Play Area Groundwater Treatment Interim Action Work Plan

Sampling and Analysis Plan and Quality Assurance Project Plan Addendum No. 4

Supplemental Investigation
Gas Works Park Site
Seattle, Washington

for
Puget Sound Energy and
City of Seattle

November 15, 2017

GeoEngineers
Earth Science + Technology

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File No. 0186-846-01

November 15, 2017

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1.0 INTRODUCTION

This document is the fourth addendum to the sampling and analysis plan (SAP) and quality assurance project plan (QAPP) for the supplemental investigation at the Gas Works Park Site (GWPS) in Seattle, Washington. This SAP and QAPP Addendum No. 4 (SAP-QAPP addendum) replaces SAP and QAPP Addendum No. 3 and presents additional investigation methods that will be used for groundwater monitoring during Play Area interim action groundwater treatment. The following changes will be made to the monitoring program:

- Modify the analytical method for arsenic by eliminating acid preservation and switching from United States Environmental Protection Agency (EPA) Method 200.8 to EPA Method 6010.
- Add well MW-46D to the short-term monitoring network.
- Add arsenic field kit testing to the short-term monitoring program.
- Add laboratory analysis to one of the short-term monitoring events.

SAP and QAPP Addendum 3 was modified as follows:

- Added a description of changes to investigation methods and list of document changes to this introduction section.
- Revised internal references and numbering (e.g., addendum and table numbers).
- Section 2.2 Short-Term Performance Monitoring text was revised to reflect the increased number of wells to be sampled, reference use of arsenic field test kits and add supplemental laboratory analysis.
- Table 2:
    - Updated the arsenic analytical method from Method 200.8 to Method 6010C,
    - Added MW-46D to the short-term performance monitoring network,
    - Added arsenic field kit testing to short-term performance monitoring,
    - Added laboratory analysis for arsenic, iron and sulfate to short-term performance monitoring and
    - Modified footnotes to specify filtering method (field versus lab) and use of unpreserved bottles, clarify sampling schedule and identify the arsenic field test kit.
- Revised Table 3 to include EPA Method 6010C for arsenic.
- Inserted arsenic field test kit information and instructions in Attachment 2.

This SAP-QAPP addendum has been prepared in general accordance with the Model Toxics Control Act (MTCA), Chapter 173-340-820 of the Washington Administrative Code (WAC) and serves as the primary guide for the integration of quality assurance (QA) and quality control (QC) functions into field activities. Unless specifically noted in this SAP-QAPP addendum, the activities described in this addendum will be conducted under the March 2013 *Supplemental Investigation Work Plan* (GeoEngineers, 2013) including the Sampling and Analysis Plan (Appendix A) and Quality Assurance Project Plan (Appendix B), approved by the Washington State Department of Ecology (Ecology) on March 11, 2013. The *Supplemental Investigation Work Plan* described an environmental investigation designed to meet the data needs for completing the Remedial Investigation (RI). Data collected during that investigation were summarized in the Agency Review Draft Site-Wide Remedial Investigation Report (GeoEngineers, 2016).

Elevated concentrations of arsenic were detected in soil and groundwater samples collected from beneath the Play Area during the 2013 supplemental upland investigation (GeoEngineers, 2016). Additional information regarding the nature and extent of arsenic in soil and groundwater was obtained during investigations of the Play Area in 2014 and 2016 (GeoEngineers, 2016 [Appendix Y]; GeoEngineers, 2017 [in progress]). An arsenic treatability study performed in 2016 indicated dissolved arsenic concentrations could likely be reduced by application of iron amendments (Anchor QEA, 2016). Groundwater injection infrastructure was installed in spring 2017 to facilitate in-situ treatment of arsenic in groundwater beneath the Play Area.

Groundwater monitoring activities summarized in this SAP-QAPP addendum will be used to document baseline groundwater conditions before treatment, and evaluate the effectiveness and permanence of in-situ treatment of dissolved arsenic.

Groundwater monitoring during the Play Area Interim Action will consist of the following:

- Baseline monitoring to evaluate pre-treatment conditions at the Play Area,
- Short-term performance monitoring during reagent injection to evaluate the immediate influence of the injection,
- Post-injection performance monitoring to evaluate treatment performance approximately one month after injection, and
- Confirmation monitoring after an extended period (3 months or more) following treatment to evaluate long-term performance and stability of the arsenic treatment.

Groundwater sample numbering will follow the sample numbering convention included in the 2013 SAP.

2.0 GROUNDWATER MONITORING

This section presents field sampling methods that are not contained in the 2013 SAP and QAPP or that deviate from the methods described therein. Play Area monitoring well locations are shown on Interim Action Work Plan Figures 5 and 6. Monitoring well construction and groundwater elevation information are summarized in Table 1. A summary of the proposed groundwater samples and analyses is presented in Table 2. The following sections describe the activities to be conducted during each groundwater monitoring event. Unless noted, groundwater samples will be collected using the procedures presented in the 2013 SAP including:

- Groundwater depth measurements,
- Light and dense nonaqueous phase liquid (LNAPL and DNAPL) depth measurements (if present), and
- Groundwater sampling using low-flow/low-turbidity methods.

Groundwater monitoring activities will be recorded in field reports and on groundwater sampling forms as described in the 2013 SAP.

2.1. Baseline Groundwater Monitoring

One groundwater monitoring event will be performed to obtain chemical analytical data to document groundwater conditions before in-situ treatment (baseline). Groundwater samples will be collected from the 17 Play Area monitoring wells, and analyzed for field parameters, total and dissolved arsenic, total and dissolved iron, sulfide and sulfate (Table 2). Samples from selected monitoring wells, as shown in Table 2, will be collected for arsenic speciation analysis using the anoxic sampling methodology described in SAP-QAPP Attachment 1. Standard low-flow sampling procedures will be used to obtain groundwater samples during the baseline event. The volume of water purged from each monitoring well before sampling will be measured and recorded, and used as the purge volume to be removed from each monitoring well during subsequent sampling events.

