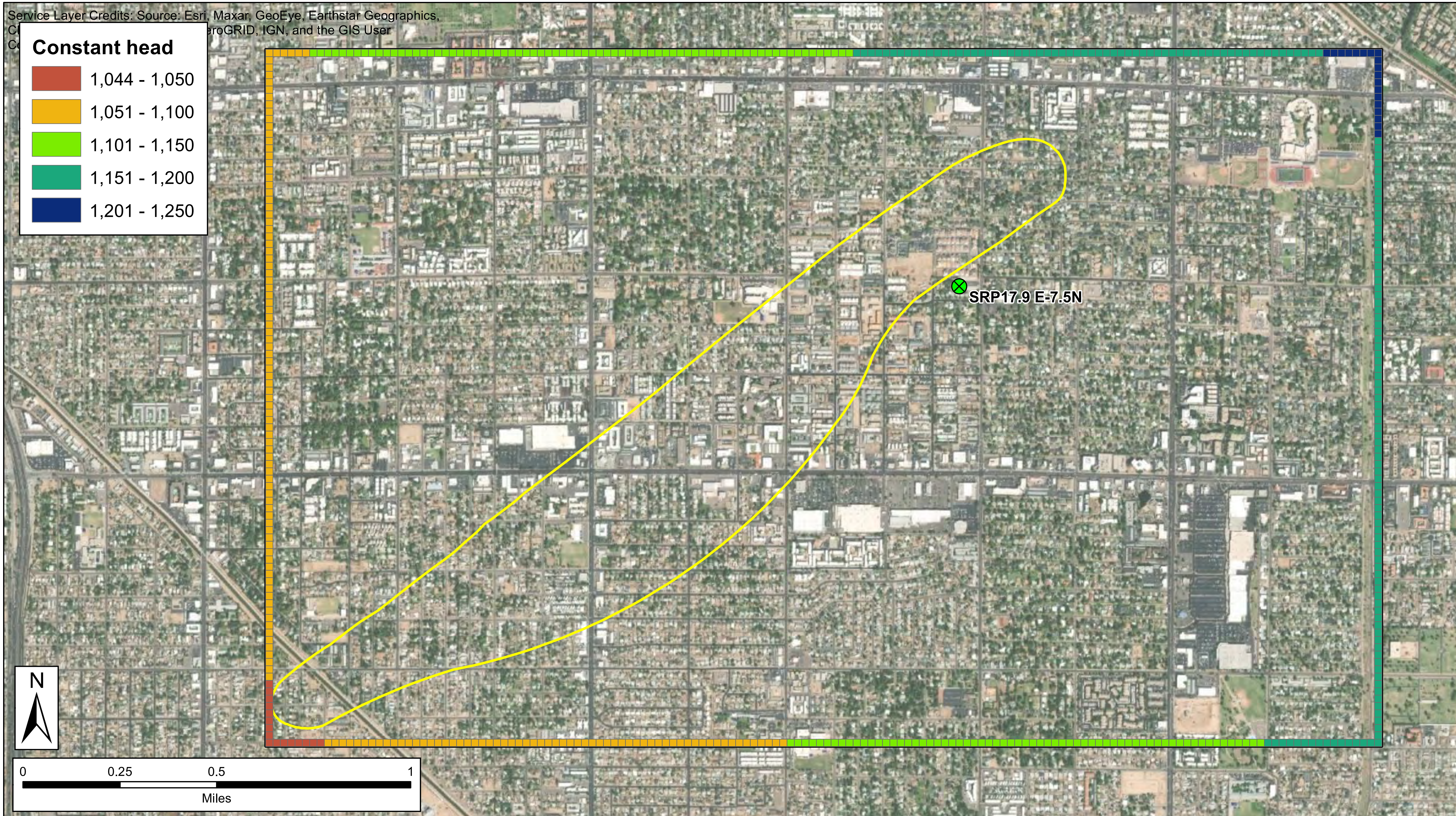
September 2020 Groundwater Elevation Map

Job No.: 14-2020-2032
PM: JC
Date: 11/18/2020
Scale: 1"= 1500'

wood.

Figure 7
Exposure Path Diagram
Feasibility Study Report
40th Street and Osborn Road WQARF Site
Phoenix, AZ





Legend

Model domain

SRP pumping well

PCE plume

CLIENT

Arizona Department of Environmental Quality

4600 East Washington Street
Suite 600
Phoenix, AZ 85034

wood.

PROJECT

40th Street & Osborn Road
Water Quality Assurance Revolving Fund

TITLE

Model Boundary Conditions

DATE

March 2021

SCALE

1:15,000

PROJECT NO.

1420202037

FIGURE

8

Document Path: B:\Amec\Emily's Backup\1420202037 FY 2021 40th & Osborn WQARF TO #1\13 GIS\MXDs\Fig_08_boundary_conditions.mxd

Legend

Particle tracks
Particle arrows
Potentiometric surface (ft)
Model domain
PCE plume
SRP pumping well

CLIENT
Arizona Department of Environmental Quality

Wood E&IS
8519 Jefferson St NE
Albuquerque, NM 87113

wood.

