PFAS Sampling and Analysis Plan and Quality Assurance Project Plan

TAYLOR WAY AND ALEXANDER AVENUE FILL AREA SITE

TACOMA, WASHINGTON

December 15, 2023

Prepared by:

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Prepared for:

GENERAL METALS OF TACOMA
GLENN SPRINGS HOLDINGS
BURLINGTON ENVIRONMENTAL

DOF DALTON OLMSTED FUGLEVAND

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1.0 INTRODUCTION

Dalton, Olmsted, and Fuglevand, Inc. (DOF) prepared this *Per- and polyfluoroalkyl Substance (PFAS) Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP)* for the Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site (Figure 1) on behalf of Glenn Springs Holdings, Inc., General Metals of Tacoma, and Burlington Environmental LLC. These parties are among those identified in Agreed Order Number 14260 (AO) with the Washington State Department of Ecology (Ecology) as potentially liable parties at the TWAAFA Site. The Port of Tacoma is part of the TWAAFA Site as identified in the Enforcement Order (EO) Number DE 19410 with Ecology.

1.1 Purpose

This PFAS SAP and QAPP were prepared to satisfy a request for PFAS sampling made by Ecology in a September 6, 2023 email Re: *Comments on fourth quarter groundwater report and requirement for additional groundwater sampling* letter to the AO and EO parties (Ecology 2023a). Ecology requested sampling that includes "wells in both the shallow and intermediate aquifers, known source area wells, and upgradient and/or distal wells from source areas."

The following sections describe the plan for sampling and protocols for collection and analysis of groundwater samples in accordance with Ecology's June 2023 *Guidance for Investigating and Remediating PFAS Contamination in Washington State* (Ecology, 2023b).

In 2022, Ecology approved the *Revised Groundwater Monitoring Plan* (DOF, 2022) for the TWAAFA Site that outlined the collection of data for use in the upcoming Remedial Investigation and Feasibility Study (RI/FS) report. This SAP and QAPP references methods included in the Revised Groundwater Monitoring Plan, where applicable, and specifies additional requirements for PFAS sampling consistent with Ecology's PFAS guidance (Ecology, 2023b). The Ecology-approved Revised Groundwater Monitoring Plan is included in Appendix A for use during upcoming field activities.

2.0 BACKGROUND

Site background information is described in detail in the *Final Data Gaps Work Plan* (DGWP) (DOF, 2020). Four quarters of groundwater monitoring of non-PFAS constituents were conducted in 2022 in accordance with the DGWP as outlined by the AO requirements. At the time the DGWP was prepared and approved, PFAS sampling and analysis was not required for the TWAAFA Site.

PFAS data will be collected at a select set of groundwater wells at the TWAAFA Site and results are expected to reflect the historically industrial nature of the Tacoma tideflats, where multiple potential sources of PFAS may exist. Therefore, full delineation of PFAS below screening levels may be impracticable as a result. Collecting PFAS data at the TWAAFA Site will support Ecology's objective of site characterization in light of the recent regulatory classification of PFAS as a hazardous substance in Washington.

3.0 PFAS DATA COLLECTION

Groundwater sampling for PFAS will generally follow methods outlined in the Revised Groundwater Monitoring Plan's Standard Operating Procedures (SOPs), which was previously approved by Ecology for

the TWAAFA Site (Appendix A). PFAS specific field protocols, requirements, and considerations are outlined in the following sections. A new SOP specific to PFAS sampling protocols, requirements, and considerations is included in Appendix B to supplement the SOPs previously prepared in the Revised Groundwater Monitoring Plan. The SOP for PFAS was based on the Michigan Department of Environmental Quality (MDEQ) Groundwater PFAS Sampling Guidance (MDEQ, 2018), which was referred to in Ecology's guidance (Ecology, 2023b).

3.1 Sample Locations

As requested in Ecology's September 6, 2023 letter (Ecology, 2023a), wells selected for sampling include existing shallow and intermediate aquifer locations in the source area and distal wells across the TWAAFA Site. Well details are included in the Revised Groundwater Monitoring Plan (DOF, 2022). The following table identifies the well ID/location and reason for sampling. Sample locations are shown on Figure 2.

Location/Well ID	Reasoning
CCW-2A	Source area well in shallow aquifer (upper zone)
CCW-2B	Source area well in shallow aquifer (lower zone)
CCW-2C	Source area well in intermediate aquifer (upper zone)
CCW-3A	Source area well in shallow aquifer (upper zone)
CCW-3B	Source area well in shallow aquifer (lower zone)
CTMW-17	Source area well in shallow aquifer
SB-2A	Shallow aquifer distal well
TWA-3	Shallow aquifer distal well

3.2 Pre-Sampling Considerations

Pre-sampling considerations are required to minimize the introduction of PFAS-containing materials and the possibility of sample cross-contamination with standard groundwater sampling equipment. Groundwater sampling will be planned consistent with the Groundwater Monitoring Plan methods (Appendix A) and additional steps outlined in SOP 130 (Appendix B).

All sample containers used for PFAS sampling will be provided by the laboratory that is performing the PFAS analysis. The laboratory selected for PFAS analysis is Eurofins, as described further in Section 4.

3.3 PFAS Sampling Procedures

Groundwater sampling will be planned and executed following the procedures and requirements outlined in the 2022 Revised Groundwater Monitoring Plan (Appendix A) and SOP-130 (Appendix B) specific to PFAS sampling. None of the wells to be sampled contain dedicated pumps and sampling equipment requirements will follow PFAS-specific sampling requirements included in SOP-130 which includes specifications for sample tubing that does not contain Teflon® or polytetrafluoroethylene (PTFE).

3.4 PFAS Sample Management

Samples will be stored in double bagged resealable low-density polyethylene (LDPE) bags (e.g., Ziploc®) and placed in laboratory provided coolers that contain ice double bagged in resealable LDPE bags.

Samples will be maintained on the Chain-of-Custody form as collected and transferred onto ice in the cooler.

3.5 Laboratory Analysis

Samples will be analyzed for the standard list of 40 PFAS constituents under EPA draft Method 1633. Ecology has identified groundwater cleanup levels in their PFAS guidance (Tables 3 and B-1 (Ecology, 2023b)) for select PFAS which were confirmed in Ecology's Cleanup Level and Risk Calculation (CLARC) online database to be current as of October 2023. Ecology's Model Toxics Control Act cleanup levels identified in CLARC, along with laboratory method detection and reporting limits, are included in Table 1.

The laboratory will analyze the collected PFAS samples by EPA draft Method 1633, as recommended in Ecology's June 2023 PFAS guidance. EPA collaborated with Department of Defense to develop and validate Method 1633 for non-drinking water aqueous matrices such as groundwater. Eurofins has received accreditation for the Method in their Sacramento, California laboratory selected for use on this project.

4.0 QUALITY ASSURANCE PROJECT PLAN

The Ecology 2022 Revised Groundwater Monitoring Plan included a QAPP (Appendix A) for non-PFAS groundwater sampling activities. Additional PFAS-specific sampling information was developed for this sampling effort in the QAPP, including use of a laboratory experienced with PFAS analysis. PFAS-specific sampling information that was not originally included in the 2022 Revised Groundwater Monitoring Plan QAPP is described in the following subsections.

4.1 Organization

The individuals responsible for planning and implementing field and laboratory operations and Quality Assurance/Quality Control (QA/QC) procedures for this project are identified in Table 2, along with contact information and a summary of each individual's responsibilities for project management and QA procedures.

Eurofins of Sacramento, California will provide analytical services for the project. The Eurofins QA Manual is available upon request. The Eurofins QA Manual includes descriptions of the laboratory organization, personnel, and responsibilities; facilities and equipment, analytical methods and QA/QC protocols; and routine procedures for sample custody and data handling.

4.2 Quality Objectives

Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, completeness, and reporting limits) and qualitative factors (representativeness and comparability). These data quality factors are discussed further in the 2022 Revised Groundwater Monitoring Plan (Appendix A). The measurement quality objectives specific to PFAS data collection associated with these data quality factors are summarized in Table 3.

4.3 Quality Control

PFAS-specific QC measures are discussed in this section. Tables 1 through 5 include PFAS-specific QA/QC information. Table 1 lists current Ecology screening levels and lab reporting limits; Table 2 summarized

project personnel; Table 3 lists measurement quality objectives; Table 4 lists sample containers, preservation, and holding times; and Table 5 summarizes quality control samples.

The following quality control samples will be collected in the field based on recommendations outlined in Ecology's PFAS guidance document and its referenced supplementary documents (Ecology, 2023b):

- **Trip Blank** - One trip blank for each cooler to assess whether contamination is introduced during sample shipment.
- **Field duplicate** – Standard field duplicate sample as specified in the 2022 Revised Groundwater Monitoring Plan to assess precision, including sampling, analysis, and site heterogeneity.
- **Source water blank** - Sample collected from potable water source used for decontamination.
- **Field blank** - Sample collected of lab provided PFAS-free water poured into sample containers in the field to evaluate the potential for contaminants introduced during sample collection, storage, and transport. The sample should be collected daily where the risk for PFAS sample cross-contamination is the most likely (before the first sample is collected in the morning, before the first sample is collected after lunch, or where the potential for cross-contamination is determined to be the highest).
- **Rinsate blank** - After final decontamination of non-dedicated equipment, lab provided PFAS-free water poured over equipment and collected in a sample bottle to assess the adequacy of the decontamination process.
- **Pre-field work blank** - Prior to field work, a rinse sample will be collected if equipment not certified as PFAS-free is used which will be in contact with the samples.

5.0 WASTE MANAGEMENT

Purge water generated during groundwater sampling will be collected and managed in appropriate waste containers such as 55-gallon poly or steel drums. DOF will coordinate with property owners and the AO and EO parties to appropriately characterize waste in accordance with applicable regulations based on the laboratory analytical results and/or historical information.

6.0 SCHEDULE AND REPORTING

Upon approval of this SAP and QAPP by Ecology, groundwater sampling will be scheduled. Results will be presented in a technical memorandum and reported to Ecology within 30 days of receiving validated data.

7.0 REFERENCES

DOF, 2020. Final Data Gaps Work Plan. Taylor Way and Alexander Avenue Fill Site. July.

DOF, 2022. Revised Groundwater Monitoring Plan. Taylor Way and Alexander Avenue Fill Site. April.

Ecology, 2023a. Comments on fourth quarter groundwater report and requirement for additional groundwater sampling. September 6.

Ecology, 2023b. Guidance for Investigating and Remediating PFAS Contamination in Washington State. Toxics Cleanup Program Publication No. 22-09-058. June.

MDEQ, 2018. General PFAS Sampling Guidance. Michigan Department of Environmental Quality. Revised October 16.

FIGURES

Legend

TWAAFA Site Boundary

Parcel Boundary

0 350

Scale in Feet

TWAAFA Site
Tacoma, Washington

PFAS Sampling and Analysis Plan and Quality Assurance Project Plan

Site Location Map

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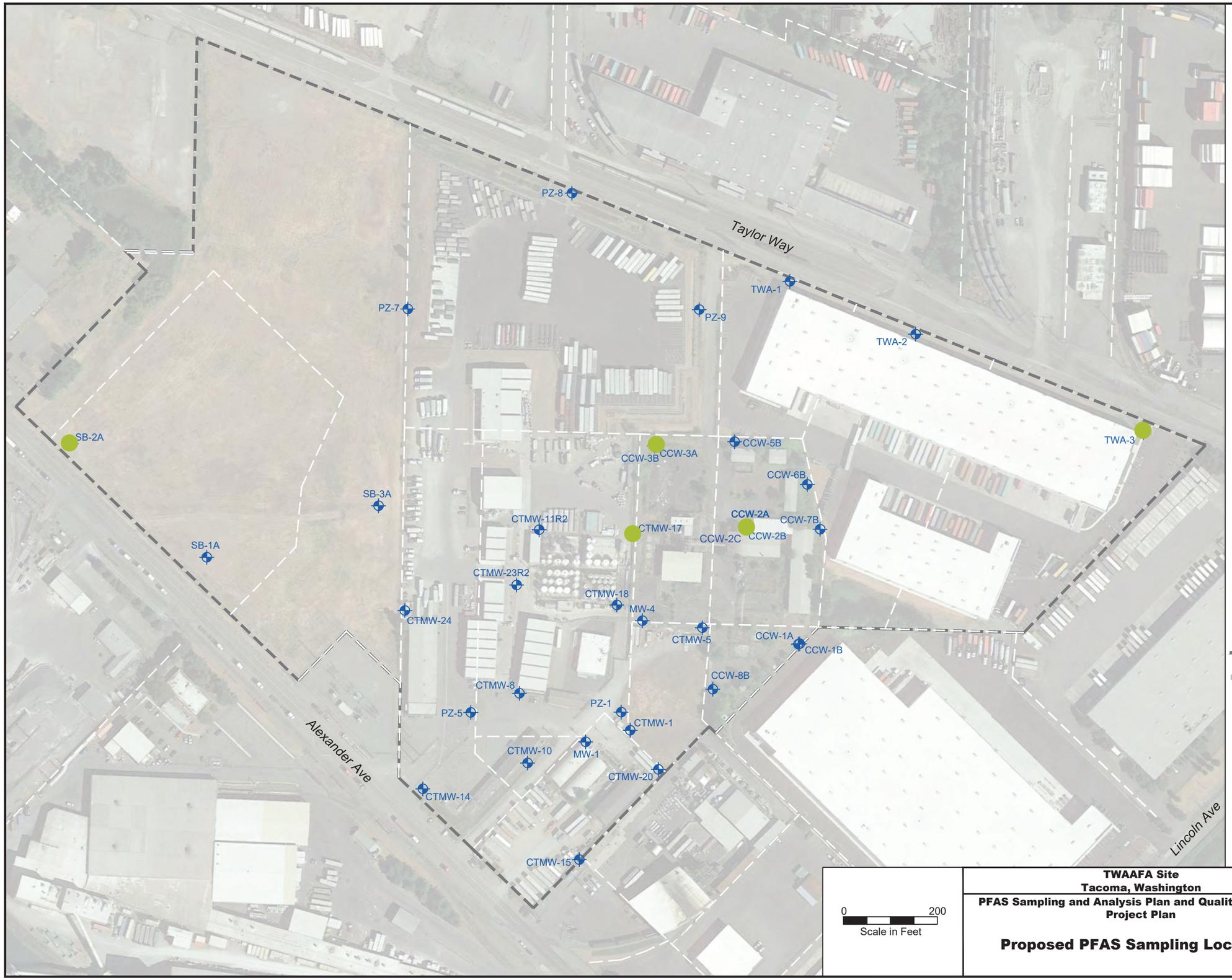
FIGURE 1

11/22/2022

PLOT TIME: 11/23/2022 1:15 PM MOD TIME: 11/22/2022 11:43 AM USER: Kelley Begley DWG: P:\TWAAFA\CAD\Figures\2022-11\2022-11 TWAAFA 02 Site Loc.dwg



TWAAFA Site
Tacoma, Washington

PFAS Sampling and Analysis Plan and Quality Assurance Project Plan

Proposed PFAS Sampling Locations

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FIGURE 2

10/01/2023

TABLES

TABLE 1
PFAS SCREENING LEVELS AND REPORTING LIMITS
Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site
Tacoma, Washington

Constituent	CAS Number	Method Reporting Limit	Method Detection Limit	MTCA Method B [1]	MTCA Method C [1]	Marine Surface Water Protection Based Concentrations[2]
Perfluorobutanoic acid (PFBA)	375-22-4	0.008	0.002	8	18	--
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.004	0.001	--	--	--
Perfluorohexanoic acid (PFHxA)	307-24-4	0.002	0.0005	8	18	--
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.002	0.0005	--	--	--
Perfluorooctanoic acid (PFOA)	335-67-1	0.002	0.0005	0.048	0.11	119
Perfluorononanoic acid (PFNA)	375-95-1	0.002	0.0005	0.04	0.088	10.4
Perfluorodecanoic Acid (PFDA)	335-76-2	0.002	0.0005	--	--	78
Perfluoroundecanoic acid (PFUnA)	2058-94-8	0.002	0.0005	--	--	--
Perfluorododecanoic acid (PFDoA)	307-55-1	0.002	0.0005	--	--	--
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.002	0.0005	--	--	--
Perfluorotetradecanoic acid (PFTeA)	376-06-7	0.002	0.0005	--	--	--
Perfluorobutanesulfonic acid (PFBS)	375-73-5	0.002	0.0005	4.8	11	127000
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	0.002	0.0005	--	--	--
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	0.002	0.0005	0.16	0.34	--
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	0.002	0.0005	--	--	--
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.002	0.0005	0.048	0.11	1.1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	0.002	0.0005	--	--	--
Perfluorodecanesulfonic acid (PFDS)	335-77-3	--	--	--	--	--
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	0.002	0.0005	--	--	--
4:2 FTS	757124-72-4	0.008	0.002	--	--	--
6:2 FTS	27619-97-2	0.008	0.002	--	--	--
8:2 FTS	39108-34-4	0.008	0.002	--	--	--
Perfluorooctanesulfonamide (FOSA)	754-91-6	0.002	0.0005	--	--	--
NMeFOSA	31506-32-8	0.002	0.0005	--	--	--
NEtFOSA	4151-50-2	0.002	0.0005	--	--	--
NMeFOSAA	2355-31-9	0.002	0.0005	--	--	--
NEtFOSAA	2991-50-6	0.002	0.0005	--	--	--
NMeFOSE	24448-09-7	0.02	0.005	--	--	--
NEtFOSE	1691-99-2	0.02	0.005	--	--	--
HFPO-DA (GenX)	13252-13-6	0.008	0.002	0.024	0.053	--
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	0.008	0.002	--	--	--
PFMBA	863090-89-5	0.004	0.001	--	--	--
NFDHA	151772-58-6	0.004	0.001	--	--	--
PFMPA	377-73-1	0.004	0.001	--	--	--
9Cl-PF3ONS	756426-58-1	0.008	0.002	--	--	--
11Cl-PF3OUdS	763051-92-9	0.008	0.002	--	--	--
PFEESA	113507-82-7	0.004	0.001	--	--	--
3:3 FTCA	356-02-5	0.01	0.025	--	--	--
5:3 FTCA	914637-49-3	0.05	0.0125	--	--	--
7:3 FTCA	812-70-4	0.05	0.0125	--	--	--

Notes:

1. Source of values- Table 3, Ecology Guidance for Investigating and Remediating PFAS Contamination in Washington State. (Publication No. 22-09-058. June 2023) and CLARC database (accessed October 2023)
2. Source of values- Table B-1, Ecology Guidance for Investigating and Remediating PFAS Contamination in Washington State. (Publication No. 22-09-058. June 2023)
3. Concentrations in micrograms per liter (µg/L)

Abbreviations:

CAS = Chemical Abstracts Service
-- = not available

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TABLE 2
PROJECT PERSONNEL AND RESPONIBILITIES
Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site
Tacoma, Washington

Personnel	Responsibilities	Contact Information
Steve Teel, Washington State Department of Ecology Project Manager	Oversee all program activities to ensure compliance; perform technical oversight and consultation on major quality assurance problems; provide final approval of all necessary actions and adjustments for activities to accomplish project objectives. Provide final approval of the Groundwater Monitoring Plan and QAPP.	Washington State Department of Ecology, SWRO PO Box 47775 Olympia, WA 98504-7775 (360) 407-6247
Tasya Gray, TWAAFA Site Coordinator (AO Parties)	Overall responsibility for sample collection activities. Oversee all program activities to ensure compliance; provide technical oversight and consultation on major quality assurance problems; manage development of Plans and QAPP; implement final approval of all necessary actions and adjustments for activities to accomplish project objectives.	Dalton, Olmsted, & Fuglevand, Inc. 1001 SW Klickitat Way, Suite 200B Seattle, WA 98134 (360) 394-7917
Anthony Cerruti, Sampling Team Leader (AO Parties)	Coordinate with TWAAFA Site Coordinator, Field Team Leaders, and project laboratories for bottle and equipment shipments to the site and sample shipments to the laboratories; track submittal and receipt of samples to the laboratory, and initiate COC/SAR forms. Ensure field procedures are completed in accordance with Plans and QAPP; authorize and document minor adjustments to the sampling plan in response to field conditions, as necessary, notify TWAAFA Site Coordinator and QA/QC Coordinator.	Dalton, Olmsted, & Fuglevand, Inc. 1001 SW Klickitat Way, Suite 200B Seattle, WA 98134 (360) 394-7917
Anthony Cerruti, Data Administrator (AO Parties)	Organize and maintain project data. Ensure that the data are stored in accordance with the Groundwater Monitoring Plan and QAPP; supervise data management personnel.	Dalton, Olmsted, & Fuglevand, Inc. 1001 SW Klickitat Way, Suite 200B Seattle, WA 98134 (360) 394-7917
James McAteer, QA/QC Coordinator	Provide technical quality assurance assistance; review QAPP; oversee quality assurance activities to ensure compliance with QAPP; coordinate and supervise data validation and data quality report preparation; review and submit quality assurance reports.	QA/QC Solutions, LLC 7532 Champion Hill Road SE Salem, OR 97306 (503) 763-6948
Nathan Horner, Laboratory Project Manager	Ensure that sample receipt and custody records are properly handled and data are reported within specified turnaround times: calibrate and maintain instruments as specified; perform internal quality control measures and analytical methods as required; take appropriate corrective action as necessary; notify the QA/QC Coordinator when problems occur; report data and supporting quality assurance information as specified in this QAPP.	Eurofins Environment Testing Northern California, LLC 880 Riverside Parkway West Sacramento, CA 95605 916-373-5600

Abbreviations

QAPP = quality assurance project plan
SWRO = Southwest Regional Office
COC = chain-of-custody
SAR = sampling analysis and request
QA/QC = quality assurance and quality control

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TABLE 3
MEASUREMENT QUALITY OBJECTIVES
Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site
Tacoma, Washington

Analyte	Analytical Method	LCS %Recovery Limits[1]	MS %Recovery Limits[1]	MS/MSD, or Laboratory Duplicate RPD Limits (%)	Field Duplicate RPD Limits (%)
Perfluorobutanoic acid (PFBA)	EPA 1633	70 - 140	70 - 140	30	30
Perfluoropentanoic acid (PFPeA)	EPA 1633	65 - 135	65 - 135	30	30
Perfluorohexanoic acid (PFHxA)	EPA 1633	70 - 145	70 - 145	30	30
Perfluoroheptanoic acid (PFHpA)	EPA 1633	70 - 150	70 - 150	30	30
Perfluorooctanoic acid (PFOA)	EPA 1633	70 - 150	70 - 150	30	30
Perfluorononanoic acid (PFNA)	EPA 1633	70 - 150	70 - 150	30	30
Perfluorodecanoic acid (PFDA)	EPA 1633	70 - 140	70 - 140	30	30
Perfluoroundecanoic acid (PFUnA)	EPA 1633	70 - 145	70 - 145	30	30
Perfluorododecanoic acid (PFDoA)	EPA 1633	70 - 140	70 - 140	30	30
Perfluorotridecanoic acid (PFTrDA)	EPA 1633	65 - 140	65 - 140	30	30
Perfluorotetradecanoic acid (PFTeA)	EPA 1633	60 - 140	60 - 140	30	30
Perfluorobutanesulfonic acid (PFBS)	EPA 1633	60 - 145	60 - 145	30	30
Perfluoropentanesulfonic acid (PFPeS)	EPA 1633	65 - 140	65 - 140	30	30
Perfluorohexanesulfonic acid (PFHxS)	EPA 1633	65 - 145	65 - 145	30	30
Perfluoroheptanesulfonic acid (PFHpS)	EPA 1633	70 - 150	70 - 150	30	30
Perfluorooctanesulfonic acid (PFOS)	EPA 1633	55 - 150	55 - 150	30	30
Perfluorononanesulfonic acid (PFNS)	EPA 1633	65 - 145	65 - 145	30	30
Perfluorodecanesulfonic acid (PFDS)	EPA 1633	60 - 145	60 - 145	30	30
Perfluorododecanesulfonic acid (PFDoS)	EPA 1633	50 - 145	50 - 145	30	30
4:2 FTS	EPA 1633	70 - 145	70 - 145	30	30
6:2 FTS	EPA 1633	65 - 155	65 - 155	30	30
8:2 FTS	EPA 1633	60 - 150	60 - 150	30	30
Perfluorooctanesulfonamide (FOSA)	EPA 1633	70 - 145	70 - 145	30	30
NMeFOSA	EPA 1633	60 - 150	60 - 150	30	30
NEtFOSA	EPA 1633	65 - 145	65 - 145	30	30
NMeFOSAA	EPA 1633	50 - 140	50 - 140	30	30
NEtFOSAA	EPA 1633	70 - 145	70 - 145	30	30
NMeFOSE	EPA 1633	70 - 145	70 - 145	30	30
NEtFOSE	EPA 1633	70 - 135	70 - 135	30	30
HFPO-DA (GenX)	EPA 1633	70 - 140	70 - 140	30	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	EPA 1633	65 - 145	65 - 145	30	30
PFMBA	EPA 1633	60 - 150	60 - 150	30	30
NFDHA	EPA 1633	50 - 150	50 - 150	30	30
PFMPA	EPA 1633	55 - 140	55 - 140	30	30
9Cl-PF3ONS	EPA 1633	70 - 155	70 - 155	30	30
11Cl-PF3OUdS	EPA 1633	55 - 160	55 - 160	30	30
PFEESA	EPA 1633	70 - 140	70 - 140	30	30
3:3 FTCA	EPA 1633	65 - 130	65 - 130	30	30
5:3 FTCA	EPA 1633	70 - 135	70 - 135	30	30
7:3 FTCA	EPA 1633	50 - 145	50 - 145	30	30

Notes

1. Recovery limits are those previously provided by the project laboratory; data will be evaluated during data review using the most current control limits provided by the laboratory.

2. EPA Method 1633 recommended in Ecology Guidance for Investigating and Remediating PFAS Contamination in Washington State. (Publication No. 22-09-058. June 2023)

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TABLE 4
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES
Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site
Tacoma, Washington

Analyte	Analytical Method[1]	Sample Container	Preservation / Temperature	Holding Time[2]
PFAS	EPA 1633	2 x 500mL HDPE & 1 x 125mL HDPE	<6°C	28 days

Notes

1. Method numbers refer to SW-846 EPA Analytical Methods (EPA,1986).
2. Holding times are based on elapsed time from date and time of collection.
3. EPA Method 1633 recommended in Ecology Guidance for Investigating and Remediating PFAS Contamination in Washington State.(Publication No. 22-09-058. June 2023) and 40 analytes shown in Table 3 provided by Eurofins.

Abbreviations

PFAS = Per- and polyfluoroalkyl substances
EPA = U.S. Environmental Protection Agency
HDPE = high density polypropylene
°C = degree Celsius

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TABLE 5

QUALITY CONTROL SAMPLE TYPES AND FREQUENCY [1, 2]

Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site

Tacoma, Washington

Parameter	Field QC				Laboratory QC			
	Field Duplicates	Source Water Blank	Field Reagent Blank	Rinsate Blank	Method Blanks	LCS	MS/MSD	Lab Duplicates
PFAS	1/10 samples per sampling event	1/20 samples per sampling event	1/20 samples per sampling event	1/20 samples per sampling event	1/batch	1/batch	1 set/batch	NR

Notes

1. A sampling event is defined as consecutive days of sampling not separated by more than two days of inactivity.
2. A 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 can be contained in one batch.

Abbreviations

PFAS = Per- and polyfluoroalkyl substances

LCS = laboratory control sample

MS = matrix spike sample

MSD = matrix spike duplicate sample

QC = quality control

NR = not required

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Appendix A

Revised Groundwater Monitoring Plan

TAYLOR WAY AND ALEXANDER AVENUE FILL AREA SITE
TACOMA, WASHINGTON

Cleanup Site ID: 4692

April 2022

Prepared by:

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1001 SW Klickitat Way, Suite 200B
Seattle, Washington 98134

Prepared for:

GENERAL METALS
GLENN SPRINGS HOLDINGS
PORT OF TACOMA
CLEAN EARTH (FORMERLY STERICYCLE ENVIRONMENTAL SOLUTIONS)

DOF DALTON OLMSTED FUGLEVAND

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Attachment B- Standard Operating Procedures

- SOP 105- Groundwater Monitoring Well Installation
- SOP for Groundwater Monitoring Well Abandonment
- SOP 120- Measuring Water and NAPL Elevations, and Total Depths
- SOP 121- Monitoring Well Development
- SOP 124- Low-Flow Groundwater Sampling Procedure
- SOP 200- Equipment Decontamination Procedure
- SOP 400- Documentation Procedures

Attachment C – Well Construction Logs

1.0 INTRODUCTION

Dalton, Olmsted, and Fuglevand, Inc. (DOF), has prepared this Revised Groundwater Monitoring Plan for the Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site on behalf of Glenn Springs Holdings, Inc. (Occidental Chemical), General Metals of Tacoma (GMT), and Clean Earth Inc. (Clean Earth) formerly known as Stericycle Environmental Solutions, Inc. (Stericycle). These parties are among those identified in the Agreed Order Number 14260 proposed by the Washington State Department of Ecology (Ecology) as potentially liable parties at the TWAAFA (each a "PLP", collectively, the "PLPs") and agreed to prepare a Groundwater Monitoring Plan requested by Ecology to be incorporated into the proposed Agreed Order. The Port of Tacoma is part of the TWAAFA Site as identified in the Ecology Enforcement Order Number DE 19410.This Revised Groundwater Monitoring Plan was prepared to incorporate information about newly installed and surveyed wells that are part of the monitoring network at the Site, updating the July 2020 version (DOF, 2020a).