2.2. Short-Term Performance Monitoring

Short-term performance monitoring will be performed to document groundwater conditions during and shortly after reagent injection. Groundwater samples will be collected from the seven or eight monitoring wells within the targeted treatment area (Table 2). Short-term performance monitoring will include hourly measurements of depth-to-groundwater during reagent injection; and monitoring of field parameters, arsenic, iron, and sulfate approximately twice per week for two weeks after reagent injection. Arsenic, iron and sulfate concentrations will be measured in the field using colorimetric field tests; Hach EZ Arsenic High Range (range: 0 to 4,000 micrograms per liter [µg/L], Hach IR-18 for iron (range: 0 to 4 milligrams per liter [mg/L]) and Hach SF-1 for sulfate (range: 50 to 200 mg/L), or equivalent, following manufacturer's instructions. Arsenic, iron and sulfate test kit information and operating instructions are included in Attachment 2. Two weeks following injection groundwater samples will be submitted to the analytical laboratory for arsenic, iron and sulfate analysis.

2.3. Post-Injection Performance Monitoring

Post-injection performance monitoring is anticipated to be completed approximately 1 month following injection. Like the baseline monitoring event, groundwater samples will be collected from the 17 Play Area monitoring wells, and analyzed for field parameters, total and dissolved arsenic, total and dissolved iron, sulfide and sulfate (Table 2). Unlike the baseline event, samples will not be collected for arsenic speciation analysis.

2.4. Confirmation Monitoring

Confirmation monitoring is anticipated to be completed at least 3 months after final reagent injection. Groundwater samples will be collected from 11 selected Play Area monitoring wells, and analyzed for field parameters and total and dissolved arsenic (Table 2).

3.0 LABORATORY ANALYTICAL METHODS

The analytical methods to be used for sample analysis, as well as details regarding containers, sample preservatives, and sample holding times, are listed in Table 3.

Table 4 lists the field QC samples to be collected during this investigation. Field QC samples will consist of equipment rinsate blanks, trip blanks, and field duplicates, and will be documented in field reports. As discussed in the 2013 QAPP, field QC samples will be used to evaluate the effectiveness of equipment decontamination procedures, potential cross-contamination of samples during transport to the laboratory, reproducibility of laboratory results, and sample heterogeneity.

4.0 FIELD DOCUMENTATION, INVESTIGATION DERIVED WASTE, AND SAMPLE HANDING PROCEDURES

Unless noted here field documentation, investigation-derived waste management, and sampling handling procedures will be performed using the procedures presented in the 2013 SAP including:

- Daily field reports including groundwater monitoring forms,
- Sample labels, and
- Laboratory Chain-of-Custody forms.

5.0 REFERENCES

Anchor QEA, 2016a. Draft Arsenic Treatability Study Report, Gas Works Park, prepared by Anchor QEA, LLC, for GeoEngineers, Inc., December 2016.

GeoEngineers, Inc. 2013. Final Supplemental Investigation Work Plan, Gas Works Park Site, Seattle, Washington.

GeoEngineers, Inc. 2014. Final Supplemental Investigation Work Plan, Gas Works Park Site, Seattle, Washington.

GeoEngineers, Inc. March 1, 2016. Agency Review Draft Site-Wide Remedial Investigation Feasibility Study Report, Gas Works Park Site, Seattle, Washington.

GeoEngineers 2017, *In progress*. Draft Play Area 2016 Supplemental Investigation Data Report, last revised June 30, 2016.

TABLES

Table 1

Play Area Monitoring Well Construction Summary

SAP-QAPP Addendum No. 4

Gas Works Park Site
Seattle, Washington

Well ID	Well Location		Top of Casing Elevation[1,2]	Screen Interval Depth Below Ground Surface at Time of Installation		Geologic Unit of Screen Interval
	Northing	Easting		Top	Bottom	
Play Area						
MW-36S	239086.77	1270783.61	26.37	8.0	22.8	Fill
MW-36D	239091.49	1270785.63	26.30	29.3	33.8	Outwash
MW-41S	239123.85	1270626.07	29.02	5.3	10.3	Fill
MW-41D	239126.07	1270628.03	29.19	18.3	28.3	Outwash
MW-42S	239153.02	1270667.56	32.85	3.8	8.8	Fill
MW-43S	239087.49	1270677.38	29.03	7.4	12.4	Fill
MW-44S	239159.31	1270720.72	30.29	7.5	17.5	Fill
MW-45S	239142.50	1270725.64	30.74	6.8	16.8	Fill
MW-45D	239138.49	1270727.34	30.00	25.8	30.8	Outwash
MW-46S	239143.44	1270760.23	24.84	7.3	17.3	Fill
MW-46D	239148.59	1270760.61	24.92	30.0	25.0	Outwash
MW-47S	239111.94	1270743.90	29.80	15.0	20.0	Fill
MW-48D	239081.86	1270756.15	26.80	22.4	32.4	Outwash
MW-49D	239063.29	1270775.15	26.15	24.9	34.9	Outwash
MW-50D	239117.04	1270793.29	25.06	28.5	33.5	Outwash
MW-51S	239136.65	1270795.79	25.37	6.4	16.4	Fill
MW-52D	239147.84	1270796.96	25.31	29.9	34.9	Outwash

Notes:

1. Elevations are relative to NAVD88 vertical datum.
2. Top-of-casing elevations for monitoring wells MW-41S, MW-41D, MW-42S, MW-44S, MW-45S, and MW-45D (shaded cells) are interim elevations. Permanent, flush-mounted protective monuments have not yet been installed. Monuments will be installed and top-of-casing elevations will be surveyed after Play Area renovations are complete.