PROJECT
40th Street & Osborn Road
Water Quality Assurance Revolving Fund

TITLE
Forward Particle Tracking Results
K = 5 ft/d

DATE
March 2021

SCALE
1:15,000

PROJECT NO.
1420202037

FIGURE
9

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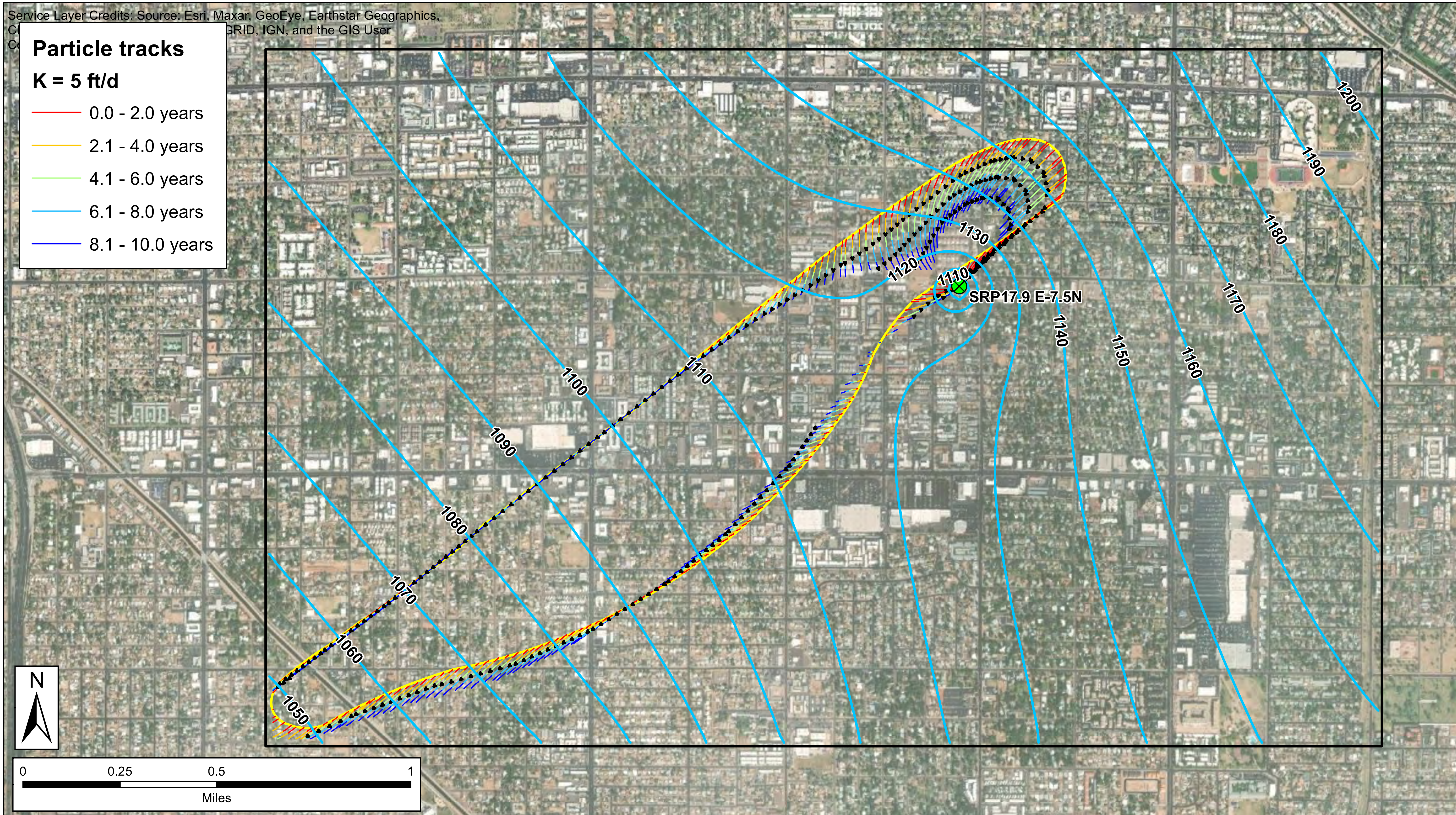

Legend

Potentiometric surface (ft)

SRP pumping well

Model domain

PCE plume

CLIENT

Arizona Department of Environmental Quality

4600 East Washington Street
Suite 600
Phoenix, AZ 85034

wood.

PROJECT

40th Street & Osborn Road
Water Quality Assurance Revolving Fund

TITLE

Forward Particle Tracking Results
K = 5 ft/d
10 Years

DATE	June 2021
SCALE	1:15,000
PROJECT NO.	1420202037
FIGURE	10

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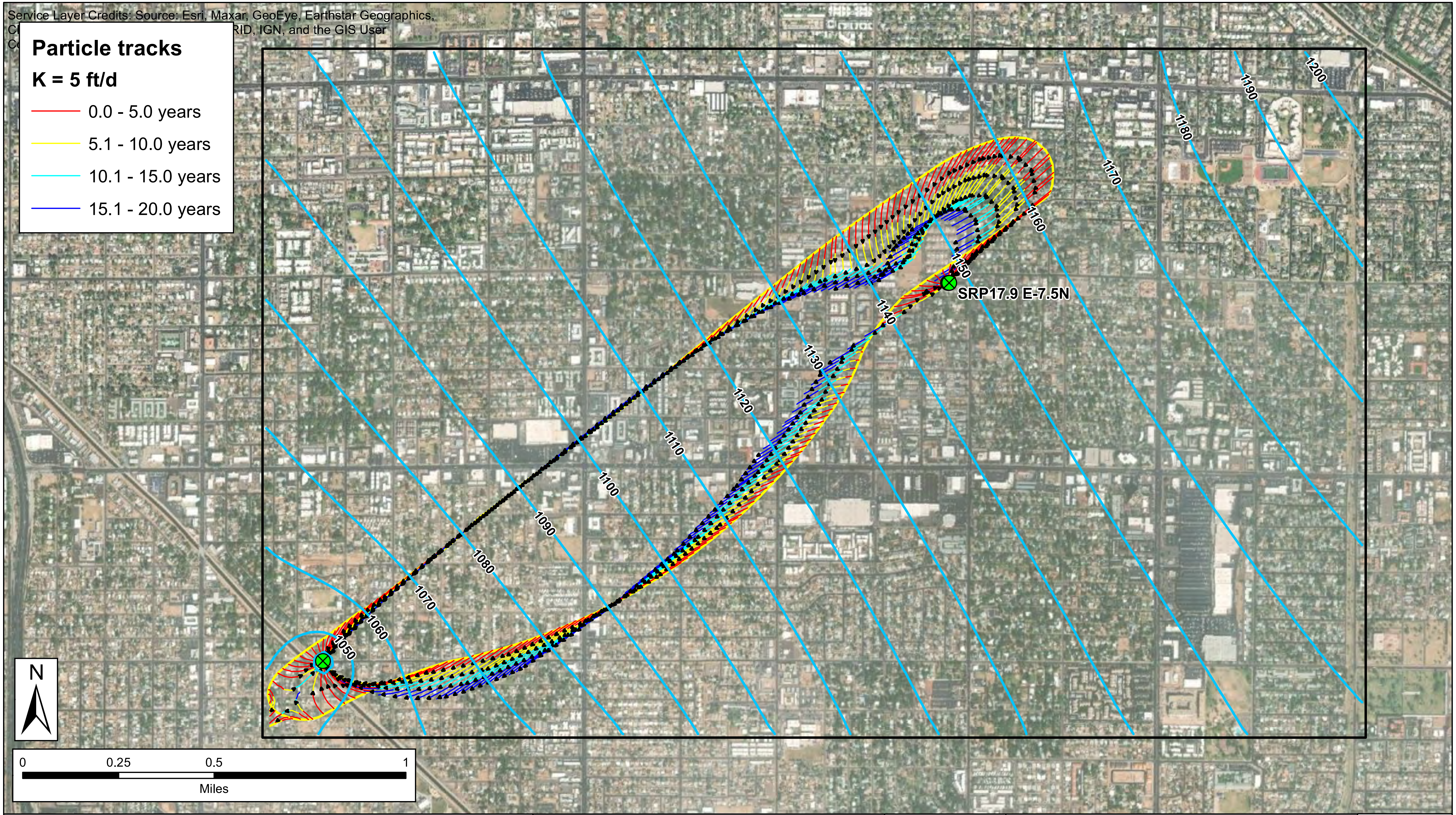