1.1 Background and Objective

The Groundwater Monitoring Plan is designed to monitor the groundwater at the TWAAFA Site. It utilizes existing groundwater monitoring wells installed at the Site including monitoring wells installed in as agreed to in the Final Data Gaps Work Plan (DOF, 2020b). The monitoring wells, the analyses conducted, and the frequency of sampling are included in Table 1. The monitoring wells are located to provide adequate information on (1) groundwater flow at the Site, (2) groundwater units underlying the Site; and (3) groundwater leaving the Site and flowing to off-site, downgradient and cross-gradient locations.

Groundwater samples will be analyzed for the chemicals of potential concern (COPCs) evaluated during past groundwater investigations on the Site, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) including 1,4-dioxane, total petroleum hydrocarbons (TPH), PCBs, and metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, and manganese) as shown in Table 1.

The groundwater monitoring program outlined in this plan is designed to address Remedial Investigation data gaps identified in the TWAAFA Site Final Data Gaps Work Plan (DOF, 2020b).

1.2 Scope of Plan

This plan addresses the following major elements:

- Description of the existing groundwater monitoring network;
- Procedures for completing water-level surveys, groundwater sampling, well evacuation, field decontamination, sample storage and transportation, sample analysis, and quality assurance/quality control;
- Procedures and requirements for new well construction, maintenance, and decommissioning;
- Requirements for reporting and notification;
- Personnel functions and responsibilities;
- Worker health and safety planning

- How the plan objective will be met; and
- Field and laboratory quality assurance.

2.0 MONITORING NETWORK

The groundwater monitoring well network and maintenance program for the TWAAFA site are described in this section.

2.1 Monitoring Well Locations

The locations of the full groundwater monitoring network are shown on Figures 1 and 2, representing monitoring wells screened in the shallow and deep aquifers, respectively. Figures 1 and 2 show the monitoring wells that will be monitored for both water levels and chemical constituents during routine sampling events.

2.2 Monitoring Well Numbering System

A variety of well numbering designation approaches have been used at the TWAAFA Site since the Site includes properties owned and historically monitored by different parties. Any new wells will follow general historical formats and avoid duplication of previously used well names. Wells installed for the TWAAFA Site evaluation purposes will be named with the prefix "TWA", followed by a number designation, as shown on Figures 1 and 2. Wells installed below the silt unit will be assigned a "D" to designate they are not screened in the Fill Unit, similar to the approach used at many of the existing wells at the TWAAFA Site.

2.3 Monitoring Well Construction

For all wells in the groundwater monitoring network, well construction details are summarized in Table 2. This table has been updated after completion of the TWAAFA above ground structures evaluation, well replacement, and deep well installation tasks under the Data Gaps Work Plan, so that the table represents an accurate summary of existing wells at the TWAAFA Site.

2.4 Monitoring Well Survey

In the Public Land Survey System, the facility is located in the SW1/4 of Section 26, and in the NW1/4 of Section 35, Township 21N, Range 3E, Willamette Meridian. All survey data are recorded relative to this section, township, and range. All historical vertical survey data was based on the National Geodetic Vertical Datum (NGVD) of 1929 and converted to the North American Vertical Datum (1988). New monitoring wells added to the Site's groundwater monitoring network and those affected by maintenance performed in response to the TWAFAA above ground structures evaluation have been surveyed based on the North American Vertical Datum 1988 (NAVD 88). Existing Site wells surveyed prior to production of the Final RI (PSC, 2005), have had vertical data converted to NAVD 88. All horizontal data are provided relative to the Washington State Plane Coordinate System, South Zone (North American Datum, 1983/91). Survey data is provided in Table 3.

2.5 Monitoring Well Network Inspection, Maintenance, and Replacement

This section describes a program to provide regular inspection, and if necessary, maintenance of the monitoring wells and associated equipment. In addition, well construction and decommissioning procedures are presented in this section.

2.5.1 Well Inspection

The integrity of monitoring wells at the Site will be inspected by the sampling team during each monitoring event. The inspection involves an all-inclusive visual inspection of each well to determine if it has been damaged or tampered with, and verifies the physical condition of the well at the ground surface as well as the internal well casing. Problems discovered during the inspection will be recorded in a field inspection logbook, as well as a well inspection checklist, and a copy will be provided to the TWAAFA Site Coordinator. Problems that require immediate attention will be reported to the TWAAFA Site Coordinator and applicable property owner so as to remedy the condition prior to the next sampling event. If a significant problem such as a broken well head, bent casing, or other damage that compromises well access is discovered, it may be necessary to remedy the problem before sampling. A problem with the well integrity may require a modification of the sampling schedule or some other change in the sampling program. All decisions regarding such modifications will be addressed by the TWAAFA Site Coordinator, who will notify and request approval from the regulatory agencies regarding such issues. The TWAAFA Site Coordinator will notify Ecology by telephone or in writing within 15 days of any visible damage to or deterioration of wells.

2.5.2 Maintenance

Borehole integrity will be maintained at each well. Borehole integrity is assessed by pulling the dedicated pumps and measuring the total well depths. This procedure will be initially performed as part of the Data Gaps Work Plan tasks and subsequently on a 5 year basis. If more than 1 foot of sediment has built up in the bottom of the well, the well will be redeveloped and the sediment removed, per Stericycle's previously approved Standard Operating Procedure (SOP)-121 (Attachment B). The 5-year period is based on experiences from annually checking wells at the Clean Earth site.

All pumps and other sampling equipment used for groundwater monitoring will be maintained regularly by the sampling team member(s) according to the equipment manuals and manufacturers' recommendations.

2.5.3 Monitoring Well Replacement

If any monitoring well in the network must be replaced, efforts will be made to replace the well prior to the next sampling event. The TWAAFA Site Coordinator will submit to Ecology a written explanation of the rationale for the well's replacement and the time frame and location for the replacement, at least 15 days prior to decommissioning. The replacement will be completed within 45 days of Ecology approval unless otherwise approved by Ecology.

If it is agreed that the well should be replaced, the replacement well will be installed as close as possible to the well being replaced. A monitoring well construction form will be completed for the new well and a copy will be submitted to the agency. When necessary, wells will be decommissioned following the procedures specified in Section 2.5.5.

2.5.4 Monitoring Well Construction

A qualified geologist will inspect the drilling and construction of all new or replacement monitoring wells consistent with SOP 105 (Attachment B) and the procedures below. A detailed log of each well will be prepared. The logs and descriptions will include the following information:

- Date and time of construction;

- Drilling method and any drilling fluid used;
- Well location (surveyed to within 0.5 foot);
- Borehole diameter and well casing diameter;
- Well depth (to within 0.1 foot);
- Initial depth to water (to within 0.1 foot);
- Drilling logs and lithologic logs from the field, including a description of soil or rock types, depth to water, color, weathering, texture, structure, and fractures;
- Casing materials;
- Screen material and design, including screen length and slot size;
- Casing and screen joint type;
- Filter pack material, including size, placement method, and approximate volume;
- Composition and approximate volume of sealant material and method of placement;
- Surface seal design and construction;
- Well development procedures;
- Ground surface elevation (to within 0.01 foot);
- Top-of-casing elevation (to within 0.01 foot); and
- Detailed drawing of well, including dimensions.

The logs and descriptions, as-built drawings, and location of the new well will be submitted to Ecology within 30 calendar days of well completion or according to the schedule approved by Ecology in specific work plans.

2.5.5 Monitoring Well Decommissioning

Requests for decommissioning wells will be submitted to Ecology for review and approval. Wells will be decommissioned in accordance with the appended SOP for well decommissioning, the WAC 173-160-460 (Abandonment of Resource Protection Wells), and applicable updates. The selected drilling contractor will file the appropriate notification of well abandonment with Ecology. In addition, the TWAAFA Site Coordinator will provide written rationale for the decision to decommission the well at least 30 days prior to the decommissioning. If the well being decommissioned is being replaced, it should be decommissioned no later than 90 days after installation of the replacement well.

Wells not needed for groundwater or water level monitoring will be decommissioned upon request to and approval by Ecology. Such wells will be decommissioned within 45 days of receipt of Ecology's approval, or a request from Ecology to decommission.

Minor deviations from the decommissioning procedures that are deemed necessary due to unforeseen events in the field at the time of well abandonment will be noted in the operating record and reported to Ecology, along with an explanation of the need for the deviation. Significant deviations will require prior approval from Ecology.

3.0 GROUNDWATER MONITORING PROCEDURES

The subsections below describe each of the principal components of the groundwater monitoring program. All of the work will be conducted in accordance with the Quality Assurance Project Plan (QAPP) included as Attachment A.

3.1 Water Level Monitoring

Water level measurements will be collected quarterly on the TWAAFA Site for at least 4 quarters. The wells included in the water level monitoring events are presented in Table 1 and shown on Figures 1 and 2.

Using an oil/water interface probe, all of the wells will be measured for water level, as well as light nonaqueous-phase liquids (LNAPL) that may have accumulated. Light, free-phase NAPL (e.g., LNAPL) in the subsurface tends to accumulate on top of the water table. The wells indicated in Table 1 routinely contain LNAPL, and the thickness of the LNAPL can be measured at the same time the water level is measured.

Water-level and LNAPL measurements will be performed by the sampling team. The procedures for these measurements are provided below.

3.1.1 Schedule

A water-level measurement event will be conducted in accordance with the schedule presented in Table 1. Water level measurements will be conducted prior to the corresponding groundwater sampling event (if applicable), and measurements will be obtained within as short a time as possible prior to sampling, not to exceed one working day.

3.1.2 Procedures

The procedure for measuring water levels is described in Ecology-approved SOP 120, presented in Attachment B.[1] Wells will be vented prior to measurement to allow water levels to stabilize before measurement. Water level measurements and well venting times will be recorded in the field on a water level measurement form.

3.1.3 Equipment

Equipment used for the water-level survey is listed in the Ecology-approved SOP-120, as provided in Attachment B. Depth-to-water measurements will be made using an electronic water-level meter. The meter consists of a coaxial cable or plastic-coated flat wire permanently marked with increments of 0.01 foot, a detection probe, and electronic controls contained in a spool or reel. The water-level meter/sounder registers a response when the probe attached to the cable contacts an electrically conductive medium such as water, thereby completing the electrical circuit. The response is visible (e.g., red light), audible (e.g., alarm), or a combination of the two.

An oil/water interface probe is used to measure LNAPL thickness. The same type of equipment used to measure water levels is used; however, the oil/water interface detector emits one type of response to indicate that the probe has contacted NAPL and one type of response to indicate that the probe has

[1] The SOPs identified in this section were developed by CleanEarth and approved for use on the Burlington Environmental Tacoma Facility site by Ecology.

contacted water. The probe is lowered until the depth of the air/LNAPL interface is detected, and the depth is recorded. The probe is then continuously lowered until the LNAPL/water interface is detected, and that depth is recorded. LNAPL depths that are less than 0.01 foot will be recorded as "sheen."

3.1.4 Reporting

All water-level data will be recorded in the field on water-level data forms. The water-level data forms facilitate transmission of data from the field to the office. The field form will be provided to the TWAAFA Site Coordinator to file with the Site field forms. The water level data will be used to create potentiometric contour maps and a summary table of the water-level measurements, which will be included with an annual report.

3.2 Water Quality Monitoring

This section describes the equipment used and the procedures for groundwater sampling, field decontamination, field records preparation, sample identification, and sample storage and transport for water quality testing.

3.2.1 Schedule

Groundwater samples will be collected in accordance with the schedule presented in Table 1. Figures 1 and 2 show the locations of wells used for groundwater sampling.

3.2.2 Groundwater Sampling Procedure

Groundwater samples will be collected following the procedures outlined in Ecology- approved SOP-124, presented in Attachment B. This is a low-flow groundwater sampling methodology based on groundwater sampling guidance and comments from Ecology and the U.S. Environmental Protection Agency under the Resource Conservation and Recovery Act (RCRA). The groundwater sampling procedure involves purging groundwater from the monitoring well prior to sampling at a flow rate less than 500 milliliters per minute (mL/min.). During the purging, groundwater quality parameters, including temperature, pH, turbidity, dissolved oxygen, oxidation/reduction potential (ORP), and specific conductivity, will be monitored approximately every 3 minutes, and purging will be conducted until these parameters stabilize within criteria outlined in SOP-124. Once the water quality parameters have stabilized, groundwater samples will be collected using a flow rate of less than 500 mL/min.

3.2.3 Equipment

The monitoring wells included in this plan will be sampled with a nondedicated peristaltic pump using dedicated polyethylene tubing. The tubing intake will be set at mid-screen for sampling or mid-water column if the top of the screen is above the water table. Other equipment to be used for well evacuation is listed in SOP 124 (Attachment B). This equipment includes a flow-through water quality meter, turbidity meter, water level meter, and/or oil/water interface detector. All meters will be calibrated according to instrument instructions. The calibration results for each parameter will be recorded in the field logbook.

3.2.4 Field Decontamination Procedures

The decontamination procedures for all nondedicated field sampling equipment are outlined in Ecology-approved SOP 200 (provided in Attachment B). This equipment includes any instrument that is placed in a well or comes in contact with the groundwater sample, including the water-level indicator and any non-dedicated pump.

The flow-through water quality meter requires decontamination with deionized water, but not with soaps or solvents, which may adversely affect the probes in the meter. The flow-through cell will be disconnected prior to sample collection; therefore, groundwater collected for laboratory analysis at the laboratory will not contact the flow-through cell.

3.2.5 Field Records

Ecology-approved SOP 400, presented in Attachment B, contains a description of field logbook documentation procedures required for field sampling events. Field observations for well evacuation and groundwater sampling will be recorded in the field in the logbook and on monitoring well water sampling sheets. The monitoring well water sampling sheet will be designed to help the sampling team determine when the water quality parameters are stable enough to collect a sample and also facilitates transmission of data from the field to the office. The following information will be recorded on the sampling sheet during well evacuation: well identification, date, sampling personnel, beginning and ending water levels, sampling method, equipment used, and samples collected. Readings of water quality parameters (pH, specific conductivity, temperature, turbidity, dissolved oxygen, and ORP) will be recorded on the sheet approximately every 3 minutes, along with flow rate and pump speed.

3.2.6 Sample Label and Identification System

A sample label will be affixed to each sample bottle before sample collection. Each label will include the following information:

- Sample number (see below),
- Sampling event location,
- Date and time of sample collection,
- Preservatives added to the sample, and
- Analytes for which the sample is to be analyzed.

Water samples will be labeled with a unique sample number. The sample number consists of the appropriate monitoring well designation followed by, and separated by a hyphen from, a date identification code. The date identification code consists of a four-digit number that represents the month and year that the sample was collected. For instance, the sample number CTMW-24-0617 denotes a sample collected in June 2017 from monitoring well CTMW-24.

Quality control samples will follow a similar nomenclature. Field duplicate samples will be labeled the same as regular samples, except a “9” will be added to the sample number preceding the well number and separated by hyphens on either side (e.g., CTMW-9-24-0617). Matrix spike and matrix spike duplicate (MS/MSD) samples will be labeled the same as regular samples, but it should be noted on the chain-of-custody form that extra volume was collected for MS/MSD. Field blank samples will be labeled “Field Blank#1-0617” and trip blank samples will be labeled “Trip Blank#1-0617”, with each consecutive blank having a different numeral after “#” sign. The location at which field blanks are collected should be noted in the field logbook and/or field form. Equipment blanks will not normally collected, but might be necessary if non-dedicated tubing or bailers are used during groundwater sampling. If they are collected, equipment blanks will be labeled “Equipment Blank#1-0617” and, if collected, the location should be noted in the field logbook and/or field form.

3.2.7 Sample Storage and Transportation

After sampling is completed for the day, all samples will be packed for shipping and placed in ice cooled transport containers. The transport containers will consist of sturdy, insulated, commercially produced coolers. All bottle caps will be secured tightly, and all glass containers will be secured into position within the shipping container to avoid breakage. Trip blanks will be included in any transport container that carries water samples being analyzed for VOCs or TPH as gasoline. A custody seal will be affixed to the container prior to laboratory pickup or delivery. The chain-of-custody form should be taped to the top of the cooler or shipping container in most circumstances.

During sample collection or at the end of each day and prior to shipping or storage, chain-of-custody forms will be completed for all samples by a designated field team member. The information on the sample labels will be rechecked and verified against field logbook entries and the chain-of-custody forms. The chain-of-custody form should include information such as sample name, sample time, sample date, type of medium, and analyses requested. Any necessary changes to chain of custody forms, sample container labels, or the field logbook will be made by striking out the error with one line and entering the correct information. The new entries will be initialed and dated. Samples with extra volume for laboratory quality control protocols (MS/MSD and laboratory duplicates) will be designated as such on the chain-of-custody form. The field team should ensure that analyte method numbers and analyte lists required for the project are either listed on the chain-of-custody form, attached to the chain-of-custody form, or referred to on the chain of custody form. Every person who takes possession of the samples while transporting the samples from the field to the laboratory must sign the chain-of-custody form.

For most samples, the field team will either transport the samples to the laboratory or have a laboratory courier come to the Site at the end of each sampling day to pick up samples for delivery to the laboratory. Upon receipt of the sample transport containers by the analytical laboratory, laboratory personnel will open the containers and examine the contents for problems, such as damaged transport containers, broken custody seals, missing or broken sample bottles, chain-of-custody discrepancies, and documentation errors. Problems will be reported to the TWAAFA Site Coordinator.

3.2.8 Analytical Procedures

The sampling and analysis schedule for this plan is included in Table 1. Typical detection limits and more detailed information about the analytical methods are provided in the QAPP (Attachment A). Groundwater monitoring analytical data will be analyzed and validated in accordance with the requirements in the QAPP.

The analytical laboratory purchases new and certified clean sample bottles for each sampling event. The recommended specifications for bottle types, volume of sample required for analysis, and types of sample preservative required for analyses are provided in in the QAPP (Attachment A). However, these recommendations may be modified by the laboratory as analytical methods are modified and improved.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

All work associated with the Groundwater Monitoring Plan will be conducted in accordance with the QAPP (Attachment A).

5.0 PERSONNEL FUNCTIONS AND RESPONSIBILITIES

All fieldwork will be completed in accordance with a project-specific Health and Safety Plan (HASP). The specific tasks of key personnel involved in the groundwater monitoring program are summarized below.

5.1 TWAAFA Site Coordinator

The function of the TWAAFA Site Coordinator will be to:

- Maintain correspondence between regulatory agencies, the parties included in the TWAAFA Agreed Order, and property owners of parcels included in the TWAAFA Site.
- Verify parameter requirements and modify the groundwater monitoring program if necessary.
- Maintain the groundwater monitoring network in good working condition.

5.2 Sampling Team Members

The functions of the sampling team members will be to:

- Learn and follow all of the procedures in this Groundwater Monitoring Plan.
- Notify the TWAAFA Site Coordinator of any unresolved problems or deviations from approved procedures.
- Obtain, maintain, and inspect all equipment used to fulfill their responsibilities.
- Oversee field sampling activities and equipment repair.
- Work to prevent sample and/or well contamination.
- Schedule sample analysis services with the analytical laboratory and the field sampling team.
- Verify or arrange for the shipment of sample bottles and sample transport containers, both from the analytical laboratory to the field and from the field to the laboratory.
- Calibrate equipment.
- Examine sample bottles, preservatives, and sample transport containers.
- Assume responsibility for storage and provide security of sample transport containers and sample equipment.
- Conduct health and safety meetings, and implement safety requirements.
- Provide field technical guidance for sampling and maintenance procedures.
- Perform or supervise the water-level survey and well inspection.
- Maintain lines of communication between those personnel involved in the field sampling activities, the TWAAFA Site Coordinator, and the analytical laboratory.
- Maintain or service all dedicated sampling equipment.
- Take all field measurements.
- Purge monitoring wells.

- Collect and preserve samples.
- Check that samples are correctly identified and packed securely with ice in the sample transport container(s).
- Take neat and complete field notes.
- Update the TWAAFA Site monitoring well information tables.
- Trend Analyses of the significant COCs for the four quarters of sampling.

6.0 SCHEDULE

Ecology should be notified at least seven days in advance of any monitoring events.

Annual monitoring events conducted on the Burlington Environmental LLC Tacoma site occur every calendar year in the second quarter(historically in June), and TWAAFA Site-specific water level and monitoring events, including monitoring well inspections, will occur quarterly.

One initial year of groundwater monitoring is proposed for the TWAAFA Site to satisfy data gap requirements outlined in the Final Data Gaps Work Plan (DOF, 2020b). Additional sampling may be conducted under this plan and would be coordinated with Ecology pending results of the Data Gaps investigation work.

Ecology may request additional wells based on review of results from sampling. The TWAAFA group will install new wells within 45 days of receipt of such request from Ecology unless otherwise approved by Ecology.

7.0 REPORTING

A groundwater data analysis report will be submitted to Ecology after each quarterly monitoring event is complete and within 30 days of receiving validated groundwater data. The report shall summarize the data collected and activities performed with respect to the groundwater monitoring program over the previous quarter. The report shall include the following information:

- A description of groundwater monitoring activities completed during the quarter;
- A description of any groundwater monitoring activities planned for the next quarter;
- A summary of any problems, how problems were resolved, deviations from this plan, and a justification for all deviations;
- A summary of significant findings, changes in personnel, and significant contacts with all federal, state, and local governments and community and public interest groups;
- All laboratory analyses in tabulated data format for which quality assurance procedures were completed during the current time period and for upload to Ecology's Environmental Information Management database;
- A summary of constituent concentrations which exceed Model Toxics Control Act (MTCA) cleanup levels;
- All field measurements; and

- A table with measured groundwater elevations for each well as well as groundwater level contour maps.

8.0 REFERENCES

DOF, 2019. Groundwater Monitoring Plan, PSC Tacoma Facility, Tacoma, Washington, November.

DOF, 2020a. Revised Ground Water Monitoring Plan, TWAAFA Site, Tacoma Washington, July.

DOF, 2020b. Final Data Gaps Work Plan, TWAAFA Site, Tacoma Washington, July.

TABLE 1
GROUNDWATER MONITORING SCHEDULE
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, Washington

Analytical Method	Water Levels	Analyses								
		VOC by 8260B	VOC by 8260B w/SIM	TPH-Diesel by NWTPH-Dx[1]	TPH-Gasoline by NWTPH-Gx	Total Metals[2] by 6020 & Mercury by 1631E	SVOCs by 8270	cPAHS only by 8270	1,4-Dioxane by 8260	PCBs by 8082
CCW-1A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-1B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-1C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-2A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-2B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-2C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-3A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-3B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-3C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-4C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-5B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-5C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-6B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-6C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-7B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-7C	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CCW-8B	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
MW-1 (Potter)[3]	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
MW-4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
SB-1A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
SB-2A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
SB-3A	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
CTMW-1	1,2,3,4	--	--	--	--	--	--	--	--	--
CTMW-5	1,2,3,4	2	2	2	--	2	--			--
CTMW-7	1,2,3,4	2	2	2		2	--	2	2	--
CTMW-8	1,2,3,4	2	2	2	--	2	--	--	--	--
CTMW-9	1,2,3,4	2	2	2		2	--		2	--
CTMW-10[3]	1,2,3,4	--	--	--	--	--	--	--	--	--
CTMW-11R2	1,2,3,4	2	2	2	--	2	--	--	--	--
CTMW-12	1,2,3,4	2	2	2		2	--	2		--
CTMW-14	1,2,3,4	2	2	2	--	2	--	2		--
CTMW-15	1,2,3,4	2	2	2	--	2	--	2	2	--
CTMW-17	1,2,3,4	2	2	2	--	2	--		2	--
CTMW-17D	1,2,3,4	2	2	2		2	--			--
CTMW-18	1,2,3,4	2	2	2	2	2	--			--
CTMW-20	1,2,3,4	2	2	2	2	2	--			--
CTMW-23R	1,2,3,4	2	2	2	--	2	--			--
CTMW-24	1,2,3,4	2	2	2	--	2	--	2		--
CTMW-24D	1,2,3,4	2	2	2	--	2	--			--
CTMW-25D	1,2,3,4	2	2	2	--	2	--	2	2	--
PZ-1[3]	1,2,3,4	--	--	--	--	--	--	--	--	--
PZ-5	1,2,3,4	--	--	--	--	--	--	--	--	--
PZ-7	1,2,3,4	--	--	--	--	--	--	--	--	--
PZ-8	1,2,3,4	--	--	--	--	--	--	--	--	--
PZ-9	1,2,3,4	--	--	--	--	--	--	--	--	--
TWA-1	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-2	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-3	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-4D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	--	2	2	--
TWA-5D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-6D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-7D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	--	2	2	--
TWA-8D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-9D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4
TWA-10D	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	--	1,2,3,4	1,2,3,4

Abbreviation
1,2,3,4 = sampling to occur in first, second, third, and fourth quarter.
-- = not measured/not applicable.
Blue shading indicates well is screened in deep zone
VOC = volatile organic compound
TPH = total petroleum hydrocarbon
SVOC = semi-volatile organic compound
cPAH = carcinogenic polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl

Notes
1. Will be analyzed with and without silica gel cleanup during the first sampling event and sample prep methods assessed in cooperation with Ecology for future events.
2. Metals: Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc, and Manganese
3. Wells that historically had LNAPL.