Table 2

Play Area Groundwater Sample Summary

SAP-QAPP Addendum No. 4
Gas Works Park Site
Seattle, Washington

Well ID	Well Screen Geologic Unit	Well Type	Baseline Sampling						Performance Monitoring													Confirmation Monitoring	
									Short-Term Performance Monitoring								Treatment Performance Monitoring						
			Prior to beginning injection						Hourly during injection	Two times per week following injection[4]				Two weeks following injection			1 month after end of injection					At least 3 months after final injection	
			Field Parameters[1]	Arsenic[2] (200.8 and 6010C)	Arsenic Speciation (IC-ICP-MS)	Iron[3] (SW6010)	Sulfide (SM4500-S2-D)	Sulfate (300.0)	Water Levels	Field Parameters[1]	Iron[5]	Sulfate[6]	Arsenic[7]	Arsenic[8] (6010C)	Iron[9] (SW6010)	Sulfate (300.0)	Field Parameters[1]	Arsenic[8] (6010C)	Iron[9] (SW6010)	Sulfide (SM4500-S2-D)	Sulfate (300.0)	Field Parameters[1]	Arsenic[8] (6010C)
MW-36S	Fill	Downgradient	X	X		X	X	X									X	X	X	X	X		
MW-36D	Outwash	Downgradient	X	X		X	X	X									X	X	X	X	X		
MW-41S	Fill	Upgradient	X	X		X	X	X									X	X	X	X	X		
MW-41D	Outwash	Upgradient	X	X		X	X	X									X	X	X	X	X		
MW-42S	Fill	Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-43S	Fill	Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-44S	Fill	Performance	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-45S	Fill	Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-45D	Outwash	Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-46S	Fill	Performance	X	X	X	X	X	X									X	X	X	X	X	X	X
MW-46D	Outwash	Performance	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-47S	Fill	Performance	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-48D	Outwash	Performance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MW-49D	Outwash	Downgradient	X	X		X	X	X									X	X	X	X	X		
MW-50D	Outwash	Downgradient	X	X		X	X	X									X	X	X	X	X		
MW-51S	Fill	Downgradient	X	X		X	X	X									X	X	X	X	X		
MW-52D	Outwash	Downgradient	X	X		X	X	X									X	X	X	X	X		

Notes:

1. Field parameters include: water level, dissolved oxygen, oxidation/reduction potential, specific conductance, turbidity, temperature, and pH.
2. Total and dissolved arsenic. Dissolved arsenic samples were field filtered. Total arsenic analyzed by two methods, EPA 200.8 and unpreserved EPA 6010C. Dissolved arsenic analyzed by one method, EPA 200.8.
3. Total and dissolved iron. Dissolved iron samples were field filtered.
4. Sample twice weekly for 2 weeks following reagent injection, total of four sampling events. MW-46D was added after the first sampling event.
5. Iron by colorimetric field test kit. Hach IR-18 or equivalent.
6. Sulfate by colorimetric field test kit. Hach SF-1 or equivalent.
7. Arsenic by Hach EZ Arsenic High Range
8. Total and dissolved arsenic. Dissolved arsenic to be lab filtered. Arsenic samples to be collected in unpreserved sample bottles.
9. Total and dissolved iron. Dissolved iron sample to be lab filtered.

Table 3

Test Methods, Sample Containers, Preservatives and Holding Times

SAP-QAPP Addendum No. 4
Gas Works Park Site
Seattle, Washington

Analysis	Method	Minimum Sample Size	Sample Containers	Sample Preservatives	Sample Holding Times[1]
		Water	Water	Water	Water
Arsenic	EPA 200.8 (water) EPA 6010C (water)	500 mL	500 mL HDPE	Cool <6 °C, HN03 to pH <2 Cool <6 °C	180 days 2 days
Iron	SW6010 (water)	500 mL	500 mL HDPE	Cool <6 °C, HN03 to pH <2 (Dissolved metals preserved after filtration)	180 days to digestion, 180 days to analysis
Sulfide	SM 4500-S2-D-0 (water)	500 mL	500 mL HDPE	Cool <6 °C, Zinc Acetate (NaOH added in lab), pH >9	7 days
Sulfate	EPA 300.0 (water)	500 mL	500 mL HDPE	Cool <6 °C	28 days
Arsenic Speciation	EPA 6800M (modified) (IC-ICP-MS) (water)	5 mL	125 mL HDPE	Cool 0-4° C, prepreserved with EDTA/acetic acid, minimal headspace, keep dark*	28 days

Notes:

1. Holding times are based on elapsed time from date of sample collection.

g = gram

°C = degrees Celsius

EDTA = ethylenediaminetetraacetic acid

EPA = U.S. Environmental Protection Agency

HDPE = High density polyethylene

HNO_3 = nitric acid

H_2SO_4 = Sulfuric acid

mL = milliliter

NaOH = Sodium hydroxide

pH = potential of hydrogen

* Field-filtration recommened, especially for samples with high levels of solids.

Table 4

Quality Control Sample Types and Minimum Frequency

SAP-QAPP Addendum No. 4

Gas Works Park Site

Seattle, Washington

		Field QC Samples			Laboratory QC Samples			
Parameter	**Reporting Limit**	**Field Duplicates**	**Trip Blanks**	**Equipment Rinsate Blanks**	**Method Blanks**	**Blank Spike, LCS or OPR**	**MS/MSD**	**Lab Duplicates**
Arsenic	0.2 µg/L	1 per 20 primary groundwater samples	NA	1	1 per batch*	1 per batch*	1 MS only per batch*	1 per batch*
Total Iron	0.05 mg/L							
Sulfide	0.05 mg/L							
Sulfate	0.1 mg/L							
Arsenic Speciation	0.2 µg/L	1 (minimum) or 1 per 20 primary groundwater samples	NA	none				

Notes:

*An analytical batch is defined as a group of samples taken through a preparation procedure and sharing a method blank, LCS, and MS/MSD (or MS and lab duplicate). No more than 20 field samples are contained in one batch.