Legend

- Potentiometric surface (ft)
- SRP pumping well
- Model domain
- PCE plume

CLIENT
Arizona Department of Environmental Quality

4600 East Washington Street
Suite 600
Phoenix, AZ 85034

wood.

PROJECT
40th Street & Osborn Road
Water Quality Assurance Revolving Fund

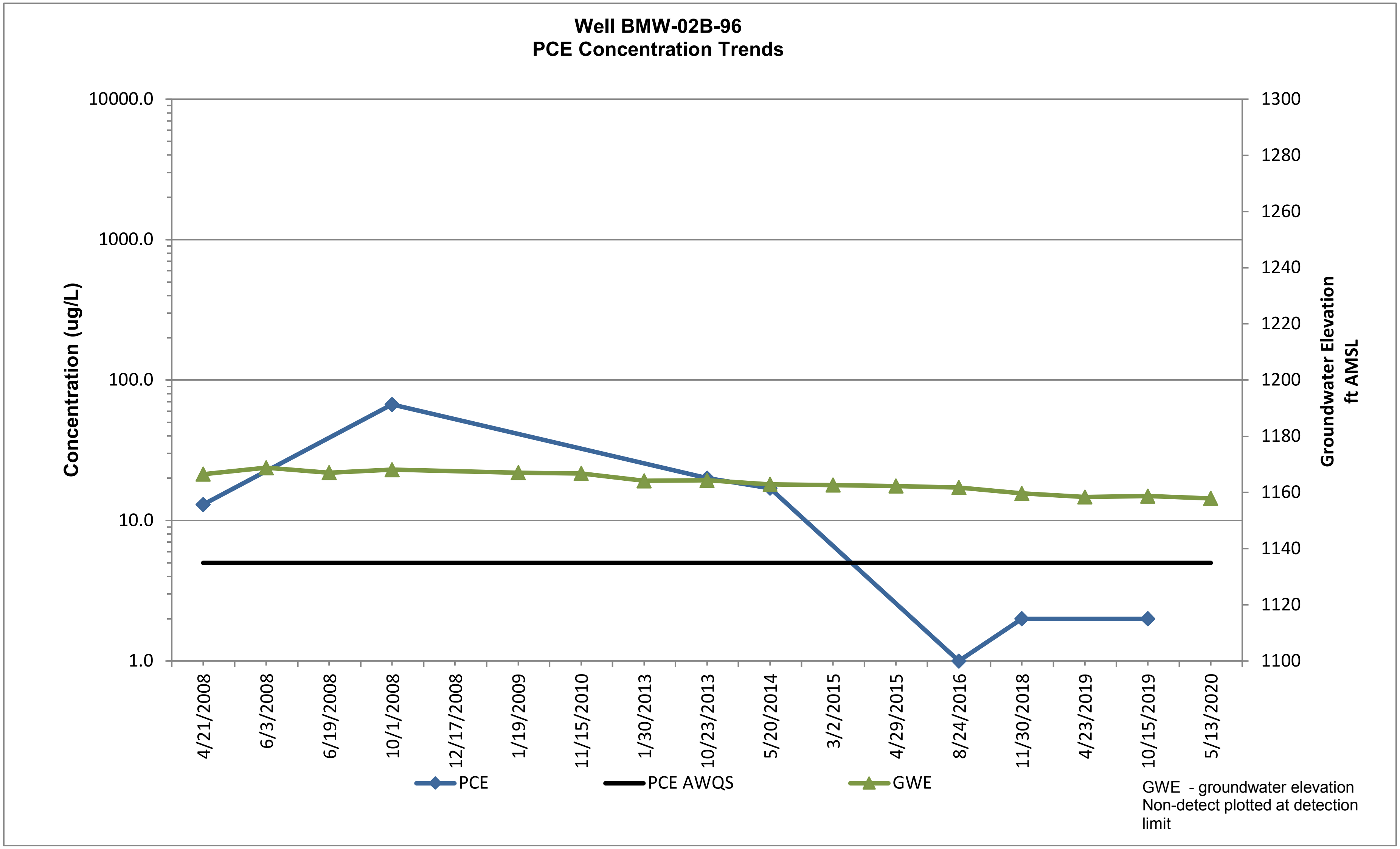
TITLE
Forward Particle Tracking Results
K = 5 ft/d
20 Years