DOF

TABLE 2
WELL CONSTRUCTION INFORMATION
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, Washington

Well ID	Well Tag ID	Installation Date	Contractor	Drilling Method	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft bgs)	Casing					Screen						Filter Pack			Seals			
							Depth Interval		Material	Nominal Diameter (inch)	Flush or Aboveground Monument	Depth Interval		Screened Hydro-geologic Unit	Material	Nominal Diameter (inch)	Slot Size (inch)	Depth Interval		Material	Depth Interval		Material	Surface Seal
							Upper	Lower				Upper	Lower					Upper	Lower		Upper	Lower		
CCW-1A	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	6.0	5.8	0.0	4.0	Sch. 40 PVC	2	Flush Mount	4	5.8	Shallow aq.	Sch. 40 PVC	2	0.02	3	6	# 10-20 silica sand	0	1.5	Concrete	Flush mount
																					1.5	3	Bentonite	
CCW-1B	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	12.0	9.6	0.0	7.8	Sch. 40 PVC	2	Flush Mount	7.8	9.6	Shallow aq.	Sch. 40 PVC	2	0.01	5.6	9.8	# 20-40 silica sand	0	1.5	Concrete	Flush Mount
																					1.5	5.6	Bentonite chips	
																					9.8	12	Bentonite chips	
CCW-1C	AGL 480	3-5 Jul 2001	Cascade Drilling, Inc.	Hollow stem auger	23.0	23.0	0.0	18.0	Sch. 40 PVC	2	Flush Mount	18	23	Deep aq.	Sch. 40 PVC	2	0.01	17	23	# 2 / 12 sand	0	0.5	Asphalt	Flush mount
																					0.5	17	Bentonite	
CCW-2A	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	6	5.8	0.0	4.0	Sch. 40 PVC	2	Flush mount	4.0	5.8	Shallow aq.	Sch. 40 PVC	2	0.02	3.0	6.0	# 10-20 silica sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	3.0	Bentonite chips	
CCW-2B	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	15	12.8	0.0	11.0	Sch. 40 PVC	2	Flush mount	11.0	12.8	Shallow aq.	Sch. 40 PVC	2	0.01	9.0	13.0	# 20-40 silica sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	9.0	Bentonite chips	
																					13.0	15.0	Bentonite chips	
CCW-2C	AGL 478	2-3 Jul 2001	Cascade Drilling, Inc.	Hollow stem auger	24	24	0.0	19.0	Sch. 40 PVC	2	Flush mount	19	24	Deep aq.	Sch. 40 PVC	2	0.01	18.0	24.0	# 2 / 12 sand	0.0	0.5	Asphalt	Flush mount
																					0.5	18.0	Bentonite	
CCW-3A	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	6	5.8	0.0	4.0	Sch. 40 PVC	2	Flush mount	4.0	5.8	Shallow aq.	Sch. 40 PVC	2	0.02	3.0	6.0	# 10-20 silica sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	3.0	Bentonite chips	
CCW-3B	--	1-2 Feb 1994	Holt Drilling	Hollow stem auger	12	10.8	0.0	9.0	Sch. 40 PVC	2	Flush mount	9.0	10.8	Shallow aq.	Sch. 40 PVC	2	0.01	6.0	11.5	# 20-40 silica sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	6.0	Bentonite chips	
																					11.5	12.0	Bentonite chips	
CCW-3C	AGL 477	29 Jun - 02 Jul 2001	Cascade Drilling, Inc.	Hollow stem auger	28	23	0.0	23.0	Sch. 40 PVC	2	Flush mount	23	28	Deep aq.	Sch. 40 PVC	2	0.01	22.0	28.0	# 2 / 12 sand	0.0	0.5	Asphalt	Flush mount
																					0.5	22.0	Bentonite	
CCW-4C	AGL 481	05 Jul 2000	Cascade Drilling, Inc.	Hollow stem auger	24	24	0.0	19.0	Sch. 40 PVC	2	Flush mount	19	24	Deep aq.	Sch. 40 PVC	2	0.01	18.0	24.0	# 2 / 12 sand	0.0	0.5	Asphalt	Flush mount
																					0.5	18.0	Bentonite	
CCW-5B	AGL 471	27 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	11	10	0.0	5.0	Sch. 40 PVC	2	Flush mount	5	10	Shallow aq.	Sch. 40 PVC	2	0.01	4.0	11.0	# 2 / 12 sand	0.0	0.5	Concrete	Concrete, flush mount
																					0.5	4.0	Bentonite	
CCW-5C	AGL 472	27 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	24	24	0.0	19.0	Sch. 40 PVC	2	Flush mount	19	24	Deep aq.	Sch. 40 PVC	2	0.01	18.0	24.0	# 2 / 12 sand	0.0	0.5	Asphalt	Flush mount
																					0.5	18.0	Bentonite	
CCW-6B	AGL 473	27 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	9.0	8.5	0.0	3.5	Sch. 40 PVC	2	Flush Mount	3.5	8.5	Shallow aq.	Sch. 40 PVC	2	0.01	3	9	# 2-12 sand	0	0.5	Concrete	Flush mount
																					0.5	3	Bentonite	
CCW-6C	AGL 474	28 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	23.0	23.0	0.0	18.0	Sch. 40 PVC	2	Flush Mount	18	23	Deep aq.	Sch. 40 PVC	2	0.01	17	23	# 2-12 sand	0	0.5	Concrete	Flush Mount
																					0.5	17	Bentonite	
CCW-7B	AGL 475	28 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	11.0	9.0	0.0	4.0	Sch. 40 PVC	2	Flush Mount	4	9	Shallow aq.	Sch. 40 PVC	2	0.01	3	11	# 2-12 sand	0	0.5	Concrete	Flush mount
																					0.5	3	Bentonite	
CCW-7C	AGL 476	28 Jun 2001	Cascade Drilling, Inc.	Hollow stem auger	26.0	26.0	0.0	21.0	Sch. 40 PVC	2	Flush Mount	21	26	Deep aq.	Sch. 40 PVC	2	0.01	20	26	# 2-12 sand	0	0.5	Asphalt	Flush Mount
																					0.5	20	Bentonite	
CCW-8B	AGL 479	03 Jul 2001	Cascade Drilling, Inc.	Hollow stem auger	12.0	11.0	0.0	6.0	Sch. 40 PVC	2	Flush Mount	6	11	Shallow aq.	Sch. 40 PVC	2	0.01	5	11	# 2-12 sand	0	0.5	Concrete	Flush mount
																					0.5	5	Bentonite	
MW-1 (Potter)	--	18 Feb 1986	--	--	9	--	0.0	3.0	Sch. 40 PVC	2	Flush mount	3.0	8.0	Shallow aq.	Sch. 40 PVC	2	0.02	2.5	9.0	Monterey Aqua #8 Crystal Amber Sand	0.0	2.5	Quik-Gel Overlain by Cement	Flush Mount
MW-4	--	18 Feb 1986	--	--	11.5	--	0.0	4.5	Sch. 40 PVC	2	Above grade monument	4.5	10.0	Shallow aq.	Sch. 40 PVC	2	0.02	4.5	9	Monterey Aqua #8 Crystal Amber Sand	0.0	3.0	Quik-Gel Overlain by Cement	Concrete, above grade monument
																					3.0	4.0	Natural Soil	
SB-1A	--	28 Mar 1991	Soil Sampling Service	Hollow stem auger	11	--	0.0	5.0	PVC	2	Above grade monument	5.0	10.0	Shallow aq.	PVC	2	0.01	3.0	11.0	# 10 / 20 Select Silica Sand	0.0	1.0	Concrete	Concrete, above grade monument
																					1.0	3.0	Bentonite chips (Enviroplug)	
SB-2A	--	29 Mar 1991	Soil Sampling Service	Hollow stem auger	11.5	--	0.0	6.0	PVC	2	Above grade monument	6.0	11.0	Shallow aq.	PVC	2	0.01	4.0	11.5	# 10 / 20 Select Silica Sand	0.0	1.0	Concrete	Concrete, above grade monument
																					1.0	4.0	Med. bentonite chips (Enviroplug)	
SB-3A	--	29 Mar 1991	Soil Sampling Service	Hollow stem auger	11.5	--	0.0	6.0	PVC	2	Above grade monument	6.0	11.0	Shallow aq.	PVC	2	0.01	4.0	11.5	# 10 / 20 Select Silica Sand	0.0	1.0	Concrete	Concrete, above grade monument
																					1.0	4.0	Med. bentonite chips (Enviroplug)	
CTMW-1	--	03 Jun 1987	Tacoma Pump & Drill	Hollow stem auger	11.2	10	0.0	10.0	Sch. 40 PVC	2	Above grade monument	3.0	10.0	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	10.2	Silica sand, 8x12 (Colorado)	0.0	1.0	Concrete	Concrete, standpipe w/
																					1.0	10.5	Bentonite pellets	

TABLE 2
WELL CONSTRUCTION INFORMATION
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Tacoma, Washington

Well ID	Well Tag ID	Installation Date	Contractor	Drilling Method	Total Borehole Depth (ft bgs)	Initial Total Well Depth (ft bgs)	Casing					Screen						Filter Pack			Seals			
							Depth Interval		Material	Nominal Diameter (inch)	Flush or Aboveground Monument	Depth Interval		Screened Hydro-geologic Unit	Material	Nominal Diameter (inch)	Slot Size (inch)	Depth Interval		Material	Depth Interval		Material	Surface Seal
							Upper	Lower				Upper	Lower					Upper	Lower		Upper	Lower		
CTMW-5	--	29 May 1987	Tacoma Pump & Drill	Hollow stem auger	13	9.48	0.0	3.0	Sch. 40 PVC	2	Flush mount	3.0	9.5	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	10.0	Silica sand, 8x12 (Colorado)	0.0	0.5	Concrete	Concrete, flush mount
																					0.5	2.5	Bentonite pellets	
																					10.0	11.5	Bentonite pellets	
CTMW-7	--	25 Nov 1987	Tacoma Pump & Drill	Cable tool	32.5	28.5	0.0	18.5	Sch. 40 PVC	2	Above grade monument	18.5	28.5	Deep aq.	Sch. 40 PVC	2	0.01	16.3	31.0	Silica sand, 8x12 (Colorado)	0.0	1.0	Concrete	Concrete, standpipe w/
																					1.0	16.3	Bentonite chips	
CTMW-8	--	27 Nov 1987	Tacoma Pump & Drill	Hollow stem auger	13	11.54	0.0	3.0	Sch. 40 PVC	2	Above grade monument	3.0	9.8	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	10.0	Silica sand, 8x12 (Colorado)	0.0	0.5	Concrete	Concrete, standpipe w/
																					0.5	2.5	Bentonite pellets	
CTMW-9	--	27 Nov 1987	Tacoma Pump & Drill	Hollow stem auger	33	30.14	0.0	18.0	Sch. 40 PVC	2	Above grade monument	18.0	28.5	Deep aq.	Sch. 40 PVC	2	0.01	15.0	29.5	Silica sand, 8x12 (Colorado)	0.0	1.0	Concrete	Concrete, standpipe w/ locking cap
																					1.0	4.0	Bentonite slurry	
																					4.0	15.0	Bentonite pellets	
CTMW-10	--	27 Nov 1987	Tacoma Pump & Drill	Hollow stem auger	10	9.8	0.0	2.8	Sch. 40 PVC	2	Above grade monument	2.8	9.8	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	10.0	Silica sand, 8x12 (Colorado)	0.0	0.5	Concrete	Concrete, standpipe w/
																					0.5	2.5	Bentonite pellets	
CTMW-11R2	BMM 968	23 Oct 2021	Cascade Drilling, Inc.	Hollow stem auger	16.5	15.9	0.0	5.0	Sch. 40 PVC	2	Flush mount	5.5	15.5	Shallow aq.	Sch. 40 PVC	2	0.01	5.0	16.0	# 2 / 12 Silica Sand	0.0	2.0	Concrete	Flush mount
																					2.0	5.0	Bentonite chips	
CTMW-12	--	27 Nov 1987	Tacoma Pump & Drill	Cable tool	37.5	37.03	0.0	21.0	Sch. 40 PVC	2	Above grade monument	21.0	31.5	Deep aq.	Sch. 40 PVC	2	0.01	20.0	33.0	Silica sand, 8x12 (Colorado)	0.0	1.0	Concrete	Conrete, standpipe w/ locking cap
																					1.0	4.0	Bentonite pellets	
																					4.0	20.0	Bentonite chips	
CTMW-14	--	12 May 1989	Hokkaido Drilling	Hollow stem auger	12	11.17	0.0	5.0	Sch. 80 PVC	2	Above grade monument	4.9	9.4	Shallow aq.	Sch. 80 PVC	2	0.01	3.5	9.5	Silica sand, 8x12 (Colorado)	0.0	0.5	Concrete	Concrete, standpipe w/ locking cap
																					0.5	3.5	Med. Bentonite chips	
CTMW-15	--	16 May 1989	Hokkaido Drilling	Hollow stem auger	12	10.46	0.0	5.8	Sch. 80 PVC	2	Above grade monument	5.8	8.2	Shallow aq.	Sch. 80 PVC	2	0.01	4.1	8.2	Silica sand, 8x12 (Colorado)	0.0	1.1	Concrete	Conrete, standpipe w/ locking cap
																					1.1	4.1	Med. Bentonite chips	
CTMW-17	--	08 Apr 1991	Tacoma Pump & Drill	Hollow stem auger	15.5	~15.5	0.0	4.0	PVC	2	Flush mount	4.0	14.5	Shallow aq.	PVC	2	0.01	3.5	15.5	# 10-20 silica sand	0.0	2.0	Concrete	Concrete, flush mount
																					2.0	3.5	Bentonite chips	
CTMW-17D	AGJ 983	11 Jan 2001	Cascade Drilling, Inc.	Hollow stem auger	31.5	30.75	0.0	25.7	Sch. 40 PVC	2	Flush mount	25.7	30.8	Deep aq.	Sch. 40 PVC	2	0.01	25.0	31.5	# 2 / 20 Pacific Materials Lapis Luster Sand	0.0	2.0	Concrete	Concrete, traffic box
																					2.0	25.0	Med. bentonite chips	
CTMW-18		09 Apr 1991	Tacoma Pump & Drill	Hollow stem auger	14.5	13	0.0	4.8	PVC	2	Above grade monument	4.8	13.0	Shallow aq.	PVC	2	0.01	4.0	14.5	# 10-20 silica sand	0.0	1.5	Concrete	Concrete, standpipe w/
																					1.5	4.0	Bentonite chips	
CTMW-20	AFF 965	20 Jun 2000	Cascade Drilling, Inc.	Hollow stem auger	11.5	10.5	0.0	3.5	Sch. 40 PVC	2	Flush mount	3.5	10.5	Shallow aq.	Sch. 40 PVC	2	0.01	3.0	11.5	# 2 / 12 Monterey sand	0.0	1.0	Concrete	Concrete, flush mount
																					1.0	3.0	Med. bentonite chips	
CTMW-23R	BMM 969	23 Oct 2021	Cascade Drilling, Inc.	Hollow stem auger	14	13.9	0.0	3.0	Sch. 40 PVC	2	Flush mount	3.5	13.5	Shallow aq.	Sch. 40 PVC	2	0.01	3.0	14.0	# 2 / 12 Silica Sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	3.0	Bentonite chips	
CTMW-24	--	16 Aug 2005	Cascade Drilling, Inc.	Hollow stem auger	11	~11	0.0	5.5	Sch. 40 PVC	2	Above grade monument	5.5	10.3	Shallow aq.	Sch. 40 PVC	2	0.01	3.5	11.0	# 2 / 12 Monterey sand	0.0	2.5	Concrete	Concrete, above grade monument with
																					2.5	3.5	Med. Bentonite chips	
CTMW-24D	--	16 Aug 2005	Cascade Drilling, Inc.	Hollow stem auger	24.5	~24.5	0.0	19.0	Sch. 40 PVC	2	Above grade monument	19.0	23.8	Deep aq.	Sch. 40 PVC	2	0.01	17.0	24.5	# 2 / 12 Monterey sand	0.0	2.0	Concrete	Concrete, above grade monument with bollards
																					2.0	4.0	Med. Bentonite chips	
																					4.0	16.0	Baroid Quickgrout	
																					16.0	17.0	Med. Bentonite chips	
CTMW-25D	--	19 Aug 2005	Cascade Drilling, Inc.	Hollow stem auger	21	~21	0.0	15.5	Sch. 40 PVC	2	Above grade monument	15.5	20.3	Shallow aq.	Sch. 40 PVC	2	0.01	13.5	21.0	# 2 / 12 Monterey sand	0.0	1.0	Concrete	Concrete, above grade monument with bollards
																					1.0	2.0	Med. Bentonite chips	
																					2.0	12.5	Med. Bentonite chips	
PZ-1	--	17 Mar 1994	Burlington	RECON	7.5	7	0.0	1.0	PVC	1.5	Flush mount	1.0	7.0	Shallow aq.	PVC	1.5	0.02	--	--	None	0.0	0.5	Bentonite	Flush mount
PZ-5	--	17 Mar 1994	Burlington	RECON	8.5	7.2	0.0	1.2	PVC	1.5	Flush mount	1.2	7.2	Shallow aq.	PVC	1.5	0.01	--	--	None	0.0	0.5	Bentonite	Flush mount
PZ-7	--	10 Jan 2001	Cascade Drilling, Inc.	Hollow stem auger	18	17	0.0	3.5	PVC	2	Flush mount	3.5	17.0	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	18	# 2 / 20 Pacific Materials Lapis Luster Sand	0.0	0.5	Concrete	Concrete, flush mount
																					0.5	2.5	Med. Bentonite chips	

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							Depth Interval		Material	Nominal Diameter (inch)	Flush or Aboveground Monument	Depth Interval		Screened Hydro-geologic Unit	Material	Nominal Diameter (inch)	Slot Size (inch)	Depth Interval		Material	Depth Interval		Material	Surface Seal
							Upper	Lower				Upper	Lower					Upper	Lower		Upper	Lower		
PZ-8	--	09 Jan 2001	Cascade Drilling, Inc.	Hollow stem auger	12	10.2	0.0	5.0	PVC	2	Flush mount	5.0	10.2	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	12.0	# 2 / 20 Pacific Materials Lapis Luster Sand	0.0	0.8	Concrete	Concrete, flush mount
																					0.8	2.5	Med. Bentonite chips	
PZ-9	--	09 Jan 2001	Cascade Drilling, Inc.	Hollow stem auger	11.5	10.2	0.0	3.0	PVC	2	Flush mount	3.0	10.2	Shallow aq.	Sch. 40 PVC	2	0.01	2.5	11.5	# 2 / 20 Pacific Materials Lapis Luster Sand	0.0	1.5	Concrete	Concrete, flush mount
																					1.5	2.5	Med. Bentonite chips	
TWA-1	BNN 191	14 Dec 2021	Holt Drilling	Hollow stem auger	17.0	13.5*	0.0	5.0	PVC	2	Flush mount	5.0	15.0	Shallow aq.	Sch. 40 PVC	2	0.01	4	15	10/20 Silica Sand	0	1	Concrete	Concrete, flush mount
																					1	4	Bentonite chips	
TWA-2	BNN 190	13 Dec 2021	Holt Drilling	Hollow stem auger	11.5	9.0*	0.0	5.0	PVC	2	Flush mount	5.0	10.0	Shallow aq.	Sch. 40 PVC	2	0.01	4	10	10/20 Silica Sand	0	1	Concrete	Concrete, flush mount
																					1	4	Bentonite chips	
TWA-3	BNN 181	14 Dec 2021	Holt Drilling	Hollow stem auger	11.5	13.5*	0.0	5.0	PVC	2	Flush mount	5.0	10.0	Shallow aq.	Sch. 40 PVC	2	0.01	3	10	10/20 Silica Sand	0	1	Concrete	Concrete, flush mount
																					1	3	Bentonite chips	
TWA-4D	BNW 193	07 Dec 2021	Cascade Drilling, Inc.	Sonic	60	57.7	0	52.5	PVC	2	Flush mount	52.4	57.4	Deep aq.	Prepack SS wire mesh wrap Sch. 40 PVC	2	0.01	50.5	60	# 2/12 Silica Sand	0	3	Concrete	Concrete, flush mount
																					3	50.5	Bentonite chips	
TWA-5D	BLU 457	07 Nov 2019	Holocene Drilling	Sonic	30	30	0.0	25.0	PVC	2	Above grade monument	25.0	30.0	Deep aq.	Sch. 40 PVC	2	0.01	23.0	30.3	# 2 / 12 Silica Sand	0	3	Concrete	Concrete, standpipe w/ locking cap
																					3	23	Med. Bentonite chips	
TWA-6D	BLU 456	07 Nov 2019	Holocene Drilling	Sonic	30	30	0.0	25.0	PVC	2	Above grade monument	25.0	30.0	Deep aq.	Sch. 40 PVC	2	0.01	23.0	30.3	# 2 / 12 Silica Sand	0	3	Concrete	Concrete, standpipe w/ locking cap
																					3	23	Med. Bentonite chips	
TWA-7D	BNW 082	26 Jan 2022	Cascade Drilling, Inc.	Sonic	60	60	0.0	53.0	PVC	2	Flush mount	54.4	59.4	Deep aq.	Prepack SS wire mesh wrap Sch. 40	2	0.01	53.0	60	# 2 / 12 Silica Sand	0	3	Concrete	Concrete, flush mount
																					3	53	Med. Bentonite chips	
TWA-8D	BNW 164	13 Oct 2021	Cascade Drilling, Inc.	Sonic	60	55.6	0.0	50.6	PVC	2	Flush mount	50.2	55.2	Deep aq.	Prepack SS wire mesh wrap Sch. 40	2	0.01	48	56	# 2 / 12 Silica Sand	0	3	Concrete	Concrete, flush mount
																					3	53	Med. Bentonite chips	
TWA-9D	BNW 163	11 Oct 2021	Cascade Drilling, Inc.	Sonic	60	60.2	0.0	55.0	PVC	2	Flush mount	54.8	59.8	Deep aq.	Prepack SS wire mesh wrap Sch. 40	2	0.01	53.0	60.0	# 2 / 12 Silica Sand	0	3	Concrete	Concrete, flush mount
																					3	48	Med. Bentonite chips	
TWA-10D	BNN 188	09 Dec 2021	Holt Drilling	Sonic	60	58.6*	0.0	52.0	PVC	2	Above grade monument	52.0	57.0	Deep aq.	Sch. 40 PVC	2	0.01	50.0	58.0	10/20 Silica Sand	0	3	Concrete	Concrete, standpipe w/ locking cap
																					3	50	Med. Bentonite chips	

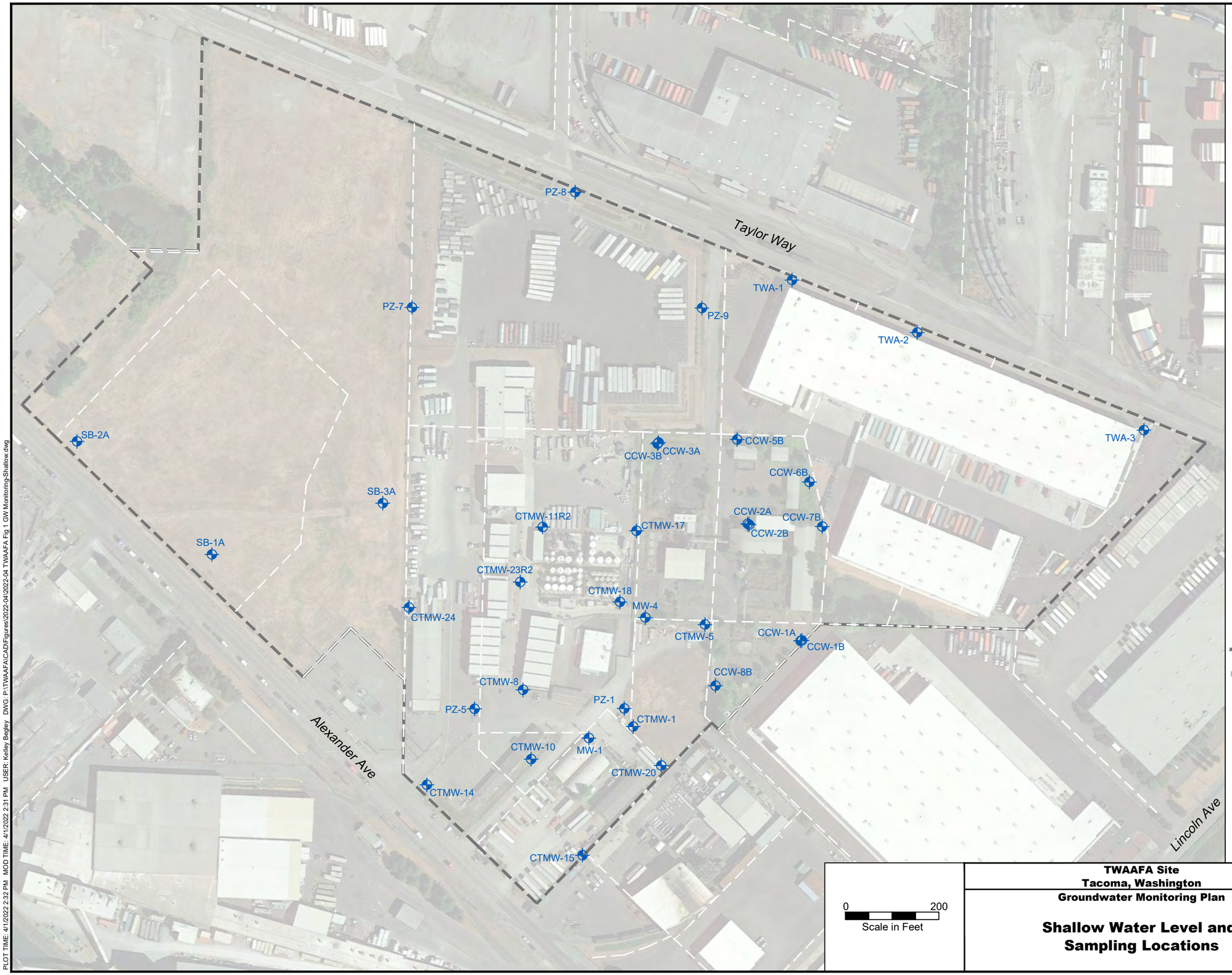
Notes & Abbreviations
NA/-- = not available
* = from top of casing
aq. = aquifer
bgs = below ground surface
Med. = medium
PVC = polyvinyl chloride
Sch = Schedule

TABLE 3
WELL SURVEY DATA
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, Washington

Monitoring Well ID	US State Plane (NAD83) Washington South (US Survey ft)		North American Vertical Datum NAVD88 (ft)
	Northing	Easting	Top of Casing
CTMW-1	712038.3	1170995.2	16.55
CTMW-5	712256.7	1171148.9	17.22
CTMW-7	712198.5	1170961.7	17.89
CTMW-8	712116.9	1170759.6	17.91
CTMW-9	712115.6	1170765.1	17.50
CTMW-10	711968.4	1170777.0	15.92
CTMW-11R2	712465.1	1170801.5	20.77
CTMW-12	712500.9	1170692.6	21.41
CTMW-14	711913.7	1170554.1	16.25
CTMW-15	711762.9	1170886.9	16.40
CTMW-17	712457.2	1171002.2	22.44
CTMW-17D	712449.9	1170995.0	19.76
CTMW-18	712304.8	1170966.9	22.50
CTMW-20	711954.9	1171055.3	14.15
CTMW-23R	712347.6	1170753.5	19.88
CTMW-24	712293.1	1170515.8	19.47
CTMW-24D	712297.2	1170515.4	19.51
CTMW-25D	711774.0	1170889.6	16.18
PZ-1	712076.8	1170976.4	16.89
PZ-5	712076.2	1170656.0	15.98
PZ-7	712935.2	1170522.1	24.09
PZ-8	713181.9	1170871.4	17.96
PZ-9	712934.0	1171142.3	18.67
CCW-1A	712221.5	1171353.3	15.81
CCW-1B	712222.5	1171356.3	15.30
CCW-1C	712228.0	1171348.8	16.14
CCW-2A	712472.2	1171240.4	15.34
CCW-2B	712470.2	1171243.2	15.24
CCW-2C	712471.7	1171237.4	15.18
CCW-3A	712646.2	1171049.7	16.87
CCW-3B	712643.4	1171047.3	17.23
CCW-3C	712651.1	1171053.4	18.80
CCW-4C	712270.1	1171047.4	16.84
CCW-5B	712652.4	1171217.6	15.74
CCW-5C	712651.6	1171212.7	15.52
CCW-6B	712561.7	1171372.4	15.43
CCW-6C	712557.1	1171380.1	15.25
CCW-7B	712466.1	1171399.6	15.03
CCW-7C	712460.0	1171400.8	15.18
CCW-8B	712125.7	1171171.2	16.44
MW-1	712013.7	1170900.5	14.07
MW-4	712271.4	1171021.4	19.22
SB-1A	712406.6	1170094.0	15.46
SB-2A	712648.5	1169805.4	15.03
SB-3A	712516.1	1170459.7	16.70
TWA-1	712993.9	1171335.1	14.78
TWA-2	712881.6	1171602.8	11.69
TWA-3	712672.7	1172087.7	15.48
TWA-4D	712176.2	1170862.7	15.28
TWA-5D	712911.9	1170480.3	18.14
TWA-6D	712397.5	1170100.0	17.65
TWA-7D	711980.5	1170617.8	15.4
TWA-8D	711983.0	1171072.2	14.92
TWA-9D	712482.8	1171238.6	15.84
TWA-10D	712271.8	1171674.7	15.97

Notes

1. Survey data obtained from Table 4-5 in Final RI (PSC, 2005) for historically installed wells.



Legend

- CTMW-17 — Groundwater Well/Piezometer
- TWAAFA Site Boundary
- Parcel Boundary

0 200
Scale in Feet

TWAAFA Site
Tacoma, Washington
Groundwater Monitoring Plan

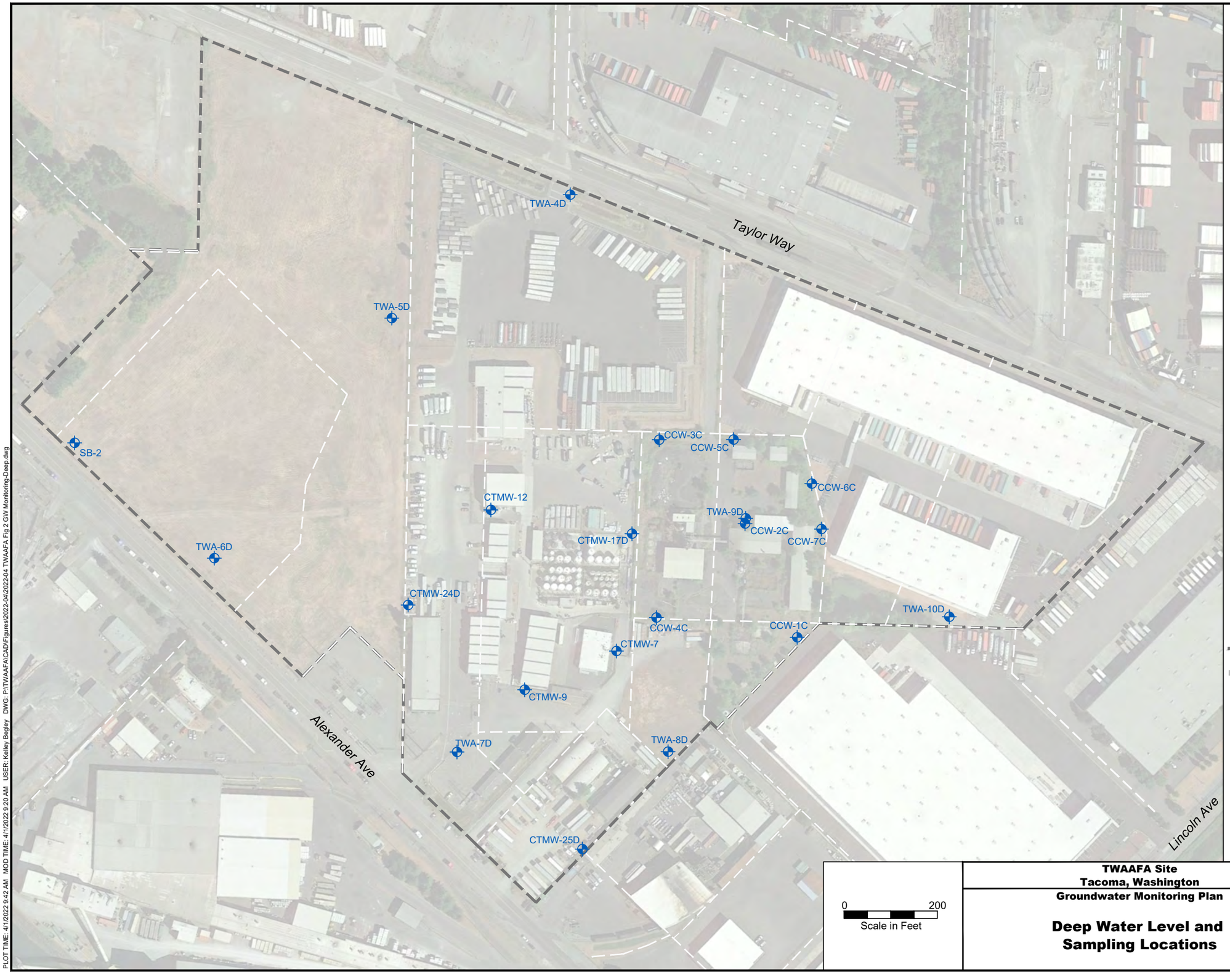
Shallow Water Level and Sampling Locations

DALTON OLMSTED FUGLEVAND

FIGURE 1

4/01/2022

PLOT TIME: 4/1/2022 2:32 PM MOD TIME: 4/1/2022 2:31 PM USER: Kelley Begley DWG: P:\TWAAFA\CAD\Figures\2022-04\2022-04 TWAAFA Fig 1 GW Monitoring-Shallow.dwg



Legend

- CTMW-17 — Groundwater Well/Piezometer
- TWAAFA Site Boundary
- Parcel Boundary

0 200
Scale in Feet

TWAAFA Site
Tacoma, Washington
Groundwater Monitoring Plan

Deep Water Level and Sampling Locations

DALTON OLMSTED FUGLEVAND

FIGURE 2

4/01/2022

PLOT TIME: 4/1/2022 9:42 AM MOD TIME: 4/1/2022 9:20 AM USER: Kelley Begley DWG: P:\TWAAFA\CAD\Figures\2022-04\2022-04 TWAAFA Fig 2 GW Monitoring-Deep.dwg

Appendix A
QAPP

Quality Assurance Project Plan

TAYLOR WAY AND ALEXANDER AVENUE FILL AREA SITE
TACOMA, WASHINGTON

Cleanup Site ID: 4692

April 6, 2021

Prepared by:

DALTON, OLMSTED, & FUGLEVAND
1001 SW Klickitat Way, Suite 200B
Seattle, Washington 98134

Prepared for:

GENERAL METALS
GLENN SPRINGS HOLDINGS
PORT OF TACOMA
CLEAN EARTH (FORMERLY STERICYCLE ENVIRONMENTAL SOLUTIONS)

DOF DALTON OLMSTED FUGLEVAND

Table of Contents

Distribution List

This list identifies all individual to receive a copy of the approved Quality Assurance Project Plan, either in hard copy or electronic format, as well as any subsequent revisions.