LCS = Laboratory control sample

MS = Matrix spike

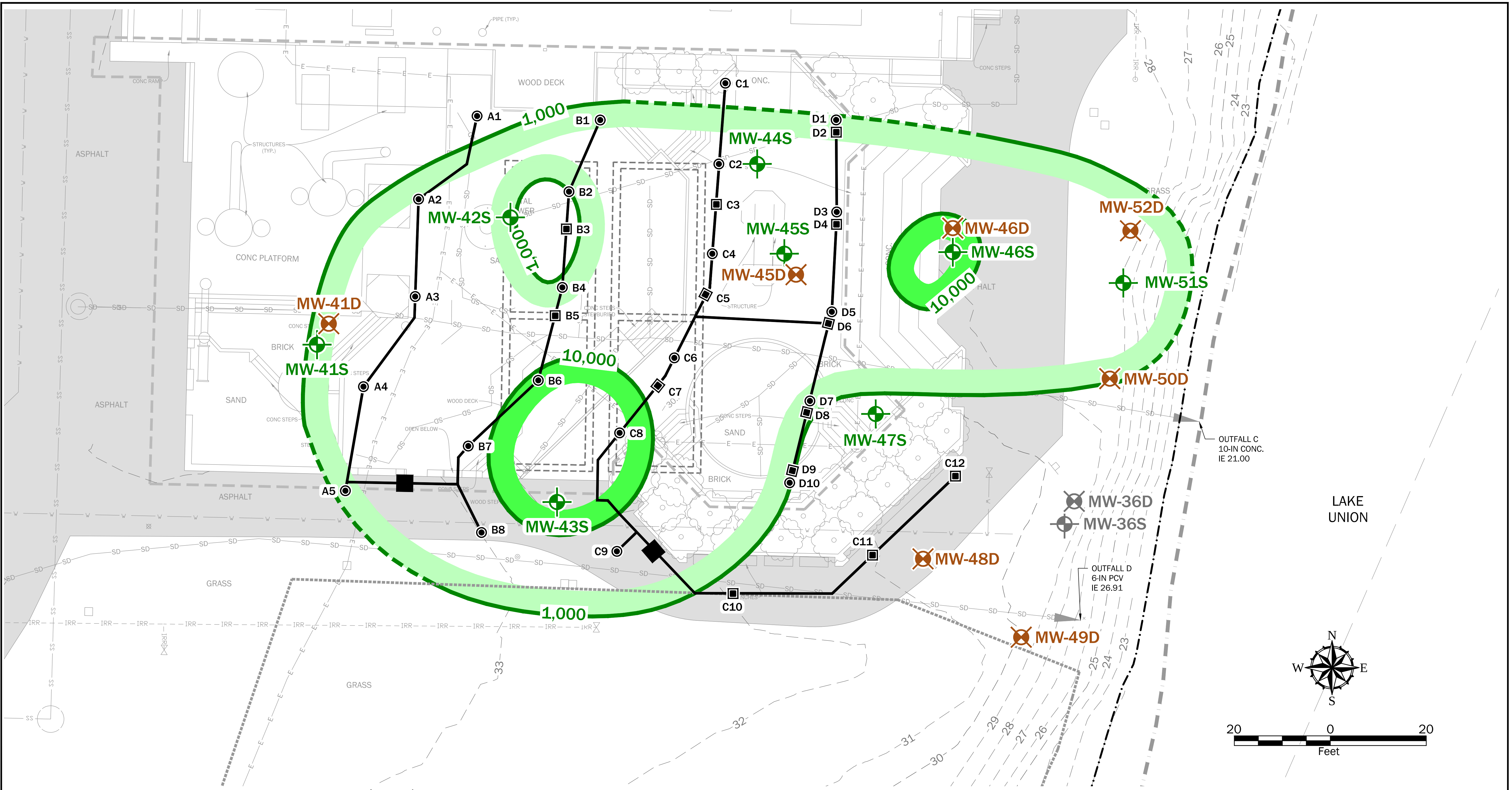
MSD = Matrix spike duplicate

NA = Not applicable

OPR = Ongoing precision and recovery

µg/L = micrograms per liter

mg/L = milligrams per liter



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

- Existing conditions survey by Seattle Parks and Recreation, November 2002
- Construction Completion Report by Thermo RETEC, January 2001
- Outfall C and D based on APS Survey, December 2014

Legend

30 Existing Contour (USACOE)

SD Existing Stormdrain

W Existing Water

E Existing Electrical

Play Area Renovation Footprint

Approximate Edge of Existing Impermeable Liner

Existing Asphalt, Gravel, and/or Concrete

Existing Monitoring Well - Fill

Existing Monitoring Well - Outwash

1,000 Interpreted Fill Dissolved Arsenic Concentration Contour (Dashed where inferred) (µg/L)