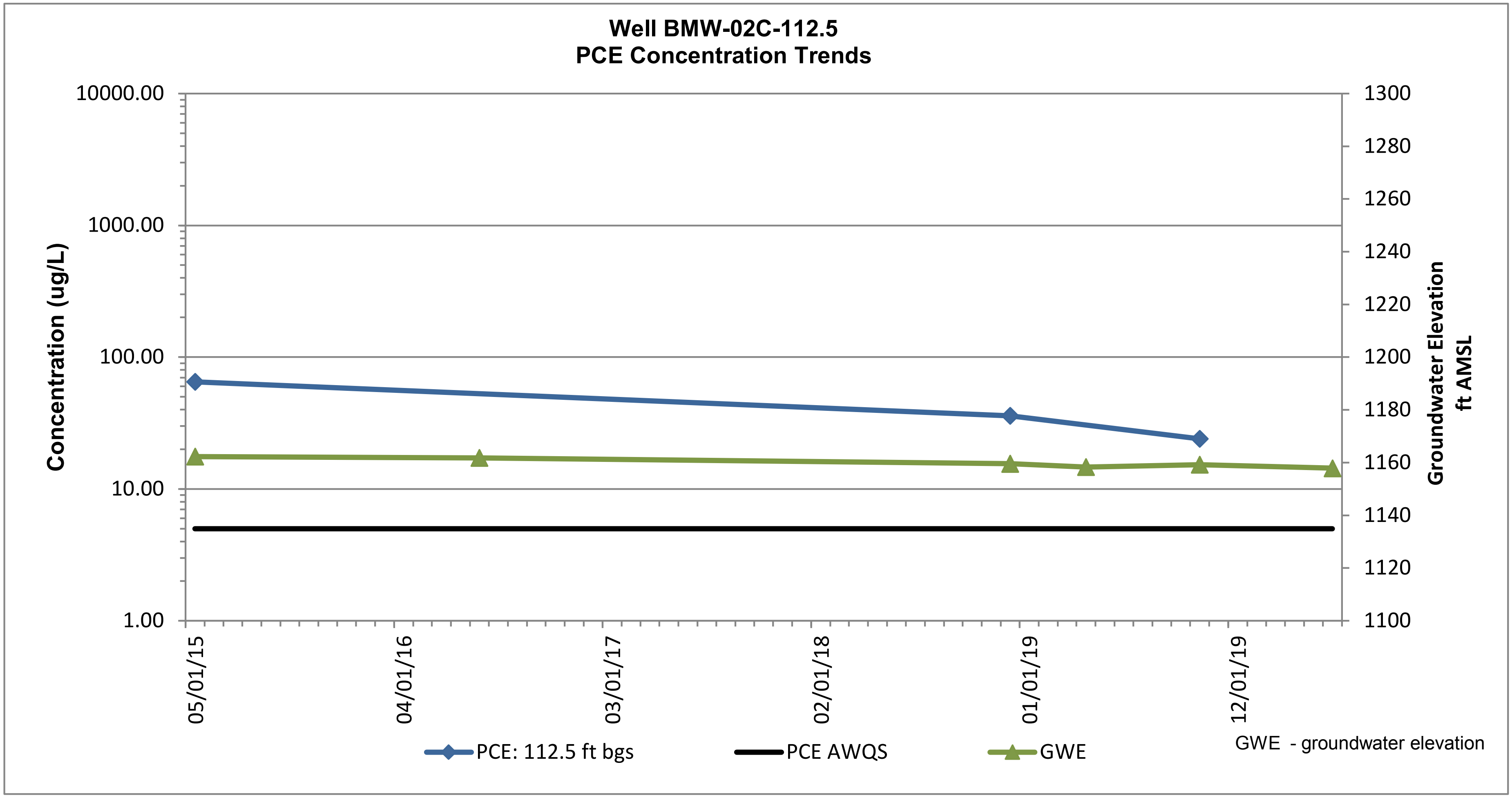
DATE June 2021
SCALE 1:15,000
PROJECT NO. 1420202037
FIGURE 11

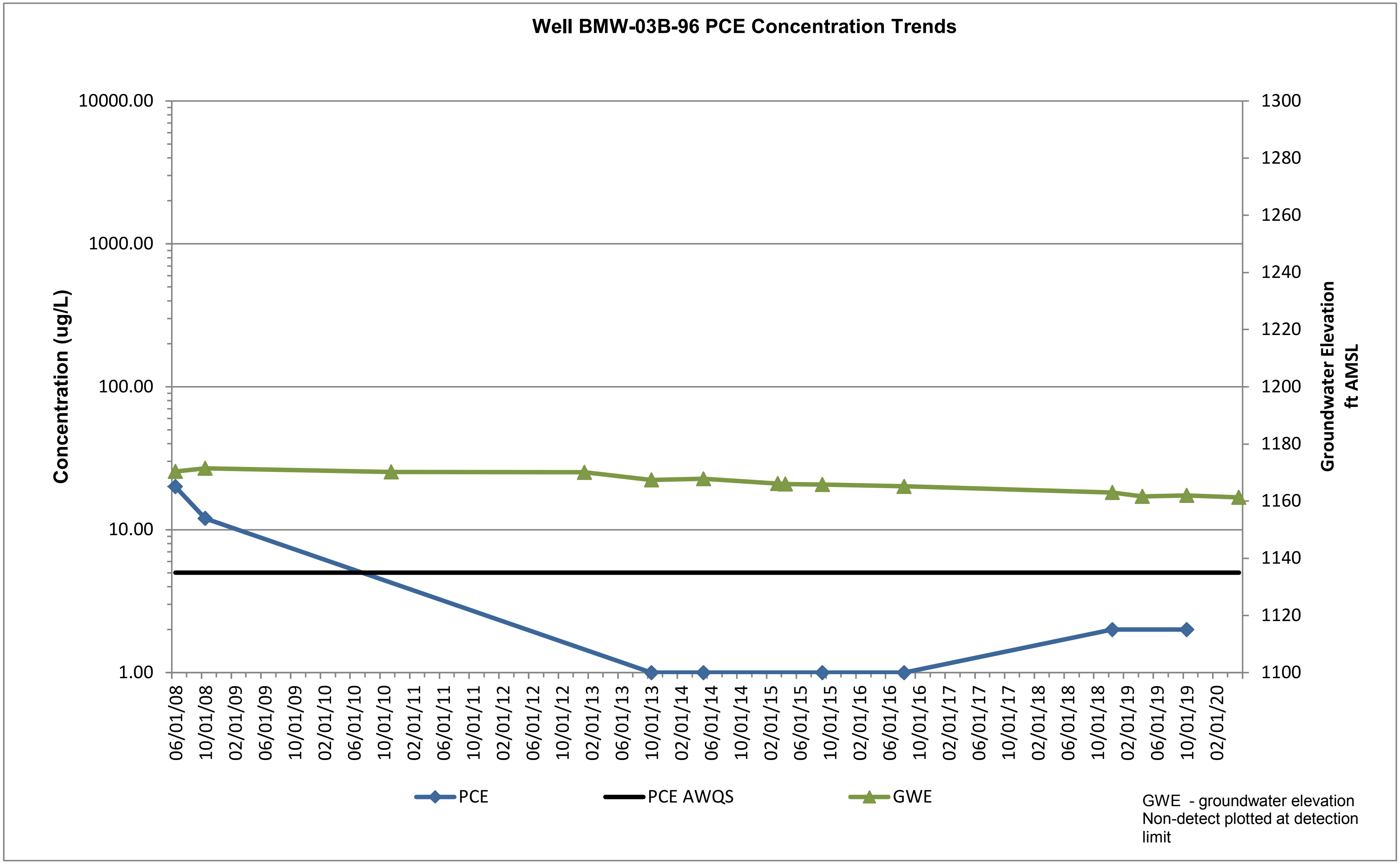
Document Path: B:\Amec\Emily's Backup\1420202037 FY 2021 40th & Osborn WQARF TO #1\13 GIS\MXDs\Fig_11_forward_tracking_K5_20_yrs.mxd