Washington State Department of Ecology Project Manager:	Steve Teel Washington State Department of Ecology Toxics Cleanup Program Southwest Regional Office PO Box 47775 Olympia, WA 98504-7775 (360) 407-6316 Steve.teel@ECY.WA.GOV
TWAAFA Project Coordinator:	Tasya Gray, DOF
Quality Assurance Leader:	Trevor Louviere, DOF
Field Coordinator:	Trevor Louviere, DOF

1.0 Background

Dalton, Olmsted, and Fuglevand, Inc. (DOF), has prepared this Quality Assurance Project Plan (QAPP) for the Taylor Way and Alexander Avenue Fill Area (TWAAFA) Site on behalf of Glenn Springs Holdings, Inc. (Occidental Chemical), Schnitzer Steel Industries, Inc., and Burlington Environmental, LLC (CleanEarth). These parties are among those identified in the Washington State Department of Ecology's (Ecology) Agreed Order Number DE 14260. The Port of Tacoma is part of the TWAAFA Site as identified in the Ecology Enforcement Order Number DE 19410.

The project description, regulatory background, site history, site characterization, and site conditions are described in the Final Data Gaps Work Plan (DOF, 2020).

This QAPP outlines quality assurance (QA) and quality control (QC) protocols to be followed in implementing the Groundwater Monitoring Plan.

2.0 Project Description

The Groundwater Monitoring Plan outlines a program to monitor the groundwater emanating from the TWAAFA site. The objective of the GWMP is to track the concentrations of known contaminants at the facility as well as provide monitoring for any potential new releases. The monitoring wells are located to provide adequate information on (1) groundwater flow at the site, (2) groundwater underlying the site; and (3) groundwater leaving the site and flowing to off-site, downgradient locations.

3.0 Organization

The individuals responsible for planning and implementing field and laboratory operations and QA/QC procedures for this project are identified in Table 1, along with contact information and a summary of each individual's responsibilities for project management and QA procedures.

3.1 Management Responsibilities

Project management responsibilities are shown in Table 1. Detailed descriptions of the management and QA responsibilities of laboratory personnel are described in the laboratory QA Manual (available upon request or on the laboratory's website).

3.2 Quality Assurance

The personnel responsible for review and approval of the QAPP and for data verification, validation, and data quality assessment are described in Table 1.

3.3 Field Responsibilities

Field Responsibilities for collection of the samples are provided in the Groundwater Monitoring Plan and in Sections 8 through 9 of this QAPP.

3.4 Laboratory Responsibilities

Friedman & Bruya, Inc. (FBI) of Seattlle, Washington will provide analytical services for the groundwater monitoring program. The laboratory QA officer, as described in Table 1, will ensure that appropriate procedures are followed during sample analysis and preparation of the data packages and electronic deliverables. The FBI QA Manual will be provided to the QA/QC coordinator. The QA Manual includes

descriptions of the laboratory organization, personnel, and responsibilities; facilities and equipment, analytical methods and QA/QC protocols; and routine procedures for sample custody and data handling.

4.0 QUALITY OBJECTIVES

The sampling design, field procedures, laboratory procedures, and QC procedures are set up to provide high-quality data for use in the groundwater monitoring program. Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, completeness, and reporting limits) and qualitative factors (representativeness and comparability). The measurement quality objectives (MQOs) associated with these data quality factors are summarized in Table 2 and discussed below.

4.1 PRECISION

Precision is the agreement among a set of replicate measurements without assuming knowledge of the true value. Precision is measured for this project by calculating the relative percentage difference (RPD) for analytical results from field duplicate and lab duplicate samples. Precision is optimized by collecting data at multiple locations and adhering to strict procedural guidelines that minimize possible sample contamination. RPD results that are outside the control limits listed in Table 2 for laboratory split samples will be qualified appropriately during data validation.

Field precision will be assessed through the collection and analytical testing of field duplicates at a rate of one duplicate per 20 field samples, or a minimum of 1 per day. These analyses measure both field and laboratory precision. The results, therefore, may have more variability than laboratory- generated duplicates.

Laboratory precision is assessed through analysis of duplicate spiked and/or unspiked samples, as specified by the analytical method. Specific discussion of the different types of laboratory duplicate samples is found in Section 8.1.

The RPD value will be calculated according to the following formula:

$$RPD(\%) = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} * 100$$

Where:

D1 = Concentration of analyte in sample.

D2 = Concentration of analyte in duplicate sample.

The calculation applies to split samples, replicate analyses, duplicate spiked environmental samples (matrix spike duplicates), and laboratory control duplicates. The RPD will be calculated for samples and compared to the applicable criteria. Precision may also be expressed as the percent difference (%D) between replicate analyses. During data validation, the data validator will evaluate all RPD values and take action as described in U.S. Environmental Protection Agency (EPA) guidance (EPA, 2008, 2010).

4.2 BIAS

Bias is systematic deviation of a measured value from the true value. Bias can be assessed by comparing a measured value to an accepted reference value in a sample of known concentration or by determining

the recovery of a known amount of contaminant spiked into a sample. Bias is minimized for this project by standardizing field activity methodologies, including methods for equipment decontamination, sample collection, field observation and documentation, sample transport, and chain-of-custody control. Descriptions of these methodologies are included in the Groundwater Monitoring Plan.

4.3 ACCURACY

Accuracy is the degree of agreement between an observed value and an accepted reference value. When applied to a set of observed values, accuracy will depend on a combination of random error and of common systematic error (or bias). Accuracy will be evaluated for this project by evaluating laboratory spike sample recoveries that represent the difference between an observed value and an accepted reference value. Control limits for spike recoveries have been documented by the project laboratory and are found in Table 2. Results showing noncompliant recoveries will be qualified appropriately during data validation. In general, if percent recoveries are consistently low, nondetect results may indicate that compounds of interest are not present when in fact these compounds are present. Detected compounds may be biased low or reported at a value less than actual environmental conditions. The reverse is true when recoveries are consistently high. In such case, results for detected analytes may be higher than the true value. Accuracy will be optimized for this project by using procedures designed to reduce potential error that might impact the accuracy of results. Proper decontamination methods and equipment will be used during field activities to ensure accurate results. The laboratory QC procedures, described in Section 8.1, also reduce error to improve accuracy.

Accuracy will be assessed by the percent recovery (%R) of a surrogate compound (also known as "system monitoring compound"), a matrix spike result, and/or results from a laboratory control sample (also known as standard reference material or blank spikes) where:

$$Recovery(\%) = \frac{Sample\ Result}{Spike\ Amount} * 100$$

The data validator will evaluate all %R values and take action as described in EPA guidance (EPA, 2008, 2010).

4.4 REPRESENTATIVENESS

Representativeness is the measure of how well data reflect the actual environment and the conditions under which the data are collected. Representativeness will be optimized for this project by using general historical and investigative information to determine proper locations of new sampling points that represent the areas of concern. The methodologies used to collect samples and measurements, as detailed in the Groundwater Monitoring Plan, are also designed to collect representative data with minimal disturbance of the environment from which they are collected.

To be considered representative, a data set should accurately and precisely represent the actual field conditions. Determination of the representativeness of the data will be performed by:

- Comparing actual sampling procedures to those prescribed in the Groundwater Monitoring Plan and this QAPP;
- Comparing analytical results from field duplicates to determine variation in the analytical results; and

- Flagging nonrepresentative data as invalid or identifying data that are noncompliant with project specifications.

Only representative data will be used in subsequent data reduction, validation, and reporting activities.

4.5 COMPARABILITY

Comparability is how well multiple data sets can be used for a common interpretation. Comparability will be optimized for this project by using the same standards for data collection at each location, and the same analytical procedures and QA procedures during each sampling event.

Comparability expresses the confidence with which one set of data can be compared to another. Since numeric goals do not exist for comparability, a statement of comparability will be prepared to determine overall usefulness of data sets, following the determination of both precision and accuracy. This statement will be included in the Data Review Reports (see Section 10.2.3).

4.6 COMPLETENESS

Completeness is a measure of the amount of data collected that are found to be valid in relation to the total amount of data intended to be collected according to the sampling design. Completeness will be optimized for this project by having all analytical results validated or reviewed by a data validator to assess the validity of the data.

The number of samples and results expected establishes the comparative basis for completeness and is defined as a ratio of acceptable measurements (including estimated data) obtained to the total number of planned measurements for an activity. Completeness (C) can be calculated as follows:

$$\%C = \frac{(number\ of\ acceptable\ data\ points)}{(total\ number\ of\ data\ points)} * 100$$

The data quality objective (DQO) for completeness for this project is 100 percent useable data for samples/analyses planned. If the completeness goal is not achieved, an evaluation will be made to determine if the data are adequate to meet study objectives. Completeness below 100 percent will require review of the sampling objectives to determine whether further sampling and analyses may be required.

4.7 REPORTING LIMITS

Analytical methods have quantitative limitations at a given statistical level of confidence that are often expressed as the method detection limit (MDL). Although results reported near the MDL provide insight to actual field conditions, quality assurance requires that analytical methods achieve a consistently reliable level of quantitation known as the practical quantitation limit (PQL). The laboratory will provide numerical results for all analytes and report them as detected above the PQL or undetected at the PQL.

Ideally, the laboratory's reporting limits (PQLs) should be low enough to compare to the applicable Model Toxics Control Act (MTCA) Method A or Method B screening levels. A reasonable level of effort will be exercised to achieve these goals.

Several factors may influence laboratory PQLs and individual sample quantitation limits. Changes in laboratory protocols may change the applicable PQL that the laboratory can achieve. The most recent laboratory QA Manual will provide the current applicable PQL. Analytical procedures may also require

dilution and/or cleanup of samples and subsequent reanalysis to accurately quantify a particular analyte at concentrations above the range of the instrument. The effect is that other analytes may be reported as undetected at a PQL much higher than a specified screening level. Data users must be aware that nondetected analytes with a high stated reporting limit, although correctly reported, can bias statistical summaries, and careful interpretation is required to correctly characterize site conditions. During data validation, evaluation will be made and the most appropriate result for each analyte will be reported.

5.0 SAMPLING PROCESS DESIGN

The sampling design, including figures showing field work locations, tables of samples to be collected, and the sample collection schedule, are included in the Groundwater Monitoring Plan.

6.0 SAMPLING PROCEDURES

Procedures for all field activities are described in the Groundwater Monitoring Plan. All field personnel will have completed 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Site Operations (HAZWOPER) training.

All instruments used in the collection of samples will be properly calibrated according to the manufacturer's recommendations and decontaminated between samples if the instrument is reusable and comes in contact with samples. All samples will be placed in iced coolers immediately following sample collection, and strict chain-of-custody control will be maintained at all times. Samples will be delivered or shipped to the project laboratory.

6.1 SAMPLE IDENTIFICATION

Each sample will be assigned a unique alphanumeric identification code (identifier) that contains sufficient information to identify the sample location and date. The sample labeling procedure is described in the Groundwater Monitoring Plan.

6.2 SAMPLE LABELING

A label will be securely attached to every sample container. Each label will include the following information:

- sample identifier;
- project name;
- date and time of collection (using 24-hour time clock to minimize potential confusion about a.m. and p.m.; e.g., "1300" vs. "1:00 p.m."); and
- analyses to be performed.

6.3 FIELD LOG MAINTENANCE

All sample location descriptions, sample identifiers, and analyte lists will be recorded in the field log. The field log will include, but not be limited to, the following information:

- all incidents observed during each sampling event;
- the names of all personnel present involved in the sampling event;
- the major events that occurred during the day;
- details about field procedures conducted; and
- details about samples collected or problems that occurred.

Procedures for maintaining the field log are described in the Groundwater Monitoring Plan.

6.4 SAMPLE CONTAINERS AND PRESERVATIVES

Table 1 in the Groundwater Monitoring Plan specifies the sample containers required for each analytical method. Table 3 also specifies the required containers as well as the sample size, preservation protocol, and holding times for the list of analyses to be performed. All sample containers will be provided by the laboratory and will include the appropriate preservatives.

Sample containers will be placed in opaque, insulated coolers packed with ice to minimize their exposure to light and to cool them approximately to the recommended temperature. The coolers will be packed with sufficient packing material to prevent sample container breakage and/or leakage during transport.

The project manager and field personnel will plan sampling activities and coordinate sample delivery with laboratory personnel so that the sample holding time limits and temperatures specified in Table 3 are not exceeded.

6.5 SAMPLE STORAGE AND TRANSPORTATION

The exteriors of all sample containers will be wiped clean after they have been closed. Blank (QC) samples will be packaged with the primary samples that they control. Any vacant space in the cooler will be filled with ice or packing material. If the cooler has a drain, it will be taped shut. Then each cooler will be secured.

6.6 SAMPLE CHAIN-OF-CUSTODY

Chain-of-custody procedures will be followed by all project personnel to document sample transfer, sample possession, and sample integrity, from the time of sample collection through the completion of sample analysis. A chain-of-custody form will be initiated at the time of sampling, and will accompany the samples at all times including upon receipt at the project laboratory. The project laboratory maintains an internal custody protocol. The chain-of-custody form has blank fields for entering the sample identifier, the date and time of sample collection, the name of the person who collected the sample, and the requested laboratory analyses. Each chain-of-custody form will be signed by every person who handles the sample containers. Sample transfers will be noted on the chain-of-custody form for each sample.

The chain-of-custody form documents sample identifications, locations, sample times, and the analyses required for each sample. This is the principal document shared by the sample generator and the project laboratory. Therefore accuracy and completeness are extremely important.

Personnel initiating the chain-of-custody form will refer to the field forms and the field log (described below) to access the required information. This continuity will help make the various forms of documentation consistent and reduce the risk of error. The chain-of-custody form will accompany all samples during transport. The field sampler also will keep a copy of the chain-of-custody form for the project file.

All samples will be delivered directly to laboratory personnel authorized to receive samples (sample custodians). When the laboratory receives the samples, the sample custodian will inspect the exterior condition of the shipping container. Then the sample custodian will open and examine the interior of

the shipping container. Next the sample custodian will examine the sample containers and check the contents of the shipping container against the chain-of-custody form. The sample custodian will record any inconsistencies or problems with the sample shipment (breakage or signs of leakage, and missing or extra samples) on the chain-of-custody record and notify the TWAAFA project coordinator or the QA Leader for immediate resolution. Official acceptance of sample custody will be documented by the sample custodian's signature on the chain-of-custody form. The samples will then be tracked through the laboratory by the laboratory's internal custody procedures.

7.0 MEASUREMENT PROCEDURES

The analytical and QA/QC procedures used by the laboratory are described in the laboratory QA Manual and SOPs.

7.1 LABORATORY MEASUREMENT PROCEDURES

Groundwater samples will be analyzed for the list of analytes as identified in the Groundwater Monitoring Plan. Chemical laboratory analyses will be performed using the following sets of standard laboratory methods:

- Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd edition (EPA, 2007);
- Ecology method NWTPH (for total petroleum hydrocarbons).

7.2 FIELD MEASUREMENT PROCEDURES

Field equipment will be used in general accordance with the manufacturer's recommendations. More details on field procedures are provided in the Groundwater Monitoring Plan.

8.0 QUALITY CONTROL

This section outlines QC procedures to be followed by both the field personnel and the analytical laboratory. Following these QC procedures will support the development of a complete and accurate data set following laboratory analysis and data validation. In this section, a sampling event is defined as consecutive days of sampling not separated by more than 2 days of inactivity.

8.1 ANALYTICAL LABORATORY QUALITY CONTROL

The project laboratories are required to adhere to specified criteria in the following areas to verify the validity of data being produced:

- Holding times;
- Instrument tuning;
- Initial calibrations and continuing calibration verification;
- Method blanks;
- Surrogate spike compounds;
- Matrix spike samples and matrix spike duplicates (MS/MSD);
- Laboratory control samples (LCS);
- Laboratory duplicates; and
- Internal standards.

8.1.1 Holding Times

Holding time constraints for each method will be met to ensure the validity of the results report. Holding times are outlined in Table 3.

8.1.2 Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) will be completed to ensure that mass resolution, identification, and, to some degree, sensitivity of the analyses are acceptable. Instrument tuning will be completed each 12-hour period during which samples or standards are analyzed. In the event that an instrument tuning does not meet control limits, analyses of project samples will be suspended until the source of the control failure is either eliminated or reduced to within control specifications. Any project samples analyzed while the instrument is out of calibration will be reanalyzed.

8.1.3 Laboratory Instrument Calibration

Initial calibration of instruments, as applicable, will be performed at the start of the project and when any ongoing calibration does not meet control criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibration verification will be performed as specified in the analytical methods to track instrument performance. In the event that continuing calibration verification does not meet control limits (as specified by the method requirements), analysis of project samples will be suspended until the source of the control failure is either eliminated or reduced to within control specifications. Any project samples analyzed while the instrument was out of calibration will be reanalyzed. Calibration documentation will be retained at the laboratory and readily available for review.

8.1.4 Laboratory Method Blanks

According to the EPA (2008, 2010), “the purpose of laboratory (or field) blank analyses is to determine the existence and magnitude of contamination resulting from laboratory (or field) activities. The criteria for evaluation of blanks apply to any blank associated with the samples (e.g., method blanks, instrument blanks, trip blanks, and equipment blanks).”

Method blanks are laboratory QC samples that consist of either a contaminant-free, soil-like material or deionized water. Method blanks are created in the laboratory during sample preparation and follow samples throughout the analysis process. The frequency of method blanks will be at least one per analytical batch for each matrix. No more than 20 non-QC field samples can be contained in one batch.

If a substance is found in the method blank then one (or more) of the following events occurred.

- The measurement apparatus or containers were not properly cleaned and contained contaminants.
- Reagents used in the process were contaminated with a substance(s) of interest.
- Contaminated analytical equipment was not properly cleaned.
- Volatile substances in the air contaminated the samples during preparation or analysis.

Given method blank results, validation guidelines aid in determining which substances in samples are considered “real” and which ones are inadvertent contaminants of the analytical process. During data validation, the data validator will evaluate all method and field blank sample results and take action as

described in EPA reference documents (EPA, 2008, 2010); professional judgment will be applied as necessary.

8.1.5 Surrogate Spikes

Surrogate spike compounds are used during analysis for organic analytes to verify the accuracy of the instrument being used and assess extraction efficiency. Surrogates are substances similar to, but not one of, the target analytes. A known concentration of surrogate compound is added to the sample and passed through the instrument, and the surrogate compound recovery is recorded. Each surrogate compound used has an established range of acceptable percent recoveries, as summarized in Table 2. If a surrogate recovery is low, sample results may be biased low, and, depending on the recovery value, a possibility of false negatives may exist. Conversely, when recoveries are above the specified range of acceptance a possibility of false positives exists, although nondetected results are considered accurate.

8.1.6 Matrix Spike/Matrix Spike Duplicates

Laboratory precision will be determined by splitting spiked or unspiked samples. MS/MSD sample analyses are used to determine accuracy and precision and to assess interferences caused by the physical or chemical properties of the sample itself. The analyst uses this information to determine the precision of the preparation and analytical techniques used to analyze the duplicate sample.

MS samples are preselected by field personnel and labeled accordingly on the chain-of-custody. The laboratory divides the sample into equal aliquots, and then spikes each of the aliquots with a known concentration of target analytes. Matrix spike samples are prepared by spiking a known amount of one or more of the target analytes at a concentration of 5 to 10 times higher than the expected sample result. Matrix spikes will be prepared and analyzed at a minimum frequency of 5 percent or one for each batch of 20 or fewer samples for each matrix. Some analyses (such as total petroleum hydrocarbons) do not require MS/MSDs, as shown on Table 4. In addition, some analyses only require an MS sample and not an MSD.

MS/MSD data are reviewed in combination with other data quality indicators (e.g., LCS/LCS duplicate [LCSD]) to determine matrix effects. In some cases, matrix effects cannot be determined due to dilution and/or high levels of related substances in the sample.

8.1.7 Laboratory Control Spikes/Laboratory Control Spike Duplicates

The purpose of the laboratory control spike samples (also known as blank spikes) is to aid in assessment of overall accuracy and precision of the entire analytical process (e.g., sample preparation, instrument performance, and analyst performance). An LCS will be prepared and analyzed at a minimum of one LCS with each batch of 20 samples or fewer for each matrix. LCS are similar to matrix spikes; however, the LCS spike medium is “clean” or contaminant free.

8.1.8 Laboratory Replicates/Duplicates

Precision for inorganic analytes is monitored by analysis of [nonspiked] sample replicates/duplicates. Laboratory duplicate sample analysis, for inorganic analytes, will be prepared and analyzed at a minimum frequency of 5 percent or one laboratory duplicate with each batch of 20 samples or fewer for each matrix.

8.1.9 Internal Standards

Internal standards are added to all field and QC samples immediately prior to analysis for analyses completed by GC/MS. The internal standards are used to quantify target compounds and to ensure that the instrument is stable and functioning as calibrated.

No special QC procedures will be required for this project. Ranges of laboratory-established control limits for surrogates, MS/MSD recoveries, LCS recoveries, and laboratory duplicate RPDs, as applicable, are provided in Table 2. The most current laboratory control limits will be used to evaluate results during data review and may be obtained directly from the laboratory Project Managers.

8.2 FIELD QUALITY CONTROL

Field QC samples are collected and analyzed to assess sample collection techniques, possible sources of contamination, interferences that may be attributed to the sample matrix, and, to some degree, the bias and precision of the reported results. Field QC will be evaluated, along with laboratory QC, by the data validator during data review and validation. Affected data will be qualified in accordance with EPA (2008 and 2010) guidelines. A description of each type of QC sample is described below. For the purpose of this discussion, the term "primary sample" is defined to be a field sample of environmental medium (e.g., soil) other than a field QC sample.

8.2.1 Field Equipment Calibration Procedures

Field equipment requiring calibration will be calibrated to known standards in accordance with manufacturer's recommended schedules and procedures for each instrument. Calibration (or drift) checks of the vapor measurement equipment will be conducted daily, and the instruments will be recalibrated as required. Calibration measurements will be recorded in the daily field logs. If field equipment becomes inoperable, it will be replaced with a properly calibrated instrument.

8.2.2 Equipment (Rinsate) Blanks

Equipment rinsate blanks will be collected whenever nondedicated or nondisposable sampling equipment will be used. Equipment rinsate blanks will be used to identify possible contamination from the sampling environment or from sampling equipment. These blanks will be collected by pouring deionized and distilled water over (or through) the decontaminated sampling equipment and into a sample jar. One equipment rinsate blank will be collected for each type of sampling equipment used during the sampling event and will be analyzed for all analytes except conventional analytes. The frequency of collection will be 1 per 20 samples collected. These are typically not required during routine sampling since PSC uses dedicated or disposable equipment for sampling all wells, but would be required if that were ever not the case.

8.2.3 Field Blanks

Sampling personnel will collect field blanks and submit the blanks to the laboratory as natural samples. Field blanks will be used to identify possible contamination occurring from the sampling environment. These blanks will consist of deionized and distilled water from the analytical laboratory in clean and preserved sampling containers. In the field, this water will be transferred to an empty sampling container at a specified sampling location. The sample will be preserved for the applicable analysis to be completed. The frequency of collection will be 1 per 20 samples collected. Field blanks will be analyzed for all analytes.

8.2.4 Trip Blanks

Trip blank samples, consisting of organic-free water poured into 40-milliliter (ml) sample vials at the laboratory under contaminant-free conditions, will be provided by the laboratory for each sampling event that includes analysis of volatile organic compounds (VOCs). Trip blanks remain sealed during sampling and are kept in the sample transport container at all times. Trip blank samples are analyzed for VOCs and gasoline-range organics and will provide a measure of potential cross-contamination with VOCs during shipment and handling.

Trip blanks will be included at a rate of one per cooler for analyses of all volatile constituents (e.g., VOCs, and gasoline-range organics). Results of trip blank samples are used to assess potential contamination that may impact groundwater samples during transport.

8.2.5 Field Duplicates

Field duplicates are used to assess the homogeneity of samples collected in the field and the precision of sampling methods. Field duplicates are prepared by collecting two aliquots (i.e., splits) of sample from the same sampling location using the same sampling equipment and technique, then submitting them for analysis as separate samples. Results from the analysis of field duplicates are used to evaluate the precision and consistency of laboratory analytical procedures and methods, and the consistency of the sampling techniques used by field personnel. Groundwater field duplicates will be collected at a rate of 1 per 20 samples per sampling event. Field duplicates will be collected at locations with suspected contamination. Any well with detections the previous sampling round would be eligible to be a field duplicate location the following round. The field duplicate RPD should be less than 30 percent for groundwater samples.

8.2.6 Matrix Spike/Matrix Spike Duplicate

Extra sample volume must be collected by field staff to enable the lab to run MS/MSD analyses for the designated analyses listed in Table 4. MS/MSD sample volume should be submitted at a rate of 1 per 20 samples collected, or one per field mobilization (lab batch) at a minimum. All MS/MSD samples should be noted on the chain-of-custody form. MS samples should be collected at relatively “clean” locations and are analyzed to assess the effects of the sample matrix on the accuracy of analytical measurements. Any well without COC detections the previous sampling round would be eligible to be a field duplicate location the following round. MSD samples are used to assess both accuracy and precision.

8.3 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or QC performance outside established criteria. Corrective action can occur during field activities, laboratory analyses, data validation, or data assessment.

Corrective actions should be designed to correct the problem and to minimize the possibility of recurrence. Examples of corrective actions include modifying nonconforming procedures, forms, or worksheets; instituting a quality check; and the like. Proposed corrective actions should be reviewed and approved by the QA Leader prior to implementation. Significant noncompliance and corrective actions will be discussed in QA reports to the TWAAFA Site Coordinator and Washington State Department of Ecology (Ecology), as appropriate.

8.3.1 Field Corrective Action

Project personnel will be responsible for reporting technical or QA nonconformances or deficiencies of any activity or issued document to the Field Coordinator. The Field Coordinator will consult with the QA Leader to determine whether the situation warrants a reportable nonconformance and subsequent corrective action. If so, a Corrective Action Report (CAR) will be initiated by the QA Leader.

Corrective actions will be implemented and documented in the field record log. No staff member will initiate corrective action without prior communication of findings using the process described above.

8.3.2 Laboratory Corrective Action

Corrective action by the laboratory may occur prior to or during initial analyses. Conditions such as broken sample containers, multiple phases, low/high pH readings, and potentially high-concentration samples may be identified during sample log-in or prior to analysis.