Ordinary High Water

Proposed Injection Infrastructure and Monitoring Wells

A1 ● Injection Well - Fill

B3 ■ Injection Well - Outwash

Trenched Injection Pipe and System Vault

MW-46S Monitoring Well - Fill

MW-46D Monitoring Well - Outwash

Injection Infrastructure and Monitoring Well Network - Fill Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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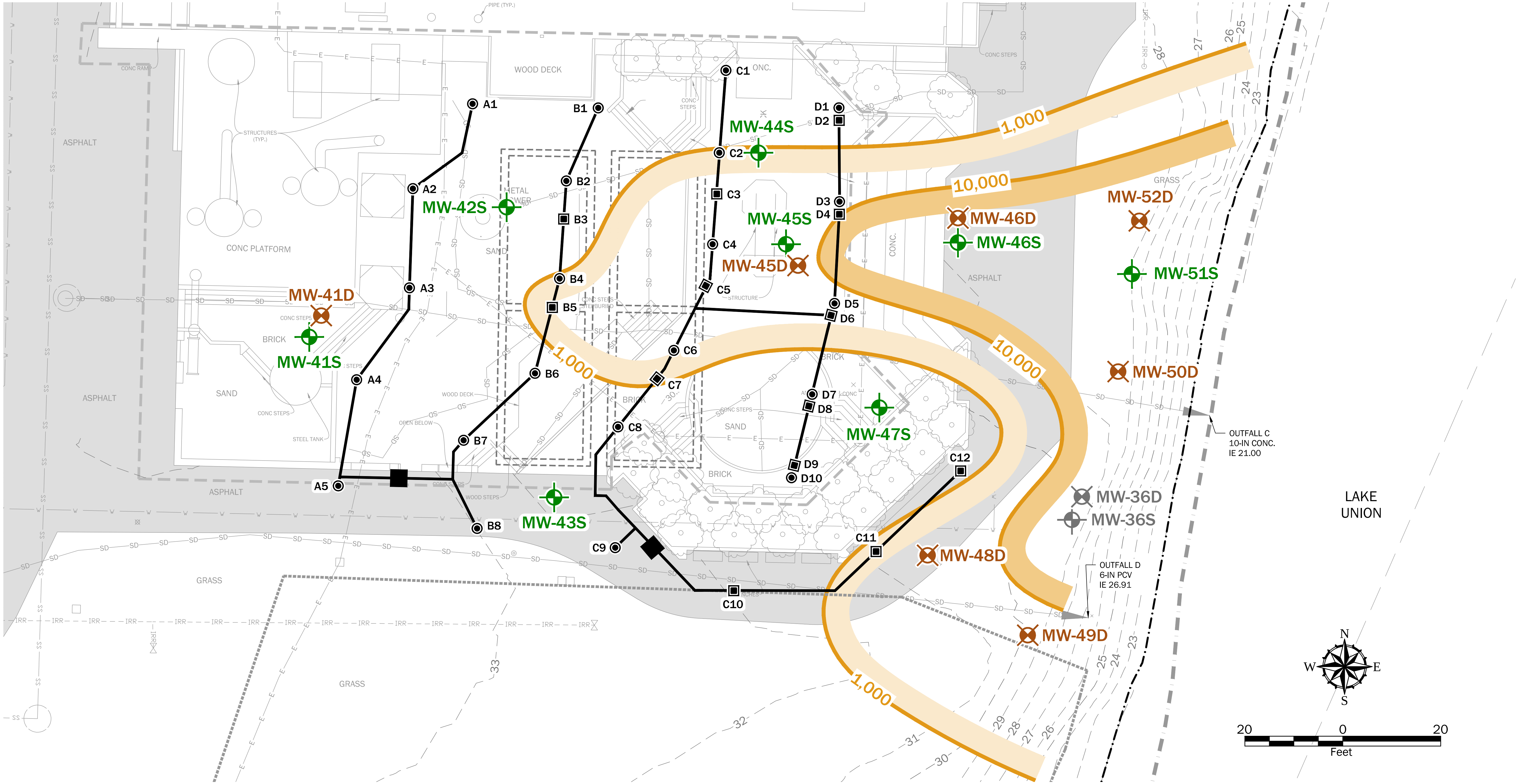
Figure 5

P:\0\0186846\01\CAD\Task 1804 2017 Play Area IA\Work Plan\0186846601_T1804S06_F05-F06 Injection Infrastructure and MW Well Networks Fill and Outwash Dissolved Arsenic.dwg TAB:F05 Date Exported: 07/28/17 - 12:13 by hmara



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Legend

---30---	Existing Contour (NAVD88)
---SD---	Existing Stormdrain
---W---	Existing Water
---E---	Existing Electrical
— — —	Play Area Renovation Footprint
······	Approximate Edge of Existing Impermeable Liner
▨	Existing Asphalt, Gravel, and/or Concrete
⊕	Existing Monitoring Well - Fill
⊗	Existing Monitoring Well - Outwash
1,000	Interpreted Outwash Dissolved Arsenic Concentration Contour (µg/L)
—·—	Ordinary High Water

Proposed Injection Infrastructure and Monitoring Wells

A1 ◉	Injection Well - Fill
B3 ▣	Injection Well - Outwash
—■	Trenched Injection Pipe and System Vault
MW-46S ⊕	Monitoring Well - Fill
MW-46D ⊗	Monitoring Well - Outwash

Injection Infrastructure and Monitoring Well Network - Outwash Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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Figure 6

P:\0\0186846\01\CAD\Task 1804 2017 Play Area IA\Work Plan\018684601_T1804S06_F05-F06 Injection Infrastructure and MW Well Networks Fill and Outwash Dissolved Arsenic.dwg TAB:F06 Date Exported: 07/28/17 - 12:14 by hmara

ATTACHMENTS

ATTACHMENT 1
Arsenic Speciation - Anoxic Field Sample Technique

ATTACHMENT 1

Arsenic Speciation - Anoxic Field Sample Technique

Safety

This method uses a surgical steel needle. Use caution to avoid injury with the needle.

Materials (see Figure 1)

15 mL Syringe barrel with Luer-lock fitting
Luer-lock 25-gauge surgical steel needle
Luer-lock 0.45 µm filter
Evacuated sample vial with septum – non-preserved or EDTA-coated
Sharps container

Method

Water samples collected for arsenic speciation analysis are sensitive to redox changes. The purpose of this groundwater sampling technique is to mimic anoxic conditions—minimizing the exposure to oxygen. Follow these procedures after low flow purging is complete, groundwater parameters are stabilized and the monitoring flow through cell (YSI) has been disconnected.