Appendix A

Hydrographs and PCE Concentration Versus Time Graphs


Well BMW-02B-96
PCE Concentration Trends
Concentration (ug/L)
10000.0
1000.0
100.0
10.0
1.0
Groundwater Elevation
ft AMSL
1300
1280
1260
1240
1220
1200
1180
1160
1140
1120
1100
4/21/2008
6/3/2008
6/19/2008
10/1/2008
12/17/2008
1/19/2009
11/15/2010
1/30/2013
10/23/2013
5/20/2014
3/2/2015
4/29/2015
8/24/2016
11/30/2018
4/23/2019
10/15/2019
5/13/2020
PCE
PCE AWQS
GWE
GWE - groundwater elevation
Non-detect plotted at detection limit


Well BMW-02C-112.5
PCE Concentration Trends
Concentration (ug/L)
10000.00
1000.00
100.00
10.00
1.00
Groundwater Elevation
ft AMSL
1300
1280
1260
1240
1220
1200
1180
1160
1140
1120
1100
05/01/15
04/01/16
03/01/17
02/01/18
01/01/19
12/01/19
PCE: 112.5 ft bgs
PCE AWQS
GWE
GWE - groundwater elevation



Well BMW-03B-96 PCE Concentration Trends
Concentration (ug/L)
10000.00
1000.00
100.00
10.00
1.00
Groundwater Elevation
ft AMSL
1300
1280
1260
1240
1220
1200
1180
1160
1140
1120
1100
06/01/08
10/01/08
02/01/09
06/01/09
10/01/09
02/01/10
06/01/10
10/01/10
02/01/11
06/01/11
10/01/11
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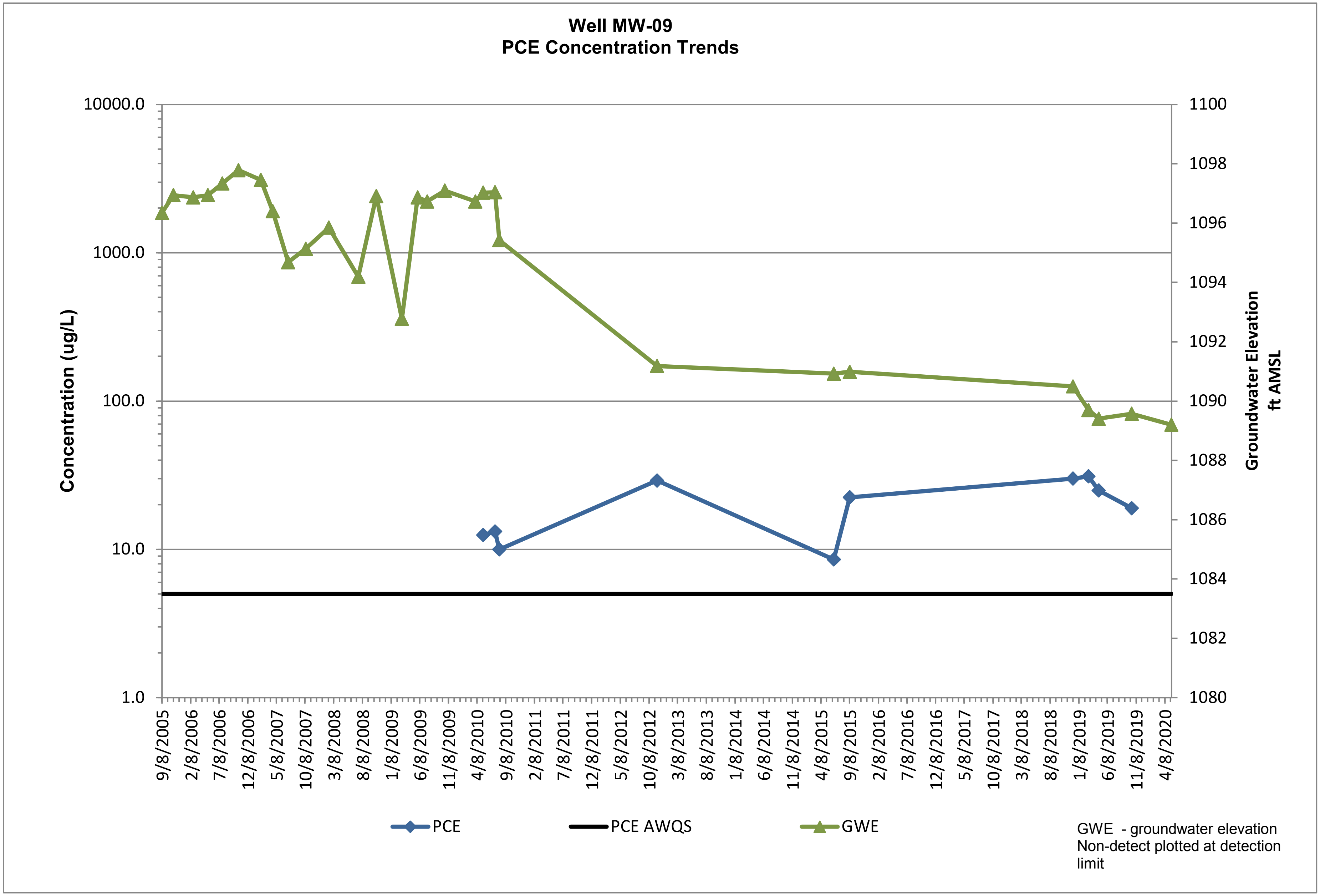
10/01/13
02/01/14
06/01/14
10/01/14
02/01/15
06/01/15
10/01/15
02/01/16
06/01/16
10/01/16
02/01/17
06/01/17
10/01/17
02/01/18
06/01/18
10/01/18
02/01/19
06/01/19
10/01/19
02/01/20
PCE
PCE AWQS
GWE
GWE - groundwater elevation
Non-detect plotted at detection limit