Laboratory corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, and who checks potential sources of error, such as instrument calibration, spike and calibration mixes, and instrument sensitivity. If the problem persists, or cannot be identified, the problem should be referred to the supervisor, manager, and/or Laboratory Project Manager for further investigation and possible formal corrective action.

The contracted laboratory's QA Manual includes specific procedures for identification and documentation of nonconformance and implementation and reporting of corrective actions.

8.3.3 Corrective Actions Resulting From Data Validation

If necessary, the data validator will contact the laboratory for further information, clarification, or needed resubmissions and/or corrective actions. All communications will be documented and included with the data validation report as an appendix.

In cases where a deficiency or problem is a recurring nonconformance requiring more extensive corrective action, it should be documented on a formal CAR. The CAR will be sent to the organization responsible for the corrective action, and a copy routed to the QA Leader. When the corrective action is complete, the data validator will complete the CAR.

9 DATA MANAGEMENT PROCEDURES

Computerized systems will be used to record, store, and sort the technical data that will support the site investigation. The data record will include a unique sample code, station ID, sample type (matrix), analyte, analyte concentration, and concentration units. Automated data handling increases the data integrity by reducing errors, omissions, and ambiguities that can be introduced by manual procedures. In addition, automated procedures will generally be used by the laboratories to capture and summarize analytical results. Sampling location coordinates will be entered into the database to enable the generation of maps and figures and upload to Ecology's Environmental Information Management System.

Field logbooks, station/sample forms, and chain-of-custody/sample analysis request forms are prepared by the field team while sample collection activities are in progress. Sample information from the field,

such as water elevation data, is entered manually. Data from the laboratories are entered directly from the electronic data deliverables (EDDs). A small portion of the laboratory data may be entered manually if electronic data cannot be supplied. Data qualifiers are entered into the database when data validation is completed and verified, and the data set is approved as final. All manual and electronic entries are verified by the data manager or validation personnel.

9.1 LABORATORY DATA REPORTS

The project laboratory will complete all analyses as described in the Groundwater Monitoring Plan and present the following, at a minimum, in a report to the QA Leader within approximately 30 days of the receipt of samples, unless a shorter turnaround time is requested.

- Case narrative: The case narrative will describe the analytical methods used and discuss any irregularities encountered during sample analyses and any resulting data qualification.
- Analyte concentrations: A summary of analytical results will be presented for each sample.
- Method reporting limits: Method reporting limits achieved by the laboratory will be presented with the analyte concentrations.
- Laboratory data qualifier codes and a summary of code definition: Data qualifiers will appear next to analyte concentrations, and associated definitions will be summarized in the report.
- Lab QC results: Results for method blanks, MS/MSD, LCS/LCSD, lab duplicates, and surrogate recoveries will be provided with final results.
- Chromatographs for all samples run for petroleum analyses.
- EDD version of results: A full set of results will be provided in database format.

9.2 PROJECT DATABASE

Data validation will be performed on specified analytical data for this project, and the data validator will enter validation qualifiers and comments into the data set as necessary.

The QA Leader will then transmit the validated EDD along with the validation report to the database uploader, who will upload it into Ecology's Environmental Information Management System. Tables from the EDD/database will then be backchecked against hard copy results. Any corrections will be made to the database based on backcheck findings. The data will then be considered final, and EDDs or tables will be created from the EDD/database as necessary for use in data analysis and reporting.

9.3 RECORDS MANAGEMENT

The QA Leader will inventory and store all analytical data, including all resubmissions collected during data validation efforts, worksheets, and original data validation reports.

10 AUDITS AND REPORTS

10.1 AUDITS

Any deviations from the Groundwater Monitoring Plan that occur during the reporting period will be included in the annual reports provided to Ecology.

10.2 REPORTS

Procedures, observations, and test results will be documented for all sample collection, laboratory analysis and reporting, and data validation activities. In addition to data reports provided by the

laboratories, reports will be prepared that address data quality and usability and that provide tabulated laboratory and field data. Internal and external reporting procedures for this project are described in this section.

Upon receipt of the chemical data from the laboratories, the data will be subjected to a QA review (i.e., data validation). The QA reviews are anticipated to be completed within 30 days of receipt of the last data package from the laboratory. The results of the validated data will then be reported according to the schedule in the Groundwater Monitoring Plan. Details regarding the validation of data are presented in Section 11.0 of this QAPP. In the event of unscheduled delays in the project schedule, the TWAAFA Site Coordinator will inform the Ecology project manager.

10.2.1 Field Records

Field records will be maintained during all stages of sample collection and preparation for shipment to the laboratories. Field records will include the following items:

- Field notebook to record daily sampling activities, conditions, and field measurements;
- Combined station/sample log to document station locations and date and time of collection;
- Sample labels and tags;
- Combined chain-of-custody/sample analysis request (COC/SAR) forms;
- Custody seals to monitor cooler security during shipment; and
- Photographic documentation (if taken).

Descriptions of the information that will be reported on each field record form are provided in SOP-400, contained in the Groundwater Monitoring Plan.

In addition to the routine field records, the following reports will be completed if a deviation from the Groundwater Monitoring Plan or QAPP is encountered:

- Corrective action reports documenting any problems encountered during field activities and corrective actions taken,
- A summary of any changes made to documented procedures and the rationale for the changes.

10.2.2 Laboratory Data Reports

The laboratories will perform data reduction as described in each test method for this project and submit complete data packages, as appropriate, with full documentation for all analyses or other determinations. The laboratory QA managers or their designees are responsible for reviewing their respective laboratory data packages, verifying all method-specific QA/QC protocols were completed and are acceptable, and checking data reduction so that a QA review has been completed for all data reported prior to submittal to the TWAAFA group. Any transcription or computation errors identified during this review will be corrected by the laboratory.

The analytical laboratories will provide all information required to complete an abbreviated QA review (i.e., summary review) on 100 percent of the data.

To complete an abbreviated QA review, the information to be reported (as applicable to the analytical method) will include, at a minimum, the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered;

- A summary of analyte concentrations and method reporting limits;
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions;
- Results for method and calibration blanks;
- Results for all QA/QC checks, including SMCs, surrogate compounds, MS samples, LCSs, MSD samples, and laboratory duplicate or triplicate samples.

10.2.3 Data Review Report

A data review report will be prepared upon completion of the data review. The data review reports will summarize the results of the data validation and data quality review and will describe any significant QA problems that were encountered. The data review reports for the chemical analyses may include all or a portion (depending on the type of data validation that may be completed) of the following items:

- Executive summary of overall data quality and recommendations for data use and limitations;
- Description of sample collection and shipping, including chain-of-custody and holding time documentation;
- Description of analytical methods and detection limits;
- Description of data reporting;
- Description of completeness relative to QAPP objectives;
- Description of instrument tuning and initial and continuing calibration results;
- Description of any contamination in field and laboratory blanks and implications for bias of the data;
- Description of accuracy relative to QAPP objectives, including results of SMC, surrogate, MS, and LCS recoveries;
- Description of precision relative to QAPP objectives, including results for field and laboratory replicate analyses;
- Identification of cases where control limits or measurement performance criteria were not met and summary of the significance of these deviations; and
- Description of analyte identification and quantification.

All data and any qualifiers applied to the data as a result of the QA review will be reported in the final data report.

10.2.4 Location of Records and Reports

The records generated during sample collection and analysis document the validity and authenticity of the project data. These records will become part of the final project file. The project file will be retained by the TWAAFA Site Coordinator. Project reports will be kept with the project files for reference purposes. Records that are more than 3 years old may be archived at a data archiving subcontractor's site, but all data will be retrievable in a quick time frame (normally 1-2 days).

11 DATA REVIEW, VERIFICATION, AND VALIDATION

Data review, verification, and validation are conducted to establish the data quality and usability for the project. These procedures are described below. Data verification is the process of determining whether data have been collected or generated according to the Groundwater Monitoring Plan, QAPP, and the

respective SOPs or method descriptions. Data validation is the process of evaluating the technical usability of the verified data with respect to the planned objectives of the project.

11.1 SAMPLE DESIGN AND SAMPLE COLLECTION PROCEDURES

The conformance of the field activities to requirements in the Groundwater Monitoring Plan will be evaluated by the Field Coordinator and/or QA Leader on an ongoing basis while field activities are in progress. The review process will include immediate evaluation of any change to the sampling plan so that an alternate field procedure may be established.

Additional verification procedures may be completed for information generated in the field. A final verification review of field activities will be made when the field effort is complete. The verification results will be included in the data quality and usability report. Specifically, field forms will be reviewed for:

- correct documentation of sample location;
- complete and accurate procedures for sample collection or measurement and proper documentation;
- proper chain-of-custody methodology, including sample shipment and preservation during transport; and
- evaluation of field QC results; field QC sample contamination could result in data qualification.

The analytical laboratories will complete a data review and verification prior to producing results. This verification will include checking that QC procedures were included at the required frequencies and that the QC results meet the control limits specified by the laboratory at the time of analysis. Any QA issues identified by the laboratory will be described in the case narrative and may result in qualification of some of the results by the laboratory.

11.2 VERIFICATION AND VALIDATION OF CHEMICAL DATA

Verification of chemical data will be completed at the laboratories and by the QA Manager. The laboratory will be responsible for the review and verification of all bench sheets; manual entry or transcriptions of data; review of any professional judgments made by a chemist during sample preparation, analysis, and calculation; and reporting of the final concentrations. The laboratory will also be responsible for the review of QC results to determine whether data are of usable quality or reanalyses are required. Any nonconformance issues identified during the laboratory's QA checks will be corrected and noted by the laboratory. Any data quality deviations will be discussed in the laboratory case narrative, including the direction and magnitude of any bias to the data, if possible.

Data validation and verification will be completed by the QA Manager prior to finalizing the data and release of the data set for interpretation. All data will be verified and validated in accordance with

U.S. EPA National Functional Guidelines (EPA, 2008, 2010), method-specific QC requirements, and laboratory-established control limits. Data will be qualified when QC procedures are not completed as required, when measurement performance criteria established in the applicable method are not met, or when specific data quality objectives established for this project are not achieved.

External data verification and validation will include an abbreviated QA review (summary data review) on 100 percent of the data. The laboratory information that will be reviewed, as applicable to the analyses completed, for each of these validation efforts is described below.

11.2.1 Abbreviated QA Review

Completion of an abbreviated QA review (i.e., a summary review data validation effort) assumes that all field results reported by the laboratory are correct. For this level of effort, summaries of applicable calibration and QC measurements are reviewed. Calculations and transcriptions are not verified or confirmed, and original instrument printouts are not reviewed. The following laboratory information will be reviewed, as applicable to each analysis:

- Chain-of-custody documentation to verify completeness of the data set;
- Case narratives discussing analytical problems (if any) and procedures;
- Sample preparation logs or laboratory summary result forms to verify analytical holding time constraints were met;
- Instrument tuning, initial calibration, and continuing calibration results to assess instrument performance;
- Method blank, trip blank, equipment rinsate blank, and other field blank results;
- Surrogate or system monitoring compound recoveries to assess preparation and analyses;
- MS and LCS recoveries; and
- Laboratory duplicate, field duplicate, and MSD results.

12 DATA QUALITY ASSESSMENT

The goal of data verification and validation is to determine the quality of each data point and to identify data points that do not meet measurement performance criteria and other project DQOs.

Nonconforming data may be qualified as estimated (J) or rejected (R) as unusable during data validation if criteria for data quality are not met. Rejected data (R) will be flagged as unreportable in the project database and will be excluded from all data retrievals. These data will not be used for any purpose. An explanation of the rejected data will be included in a data validation report. If the rejected data are needed to make a decision, then it may be necessary to resample. Any decision to resample would be based on discussions among the project management team.

Data qualified as estimated (J) will be appropriately qualified in the final project database. Although estimated data are less precise or less accurate than unqualified data, estimated results may still be used to evaluate and interpret site conditions provided that consideration of these data does not compromise the project objectives. The data review report will include all available pertinent information regarding the direction or magnitude of bias or the degree of imprecision for qualified data to facilitate the assessment of data usability.

The effect of estimated sample results in interpretation of site conditions depends on several factors.

- The nature and magnitude of the data quality problem: for example, a small positive bias in sample(s) concentration near a screening level may result in a conservative conclusion but a large negative bias may render the screening-level comparison meaningless.

- The nature and location of the affected sample(s): for example, a data deficiency in a result for a reference area may have a much greater impact on data interpretation than a similar deficiency in one of many results for a study site.
- The context of the sample results within the data set: for example, a questionable result for an analyte that is detected at high concentrations and important for site interpretation is likely to have a much greater impact on data interpretation than a questionable result for an analyte that is present at only low concentrations.
- The assessment of any data deficiencies on interpretive activities will be completed on a case-by-case basis. The data users are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on comparisons to screening criteria, statistical procedures, risk assessments, and other data uses. The effect of any data deficiencies on risk assessment and other interpretive activities and conclusions will be described in the final report.

13 REFERENCES

EPA (U.S. Environmental Protection Agency), 2007, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd edition, February.

EPA, 2008, USEPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Review, EPA-540-R-0801, June.

EPA, 2010, USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-10-011, January.

Table 1
Project Personnel and Responsibilities
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, WA

Personnel	Responsibilities	Contact Information
Steve Teel, Washington State Department of Ecology Project Manager	Oversee all program activities to ensure compliance; perform technical oversight and consultation on major quality assurance problems; provide final approval of all necessary actions and adjustments for activities to accomplish project objectives. Provide final approval of the Groundwater Monitoring Plan and QAPP.	Washington State Department of Ecology, SWRO PO Box 47775 Olympia, WA 98504-7775 (360) 407-6247
Tasya Gray, TWAAFA Site Coordinator (AO Parties)	Overall responsibility for sample collection activities. Oversee all program activities to ensure compliance; provide technical oversight and consultation on major quality assurance problems; implement final approval of all necessary actions and adjustments for activities to accomplish project objectives.	Dalton, Olmsted, & Fuglevand, Inc. 1001 SW Klickitat Way, Suite 200B Seattle, WA 98134 (360) 394-7917
Trevor Louviere, Sampling Team Leader (AO Parties)	Coordinate with TWAAFA Site Coordinator, Field Team Leaders, and project laboratories for bottle and equipment shipments to the site and sample shipments to the laboratories; track submittal and receipt of samples to the laboratory, and initiate COC/SAR forms. Ensure field procedures are completed in accordance with Plans and QAPP; authorize and document minor adjustments to the sampling plan in response to field conditions, as necessary, notify TWAAFA Site Coordinator and QA/QC Coordinator.	Dalton, Olmsted, & Fuglevand, Inc. 1001 SW Klickitat Way, Suite 200B Seattle, WA 98134 (360) 394-7917
Trevor Louviere, Data Administrator (AO Parties)	Organize and maintain project database. Ensure that the data are stored in accordance with the Groundwater Monitoring Plan and QAPP; supervise data management personnel.	see above
James McAteer, QA/QC Coordinator	Provide technical quality assurance assistance; develop and review QAPP; oversee quality assurance activities to ensure compliance with QAPP; coordinate and supervise data validation and data quality report preparation; review and submit quality assurance reports.	QA/QC Solutions, LLC 7532 Champion Hill Road SE Salem, OR 97306 (503) 763-6948
Michael Erdahl, Laboratory Project Manager	Ensure that sample receipt and custody records are properly handled and data are reported within specified turnaround times: calibrate and maintain instruments as specified; perform internal quality control measures and analytical methods as required; take appropriate corrective action as necessary; notify the QA/QC Coordinator when problems occur; report data and supporting quality assurance information as specified in this QAPP.	Friedman & Bruya, Inc. 3012 16th Avenue West Seattle, WA 98119 (206) 285-8282

Abbreviations

COC = chain-of-custody

GWMP = groundwater monitoring plan

QAPP = quality assurance project plan

QA/QC = quality assurance and quality control

SAR = sampling analysis and request

Table 2
Measurement Quality Objectives
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, WA

Analyte	Analytical Method	LCS %Recovery Limits	MS %Recovery Limits	Sample Surrogate %Recovery Limits	MS/MSD, or Laboratory Duplicate RPD Limits (%)	Field Duplicate RPD Limits (%)
Total Metals	EPA 6020B	80-120	75-125	NA	≤20	<30
Total Mercury	EPA 1631E	78-125	75-125	NA	<20	<30
TPH-Diesel	NWTPH-Dx	58-134	45-140	47-140	<20	<30
TPH-Gasoline	NWTPH-Gx	69-134	71-128	51-134	<20	<30
1,4-Dioxane	EPA 8260D SIM	70-130	50-150	50-150	<20	≤30
PCBs	EPA 8082A	50-115	50-115	24-127	<20	≤30
SVOCs	EPA 8270E/SIM Dual Acquisition	10-149	10-197	10-150	<20	≤30
VOCs	EPA 8260D/SIM Dual Acquisition	10-171	50-150	78-126	<20	≤30

Abbreviations:
TPH = total petroleum hydrocarbons
PCB = polychlorinated biphenyls
SVOC = semi-volatile organic compounds
VOC = volatile organic compounds

Notes:
Recovery limits are those previously provided by the project laboratory; data will be evaluated during data review using the most current control limits provided by the laboratory.

Table 3
Sample Containers, Preservation, and Holding Times
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, WA

Analyte	Analytical Method[1]	Sample Container	Preservation / Temperature	Holding Time[2]
Total Metals	EPA 6020B	500 mL HDPE	2.5 mL 1:1 HNO_3; ≤6°C	6 months
Total Mercury	EPA 1631E	500 mL HDPE	5 mL 1:1 HNO_3; ≤6°C	28 days
TPH-Diesel	Ecology NWTPH-Dx	500 mL amber glass	≤6°C	7 days
TPH-Gasoline	Ecology NWTPH-Gx	3 x 40 mL VOA vials	HCl to pH<2.0; ≤6°C	14 days
1,4-Dioxane	EPA 8260D SIM	3 x 40 mL VOA vials	HCl to pH<2.0; ≤6°C	7 days
SVOCs	EPA 8270E/SIM Dual Acquisition	2 x 1 L amber glass	≤6°C	7 days to extraction; 40 days to analysis
PCBs	EPA 8082A	2 x 1 L amber glass	≤6°C	7 days
VOCs	EPA 8260D/SIM Dual Acquisition	3 x 40-mL VOA vials	HCl to pH<2.0; ≤6°C	14 days

Notes
1. Method numbers refer to SW-846 EPA Analytical Methods (EPA,1986), or Washington State Department of Ecology analytical methods, or Standard Methods (SM) for the Examination of Water and Wastewater.
2. Holding times are based on elapsed time from date and time of collection.

Abbreviations
°C = degree Celsius
EPA = U.S. Environmental Protection Agency
HCl = hydrochloric acid
HDPE = high density polypropylene
HNO3 = nitric acid
L = liter
mL = milliliter
PCB = polychlorinated biphenyls
SIM = selective ion monitoring
SVOC = semi-volatile organic compounds
TPH = total petroleum hydrocarbons
VOA = volatile organic analysis
VOC = volatile organic compounds

Table 4
Quality Control Sample Types and Frequency
TWAAFA Revised Groundwater Monitoring Plan
Tacoma, WA

Parameter	Field QC			Laboratory QC			
	Field Duplicates[3]	Field Blank	Trip Blanks	Method Blanks	LCS	MS/MSD	Lab Duplicates
Total Metals	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	1 set/batch	NR
Total Mercury	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	1 set/batch	NR
TPH-Diesel	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	NR	1/batch
TPH-Gasoline	1/20 samples per sampling event	1/20 samples per sampling event	1/cooler	1/batch	1/batch	NR	1/batch
SVOCs	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	1 set/batch	NR
PCBs	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	1 set/batch	NR
VOCs	1/20 samples per sampling event	1/20 samples per sampling event	1/cooler	1/batch	1/batch	1 set/batch	NR
1,4-Dioxane	1/20 samples per sampling event	1/20 samples per sampling event	NR	1/batch	1/batch	1 set/batch	NR

Notes

1. A sampling event is defined as consecutive days of sampling not separated by more than two days of inactivity.
2. A 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 can be contained in one batch.
3. Field duplicates will be collected only for events with more than five samples.

Abbreviations

LCS = laboratory control sample
MS = matrix spike sample
MSD = matrix spike duplicate sample
NR = not required
PCB = polychlorinated biphenyls
QC = quality control
SVOC = semi-volatile organic compounds
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds

Appendix B
Standard Operating Procedures

Groundwater Monitoring Well Installation

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Carolyn Mayer	Carolyn Mayer	7/1/98	Laurel Muselwhite	7/1/98

This SOP contains nine sections:

1.0 Purpose
1.0 Application
1.0 References
1.0 Associated SOPs
1.0 Installation Equipment and Materials
1.0 Monitoring Well Installation Procedure
1.0 Standard Surface Finishing Designs
1.0 Documentation
1.0 Measure of Proficiency

1.0 Purpose

The purpose of this SOP is to provide geotechnical field personnel with an outline of the specific information needed to install and construct monitoring wells in both unconsolidated and bedrock media. The required equipment and documentation are also outlined for each of these procedures. The recommended monitoring well design, as presented in this SOP, is based on the assumption that the objective of the program is to obtain representative ground water information and water quality samples from aquifers.

1.0 Application

Ground water monitoring wells are generally used as collection points for ground water samples and as measuring points for aquifer hydraulic properties.

This SOP provides a step-by-step guideline to be followed by the site geologist to design and install monitoring wells suited to these purposes.

1.0 References

ASTM Proposed Recommended Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers (February 19, 1990).

U.S. EPA, Office of Solid Waste. 1992. RCRA Ground-Water Monitoring Draft Technical Guidance. November.

Driscoll, Fletcher G. 1986. Groundwater and Wells. Second Edition. Published by Johnson Filtration Systems, Inc., St. Paul Minnesota.

1.0 Associated SOPs

PSC-103
PSC-121
PSC-400

1.0 Installation Equipment and Materials

The following equipment should be provided and maintained by the site geologist:

- a calibrated photoionization detector; isobutylene span gas, regulator, and tedlar bag;
- a weighted fiberglass tape calibrated to .001 foot and of sufficient length to reach the bottom of the deepest bore hole;
- a wooden folding ruler calibrated to a .001 foot;
- an electric water level indicator, immiscible phase probe or chalked steel tape for obtaining water level measurement to an accuracy of .001 foot;
- a field notebook and calculator.
- a camera;

- a small file or saw to permanently mark a double notch at the top of the well casing/riser;
- permanent marker or paint pen to mark the identification of the well on the steel pipe finish;
- a sufficient supply of blank daily drilling reports and monitoring well construction field forms;
- a copy of the Field Operations Plan including, at a minimum, the Field Sampling Plan, the Health and Safety Plan and the Quality Assurance Project Plan
- all required personnel protective equipment as defined in the Health and Safety Plan;
- a sufficient amount of deionized water to hydrate the bentonite.
- A brass or hardened-steel security lock.

The drilling contractor is responsible for providing the following:

- well screen and riser components with flush joints with square profile threads to obtain water tight seals;
- machine slotted well screens (0.010 size);
- bentonite pellets or chips;
- "quick-set" additive (if necessary when cold weather conditions);
- filter sand;
- a steam cleaner;
- cement grout, mixer, tremie pipe;
- the project specific required surface finishing materials; and
- all required personnel protective equipment as defined in the Health and Safety Plan.

6.0 Monitoring Well Installation Procedure

Once a stable bore hole has been advanced to the desired depth in accordance with Standard Operating Procedure PSC-103, the installation of a well screen and riser will proceed as follows:

Materials Inspection and Cleaning

- decontaminate both inside and outside of the well screen, bottom plug and riser immediately prior to assembly and installation, using a water source of known chemistry and a mild non-phosphate detergent then rinse with deionized water; store decontaminated riser and screen in an area free of contaminants and cover with plastic sheeting;

- inspect all materials prior to assembly to insure material integrity.

Bore Hole Preparation

- if viscous drilling fluids were introduced to the borehole, then the borehole should be flushed with clean water of known chemistry. This is done to remove all viscous drill fluids from the bore hole which could prevent proper setting of well construction materials;

- record the volume of water introduce into the bore hole and recovered from the bore hole during flushing. The difference in there two volumes requires recovery during well development in addition to the calculated well volume to be removed PSC-121.

- check the total depth of the bore hole using a weighted fiberglass tape and a constant datum such as the ground surface. Bore holes that are partially obstructed by caved or blow-in sediments should be cleared in accordance with Standard Operating Procedure PSC-103 prior to initiating well installation;

- a 1.0 foot thick base layer of filter san should be placed at the base of the bore hole using a decontaminated, flush threaded, one inch internal diameter (minimum) tremie pipe. Alternatively, the filter sand may be added directly between the rise pipe and the auger or casing. Verify the depth of the top of the sand base;

Monitoring Well Pre-assembly

- pre-cut the uppermost section of the well riser so that when the well is in place, the top of the well riser will be approximately 4 to 6 inches below the ground surface for flush finished wells, or 3.0 feet above the ground surface for wells designed with a standpipe finish;

- permanently identify the survey and measuring point on the upper rim of the well riser by cutting a double notch into the rim (Figure 1);

Monitoring Well Installation

- quickly assemble the well within the bore hole by adding sections to the top of the column until the screened section is set at the desired depth. Care should be taken to prevent any materials from entering the well during down hole assembly;

- use of a geosock to prevent fines from entering the well should be discussed on an individual basis per project. If used, slip it on over the screened interval as the well is being assembled.

- cap the well riser to prevent materials from entering the well during construction;

- begin placing the chemically inert filter pack within the annular space surrounding the well screen while simultaneously removing the augers or casing;

- the filter pack should be added slowly in order to prevent bridging of the sand between the riser and the borehole or auger; when adding filter pack below the water table or to a deep well, a tremie pipe should be used;

- add the filter sand until it extends no more than 2.0 feet inside the auger or casing, then pull the casing upward allowing the filter sand to flow from the bottom, filling the resultant annular space. Frequent depth measurements should be taken using a weighted tape to verify the effectiveness of this procedure. The augers or casings should not be extracted in greater than 2.0 foot increments to minimize the potential for native sediments to cave or slump into the annular space;

- continue placing the filter pack until it extends above the screen for a distance equal to approximately 20% of the total screened interval, but not less than 2.0 feet above the top of the screen. Where there is a hydraulic connection between the zone to be monitored and the overlying strata, this upward extension of the filter pack should be minimized, subject to the construction described above, to prevent seepage from upper zones which may result in less than representative sampling;

- it is optional to place a secondary, finer filter pack directly above the first to prevent intrusion of the bentonite seal into the primary filter pack. This filter pack should be designed with a vertical thickness ranging between 0.5 and 2.0 feet. As with the primary filter pack, the secondary filter must not extend into an overlying hydrologic unit. The need for this filter pack should consider the gradation of the primary filter pack, the hydraulic heads between adjacent units, and the potential for grout intrusion into the primary filter pack;

- place an annular sealant seal directly above the filter pack(s) while continuing to remove the augers or casing in 2.0 foot increments. This seal consisting of bentonite pellets or chips, should extend a minimum of 3.0 feet above the top of the filter pack. Frequent depth measurements should be taken using a weighted tape to verify the efficiency of this procedure.

- pour water of a known chemistry over the bentonite pellets or ships if the seal is located in the vadose (unsaturated) zone (i.e., above the water table) to hydrate the bentonite. Record the amount of water added during this procedure for corrected well water removal during well development (PSC-121).

- fill the remaining annular space with a bentonite grount slurry continuing to remove the augers or casing in two foot increments. The slurry should extend to approximately 5.0 to 6.0 feet below ground surface and all augers or casing should be withdrawn. Allow 24 hours to settle and set;

- top-off the grouted column to 5.0 to 6.0 feet below the ground surface and allow to set overnight.

6.0 Standard Surface Finishing Designs

The following defined our standard "flush mount" and "stand pipe" monitoring well finishing procedures:

7.1 Standard Flush Mount Finish

This finishing design (Figure 2) is used when monitoring wells are installed in high traffic areas or other areas where a low profile design is needed. Flush mount wells are less preferable than stand pipe wells because there is a greater chance of surface water entering a flush mount well. The standard flush mount finish is constructed as follows:

- add filter sand to the annular space above the grouted column to a depth of approximately 3.5 feet below ground surface;
- center a 4.0 foot length of 4 or 5 inch diameter steel casing, with locking steel cap into the bore hole. This casing should be placed so that the locking lid rests approximately 2 inches above the top of the capped well riser, and is seated a minimum of 6 inches into the filter sand;
- place a bentonite seal using water of known chemistry;
- place filter sand in the annular space between the well riser and the steel casing to a depth of 1.0 foot below ground surface;
- center a 13 inch diameter, aluminum cast, manhole-type cover equipped with a water tight gasket and a 1.0 foot aluminum vertical extension, over the locking steel casing. The top of the aluminum cover should be approximately a ¼ inch above the ground surface;

- add grout to the excavated area, allowing the grout to flow into the annular spacing surrounding the steel casing. Fill the excavation evenly to a depth of approximately 8 inches below the ground surface and allow to settle and set (to shorten the setting time, the use of adding "quick-set" to the grout is acceptable). The bottom few inches of the aluminum cover should be seated in the cement;

- add cement to the excavated area surrounding the aluminum cover until the cement is flush with the ground surface. Gently grade and smooth the cement from the edge to the cover, so that runoff is away from the well and allow to set;

- permanently identify the well by labeling the cement pad, aluminum cover and lid to the locking steel casing; and

- secure well with an approved brass or hardened-steel lock.