1. Label the sample vial before sampling.
2. Allow for a segment of silicon (Tygon, Masterflex, or equivalent) tubing, approximately 6-inches long, on the discharge end of the peristaltic or submersible pump.
3. Remove any air within the syringe barrel. Attach the surgical needle to the barrel.
4. Point the needle against the current of the groundwater, insert the needle into the silicon tubing. Puncture tube about 3 inches from the end, this punctured segment will need to be cut to minimize spillage when filling subsequent bottle ware.
5. Draw approximately 15 millileters (mL) of water into the barrel. To minimize the amount of oxygen in the barrel, draw water slowly. Water may flow into the barrel by itself, displacing the small amount of air in the barrel. Be careful not to pull the plunger out of the barrel.
6. Extract the syringe from the tubing. Detach the needle from the barrel. Hold the syringe needle side up, gently flick the barrel to dislodge bubbles from the walls within, and slowly depress the syringe plunger to expel any air pockets.
7. Attach the Luer-lock 0.45 micrometer (µm) filter onto the barrel (fits only in one direction). Attach the needle on the filter.
8. Gently depress the plunger to expel a small amount of water through the filter and needle, this will hydrate the filter and the needle. Be sure to retain approximately 6 mL to fill each vial.
9. Insert the needle through the septum of the evacuated sample vial. Gently depress the plunger to fill the vial with water. Note it is normal for the vial to pull some water into the vial. Do not fill the vial completely, instead try to "balance" the vial without over pressurizing it, the plunger will resist. The vial will contain a small amount of headspace.

10. Remove the needle from the evacuated sample vial.
11. Place the vial in a plastic bag, seal the bag, and place the sample in a cooler with ice.
12. Discard the syringe into an appropriate “sharps” disposal container when finished.

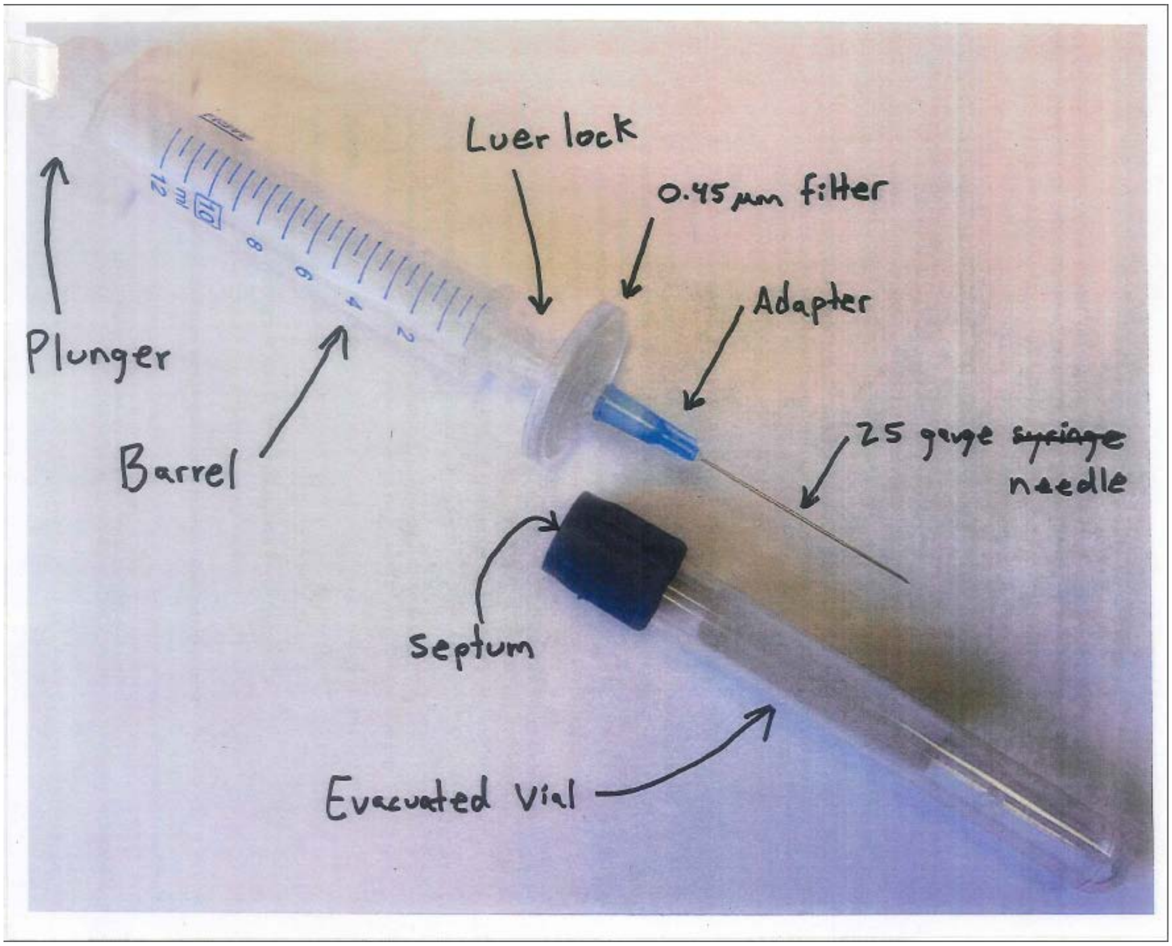


Figure 1
Groundwater Arsenic Speciation Sample Collection Materials

ATTACHMENT 2

Field Test Kit Information and Instructions (Arsenic, Iron and Sulfate)