Well MW-09
PCE Concentration Trends
Concentration (ug/L)
10000.0
1000.0
100.0
10.0
1.0
Groundwater Elevation
ft AMSL
1100
1098
1096
1094
1092
1090
1088
1086
1084
1082
1080
9/8/2005
2/8/2006
7/8/2006
12/8/2006
5/8/2007
10/8/2007
3/8/2008
8/8/2008
1/8/2009
6/8/2009
11/8/2009
4/8/2010
9/8/2010
2/8/2011
7/8/2011
12/8/2011
5/8/2012
10/8/2012
3/8/2013
8/8/2013
1/8/2014
6/8/2014
11/8/2014
4/8/2015
9/8/2015
2/8/2016
7/8/2016
12/8/2016
5/8/2017
10/8/2017
3/8/2018
8/8/2018
1/8/2019
6/8/2019
11/8/2019
4/8/2020
PCE
PCE AWQS
GWE
GWE - groundwater elevation
Non-detect plotted at detection limit

Appendix B

Detailed Cost Estimates

Table B-1
Estimated Costs for Less Aggressive Remedy
Feasibility Study Report
40th St and Osborn Rd WQARF Site

	Quantity	Unit	Unit Cost[1-3]	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
Semi-Annual Monitoring						
Estimated Capital Costs						
Work Plan/Design	1	LS	$24,000	$24,000	$17,000	$36,000
Downgradient Performance Well Installation						
Monitoring Well Installation and Oversight (includes vertical profile)	2	LS	$50,000	$100,000	$70,000	$150,000
Survey, Permitting, Sampling and IDW Disposal	2	LS	$11,000	$22,000	$15,000	$33,000
Tech Memo	1	LS	$9,000	$9,000	$6,000	$14,000
Project Management/Oversight/Administration	15%	n/a	n/a	$20,000	$14,000	$30,000
Capital Costs Subtotal				**$175,000**	**$122,000**	**$263,000**
Estimated GW Monitoring Annual Costs						
Semiannual GW Monitoring/Reporting (all wells)	2	LS	$25,000	$50,000	$35,000	$75,000
Project Management/Oversignt/Administration	15%	n/a	n/a	$8,000	$6,000	$11,250
Annual Cost for GW Monitoring Subtotal				**$58,000**	**$41,000**	**$87,000**
Year 2-65 Total GW Monitoring Costs (3% annual escalation)				**$11,972,000**	**$8,381,000**	**$17,958,000**
Less Aggressive Alternative Remedy Capital and Monitoring Costs				**$12,054,000**	**$8,439,000**	**$18,081,000**

Total Less Aggressive Alternative Remedy Costs				**$12,054,000**	**$8,439,000**	**$18,081,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
LS = lump sum
GW - groundwater
IDW - Investigation Derived-Wastes
n/a - not applicable

Notes:

1. Total costs are rounded up to the nearest thousand dollars ($1000).
2. Pricing is subject to commodity pricing increases. Contingencies for possible price escalation due to steel or other tariffs is not included.
3. No estimated costs have been included for taxes or other fees relative to the project.

Table B-2
Estimated Costs for Reference Remedy
Feasibility Study Report
40th St and Osborn Rd WQARF Site

	Quantity	Unit	Unit Cost[1-3]	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
GWET (wellhead treatment)						
Estimated Capital Costs						
Remedy Final Design						
Remedy Final Design	1	LS	$75,000	$75,000	$53,000	$113,000
SRP Well System Installation						
Well rehabilitation and pump replacement[4]	1	LS	$160,000	$160,000	$112,000	$240,000
LGAC Cannister Installation, including pads and piping[5,6]	1	LS	$35,000	$35,000	$25,000	$53,000
LGAC Cannister Purchase (2-20,000 lb units, manifold, and frieght)	2	EA	$85,000	$170,000	$119,000	$255,000
Virgin LGAC fill	2	EA	$16,000	$32,000	$23,000	$48,000
GWET System Installation Report (includes as-built drawings)	1	LS	$15,000	$15,000	$10,000	$23,000
GWET System O&M Plan	1	LS	$5,000	$5,000	$4,000	$8,000
Poor Quality Groundwater Withdrawal Permit Application + fee (one time)	1	LS	$2,000	$2,000	$2,000	$3,000
Project Management/Oversight/Administration	15%	n/a	n/a	$73,000	$51,000	$110,000
SRP Well GWET System Capital Costs Subtotal				**$567,000**	**$399,000**	**$853,000**
Grand Canal System Installation[7]						
Well and pump installation[8]	1	LS	$192,000	$192,000	$135,000	$288,000
power drop installation[9]	1	LS	$30,000	$30,000	$21,000	$45,000
LGAC Cannister Installation, including pads and piping[6]	1	LS	$43,000	$43,000	$31,000	$53,000
LGAC Cannister Purchase (2-10,000 lb units, manifold, and freight)	2	EA	$27,000	$54,000	$38,000	$81,000
Virgin LGAC fill	2	EA	$8,000	$16,000	$12,000	$24,000
GWET System Installation Report (includes as-built drawings)	1	LS	$15,000	$15,000	$10,000	$23,000
GWET System O&M Plan	1	LS	$5,000	$5,000	$4,000	$8,000
Project Management/Oversight/Administration	15%	n/a	n/a	$54,000	$38,000	$79,000
Grand Canal GWET System Capital Costs Subtotal - current value				**$409,000**	**$289,000**	**$601,000**
Grand Canal System Installation - assumes installed year 7 (3% annual escalation)[7]				**$606,000**	**$427,000**	**$893,000**
Estimated O&M Annual Costs						
SRP Well GWET System						
GWET System O&M costs (Virgin LGAC)	1.0	EA	$22,000	$22,000	$16,000	$33,000
GWET System monitoring analytical fees	1	LS	$3,000	$3,000	$3,000	$5,000
GWET System electrical and land rental fees[10]	12	Months	$4,000	$48,000	$34,000	$72,000
GWET System water withdrawal and use fees + annual ADWR report	1	LS	$5,000	$5,000	$4,000	$8,000
GWET O&M Labor and Reporting	1	LS	$17,000	$17,000	$12,000	$17,000
Remedial Progress Report	1	LS	$10,000	$10,000	$7,000	$15,000
O&M Project Management/Oversight/Administration	15%	n/a	n/a	$16,000	$7,000	$24,000
Annual Costs for GWET O&M Subtotal				**$121,000**	**$66,000**	**$140,000**
Total O&M Costs for Years 2-10 (3% annual escalation)[11]				**$1,498,000**	**$1,049,000**	**$2,247,000**
Grand Canal GWET System - current						
GWET System O&M costs (Virgin LGAC)	1.0	EA	$11,000	$11,000	$8,000	$17,000
GWET System monitoring analytical fees	1	LS	$3,000	$3,000	$3,000	$5,000
GWET System electrical fees	12	Months	$700	$9,000	$7,000	$14,000
GWET System water withdrawal and use fees + annual ADWR report	1	LS	$3,000	$3,000	$3,000	$5,000
GWET O&M Labor and Reporting	1	LS	$17,000	$17,000	$12,000	$26,000
Remedial Progress Report	1	LS	$10,000	$10,000	$7,000	$15,000
O&M Project Management/Oversight/Administration	15%	n/a	n/a	$8,000	$6,000	$13,000
Annual Cost for GWET O&M Subtotal (current)				**$61,000**	**$46,000**	**$95,000**
Annual Cost for GWET O&M Subtotal - Start Year 7 (3% annual escalation)				**$76,000**	**$57,000**	**$117,000**
Total O&M Costs for Years 8-24 (3% annual escalation)[12]				**$1,763,000**	**$1,235,000**	**$2,645,000**