7.2 Standard Stand Pipe Finish

This finishing design (Figure 3) is used when the flush finish design is not needed. The standard stand pipe finish is constructed as follows:

- add filter sand to the annular space above the grouted column to a depth of approximately 1.5 feet below ground surface;

- center a 5.0 foot length of 4 or 5 inch inside diameter steel casing, with locking steel cap into the bore hole. This casing should be placed so that the locking lid rests approximately 2 inches above the top of the capped well riser, and is seated a minimum of 6 inches into filter sand;

- place filter sand in the annular space between the well riser and the steel casing to ground surface;

- excavate a 2.5 foot square which measures approximately 6 inches deep around the edges and grades deeper with depth at a slope of approximately 45° toward the bore hole. Take care to minimize the deposition of soil into the annular space outside the steel casing;

- using 2' x 6' lumber, construct a 3.0 foot square wooden frame and insert the frame into the excavation. Situate the frame so that all edges are flush with the ground surface;

- place three 3.0 foot long steel bumper guards in the excavation to protect the stand pipe from damage resultant from vehicular traffic on the line;

- add cement to the excavated area, allowing the cement to flow into the annular spacing surrounding the steel casing, until the cement is flush with the ground surface. Gently grade and smooth the cement from the edge to the casing, so the runoff is away from the well, and allow to set (to shorten the setting tiem, the sue of adding "quick-set" to the cement is acceptable under cold weather conditions);

- permanently identify the well by labeling the cement pad, stand pipe and lid to the locking steel casing; and,

- secure well with an approved brass or hardened-steel lock and record key number in field log book.

8.0 Documentation

Documentation of all monitoring well installation activities including all geotechnical forms and the maintenance of a detailed field notebook will be recorded in accordance with Standard Operating Procedure PSC-400.

9.0 Measure of Proficiency

Field staff will demonstrate proficiency on this SOP by successfully completing Sections 6.0, 7.0 and 8.0 a minimum of twice under the direct supervision of the Corrective Actions Manager or a designee.

JSA Title:		Well Abandonment – Chip in Place					
Step No: order	**Sequence of Job Steps** Break down Job into steps.	**Potential Hazards & Impacts** Identify hazards faced at each step of the task. Identify what may happen if the hazard is not effectively controlled.	**Risk Rating** pre action	**Procedure or action required** Determine the actions necessary to reduce risk to an acceptable level. Record responsibility for the action as applies	**Risk Rating** post action	**Responsible Person(s) - Initials**	**Mitigation on Steps Verified**
1	Unload tooling	Exertion - strain and sprains Contact with pinch points	8	• Wear all required PPE • Buddy system for awkward or heavy objects over 50 lbs. • *Use "Safety In Motion" Training* • Watch hand placement	3		
2	Remove well box	OE, SB – jackhammer use, flying debris	8	• Set up exclusion zone and ensure adequate protection from traffic and pedestrian interference. • Refer to JSA Jackhammer Use. • Refer to JSA Well Box Removal	3		
3	Back fill with bentonite chips	Exertion - back strain Fall - Create tripping hazard	5	• Use proper lifting techniques lifting 50 lbs. bags. • Fill hole with bentonite chips to 2 ft. below surface. Do not overfill. • Hydrate chips completely to prevent future swelling of chips. • Use an adequate amount of concrete on top of chips. • Overfilling with bentonite chips, failing to properly hydrate chips, and using an inadequate amount of concrete, can all cause future "eruption" of surface layer resulting in a trip hazard.	3		

JSA Title:	Well Destruction – Pressure Grout with Drill Rig						
Step No: order	**Sequence of Job Steps** Break down Job into steps.	**Potential Hazards & Impacts** Identify hazards faced at each step of the task. Identify what may happen if the hazard is not effectively controlled.	**Risk Rating** pre action	**Procedure or action required** Determine the actions necessary to reduce risk to an acceptable level. Record responsibility for the action as applies	**Risk Rating** post action	**Responsible Person(s) - Initials**	**Mitigation on Steps Verified**
1	Remove well box	Contact - Flying debris Exertion - Back strain	12	• See JSA Jackhammer Use if appropriate • Communicate with co-workers and make sure nobody is in the way • Stretch before lifting, get assistance with heavy (>50 lbs.) or awkward objects • Use appropriate tools such as hand trucks, booms, lift trucks, etc. • Use “Safety In Motion” Training	6		
2	Mix Grout	Exposure - Dust inhalation Exertion - Back Strain from removing Whirlybird mixer	8	• Avoid breathing dust, stand upwind. • Do not lift and twist at the same time. Lift the mixer all the way out. Point your toes in the direction you are turning. • If you are not tall enough to lift it all the way out before twisting, use the buddy system. • Use “Safety In Motion” Training	3		
3	Hook up pressure grout system	Contact - smashed fingers due to system binding up	5	• Make sure coupler is properly seated all the way down on casing • Secure manifold with auger bolt to spindle • Never pressure grout any well unless you can get your drill head on it • Use “Show Your Hands” procedure	3		
4	Pressure up grout system	Contact - Injury due to casing blowout Contact - Flying dirt/mud	12	• Whip checks must be used on all pressurized hose connections • Inspect casing for cracks and breaks • Use and watch pressure gauge, Do not exceed 50 psi • Back away from system while pressuring up • Safety Glasses required	6		
5	Disconnect air hose/ remove manifold	Contact Struck by air hose	8	• Check gauge to make sure pressure is reduced to below 5 psi • Be aware of pressure still in casing when removing manifold	3		
6	Remove the top 5 ft. of well	Contact with flying debris due to breaking casing	8	• Make sure everybody but the Driller is at least 10 ft. away • Driller should be aware of possible flying debris	3		
7	Cap hole with concrete	Exposure- Cement dust	8	• Avoid breathing dust • Wash hands before you eat or drink	3		

Measuring Water and NAPL Elevations, and Total Depths

SOP No. PSC-120
Origination Date: 4/28/98
Revision No. 3 10/29/02

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Joe Depner	Carolyn Mayer		Tasya Gray Lou La Rosa	

This standard operating procedure (SOP) contains the following sections:

1 Purpose

The purpose of this SOP is to provide personnel with the specific information needed to collect and document consistent and representative data on liquid levels at, and total depths of, monitoring wells and piezometers.

2 Application

This SOP shall be followed by all personnel who measure liquid levels at, and total depths of, monitoring wells and piezometers at the following PSC facilities in Washington state: Seattle (Georgetown), Kent, Tacoma, Washougal.

3 References

Yeskis, D. and B. Zavala. May 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. EPA Office of Solid Waste and Emergency Response. EPA 542-S-02-001.

U.S. EPA. Nov 1992. RCRA Groundwater Monitoring: Draft Technical Guidance. Office of Solid Waste. EPA/530-R-93-001.

4 Associated SOPs

PSC-124 – Low-Flow Groundwater Sampling Procedure
PSC-200 – Equipment Decontamination Procedure
PSC-300 – Photoionization Detector Calibration and Operation
PSC-400 – Documentation Procedures

5 Terminology

The following terminology is used in this SOP:

"NAPL" means nonaqueous-phase liquid. "DNAPL" and "LNAPL" mean dense and light NAPL (described below), respectively.

"Wells" means groundwater-monitoring wells and piezometers.

"Liquid levels" means the elevations of fluid interfaces in wells. These include the following:

The "LNAPL level" is the elevation of the air/LNAPL interface, if floating LNAPL is present.

The "water level" is either (1) the elevation of the air/water interface if LNAPL is absent, or (2) the elevation of the LNAPL/water interface if LNAPL is present.

The "DNAPL level" is the elevation of the water/DNAPL interface, if DNAPL is present.

The level is measured as the depth of the interface, from the well's measuring point (MP).

6 Equipment and Supplies

The following equipment and supplies are necessary to properly measure liquid levels and total depths:

- Equipment required to open the well monuments (e.g., padlock keys, well keys, hand drill, socket set, Allen wrenches or other tools).
- A photoionization detector (PID) or similar instrument to monitor the well headspace.
- An electric water-level indicator and/or an electric oil/water interface detector. Each such instrument must have a chemically inert suspension line that is graduated in 0.01-foot increments and sufficiently long to reach the bottom of the well.
- Fully charged batteries for each battery-powered instrument.
- An accurate and reliable watch that has been properly set.
- Documentation materials as described in SOP PSC-400.
- Health-and-safety equipment and supplies (e.g., personal protective equipment [PPE]) as described in the relevant site health-and-safety plan (HSP).
- Decontamination equipment and supplies as specified in SOP PSC-200.

Although not essential, the following items are useful for verifying the correctness of field measurements:

- A construction (as-built) diagram for each well, showing the well's total depth and its screened interval.
- A table or graph (e.g., a well hydrograph) of field measurement results (liquid levels, total depth) from previous monitoring events, for each well.

7 Procedures

7.1 Simultaneity of Measurements

If liquid-level measurements are to be completed at a group of wells at a site, then complete the entire set of measurements for the group within a single business day. In addition, if any of the wells at a site are screened in tide-influenced hydrogeologic units, then complete the set of measurements corresponding to those wells within a single one-hour period. To facilitate compliance with this requirement, the water-level field form for each site shall identify those wells screened in tide-influenced units.

7.2 Order of Completion

At each well, complete the liquid-level and total-depth measurements in the following order:

1. LNAPL level
2. water level
3. DNAPL level
4. total depth

7.2.1 Special Instructions for Wells with Dedicated Pumps

The instrument access ports on some dedicated pumps will not accommodate some probes (e.g., most oil/water interface probes). If so, the pump must be removed from the well to measure the DNAPL level and the total depth. At wells with dedicated pumps, complete the measurements in the following order:

1. Measure the water level.
2. Remove the pump from the well and place it in a clean plastic bag.
3. Allow the liquid levels to stabilize.
4. Measure the DNAPL level.
5. Measure the total depth.

7.3 Pre-Measurement Procedures

On arrival at each well, complete the following steps in the order listed:

1. Don appropriate PPE as described in the site HSP.
2. Remove any debris (e.g., soil, vegetation, or refuse) and any standing water from the well opening, to prevent foreign matter from entering the well.
3. Open the well monument.
4. Vent the well by carefully removing the well cap. Record the time at which the well is initially vented to the atmosphere (i.e., the time at which the well cap is removed). If the gas in the well casing appears to have been over-pressurized or under-pressurized relative to the atmosphere, then note this in the field book.

Caution (1): Never put your face, head, or any other body part over the well when venting it. If possible, vent the well gradually, so the cap does not become airborne.

Caution (2): Handle monitoring wells with care at all times. If it is necessary to apply lift or torque to a well cap to remove it (e.g., if the casing is airtight and under a vacuum), then be extremely careful to prevent the well casing from being raised or rotated.

5. Immediately after removing the well cap, monitor the headspace within the well using the PID (see SOP PSC-300 for PID operation). Do this by placing the instrument probe at the opening of the well, and recording the reading in the field book and on the appropriate field forms.

6. Wait at least 20 minutes from the time the well is vented, to allow the liquid levels in the well to equilibrate to the current atmospheric pressure, before measuring liquid levels. At some wells it may be necessary to vent for longer periods.

7.4 General Measurement Procedures

Each liquid level measurement involves lowering an instrument probe into the well, until the instrument emits the appropriate response, indicating the probe has reached the desired fluid interface in the well. Depending on the type (manufacturer and model) of instrument, the response may be audible (e.g., a tone is steadily or intermittently emitted), visible (e.g., an indicator light is steadily or intermittently illuminated), or both. Consult the instrument's operating manual for details. The probe is attached to the body of the instrument by a flexible suspension line consisting of a graduated "tape" or coaxial cable that sheathes an electric conductor. After lowering the probe to the appropriate level in the well (see below), hold the upper end of the graduated tape against the well's MP and read the numeric value off the tape. Record all of the measurements to the nearest 0.01 foot below the well's MP. If the MP is not clearly marked (typically by a notch cut into the top of the well riser), then measure all levels from the top of the north side of the riser or dedicated pump.

Duplicate each liquid-level and total-depth measurement in the field to ensure that the reading is accurate. Record all results (times, measured values, etc.) both in the field book and on the water-level field form.

7.5 Measuring LNAPL Levels

LNAPLs are NAPLs that are less dense than water. In the subsurface, free-phase LNAPL tends to accumulate on the water table. Free-phase LNAPL that enters a well tends to accumulate on the air/water interface. Some wells routinely contain LNAPL. Typically, the thicknesses of the LNAPL layers in such wells are measured at the same time the water levels are measured.

Use an oil/water interface detector for the measurement. Turn the detector on. Then slowly lower the probe into the well. In some cases a very thin (~ 0.01 foot) layer of LNAPL may accumulate on the air/water interface in the well, so the probe must be lowered very slowly if the

LNAPL layer is to be detected and accurately measured. The oil/water interface detector emits one type of response to indicate that the probe has contacted NAPL, and a different type of response to indicate that the probe has contacted water. First, lower the probe until the air/LNAPL interface is detected. Measure the depth to the interface. Record the result. Record "sheen" if the instrument detects an LNAPL layer whose thickness is less than 0.01 foot.

7.6 Measuring Water Levels

Measure water levels using either an oil/water interface detector or, if no LNAPL is present, using an electric water-level indicator.

7.6.1 Measuring Water Levels Using the Oil/Water Interface Detector

After measuring the depth to LNAPL in the well, and before retrieving the probe from the well, slowly lower the probe further into the well. When the LNAPL/water (or air/water) interface is detected, measure the depth to the interface. Record the result.

7.6.2 Measuring Water Levels Using the Electric Water-Level Indicator

Turn the water-level indicator on. Manually adjust the sensitivity to a medium level. Slowly lower the indicator probe into the well until the indicator emits a short audible tone, indicating the probe has contacted the air-water interface. Measure the depth to the interface. Record the result.

7.7 Measuring DNAPL Levels

DNAPLs are NAPLs that are denser than water. In the subsurface, free-phase DNAPL tends to sink below the water table. Free-phase DNAPL that enters a well tends to sink to the bottom of the well. DNAPL levels are measured at some wells at the same time that the water levels are measured. Use an oil/water interface detector to measure the DNAPL level as described below.

If the well does *not* have a dedicated pump, then after measuring the water level in the well, and before retrieving the probe from the well, slowly lower the probe further into the well. If the well *does* have a dedicated pump, then after the pump has been removed from the well and the liquid levels in the well have been allowed to stabilize, slowly lower the probe into the well.

When (if) the water/DNAPL interface is detected, measure the depth to the interface. Record the result.

7.8 Measuring Well Total Depths

For measuring well total depths, complete the following steps in the order listed:

1. Lower the instrument (water-level indicator or oil/water interface detector) probe to the bottom of the well to measure the well's total depth.

2. Gently bounce the probe on the well bottom to determine when the probe is at the bottom of the well, and take up the slack on the suspension line.

3. Measure the total depth. Record the result.

7.9 Post-Measurement Procedures

After all of the measurements have been made at a well, and the results have been recorded, complete the following steps in the order listed:

1. Retrieve the instrument (water-level indicator and/or the oil/water interface detector) suspension line and probe from the well, and simultaneously decontaminate the instrument suspension line and probe (see below).

2. If the well has a dedicated pump that was removed to complete the measurements, replace the pump.

3. Close (seal) and secure the well.

4. Record any well integrity concerns in the field book and on the well maintenance form.

8 Decontamination

Decontaminate all equipment that may come in contact with the well water or NAPL, at the following times:

- prior to, or on, arrival at the site
- on moving from one well to another, on site
- immediately prior to exit from the site.

Follow the decontamination procedures given in SOP PSC-200.

9 Documentation

Record all measurement results (liquid levels, total depth, and time of measurement) on the appropriate field forms and field notebook. Follow the documentation procedures given in SOP PSC-400.

10 Measure of Proficiency

Field staff shall demonstrate proficiency on this SOP by successfully completing sections 7, 8, and 9 at least twice under the direct supervision of the Corrective Actions Manager or her/his designee.

Monitoring Well Development

Written By:	Edited by:	Approved By:	QA Concurrence:
Carolyn Mayer	Tasya Gray	Carolyn Mayer	Kevin McNeil
11/23/97	**1/22/02**	7/24/01	7/24/01

This SOP contains nine sections:

1.0 Purpose

The purpose of this SOP is to provide field personnel with a set of guidelines to assure proper monitoring well development. According to EPA all monitoring wells should be developed to create an effective filter pack around the well screen, to rectify damage to the formation caused by drilling, to remove fine particulates from the formation near the borehole, and to assist in restoring the natural water quality of the aquifer in the vicinity of the well.

2.0 Application

This SOP provides a step-by-step guideline to be followed by the field sampling crew for performing or overseeing monitoring well development.

3.0 References

RCRA Groundwater Monitoring Draft Technical Guidance (Nov. 1992) EPA/530-R-93-001

4.0 Associated SOPs

PSC-200 – Equipment Decontamination Procedure
PSC-300 – Photo-ionization Detector Calibration and Operation
PSC-400 – Documentation Procedures

5.0 Equipment

The following equipment is necessary to properly develop a ground water monitoring well:

- A well key, hand drill, socket set, pad lock key, or other well access equipment.
- A calibrated photo-ionization detector (PID) to monitor and record the well headspace.
- An electric water meter and oil/water interface probe calibrated to a hundredth of a foot, and sufficiently long to reach the bottom of the well.
- Well purging equipment (e.g. bailer, silicone line, PVC pipe, plug, pump, tubing, power supply, and extension cord), as needed.
- A solid PVC surge block.
- A sufficient number of 55-gallon drums (including lids, gaskets, and fasteners) to contain all purge water, unless other water handling arrangements have been made.
- A calibrated water quality meter that measures temperature, pH, specific conductivity, dissolved oxygen, redox potential, and turbidity.
- All required documentation including sample labels, field books, sampling forms, and chains-of-custody.
- Personal protective equipment as described in the Site Health and Safety Plan.

- Decontamination equipment as specified in the Work Plan.

6.0 Decontamination

All equipment that will come in contact with the well water will be decontaminated prior to arrival on site, relocation on site, and site exit. Standard Operating Procedure PSC-200 shall be followed.

7.0 Well Development Procedures

Upon arrival at each well, the following procedures shall be followed:

- Suit up in appropriate personal protective equipment as described in the Site Health and Safety Plan.

- Brush any soil or vegetation and pump any standing water away from the well opening.

- Lay plastic sheeting around well to place equipment on and keep cords, tubing and pumps from touching the ground.

- Open the well cap.

- Monitor the headspace within the well using the PID (PSC-300 for PID operation). This is done by placing the instrument probe at the opening of the well, and recording the reading in the field book and on the appropriate field forms.

- Measure and record the depth to LNAPL, water, DNAPL, and total depth of the well using a decontaminated oil/water interface probe or water level indicator (depending on the historical presence of NAPLs in the well). All LNAPL and DNAPL measurements are to be made in accordance with PSC-120. Measurements are to be made to the nearest one hundredth of a foot and recorded in the field book and on the appropriate field form.

- Compute the unit purge volume using the following formula and the input values on the attached Well Volumes Sheet.

  1 well volume (including annular space) = [x(total well depth – water level)] + [(y **x 0.40)**(total well depth – bottom of seal)]

where "x" is the Casing/Riser Volume per Unit Length, Internal (gal/ft), "y" is the Annular Volume per Unit Length (gal/ft), **and 0.40 is a conservative estimate of the porosity of the sand pack.**

7.1 New Well Development Procedure

- If a submersible pump is to be used for well development, gently lower the pump to the well bottom. If a non-submersible pump is used, lower the tubing to the bottom of the well.

- Begin to purge the well at a rate sufficient to remove fines, slowly run the pump up and down the well over the length of the screen, and initiate physical water quality testing at least every 20% water removed for temperature, pH, conductivity, dissolved oxygen, and turbidity.

- A minimum of three and maximum of five well volumes (including annular space) will be removed. If this is the first time the well has been developed and water was used in the drilling process, the volume of water introduced into the formation during well formation must also be removed during development. *Purging is completed once the following has occurred:*
  - *the minimum purge volume has been removed and the water quality parameters have stabilized by the following screening requirements for three consecutive readings: Turbidity <5 NTU, specific conductivity within 10% of each other, and pH within 0.5 units; OR*
  - *the well runs dry; OR*
  - *five purge volumes and drilling process water volumes have been removed.*

- Measure total depth of well after development.

- Containerize all purge water in 55-gallon drums, unless other handling arrangements have been made.

- Record additional information such as unique odors or water color, and a description of the suspended particle content in the field notes and on appropriate field forms.

- Upon completion of development, both the well and the purge drums are to be properly sealed and secured.

- All drums are to be permanently labeled as follows:
  Well ID
  Facility Name
  Drum Contents
  Date
  Drum Number

- Close the well appropriately and record any well integrity concerns in the field book and on the sampling form.

7.2 Existing Well Development Procedure

- Remove pump from well.

- Attach one length of twine to the surge block or use a drill rig or tripod and lower it to the bottom of the well.

- Vigorously begin moving the surge block up and down in the well creating a surging action across the screened interval. This action will bring the finer grained materials into suspension.

- Remove the surge block.

- Begin to purge the well at a sufficient rate to remove fines and initiate physical water quality testing at a minimum of every 20% water removed for turbidity.

- Repeat surging and purging to reduce silt presence in water and keep checking total depth measurements.

- A minimum of three and maximum of five well volumes (including annual space) will be removed. *Purging is completed once the following has occurred:*
  - *the minimum purge volume has been removed and the water quality parameters have stabilized by the following screening requirements for three consecutive readings: Turbidity <5 NTU, specific conductivity within 10% of each other, and pH within 0.5 units; OR*
  - *the well runs dry; OR*
  - *five purge volumes and drilling process water volumes have been removed.*

- Measure total depth of well after development.

- Containerize all purge water in 55-gallon drums, unless other handling arrangements have been made.

- Record additional information such as unique odors or water color, and a description of the suspended particle content in the field notes and on appropriate field forms.

- Upon completion of development, both the well and the purge drums are to be properly sealed and secured.

- All drums are to be permanently labeled as follows:
  Well ID
  Facility Name
  Drum Contents
  Date
  Drum Number

- Close the well appropriately and record any well integrity concerns in the field book and on the sampling form.

8.0 Documentation

Documentation of all monitoring well development activities including all field forms and the maintenance of a detailed field notebook are described in PSC-400.

9.0 Measure of Proficiency

Field staff will demonstrate proficiency on this SOP by successfully completing sections 6.0, 7.0, and 8.0 a minimum of twice under the direct supervision of the Corrective Actions Manager or her/his designee.

Low-Flow Groundwater Sampling Procedure
SOP No. PSC – 124
Origination Date: 11/23/97
Revision Date: 12/1/09
Revision No.5

Written By:	Edited by:	Approved By:	QA Concurrence:	Date:
Carolyn Mayer	Jimmy McKechnie	Lou La Rosa	Lou La Rosa	12-1-09

This SOP contains nine sections:

1 Purpose

The purpose of this SOP is to provide personnel with the specific information needed to consistently collect and document representative groundwater samples for laboratory analyses from monitoring wells using a low-flow groundwater sampling technique.

The purpose of low-flow groundwater sampling is to collect a groundwater sample that is representative of actual site conditions. Therefore, the purge rate is designed to be low enough to simulate actual groundwater flow and to pull water from a discrete zone near the pump intake into the pump rather than pulling groundwater from a large area around the well or outside of the screened area of the well. A low purge rate is also intended to reduce the possibility of stripping volatile organic compounds from groundwater and to reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

2 Application

This SOP applies to groundwater sampling of permanent monitoring wells at PSC facilities that are undergoing RCRA Corrective Action in Washington State.

The basis for choosing low-flow sampling methodology for these sites is that all of the sites have defined groundwater plumes and wells that are accurately screened in the known plume areas.

3 References

U.S. EPA. 1992. RCRA Groundwater Draft Technical Guidance.

U.S. EPA, Region I. 30 July 1996. SOP GW-0001, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

Puls, R. and M. Barcelona. April 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. U.S. EPA. EPA/540/S-95/504.

Wilde, F.D., D.B. Radtke, J.Gibs and R.T. Iwatsubo, eds. 1998. *National Field Manual for the Collection of Water-Quality Data*; U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, variously paginated.

Wilkin, R.T., M.S. McNeil, C.J. Adair and J.T. Wilson. 2001. Field Measurement of Dissolved Oxygen: A Comparison of Methods. *Ground Water Monitoring and Remediation*, Vol. 21, No. 4, pp. 124-132.

Phoenix Health and Safety, Inc. January 2001. Site Health and Safety Plan – Corrective Actions Group.

PSC, 2002. Groundwater Sampling Field Manual. (Updated Annually)

4 Associated SOPs

PSC-120 – Measuring Water, LNAPL, and DNAPL Elevations
PSC-200 – Equipment Decontamination Procedure

PSC-300 – Photoionization Detector Calibration and Operation
PSC-302 - Hach Digital Titrator and Colorimeter Procedures
PSC-303 – LaMotte Turbidimeter Calibration and Operation
PSC-305 – Hydrolab Surveyor 4 Water Quality Data Logger, FC 5000 Data Sonde Flow-Through Cell Calibration and Operation
PSC-400 – Documentation Procedures

5 Equipment

The following equipment is recommended for properly sampling a groundwater monitoring well:

- A Groundwater Sampling Field Manual that includes a map of well locations, sampling plan, appropriate SOPs and well construction information.
- A well key, hand drill, socket set, padlock key, or other well access equipment.
- A calibrated photoionization detector (PID) or similar device (and calibration gases), to monitor volatile constituents in the well headspace and breathing zone.
- An electric water-level indicator and/or oil/water interface detector calibrated to 0.01 foot, and sufficiently long to reach the bottom of the well.
- A weighted tape measure (Oil/Water Interface Indicator) for determining total depths of wells, when this is required.
- Well purging equipment (e.g.; pump, converter, tubing, power supply and extension cord).
- A sufficient number of containers (e.g., 55-gallon drums with lids, labels, gaskets, and fasteners) to store all purge water, unless other water handling arrangements have been made.
- A calibrated flow-through water-quality meter(s) and calibration solutions to measure, pH, specific conductivity, and oxidation-reduction potential (ORP).
- An instrument and calibration solutions to measure turbidity.
- In-line disposable 0.45 micron filters, if necessary, for metals analyses when

Turbidity is > 5 NTU's.

- A sufficient number of sampling containers, including containers for regular samples and quality control samples (e.g., field blanks, equipment blanks, duplicates, trip blanks, and matrix spike/matrix spike duplicates).

- All required documentation including weather proof sample labels, weather proof field books, sampling forms, chain-of-custody (COC) forms, weatherproof pens and paper for sampling forms, and COC seals.

- Personal protective equipment (PPE) described in the site health and safety plan.

- Decontamination equipment as specified in SOP PSC-200.

- Water flow-rate measurement equipment (e.g., flow meter, or graduated container and stopwatch).

- Sampling support equipment and supplies (e.g., sample coolers, clean bagged ice, bubble wrap and VOC bottle holders, clear tape, plastic locking bags, razor knives, garbage bags, paper towels, deionized water, nitrile gloves, disposable 0.45 micron in-line filter, five-gallon buckets, clean fold out table for sample bottles and equipment, fabricated foam spill berm equivalent to 5 gallon bucket) as needed.

6 Decontamination

All reusable equipment that will contact the well and/or water samples will be decontaminated prior to its use, according to the procedures described in SOP PSC-200.

7 Well Sampling Procedures

7.1 Set Up

On arrival at each well, the following procedures shall be followed:

- Don appropriate PPE & safety vests as described in the site health and safety plan.

- Remove any soil or vegetation, and standing water from the well monument casing. Check the well condition, making sure the flexible gasket seals are clean and intact. If applicable, also check the condition of the dedicated pump cap. Record any problems in the field book and the appropriate field forms.

- Place fabricated foam spill berm on the ground next to the well, and place the sampling equipment and bottles on a clean fold out table to keep them from touching the ground.

- Remove the well cap.

- Monitor the headspace within the well using a PID or similar instrument (see SOP PSC-300 for PID operation). Record the reading in the field book and on the appropriate field form(s).

- Set up the pump, converter, and flow-through cell and turbidity meter in preparation for purging. Connect the discharge line from the pump to a flow-through cell. A "T" connection is needed in the tubing between the pump discharge line and the influent flow-through cell to allow for the collection of water for the turbidity measurements, using a turbidimeter or similar instrument. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the well.

- Record the depth of the pump intake on the sampling form and/or in the sampling field book. The Groundwater Sampling Field Manual should specify the pre-determined depths for the pump intakes. The dedicated pump intake is set at the interval within the screen where the contamination is known to exist. Check with the project manager if there is uncertainty regarding this issue. If the well doesn't have a dedicated pump, (e.g.; well with dedicated tubing for use with a Parastaltic Pump) the tubing should be lowered into the well alongside of a weighted measuring tape or water-level indicator to ensure that the intake of the pump is set at the appropriate depth.