EZ Arsenic

0 to 500, 0 to 4000 ppb As

For test kit 2822800 (EZ Arsenic)

DOC326.98.00006

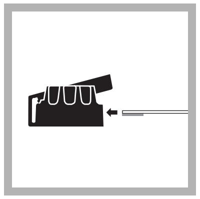
Additional copies available on www.hach.com

Test preparation

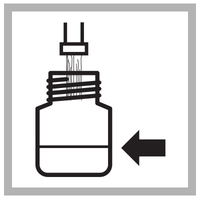
- For samples with sulfide greater than 15 ppb, follow the Optional procedure for removing sulfide before performing the test.
- Do not expose reacted strips to direct sunlight. Reaction products are photosensitive and may turn dark.
- Do not allow test strips to touch the reaction vessel solution. Test strips react with gases, not solution.
- Orient the test strip pad **paper side down** and **centered** over the hole in the black cap so the generated gases can make good contact with the pad.
- Two samples may be analyzed simultaneously with this kit.

DANGER: Hydrogen and arsine gasses are generated during the test. Work in a well-ventilated area away from open flames and other sources of ignition. Review Material Safety Data Sheets for safe handling, storage and disposal information.

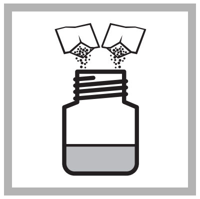
0–500 ppb (0, 10, 25, 50, 100, 250, 500 ppb) test procedure



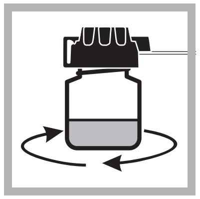
1. Insert a test strip into the cap so the pad completely covers the small opening. Close the flap and press to secure.



2. Fill the reaction bottle with sample to the fill line (50 mL).

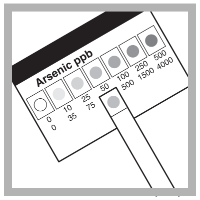


3. Add one Reagent #1 and one Reagent #2 powder pillow to the sample.



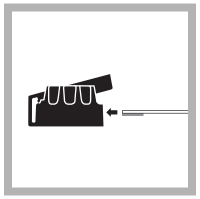
4. Immediately attach the cap to the reaction botle. Swirl continuously for 60 seconds. **Do not shake or invert or allow sample to get on the strip.**

5. Wait 20 minutes. Swirl twice during the reaction period.

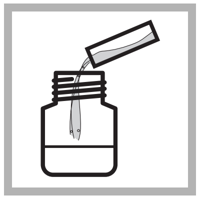


6. Remove the test strip and immediately compare the developed color to the chart on the test strip bottle (0–500 ppb row). Read strips in the shade.

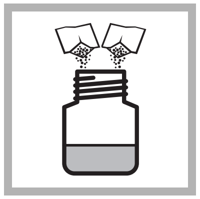
0–4000 ppb (0, 35, 75, 175, 500, 1500, 4000 ppb) test procedure



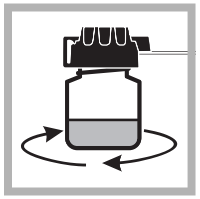
1. Insert a test strip into the cap so the pad completely covers the small opening. Close the flap and press to secure.



2. Fill the square measuring vial to the top with sample (9.6 mL). Pour the sample into the reaction bottle.

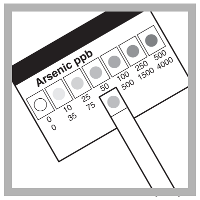


3. Add one Reagent #1 and one Reagent #2 powder pillow to the sample.



4. Immediately attach the cap to the reaction botle. Swirl continuously for 60 seconds. **Do not shake or invert or allow sample to get on the strip.**

5. Wait 20 minutes. Swirl twice during the reaction period.



6. Remove the test strip and immediately compare the developed color to the chart on the test strip bottle (0–4000 ppb row). Read strips in the shade.

Required items

Description	Unit	Catalog no.
EZ Arsenic Reagent Set	each	2823200
Reaction Bottle	each	2800200
Cap, reaction bottle	each	4934800

Interferences

Refer to Table 1 and Table 2 for interference information. Interferences other than those listed are not likely.

Table 1 Interfering substances

Ion or Substance	Concentration
Acidity	< pH 5. Do not acid-preserve samples. If samples are below pH 5, adjust pH to between 5 and 6 before beginning test.
Antimony	> 250 ppb
Nitric acid	Interferes with the reduction step. Do not use samples preserved with nitric acid because low results will be observed. If samples must be preserved, use HCl or sulfamic acid to adjust sample to pH 2. Adjust to pH 5–7 before running the test.
Selenium	> 1 ppm
Sulfide	>15 ppb (see Optional procedure for removing sulfide)
Tellurium	Likely to interfere, but not tested.

Table 2 Non-interfering substances

Ion or Substance	Highest concentration tested
Alkalinity	1000 ppm as $CaCO_3$
Hardness	1000 ppm as $CaCO_3$
Iron	100 ppm
Temperature	10 to 40 °C (50 to 104 °F)

Optional procedure for removing sulfide

If a rotten egg smell is detected after adding reagent #1, sulfide is present at interfering levels. Complete the following steps to remove the sulfide before beginning the test procedure:

1. Tear off a small piece of cotton and form a ball the size of a pea.
2. Saturate the cotton with a few drops of lead acetate. Squeeze the excess liquid out of the cotton, leaving it damp.
3. Press the saturated cotton ball into the small opening of the reaction bottle cap from the bottom. Be sure that the cotton is firmly in place and that a gap remains between the cotton and the top surface of the cap.
4. Insert the test strip as detailed in step 1 of the 0–500 or 0–4000 ppb test procedure and continue with the test.