Table B-2
Estimated Costs for Reference Remedy
Feasibility Study Report
40th St and Osborn Rd WQARF Site

Estimated GW Monitoring Annual Costs							
Semiannual GW Monitoring/Reporting (all wells)	2	EA	$25,000	$50,000	$35,000	$75,000
Project Management/Oversight/Administration	15%	n/a	n/a	$8,000	$6,000	$12,000
Annual Cost for GW Monitoring Subtotal				**$58,000**	**$41,000**	**$87,000**
Total GW Monitoring Costs for Years 2-26 (3% annual escalation)				**$2,400,000**	**$2,031,000**	**$4,352,000**
O&M and Monitoring Costs Subtotal				**$5,858,000**	**$4,438,000**	**$9,501,000**
Reference Remedy Capital, O&M and Monitoring Costs				**$7,031,000**	**$5,264,000**	**$11,247,000**
Estimated Contingency Costs						
Estimated Capital Costs						
Downgradient Performance Well Installation						
Monitoring Well Installation and Oversight (includes vertical profile)	2	LS	$50,000	$100,000	$70,000	$150,000
Survey, Permitting, Sampling and IDW Disposal	2	LS	$11,000	$22,000	$15,000	$33,000
Tech Memo	1	LS	$9,000	$9,000	$6,000	$14,000
Project Management/Oversight/Administration	15%	n/a	n/a	$20,000	$14,000	$30,000
Capital Costs Subtotal				**$151,000**	**$105,000**	**$227,000**
Contingency Costs Subtotal				**$151,000**	**$105,000**	**$227,000**
Reference Remedy Costs (Including Contingencies)				**$7,182,000**	**$5,369,000**	**$11,474,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
GWET - groundwater extraction and treatment
GW - groundwater
IDW - Investigation Derived-Wastes
n/a - not applicable

LF = linear feet
LGAC = liquid phase granular activated carbon
LS = lump sum
O&M = operations and maintenance
EA - each

Remedy Notes and Assumptions:

1. Total costs are rounded up to the nearest thousand dollars ($1000).
2. Pricing is subject to commodity pricing increases. Contingencies for possible price escalation due to steel or other tariffs is not included.
3. No estimated costs have been included for taxes or other fees relative to the project.
4. SRP Well 17.9E-7.5N is lined with a new casing and a new 700 gpm is installed. Assumes electrical service is present.
5. Treated water discharge will be tied in to the existing production well conveyance pipeline.
6. Treatment system will be installed on a 1-foot thick on grade concrete slab with secondary containment curbing enclosed in a masonry wall.
7. Cost assumes Grand Canal GWET System is installed at Year 7 of the remedy based on 3% escalation. The cost decreases exponentially at 3% rate as time decreases.
8. New extraction well installed with 300 gpm submersible pump.
9. Installation of a power drop is required.
10. Includes monthly private land rental fee of $2,000.
11. Includes costs for two pump replacements
12. Includes costs for three pump replacements

Table B-3
Estimated Costs for More Aggressive Alternative Remedy
Feasibility Study Report
40th St and Osborn Rd WQARF Site