- Measure and record the depth to water using a decontaminated water-level indicator or oil/water interface detector to the nearest 0.01 foot, in accordance with SOP PSC-120. Record the reading in the field book and on the appropriate field form(s). Calculate the volume of water in the casing and the screened interval. The following equation is used to calculate the well volume:

$$V = V_{casing} \text{ (well depth - static water depth)}$$

where:
V_{casing} = casing volume per unit length
(e.g., ~ 0.17 gal/ft for two-inch casing)

(The Groundwater Sampling Field Manual includes all well specifications necessary for this calculation.)

- Before purging, adjust the pumping rate to its lowest setting, and set the data logger in the flow-through cell to record readings every three minutes.

7.2 Purging Monitoring Wells

7.2.1 Purging Procedure

Measure the initial (static) water level in the well and record the reading on the field form(s). All wells have dedicated tubing that will be used for both purging and sampling.

Start the pump at a flow rate of 200 to 500 mL/min. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 foot. The flow rate can be measured using a graduated cup and a stop watch.

To determine water-level stability, subtract the second water-level reading (not the static water-level reading) from the current water-level reading to determine the current drawdown.

After the flow rate is stable, record the water level and the flow rate every three minutes. Record water levels more frequently if the rate is being adjusted. A drawdown less than 0.33 foot is preferred but may not always be possible. If the drawdown exceeds 0.33 foot at low flow rates (≤ 500 mL/min), lower the flow rate as practical (not to drop below 100 mL/min) to reduce the drawdown.[*]

Begin recording water-quality parameters after all water has been purged from the sample

---

[1] *The 0.33-foot drawdown goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. The water levels in water-table wells should not be allowed to drop below the pump intake. In all other cases, the water level should not be allowed to drop below the top of the well screen. If the water table drops below one of these minimum values, the pump should be turned off and the water level should be allowed to recover. See section 7.2.2, fifth bullet for more information.*

tubing, pump, and flow-through cell. Initiate water-quality testing for temperature, pH, specific conductivity, DO, ORP and turbidity. Record water-quality parameters every three minutes.

7.2.2 Purging Requirements

Sampling cannot begin until the drawdown is no greater than 0.33 foot, and all water-quality parameters are stable. Each water-quality parameter is considered stable when it satisfies the corresponding stability criterion specified in the table below.

Water-Quality Parameter	Stability Criterion
Turbidity	{X} < 5 NTU or RPD < 10 % for values {X} > 5 NTU
Dissolved Oxygen	$\Delta \leq 0.3$ mg/L
Specific Conductivity	RPD ≤ 3 %
ORP	$\Delta < 10$ mV
Temperature	$\Delta < 3\%$
pH	$\Delta < 0.1$ unit

Where: {X} = the last three water-quality readings

$$m = \text{mean} = \frac{\text{Max } \{X\} + \text{Min}\{X\}}{2}$$

$$\Delta = \text{Max } \{X\} - \text{Min } \{X\}$$

$$\text{RPD} = \frac{\Delta}{m} \times 100\%$$

In some circumstances, the well may not stabilize according to the above criteria, but the well can be sampled if one of the following conditions occurs:

- Wells are unable to meet stability criteria due to equipment accuracy. The accuracy of the instruments will often limit the ability to achieve stabilization on a percentage basis. For example, if the ORP is consistently fluctuating between 1 and 15 mV, then $\Delta = 14$ mV, which is not within the requirements for stability. However, the accuracy

of the instrument currently used is +/- 20 mV. Therefore, in this case the stability criterion would be considered satisfied within the range of accuracy of the equipment. This is particularly important when the water-quality parameter values are low. Examples of accuracy limits for the equipment that is currently used (e.g.; Hydrolab Surveyor 4 Water-Quality Data Logger and Hydrolab FC 5000 Data Sonde flow-through cell, and the LaMotte 2020e Turbidimeter) are provided here for reference. However, if another instrument is used, field personnel must consult the instrument's manual to determine its accuracy.

Water-Quality Parameter	Equipment Accuracy
Turbidity	+/- 0.02 NTU
Dissolved Oxygen[2]	+/- 0.2 mg/L
Specific Conductivity	+/- 0.001 mS/cm
ORP[2]	+/- 20 mV
pH	+/- 0.2 unit

- Wells for which all water-quality parameters have stabilized may be sampled if it is clear that the drawdown will not stabilize before the water level drops below the minimum allowable value (i.e., pump intake, or top of screen if aquifer is confined).

- If collecting metals samples and all water-quality parameters except turbidity stabilize, it is acceptable to collect filtered and unfiltered metals samples without waiting for turbidity to stabilize or for one well volume to be purged. A filtered sample should be collected using a disposable 0.45 micron in-line filter. If there are no directions on the filter for rinsing, then a minimum of 0.5 liter of groundwater from the well should be run through the filter prior to collecting the sample.

- Water-quality parameters are not stable, but at least one well volume of water has been removed from the well. See the equation in Section 7.1.

- The water level drops below the minimum value (i.e., the pump intake, or the top of the screen if the aquifer is confined) during purging. In this case, the pump

[2] If the final dissolved oxygen measurement is less than 1 mg/L, a sample should be collected and analyzed by the spectrometric, colorimetric or Winkler titration methods.
[3] ORP may not always be an appropriate stabilization parameter, depending on site conditions. The project manager may designate wells in the Groundwater Sampling Field Manual that will not require ORP measurements.

should be turned off and the well should be allowed to recover. As long as a minimum of two tubing volumes (including the tubing and pump) has been removed from the well, then the well should be sampled as soon as the water level has recovered sufficiently to collect volume of groundwater necessary for all samples. Use the following equations to determine the minimum volume of groundwater to be removed prior to sampling when this problem occurs:

Minimum purge volume = 2 [500 mL + M (length of tubing in feet)]
where M is the volume (in mL) contained in a one-foot length of tubing

For tubing of various inner diameters, M is equal to:

Inner Diameter	M
1/8"	2.4
¼"	9.7
½"	39

This is acceptable even though the water-quality parameters have not stabilized and one well volume has not been removed.

Record in the field book and field form if any monitoring wells did not meet the stabilization and drawdown criteria and describe the rationale for sampling the well at the time it was sampled.

7.3 Sampling Procedure

Do not stop pumping after the purging requirements have been met. Don clean nitrile gloves. Disconnect the sampling tube from the influent flow-through cell. All wells have dedicated tubing that will be used for both purging and sampling. Collect each sample directly from the dedicated tubing. Minimize the turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container.

The sampling flow rate may remain at the established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 500 mL/min are appropriate.

When collecting the dissolved gas samples (e.g. volatile organic compounds, total petroleum hydrocarbons – gasoline range, or methane/ethane/ethane) the following

procedures should be followed:

- The tubing should be completely filled with water to prevent the groundwater from being aerated as it flows through the tubing.
- A meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and headspace prior to capping.

Samples do not have to be collected in a particular order unless unfiltered metals samples are collected, in which case they should be collected last.

7.4 Post-Sampling Procedures

After all of the samples have been collected in containers that are labeled and appropriately treated with preservatives, the following tasks should be completed:

- Measure and record the depth to water to determine total drawdown. Record the estimated total volume of water purged from the well.
- If dedicated equipment is in place at the well, disconnect aboveground tubing and properly seal the well.
- If non-dedicated equipment is used, then remove the equipment. Discard disposable items and decontaminate reusable items according to PSC SOP-200.
- Close and secure the well, and record any well integrity concerns (bolt tightness, etc) in the field book and on the sampling form.
- Rinse the water-quality meters with deionized water between wells.
- Report if any monitoring wells did not meet the stabilization and drawdown criteria with recommendation on how to conduct the sampling for the next sampling event.

8 Documentation

SOP PSC-400 describes the documentation of all monitoring well sampling activities, including all field forms, and the maintenance of a detailed field notebook.

9 Measure of Proficiency

Field staff will demonstrate proficiency on this SOP by properly completing sections 6, 7 and 8 at least twice under the direct supervision of the project manager or her/his designee.

Equipment Decontamination Procedure
SOP No. PSC - 200
Origination Date: 10/28/99
Revision Date: 7/6/01
Revision No.2

Written By:	Edited by:	Approved By:	Date:	QA Concurrence:	Date:
Tasya Gray	Tasya Gray	Carolyn Mayer	7/6/01	Kevin McNeil	7/6/01

This SOP contains eight sections:

1.0 Purpose

The purpose of this SOP is to provide field personnel with an outline of the procedure and frequency of decontaminating equipment that has come into contact with monitoring well water.

2.0 Application

This SOP provides a step-by-step guideline to be followed by the field sampling crew to prevent cross-contamination between monitoring wells and preserve well integrity.

3.0 References

RCRA Groundwater Draft Technical Guidance (EPA, 1992)

4.0 Associated SOPs

PSC-120 - Measuring Water, LNAPL, and DNAPL Elevations
PSC-121 - Monitoring Well Development
PSC-124 – Micropurge Groundwater Sampling Procedure
PSC-400 – Documentation Procedures

5.0 Equipment

The following equipment is necessary to properly decontaminate equipment used with monitoring wells:

- Di-ionized water and spray bottle.
- Alconox and spray bottle, hexane and spray bottle, and 10% Nitric acid and spray bottle, paper towels/rags.
- PVC pipe, capped on one end, 5 feet long.
- A clean hose and tap water source.
- A labeled 55-gallon drum for wastewater and a bucket to use for smaller volume prior to containing in drum.
- Personal protective equipment as described in the Site Health and Safety Plan.

6.0 General Decontamination Procedures

All reusable equipment that will come in contact with the well and/or be used to acquire samples will be decontaminated prior to arrival on site, relocation on site, and site exit.

6.1 Decontamination When Organic Constituents Are of Interest

- Wash the equipment with a solution of nonphosphate detergent (Alconox or equivalent) and water.
- Rinse the equipment with tap water.
- Rinse the equipment with Hexane.
- Rinse the equipment with DI water.

6.2 Decontamination When Inorganic Constituents Are of Interest

- Wash the equipment with a solution of nonphosphate detergent (Alconox or equivalent) and water.
- Rinse the equipment with tap water.
- Rinse the equipment with 10% Nitric Acid solution.
- Rinse the equipment with DI water.

6.3 Decontamination When Inorganic and Organic Constituents Are of Interest

- Wash the equipment with a solution of nonphosphate detergent (Alconox or equivalent) and water.
- Rinse the equipment with tap water.
- Rinse the equipment with Hexane.
- Rinse the equipment with DI water.
- Rinse the equipment with 10% Nitric Acid solution.
- Rinse the equipment with DI water.

7.0 Specific Decontamination Procedures

7.1 Non-Dedicated Submersible Pump Decontamination Procedure

After sampling or developing a well using a non-dedicated submersible pump, decontaminate the pump as follows:

- Use hose to spray off pump with tap water.
- Place pump into a capped approximately 5’ long, 3” diameter PVC pipe.
- Fill the PVC pipe with tap water and detergent.

- Run the pump until the pipe is empty, refilling it with tap water 3 times. The discharge decontamination water will be pumped into a 55-gallon drum.
- Remove the pump and wash out the pipe using tap water from the hose.
- Place the pump in the pipe again and fill with tap water.
- Repeat the process, running the pump until the pipe empties 3 times, when there is half a pipe of water left, add 2L of Hexane and continue pumping until pipe is empty.
- Remove the pump and rinse out the pipe with tap water.
- Place the pump back in the pipe and fill with tap water.
- Run the pump until the pipe empties 3 times, when there is half a pipe of water left add 2L of 10% Nitric Acid.
- Run the pump until it empties, then rinse it with water and refill the pipe with di-ionized water.
- Run the pump until the pipe empties three times with the deionized water.

8.0 Documentation

Documentation of all decontamination procedures associated with monitoring well activities including all field forms and the maintenance of a detailed field notebook as described in PSC-400.

9.0 Measure of Proficiency

Field staff will demonstrate proficiency on this SOP by successfully completing sections 6.0, 7.0, and 8.0 a minimum of twice under the direct supervision of the Corrective Actions Manager or her/his designee.

Documentation Procedure

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Carolyn Mayer	Carolyn Mayer	7/6/01	Tasya Gray	7/6/01

This SOP contains seven sections:

1.0 Purpose
2.0 Application
3.0 References
4.0 Associated SOPs
5.0 Field Books
6.0 Field Forms
7.0 Measure of Proficiency

1.0 Purpose

The purpose of this SOP is to outline, in detail, the required documentation needed to maintain accurate logs and files of all field procedures conducted by Philip Services Corporation (PSC).

2.0 Application

This SOP provides documentation guidelines, including examples, required for all geotechnical exploratory and sampling procedures conducted or overseen by PSC personnel (see Table 1).

3.0 References

None

4.0 Associated SOPs

PSC-100 – Surface Water Sampling Procedures
PSC-101 – Collection and Handling of Sediment Samples
PSC-102 – Collection and Handling of Surface Soil Samples
PSC-103 – Standard Penetration Tests and Split Spoon Sampling

PSC-120 – Measuring Water, LNAPL, and DNAPL Elevations
PSC-121 – Monitoring Well Development
PSC-124 – Micropurge Groundwater Sampling Procedure
PSC-126 – Soil Gas Monitoring Port Sampling
PSC-200 – Equipment Decontamination Procedure
PSC-300 – Photoionization Detector Calibration and Operation
PSC-301 – YSI Calibration and Operation

5.0 Field Books

All field books should be pocket size "Rite in the Rain" or equivalent and should have non-removable pages. These field books are to be dedicated to a project, and the corrective actions' project manager is responsible for maintaining a field book inventory. This inventory should include a numbering and tracking mechanism for each field book assigned to a particular case.

Each field book is to be maintained as follows:

- Label the outside front cover with the following information: Burlington Environmental dba Philip Services Corporation, Facility Name, Dates Included, and Book Number. The inside cover should include: Burlington Environmental dba Philip Services Corporation, Project Manager's Name, 955 Powell Avenue, Renton, WA 98155. (206) 227-XXXX, Dates Included, and Book Number.

- Inside the cover, list the full names and initials of each person working on the project that will be referred to in the field book.

- Maintain all field notes directly in the field books (i.e. notes are not to be taken then transferred to the field books at a later time).

- Record all field notes in permanent ink (sharpie markers).

- Initial, date, and number each page upon completion.

- Correction of mistakes are made with a single line and initialing the correction.

- Avoid blank spaces within the notes. Unavoidable blank spaces are to be struck with a single line.

Examples of information required in the field book include:

- The date of entry.
- Time of entry for specific events (in military time).
- A meteorological description of daily changes.
- Personnel present including arrival and departure times and affiliations.
- Make, model and condition of equipment used.
- The time interval and reasons for delays including a detailed description of corrective actions taken by the field crew.
- A detailed description and rationale for any deviations from the Work Plan, Sampling Plan, or Health and Safety Plan.

6.0 Field Forms

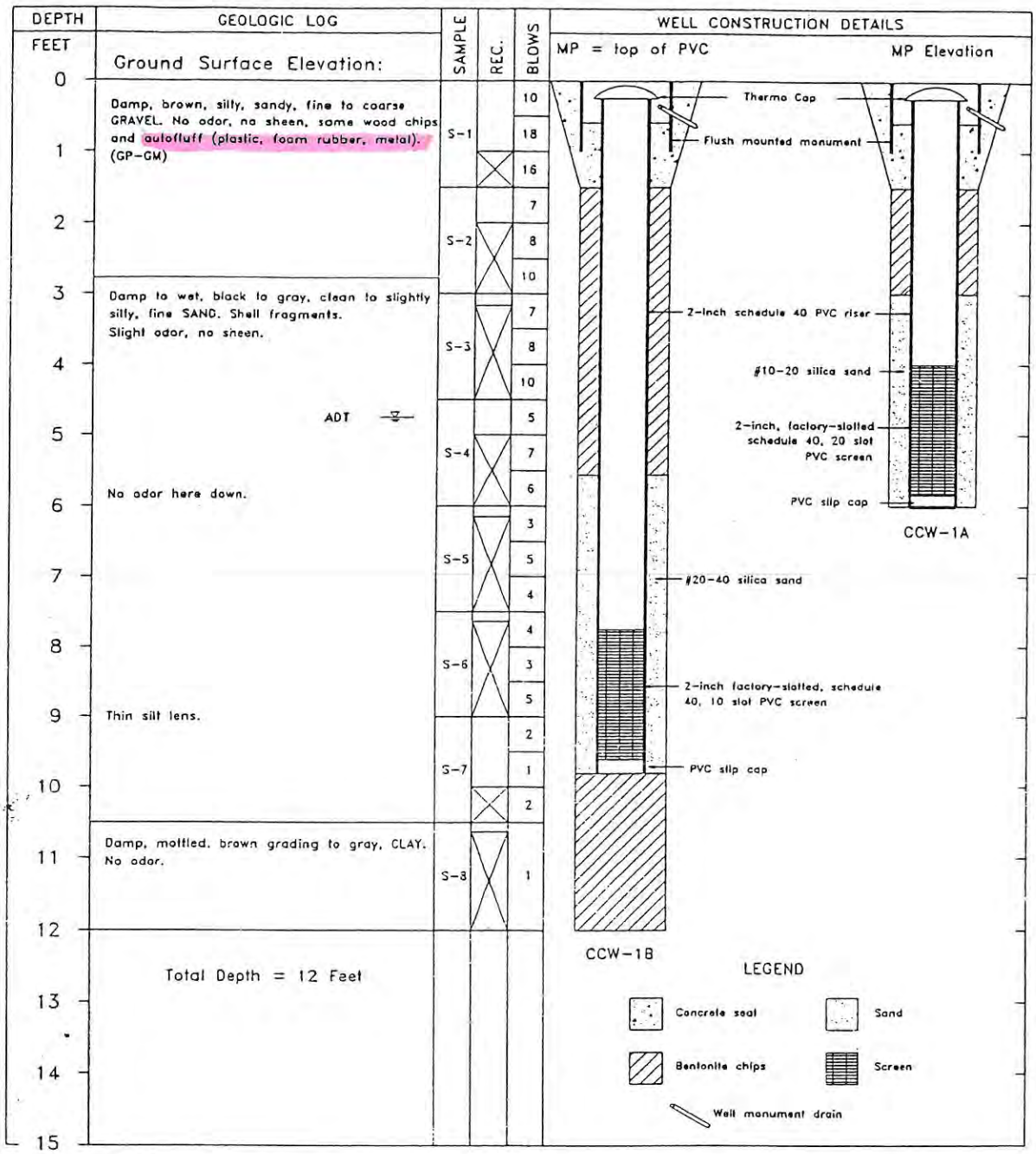
The field forms have been designed to detail all steps, actions, and readings associated with specific field procedures. These forms are to be completed in full. No sections are to be left blank, if a section is "not applicable", it is to be indicated as such. All forms, including location diagrams, are to be completed in the field with permanent ink. Refer to Table 1 to see which forms are required for specific field procedures. Examples of each form are also attached.

7.0 Measure of Proficiency

Proficiency assessment for documentation is associated with specific procedural proficiency, therefore, no separate proficiency measures for documentation are needed.

Appendix C
Boring Logs

GEOLOGIC LOG AND WELL AS-BUILT, MONITORING WELLS CCW-1A AND CCW-1B



NOTE: Descriptions of odors and sheens are included on this log where noted in the field.
No references to odors or sheens generally indicates the absence of odors or sheens.

FIGURE ##, GEOLOGIC LOG AND WELL AS-BUILTS
MONITORING WELLS CCW-1A & CCW-1B

PACIFIC GROUNDWATER GROUP
JE9205.03

PROJECT NAME: Clean Care
WELL INDENTIFICATION NUMBERS: CCW-1A, CCW-1B
DRILLING METHOD: Hollow Stem Auger
DRILLER: Charles Richard
FIRM: Holt Drilling
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Chad Bring

LOCATION: NW¼ SW¼ Sec.
DATUM: NGVD
WATER LEVEL ELEVATION:
INSTALLED: February 1-2, 1994
DEVELOPED: February 14, 1993
START CARD NO.: 06851

TECH SOLV

TechSolv Consulting Group, Inc.
12930 NE 178th Street, Woodinville, WA 98072
(425) 402-8277 FAX (425) 402-7917

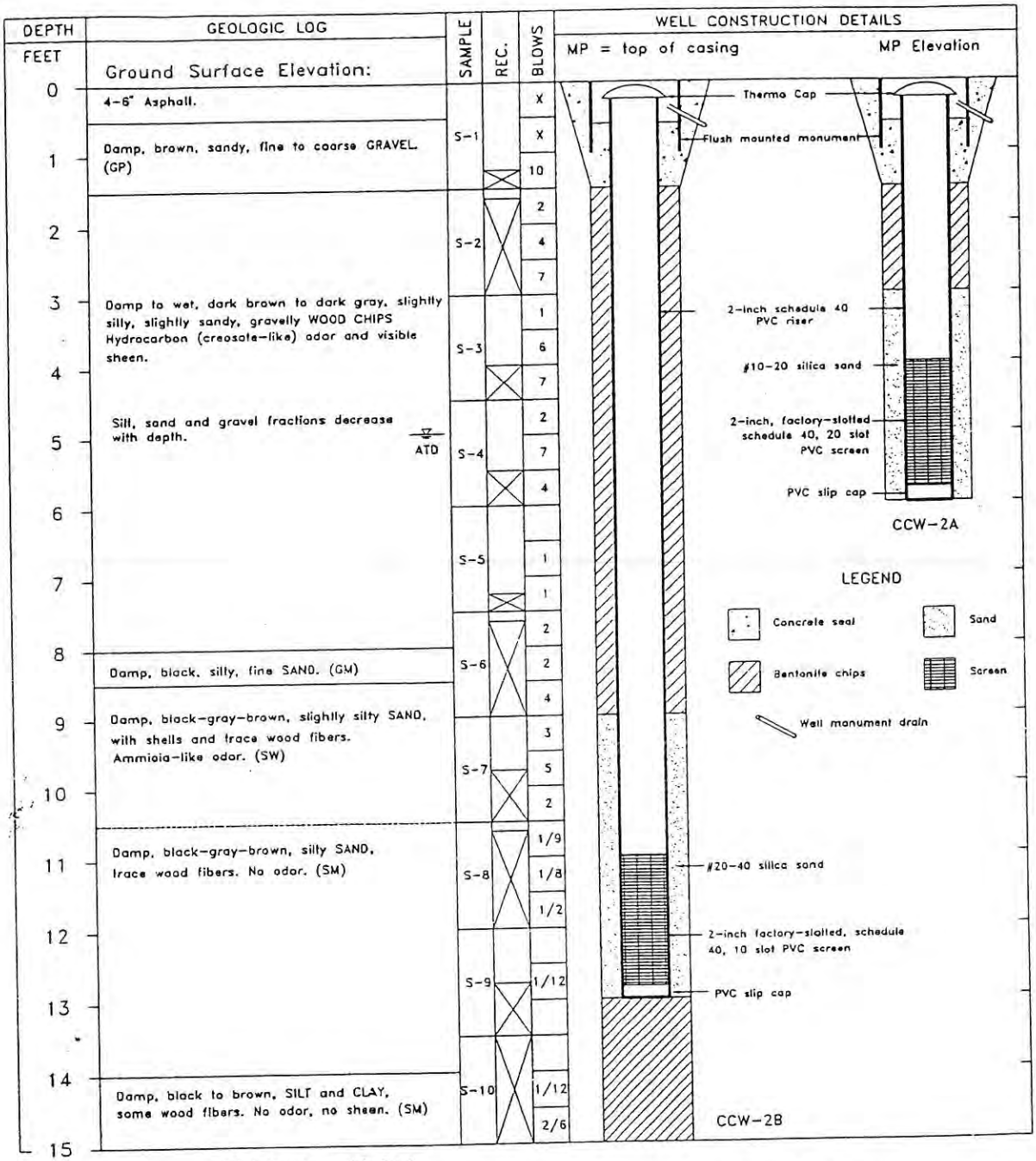
RECEIVED
AUG 01 2001
Tacoma-Pierce County
Health Dept.

SOIL BORING LOG

Project Name and Location: Former CleanCare Site, 1510 Taylor Way, Tacoma, Washington	**Boring Number:** CCW-1C	**Page:** 1 of 1
	Contractor: Cascade Drilling, Inc.	**Drilling Method:** HSA
	Drill Crew: Cody Pulis, Frank Scott, Steve Choate	**Drill Rig:** CME-75
	Date Started: July 3, 2001	**Date Finished:** July 5, 2001
Surface Elevation: NA	**Logged by:** R. Honsberger	**Protective Cover:** 8" water tight manhole
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 23 to 18	**Screen:** 2" dia. 0.010" slot PVC	**Water Level While Drilling (ft bgs):** ~7
Filter Pack Interval (ft bgs): 23 to 17	**Riser:** 2" dia. PVC	
Seal Interval (ft bgs): 17 to 2	**Seal Type:** bentonite	**Water Level at Completion (ft bgs):** 10.92
Grout Interval (ft bgs): 2 to 0	**Filter Pack:** 2/12 sand	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							6" asphalt
1	2	NR	1-3	286	SP		Moderate brown 5YR 4/4 coarse sand with some gravel and wood waste, moist with strong solvent odor.
2							
3	12	NR	3-5	132	SP		Same as above with lime solvent sludge.
4							
5	18	NR	5-7	26	SP		Olive black 5Y 2/1 fine to medium sand, wet with no solvent or hydrocarbon odor.
6							
7	20	NR	7-9	9	SP		▽ Same as above but saturated with water.
8							
9	24	NR	9-10	7	SP		Same as above
10					ML		Olive gray 5Y 4/1 silt with rootlets and reeds.
11	24	NR	11-13	6	OL		Same as above but color is olive black 5Y 2/1 and more plant material.
12							
13	24	NR	13-15	5	OL		Olive gray 5Y 4/1 silt with rootlets and reeds, no solvent or hydrocarbon odor.
14							
15	24	NR	15-17	4	ML		Olive gray 5Y 4/1 silt with fine sand, no solvent or hydrocarbon odor.
16							
17	24	NR	17-19	3	SP		Olive black 5Y 2/1 fine to medium sand with silt interbeds.
18							
19	24	NR	19-21	7	SP		Olive black 5Y 2/1 fine to medium sand saturated with water, no solvent or hydrocarbon odor.
20							
21							
22							
23							End of Boring at 23 feet.

GEOLOGIC LOG AND WELL AS-BUILTS, MONITORINGS WELL CCW-2A AND CCW-2B



Total Depth = 15 Feet

NOTE: Descriptions of odors and sheens are included on this log where noted in the field.

No references to odors or sheens generally indicates the absence of odors or sheens.