Note: *The lead acetate must not contact the test strip!*

Always wear gloves or wash hands thoroughly after handling lead acetate.

For technical assistance or ordering information: visit www.hach.com, call 800-227-4224 or email techhelp@hach.com.

Edition 1, August 2006

Iron Test Kit

IR-18 (146400)

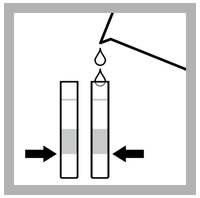
DOC326.98.00042

Test preparation

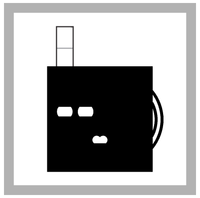
CAUTION:* ⚠ *Review the Safety Data Sheets (MSDS/SDS) for the chemicals that are used. Use the recommended personal protective equipment.

- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use the indoor light color disc when the light source is fluorescent light. Use the outdoor light color disc when the light source is sunlight.
- Rinse the tubes with sample before the test. Rinse the tubes with deionized water after the test.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.
- To verify the test accuracy, use a standard solution as the sample.
- If the sample contains rust or precipitated iron, fully mix the sample and then fill the tubes. Wait 2–5 minutes after the reagent is added. Dissolved iron develops a color immediately.
- Samples that contain more than 4 mg/L iron can give low results. If high iron levels are possible, dilute the sample as follows. Use a 3-mL syringe to add 2.5 mL of sample to each tube. Dilute the sample to the 5-mL mark with deionized water. Use the diluted sample in the test procedure and multiply the result by 2. Use the syringe to add 1 mL of sample to each tube. Dilute the sample to the 5-mL mark with deionized water. Use the diluted sample in the test procedure and multiply the result by 5.

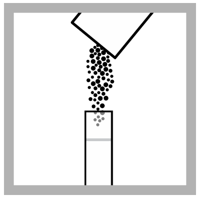
Test procedure—Iron (0–4 mg/L Fe)



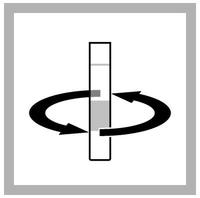
1. Fill two tubes to the first line (5 mL) with sample.



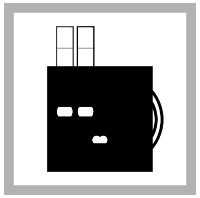
2. Put one tube into the left opening of the color comparator box.



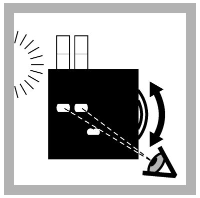
3. Add one FerroVer Iron Reagent Powder Pillow to the second tube.



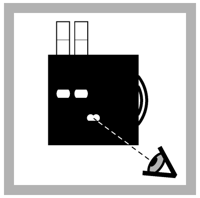
4. Swirl to mix. An orange color develops.



5. Put the second tube into the color comparator box.



6. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



7. Read the result in mg/L in the scale window.

Replacement items

Description	Unit	Item no.
FerroVer® Iron Reagent Powder Pillows, 5 mL	100/pkg	92799
Color disc, iron, indoor light, 0–4 mg/L	each	9262400
Color disc, iron, outdoor light, 0–4 mg/L	each	9263800
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004

Optional items

Description	Unit	Item no.
Caps for plastic viewing tubes (4660004)	4/pkg	4660014
Water, deionized	500 mL	27249
Glass viewing tubes, glass, 18 mm	6/pkg	173006
Iron standard solution, 1 mg/L Fe	500 mL	13949
Stoppers for 18-mm glass tubes and AccuVac Ampuls	6/pkg	173106
Syringe, Luer-Lok® Tip, 3 mL	each	4321300

www.hach.com 800-227-4224 techhelp@hach.com

12/2015, Edition 1

SULFATE TEST KIT

Model SF-1

Cat. No. 2251-00

HACH

To ensure accurate results, please read carefully before proceeding.

The sample mixing bottle, graduated cylinder and dipstick should be cleaned thoroughly after each use. If this is not done, a white film will form on the wall of the apparatus.

Test Instructions:

1 Fill the sample mixing bottle to the 25-mL mark.

WARNING: The chemical in this kit may be hazardous to the health and safety of the user if inappropriately handled. Please read all warnings before performing the tests and use appropriate safety equipment.

2. Use the clippers to open one SulfaVer® 4 Powder Pillow. Add the contents of the pillow to the mixing bottle. Press the cap on tightly and shake the bottle for 15 seconds.

3. A white turbidity will appear if sulfate is present.

4. Allow the sample to stand five minutes.

5. Invert the bottle to mix any solids left on the bottom. Remove the cap on the mixing bottle and slowly pour the contents into the clean 25 mL graduated cylinder

6. Hold the cylinder in a vertical position. While looking straight down into the cylinder slowly insert the sulfate dipstick down into the cylinder until the black dot disappears completely Hold the dipstick in that position and rotate the cylinder so you view the scale on the dipstick through the non-graduated portion of the cylinder

7 Read the concentration by looking across the surface of the sample to the scale on the dipstick. The number on the dipstick scale that meets with the surface of the sample corresponds to mg/L of sulfate in the sample.

8. If the black dot disappears before the first test mark (200 mg/L), the concentration of sulfate is greater than 200 mg/L. If the black dot does not disappear after the dipstick is inserted to the cylinder bottom, the sulfate concentration is less than 50 mg/L.

Replacements

Cat. No.	Description	Unit
12065-66	SulfaVer 4 Powder Pillows	pkg/50
46814-00	Dipstick, Sulfate Measure	each
24102-00	Bottle, mixing, plastic	pkg/2
968-00	Clippers	each
2172-40	Cylinder, graduated, polymethylpentene	each

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4/92

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