	Quantity	Unit	Unit Cost[1-3]	Total Cost	Estimated Low Range (-30%)	Estimated Upper Range (+50%)
GWET (wellhead treatment)						
Estimated Capital Costs						
Remedy Final Design						
Remedy Final Design	1	LS	$75,000	$75,000	$53,000	$113,000
SRP Well System Installation						
Well rehabilitation and pump replacement[4]	1	LS	$160,000	$160,000	$112,000	$240,000
LGAC Cannister Installation, including pads and piping[5,6]	1	LS	$35,000	$35,000	$25,000	$53,000
LGAC Cannister Purchase (2-20,000 lb units, manifold, and frieght)	2	EA	$85,000	$170,000	$119,000	$255,000
Virgin LGAC fill	2	EA	$16,000	$32,000	$22,400	$48,000
GWET System Installation Report (includes as-built drawings)	1	LS	$15,000	$15,000	$10,000	$23,000
GWET System O&M Plan	1	LS	$5,000	$5,000	$4,000	$8,000
Poor Quality Groundwater Withdrawal Permit Application + fee (one time)	1	LS	$2,000	$2,000	$2,000	$3,000
Project Management/Oversight/Administration	15%	n/a	n/a	$73,000	$51,000	$110,000
SRP Well GWET System Capital Costs Subtotal				**$567,000**	**$392,000**	**$853,000**
Grand Canal System Installation[7]						
Well and pump installation[8]	1	LS	$192,000	$192,000	$135,000	$288,000
power drop installation[9]	1	LS	$30,000	$30,000	$21,000	$45,000
LGAC Cannister Installation, including pads and piping[6]	1	LS	$43,000	$43,000	$31,000	$53,000
LGAC Cannister Purchase (2-10,000 lb units, manifold, and freight)	2	EA	$27,000	$54,000	$38,000	$81,000
Virgin LGAC fill	2	EA	$8,000	$16,000	$12,000	$24,000
GWET System Installation Report (includes as-built drawings)	1	LS	$15,000	$15,000	$10,000	$23,000
GWET System O&M Plan	1	LS	$5,000	$5,000	$4,000	$8,000
Project Management/Oversight/Administration	15%	n/a	n/a	$54,000	$38,000	$79,000
Grand Canal GWET System Capital Costs Subtotal - current value				**$409,000**	**$289,000**	**$601,000**
Grand Canal System Installation - assumes installed year 2 (3% annual escalation)[7]				**$434,000**	**$307,000**	**$638,000**
Estimated O&M Annual Costs						
SRP Well GWET System						
GWET System O&M costs (Virgin LGAC)	1.0	EA	$22,000	$22,000	$16,000	$33,000
GWET System monitoring analytical fees	1	LS	$3,000	$3,000	$3,000	$5,000
GWET System electrical and land rental fees[10]	12	Months	$4,000	$48,000	$34,000	$72,000
GWET System water withdrawal and use fees + annual ADWR report	1	LS	$5,000	$5,000	$4,000	$8,000
GWET O&M Labor and Reporting	1	LS	$17,000	$17,000	$12,000	$17,000
Remedial Progress Report	1	LS	$10,000	$10,000	$7,000	$15,000
O&M Project Management/Oversight/Administration	15%	n/a	n/a	$16,000	$7,000	$24,000
Annual Costs for GWET O&M Subtotal				**$121,000**	**$66,000**	**$140,000**
Total O&M Costs for Years 2-10 (3% annual escalation)[11]				**$1,498,000**	**$1,049,000**	**$2,247,000**
Grand Canal GWET System - current						
GWET System O&M costs (Virgin LGAC)	1.0	EA	$11,000	$11,000	$8,000	$17,000
GWET System monitoring analytical fees	1	LS	$3,000	$3,000	$3,000	$5,000
GWET System electrical fees	12	Months	$700	$9,000	$7,000	$14,000
GWET System water withdrawal and use fees + annual ADWR report	1	LS	$3,000	$3,000	$3,000	$5,000
GWET O&M Labor and Reporting	1	LS	$17,000	$17,000	$12,000	$26,000
Remedial Progress Report	1	LS	$10,000	$10,000	$7,000	$15,000
O&M Project Management/Oversight/Administration	15%	n/a	n/a	$8,000	$6,000	$13,000
Annual Cost for GWET O&M Subtotal (current)				**$61,000**	**$46,000**	**$95,000**
Annual Cost for GWET O&M Subtotal - Start Year 2 (NPV - Discounted 3%)				**$65,000**	**$49,000**	**$101,000**
Total O&M Costs for Years 3-19 (3% annual escalation)[12]				**$1,532,000**	**$1,072,400**	**$2,298,000**

Table B-3
Estimated Costs for More Aggressive Alternative Remedy
Feasibility Study Report
40th St and Osborn Rd WQARF Site

Estimated GW Monitoring Annual Costs						
Semiannual GW Monitoring/Reporting (all wells)	2	EA	$25,000	$50,000	$35,000	$75,000
Project Management/Oversight/Administration	15%	n/a	n/a	$8,000	$6,000	$11,250
Annual Cost for GW Monitoring Subtotal				**$58,000**	**$41,000**	**$87,000**
Total GW Monitoring Costs for Years 2-21 (Net Present Value - Discounted 3%)				**$1,714,000**	**$1,200,000**	**$2,571,000**
O&M and Monitoring Costs Subtotal				**$4,930,000**	**$3,437,000**	**$7,357,000**
Reference Remedy Capital, O&M and Monitoring Costs				**$5,931,000**	**$4,136,000**	**$8,848,000**

Estimated Contingency Costs						
Estimated Capital Costs						
Downgradient Performance Well Installation						
Monitoring Well Installation and Oversight (includes vertical profile)	2	LS	$50,000	$100,000	$70,000	$150,000
Survey, Permitting, Sampling and IDW Disposal	2	LS	$11,000	$22,000	$15,000	$33,000
Tech Memo	1	LS	$9,000	$9,000	$6,000	$14,000
Project Management/Oversight/Administration	15%	n/a	n/a	$20,000	$14,000	$30,000
Capital Costs Subtotal				**$151,000**	**$105,000**	**$227,000**
Contingency Costs Subtotal				**$151,000**	**$105,000**	**$227,000**
Reference Remedy Costs (Including Contingencies)				**$6,082,000**	**$4,241,000**	**$9,075,000**

Abbreviations:

WQARF = Water Quality Assurance Revolving Fund
% = percent
GWET - groundwater extraction and treatment
GW - groundwater
IDW - Investigation Derived-Wastes
n/a - not applicable

LF = linear feet
LGAC = liquid phase granular activated carbon
LS = lump sum
O&M = operations and maintenance
EA - each

Remedy Notes and Assumptions:

1. Total costs are rounded up to the nearest thousand dollars ($1000).
2. Pricing is subject to commodity pricing increases. Contingencies for possible price escalation due to steel or other tariffs is not included.
3. No estimated costs have been included for taxes or other fees relative to the project.
4. SRP Well 17.9E-7.5N is lined with a new casing and a new 700 gpm is installed. Assumes electrical service is present.
5. Treated water discharge will be tied in to the existing production well conveyance pipeline.
6. Treatment system will be installed on a 1-foot thick on grade concrete slab with secondary containment curbing enclosed in a masonry wall.
7. Cost assumes Grand Canal GWET System is installed at Year 2 of the remedy (3% annual escalation). The cost decreases exponentially at 3% rate as time decreases.
8. New extraction well installed with 300 gpm submersible pump.
9. Installation of a power drop is required.
10. Includes monthly private land rental fee of $2,000.
11. Includes costs for two pump replacements
12. Includes costs for three pump replacements