FIGURE ##, GEOLOGIC LOG AND WELL AS-BUILTS
MONITORING WELLS CCW-2A & CCW-2B

PACIFIC GROUNDWATER GROUP
JE9205.03

PROJECT NAME: Clean Care
WELL INDENTIFICATION NUMBERS: CCW-2A, CCW-2B
DRILLING METHOD: Hollow Stem Auger
DRILLER: Charles Richard
FIRM: Holt Drilling
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Chad Bring

LOCATION: NW¼ SW¼ Sec.
DATUM: NGVD
WATER LEVEL ELEVATION:
INSTALLED: February 1-2, 1994
DEVELOPED: February 14, 1993
START CARD NO.: 06851

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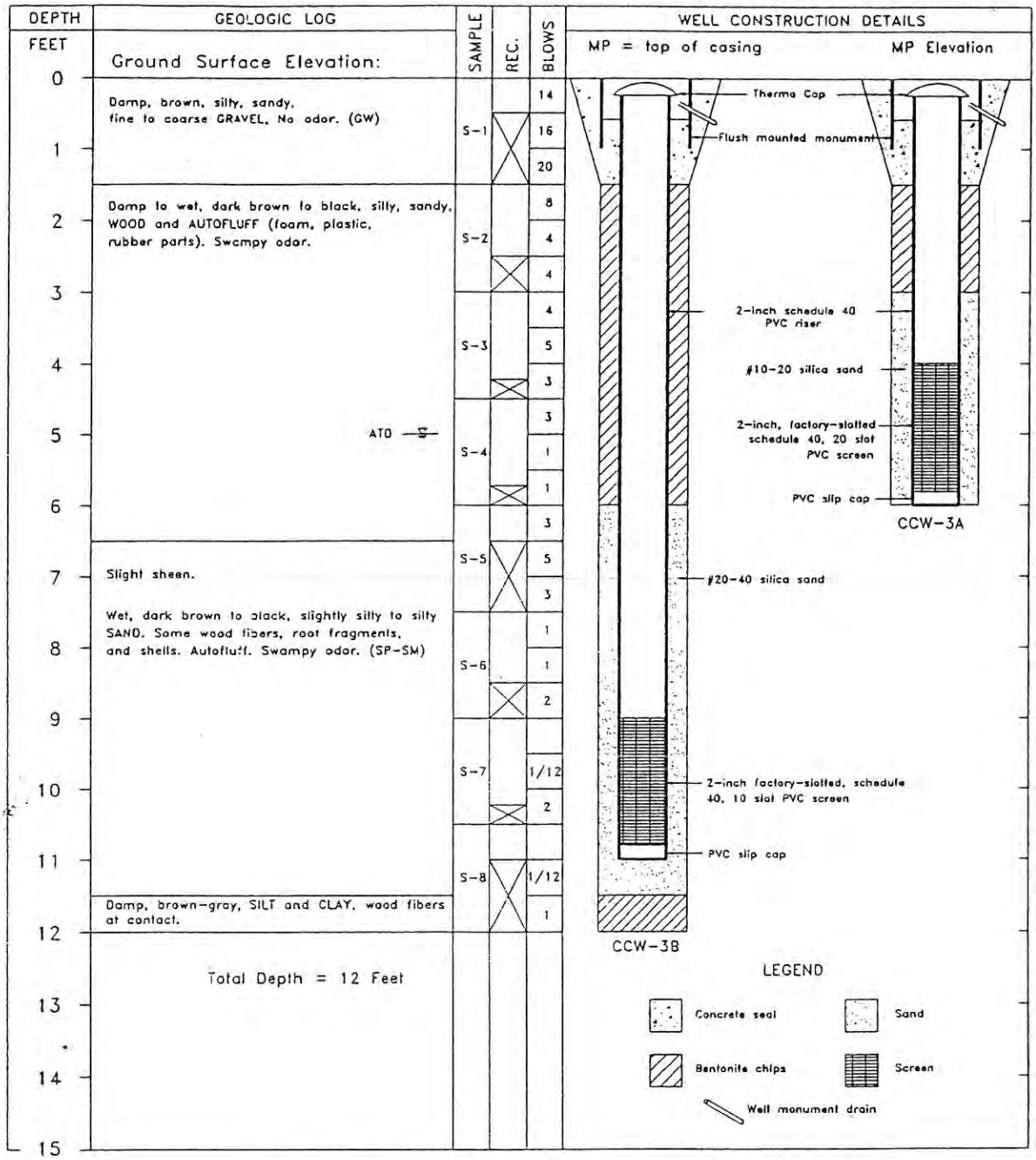
SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-2C**	**Page: 1 of 1**
	Contractor: Cascade Drilling, Inc.	**Drilling Method: HSA**
	Drill Crew: Yancy White, Charles Chambarger, Steve Choate	**Drill Rig: CME-75**
	Date Started: July 2, 2001	**Date Finished: July 3, 2001**
Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 24 to 19	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~4.5**
Filter Pack Interval (ft bgs): 24 to 18	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 18 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 9.85**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							6" Asphalt
1	6	5,3,11	1-3	33	NA		Greenish gray 5G 6/1 lime solvent sludge.
2							
3	NR	3,4,7,10	3-5	NR	NA		No recovery. Wood waste and fine sand in the cuttings.
4							▽
5	3	6,8,3,3	5-7	NA	NA		Wood plug, strong hydrocarbon odor, wet.
6							
7	3	1,1,1,1	7-9	270	NA		Same as above.
8							
9	3	7,6,1,1	9-11	283	GP		Moderate brown 5YR 4/4 medium gravel with fine sand and wood waste saturated with water, strong hydrocarbon odor.
10							
11	3	6,4,4,4	11-13	15	SP		Olive black 5Y 2/1 fine to medium sand with coarse gravel, saturated with water and has a slight hydrocarbon odor.
12							
13							
14	12	10,10,10	14-15.5	301	SM		Olive black 5Y 2/1 silty sand with rootlets and wet with hydrocarbon odor.
15	12	3,5,58	15.5-17	13	SM		Moderate brown 5YR 2/1 coarse sand at 15 feet.
16	NR	NA	16-18	NR	NA		No recovery.
17							16' 10" Olive black 5Y 2/1 fine to medium sand moist with no hydrocarbon odor.
18	24	NA	18-20	5	SP		
19							
20	NA	NA	20-22	7	SP		Same as above.
21							
22							
23							
24							End of Boring at 24 feet.

GEOLOGIC LOG AND WELL AS-BUILTS, MONITORING WELLS CCW-3A AND CCW-3B



NOTE: Descriptions of odors and sheens are included on this log where noted in the field. No references to odors or sheens generally indicates the absence of odors or sheens.

FIGURE ##, GEOLOGIC LOG AND WELL AS-BUILTS
MONITORING WELLS CCW-3A & CCW-3B

PACIFIC GROUNDWATER GROUP
JE9205.03

PROJECT NAME: Clean Care
WELL INDENTIFICATION NUMBERS: CCW-3A, CCW-3B
DRILLING METHOD: Hollow Stem Auger
DRILLER: Charles Richard
FIRM: Holt Drilling
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Chad Bring

LOCATION: NW¼ SW¼ Sec.
DATUM: NGVD
WATER LEVEL ELEVATION:
INSTALLED: February 1-2, 1994
DEVELOPED: February 14, 1994
START CARD NO.: 06851

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SOIL BORING LOG

Project Name and Location:	**Boring Number: CCW-3C**	**Page: 1 of 2**
	Contractor: Cascade Drilling, Inc.	**Drilling Method: HSA**
Former CleanCare Site 1510 Taylor Way Tacoma, Washington	**Drill Crew: Brian Gose, Frank Scott, Steve Choate**	**Drill Rig: CME-75**
	Date Started: June 29, 2001	**Date Finished: July 2, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 6" metal above ground casing with locking cover**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 28 to 23	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~5**
Filter Pack Interval (ft bgs): 28 to 22	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 22 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 13.35**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							
1	12	40,32, 15,17	1-3	2	GP		Coarse gravel fill with a fine to medium sand matrix, dry.
2							
3	1	15,11,12 ,5	3-5	2	GP		Same as above.
4							
5	NR	NA	5-7	NR	NA		▽ Miscellaneous automobile debris in the cuttings.
6							
7	12	3,4,2,2	7-9	14	SP		Olive black 5Y 2/1 fine to medium sand saturated with water. Very slight hydrocarbon odor.
8							
9	6	2,1,1,1	9-11	18	SP		Same as above with wood waste and silt.
10							
11	8	1,1,1,1	11-13	2	ML		Olive gray 5Y 4/1 silt with rootlets and reeds, moist with no hydrocarbon odor.
12							
13	4	2,1,1,1	13-15	2	ML		Olive black 5Y 2/1 silt with rootlets and reeds, moist with no hydrocarbon odor.
14							
15	24	NA	15-17	2	ML		Olive gray 5Y 4/1 silt with rootlets and reeds, moist with no hydrocarbon odor.
16							At 16.5 feet Olive black 5y 2/1 fine to medium sand saturated with water, with no hydrocarbon odor.
17	24	4,4,4,6	17-19	3	SP		Olive black 5Y 2/1 fine to medium sand with silt interbeds, saturated with water with no hydrocarbon odor.
18							
19	24	3,4,7,11	19-21	2	SP		Same as above.
20							

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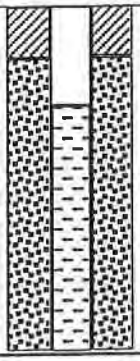
SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-3C**	**Page: 2 of 2**
	Contractor: Cascade Drilling, Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 29, 2001	**Date Finished: July 2, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 6" metal above ground casing with locking cover**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 28 to 23	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~5**
Filter Pack Interval (ft bgs): 28 to 22	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 22 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 13.35**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
21	24		21-23	2	SP		Olive black 5Y 2/1 fine to medium sand saturated with water. No hydrocarbon odor.
22							
23							
24							
25							
26							
27							
28							End of Boring at 28 feet

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-4C**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: July 5, 2001	**Date Finished: July 5, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 24 to 19	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~5**
Filter Pack Interval (ft bgs): 24 to 18	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 18 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 9.93**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0					GP		12" Gravel fill.
1	12	16,12,6,3	1-3	3	GM		Grayish brown 5YR 3/2 angular coarse to fine gravel with fine to medium sand, dry with no hydrocarbon odor.
2							
3	8	NA	3-5	3	GM		Same as above with miscellaneous automobile debris.
4							
5	8	1,3,2,3	5-7	4	SP		Moderate brown 5YR 3/4 fine to medium sand with miscellaneous automobile debris, dry with no hydrocarbon odor.
6							▽
7	16	1,1,2,1	7-9	3	SP		Olive black 5Y 2/1 fine to medium sand with shell fragments. Saturated with water.
8							
9	12	4,5,5	9-10	3	SP		Same as above with auto fluff and few medium gravels.
10	6	4,5	10-11	3	SP		Olive black 5Y 2/1 fine to coarse sand with medium gravel, slight hydrocarbon odor and saturated with water.
11	12	5,1	11-12	3	SP		Same as above.
12	12	3,1	12-13	4	ML		Olive gray 5Y 4/1 silt with rootless and other plant material.
13	1	2,1	13-14	1	OL/OH		Trace amounts of peat and slight hydrocarbon odor.
14	12	0,0,12	14-16	1	ML		Olive gray 5Y 4/1 silt with rootlets and trace fine sand. No hydrocarbon odor.
15							
16	20	NA	16-18	1	ML		Same as above.
17							
18	20	6,2,5,3	18-20	0	SP		Olive black 5Y 2/1 fine to medium sand saturated with water, no hydrocarbon odor.
19							
20							
21							
22							
23							
24							End of Boring at 24 feet.

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-5B**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 27, 2001	**Date Finished: June 27, 2001**
Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 10 to 5	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~5**
Filter Pack Interval (ft bgs): 11 to 4	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 4 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 4.82**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0					GP		6" Coarse angular gravel.
1	14	32,9,12	1-3	3	SP		Moderate brown 5YR 4/4 fine sand with wood waste and lime solvent sludge. Slight solvent odor.
2							
3	5	3,8,6,6	3-5	8	SP		Moderate brown 5YR 4/4 fine to medium sand with wood waste and few fine gravels dry with hydrocarbon odor and no solvent odor.
4							
5	5	3,8,6,6	5-7	NM	SP		▽ Same as above with a visible sheen on the water in the sampler.
6							
7	10	3,3,2,2	7-9	10	SM		Black to dusky brown fine to medium sand with wood waste and lenses of silty clay. Saturated with product.
8							
9	24	NA	9-11	7	OL		Greenish gray 5Y 4/1 silty clay with rootlets and plant material, moist with no solvent or hydrocarbon odor.
10							
11							End of boring at 11 feet.

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-5C**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 27, 2001	**Date Finished: June 27, 2001**
Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 24 to 19	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~5**
Filter Pack Interval (ft bgs): 24 to 18	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 18 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 9.93**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							
1							Subsurface conditions are the same as Well CCW-5B to 11 feet bgs. No soil samples collected.
2							
3							
4							
5							▽
6							
7							
8							
9							
10							
11	24	1,2,3,4	11-13	0	OL		Olive gray 5Y 4/1 silty clay with rootlets and plant material, no solvent or hydrocarbon odor.
12							
13	24	1,1,1,2	13-15	1	OL		Same as above, but silty sand at 14.5 feet.
14							
15	24	2,5,9,11	15-17	0	SM		Brownish black 5YR 2/1 silty sand with Olive gray 5Y 4/1 silt interbeds, moist to damp with no solvent or hydrocarbon odor.
16							
17	24	2,1,1,2	17-19	0	SP		Brownish black 5YR 2/1 fine to medium sand, saturated with water. No solvent or hydrocarbon odor.
18							
19							
20							
21							
22							
23							
24							End of Boring at 24 feet.

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SOIL BORING LOG

Project Name and Location:	**Boring Number: CCW-6B**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
Former CleanCare Site 1510 Taylor Way Tacoma, Washington	**Drill Crew: Brian Gose, Frank Scott, Steve Choate**	**Drill Rig: CME-75**
	Date Started: June 27, 2001	**Date Finished: June 27, 2001**
Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover: 8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 8.5 to 3.5	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs): ~4.5**
Filter Pack Interval (ft bgs): 9 to 3	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 3 to 1	**Seal Type: bentonite**	**Water Level at Completion (ft bgs): 4.37**
Grout Interval (ft bgs):1 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0					GP		6" Coarse angular gravel.
1	12	1,1	1-3	1	NA		Brownish gray 5YR 4/1 lime solvent sludge with wood waste.
2							
3	12	1,1,3,5	3-5	0	NA		Wood waste dry with no hydrocarbon odor.
4							
5	10	1,3,5,6	5-7	20	OL		Olive gray 5Y 4/1 Silty clay, very wet, slight hydrocarbon odor.
6							
7	NR	1	7-8	NR	NA		No recovery.
8	12	1,2	8-9	1	SM		Olive black 5Y 2/1 silt with fine sand, very soft, saturated with water and has no hydrocarbon odor.
9							End of Boring at 9'

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-6C**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 28, 2001	**Date Finished: June 28, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover:**
Top of Casing Elevation: NA		**8" water tight manhole**
Well Construction Information:		
Screened Interval (ft bgs): 23 to 18	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs):**
Filter Pack Interval (ft bgs): 23 to 17	**Riser: 2" dia. PVC**	**~4.5**
Seal Interval (ft bgs): 17 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs):**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	**9.61**

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							
1							Subsurface conditions are the same as Well CCW-6B to 9 feet bgs. No soil samples collected.
2							
3							
4							▽
5							
6							
7							
8							
9	NR	NA	9-11	NR	NA		No recovery.
10	24	1	10-12	1	ML		Olive gray 5Y 4/1 silty clay with rootlets and some wood waste, moist, no hydrocarbon odor.
11							
12	24	1,2,2,1	12-14	2	ML		Same as above with olive black 5Y 2/1 silty sand at 13.5 feet.
13							
14	24	1,2,5,7	14-16	3	ML		Olive gray 5Y 4/1 silt with sand. At 15.5 feet brownish black 5YR 2/1 fine to medium sand saturated with water.
15							
16	20	NA	16-18	0	SP		Brownish black 5YR 2/1 fine to medium sand, saturated with water and no hydrocarbon odor.
17							
18							
19							
20							
21							
22							
23							End of Boring at 23 feet.

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-7B**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Frank Scott, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 28, 2001	**Date Finished: June 28, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover:**
Top of Casing Elevation: NA		**8" water tight manhole**
Well Construction Information:		
Screened Interval (ft bgs): 9 to 4	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs):**
Filter Pack Interval (ft bgs): 11 to 3	**Riser: 2" dia. PVC**	**~5**
Seal Interval (ft bgs): 3 to 1.5	**Seal Type: bentonite**	**Water Level at Completion (ft bgs):**
Grout Interval (ft bgs): 1.5 to 0	**Filter Pack: 2/12 sand**	**3.95**

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0					GP		6" Coarse angular gravel.
1	20	1,2,3,2	1-3	35	NA		Olive black 5Y 2/1 line solvent sludge and wood waste damp with hydrocarbon odor.
2							
3	12	1,2,3,2	3-5	12	NA		Olive black 5Y 2/1 wood waste.
4							
5	12	1,4,7,14	5-7	31	NA		▽ Olive black 5Y 2/1 wood waste saturated with water and product, hydrocarbon odor and sheen.
6							
7	6	27,3,3,3	7-8	25	NA		Same as above
8	6		8-9	11	NA		Same as above.
9	2	1,2	9-10	3	ML		Same as above with trace of olive black 5Y 2/1 silty clay
10	12	2	10-11	3	ML		Olive gray 5Y 4/1 silt with plant material, saturated with water and no hydrocarbon odor.
11							End of boring at 11 feet

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SOIL BORING LOG

Project Name and Location: **Former CleanCare Site** **1510 Taylor Way** **Tacoma, Washington**	**Boring Number: CCW-7C**	**Page: 1 of 1**
	Contractor: Cascade Drilling Inc.	**Drilling Method: HSA**
	Drill Crew: Brian Gose, Hank Monroe, Steve Choate	**Drill Rig: CME-75**
	Date Started: June 28, 2001	**Date Finished: June 28, 2001**

Surface Elevation: NA	**Logged by: R. Honsberger**	**Protective Cover:** **8" water tight manhole**
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 26 to 21	**Screen: 2" dia. 0.010" slot PVC**	**Water Level While Drilling (ft bgs):** **~5**
Filter Pack Interval (ft bgs): 26 to 20	**Riser: 2" dia. PVC**	
Seal Interval (ft bgs): 20 to 2	**Seal Type: bentonite**	**Water Level at Completion (ft bgs):** **9.84**
Grout Interval (ft bgs): 2 to 0	**Filter Pack: 2/12 sand**	

Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0							
1							Subsurface conditions are the same as Well CCW-7B to 11 Feet bgs. No soil samples collected.
2							
3							
4							
5							▽
6							
7							
8							
9							
10							
11	24	0,0,2,4	11-13	3	ML		Olive gray 5Y 4/1 silt with rootlets and plant material, no hydrocarbon odor.
12							
13	24	1,2,4,5	13-15	3	ML		Same as above.
14							
15	24	2,2	15-17	3	ML		Olive gray 5Y 4/1 silt with rootlets interbedded with olive black 5Y 2/1 fine to medium sand, saturated with water.
16							
17	20	5,3,4,6	17-19	3	ML		Same as above.
18							
19	18	5,7,10, 12	19-21	2	SP		Olive black 5Y 2/1 fine to medium sand saturated with water with few silt interbeds.
20							
21	24	5,7,10, 12	21-23	NA	SP		Olive black 5Y 2/1 fine to medium sand saturated with water and no hydrocarbon odor.
22							
23							
24							
25							
26							End of Boring at 26 feet.

TECH SOLV

TechSolv Consulting Group, Inc.
12930 NE 178th Street, Woodinville, WA 98072
(425) 402-8277 FAX (425) 402-7917

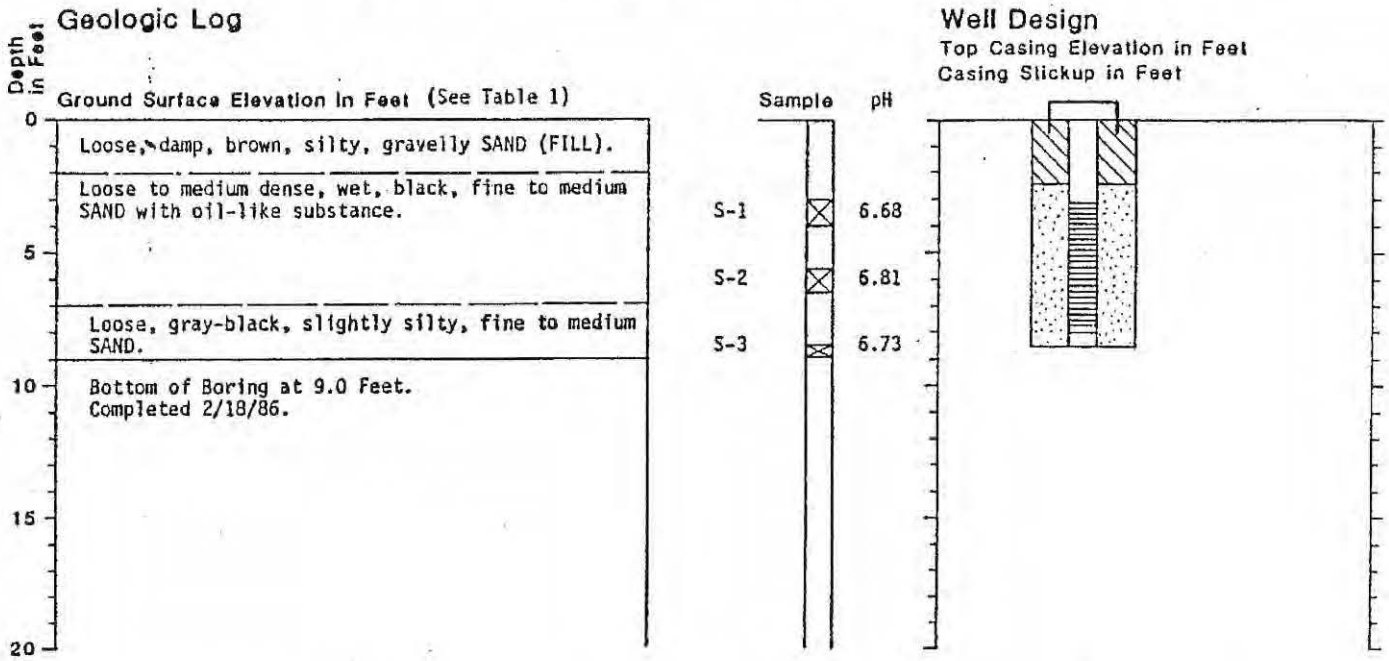
SOIL BORING LOG

Project Name and Location: Former CleanCare Site, 1510 Taylor Way, Tacoma, Washington	**Boring Number:** CCW-8B	**Page:** 1 of 1
	Contractor: Cascade Drilling Inc.	**Drilling Method:** HSA
	Drill Crew: Drill Crew: Cody Pulis, Frank Scott, Steve Choate	**Drill Rig:** CME-75
	Date Started: July 3, 2001	**Date Finished:** July 3, 2001
Surface Elevation: NA	**Logged by:** R. Honsberger	**Protective Cover:** 8" water tight manhole
Top of Casing Elevation: NA		
Well Construction Information:		
Screened Interval (ft bgs): 11 to 6	**Screen:** 2" dia. 0.010" slot PVC	**Water Level While Drilling (ft bgs):** ~7
Filter Pack Interval (ft bgs): 11 to 5	**Riser:** 2" dia. PVC	
Seal Interval (ft bgs): 5 to 2	**Seal Type:** bentonite	**Water Level at Completion (ft bgs):** 5.15
Grout Interval (ft bgs): 2 to 0	**Filter Pack:** 2/12 sand	

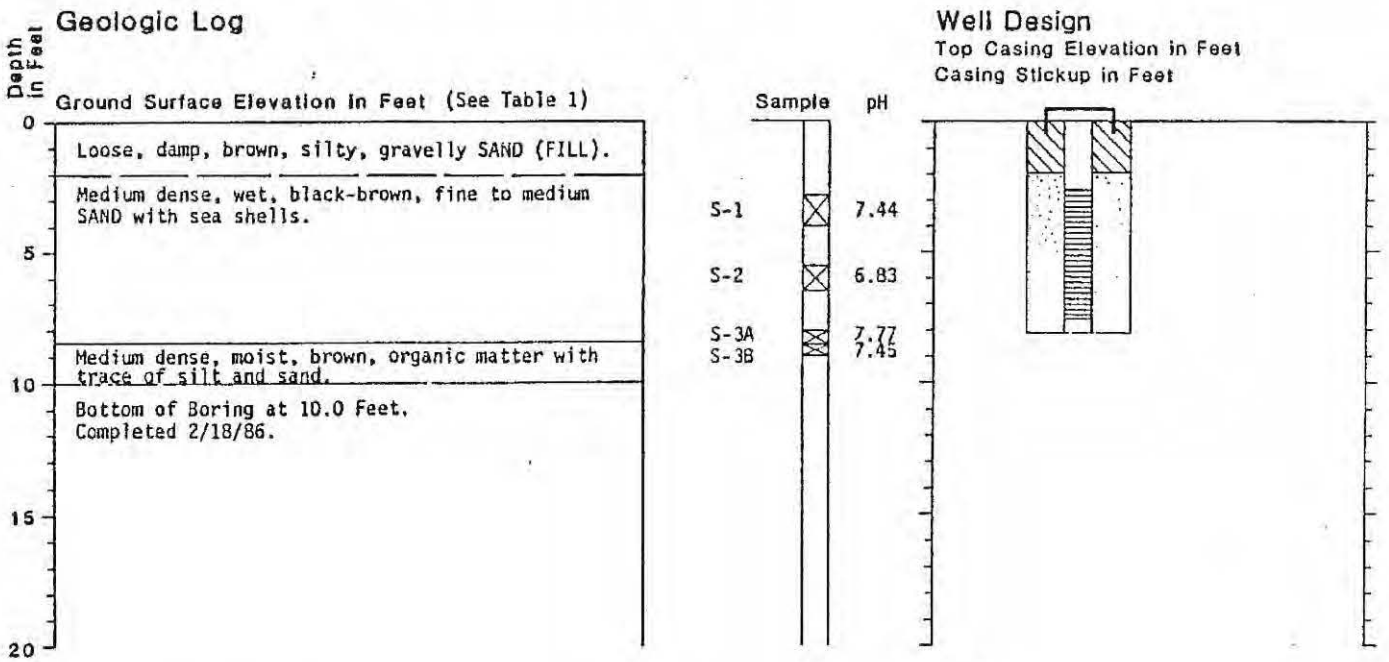
Depth (ft bgs)	Recov. (in.)	Blow Counts	Sample Interval	OVM / PID (ppm)	USCS Symbol	Well Construction	Sample Description
0					GP		6" Coarse angular gravel.
1	12	8,12,13, 18	1-3	285	SP		Olive black 5Y 2/1 fine to medium sand with few coarse gravels and a strong hydrocarbon odor.
2							
3	20	8,8,9,11	3-5	338	SP		Olive black 5Y 2/1 medium sand with shell fragments, moist with a strong hydrocarbon odor, stains gloves.
4							
5	18	4,6,6,6	5-7	425	SP		Olive black 5Y 2/1 fine to medium sand with shell fragments, damp with a strong hydrocarbon odor, stains gloves.
6							
7	24	3,3,4,4	7-9	214	SP		▽ Same as above but saturated with water slight sheen on water.
8							
9	24	0,0,0,4	9-11	167	SP		Same as above.
10							
11	12	2,3	11-12	9	OL		Olive gray 5Y 4/1 silt with a trace of fine sand plant, saturated with water and slight hydrocarbon odor.
12							
							End of boring at 12 feet.

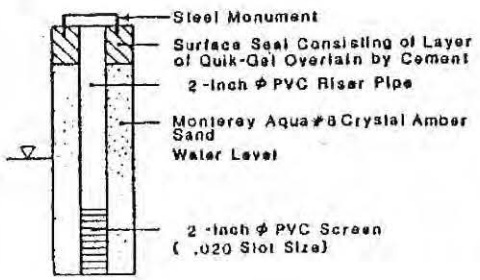
MW-1
MW-2
HART CROWSER

Boring Log and Construction Data for Well MW-1



Boring Log and Construction Data for Well MW-2





2-inch O.D. Split Spoon Sample

★ No Sample Recovery

N Standard Penetration Resistance, Blows per foot

GS Grain Size Analysis

K Permeability Test

pH Test for pH of Soil Slurry Consisting of 50% Soil and 50% Distilled Water

NOTES:

1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

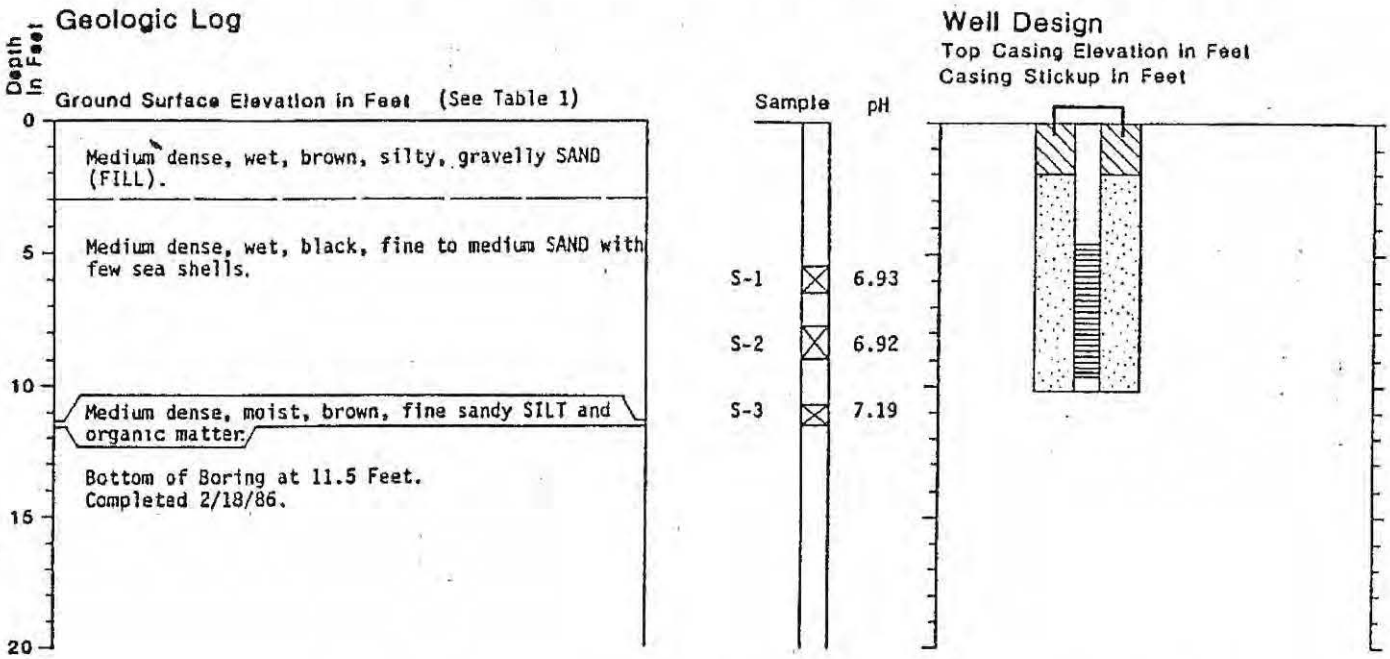
J-1615-03 March 1986

HART-CROWSER & associates, inc.

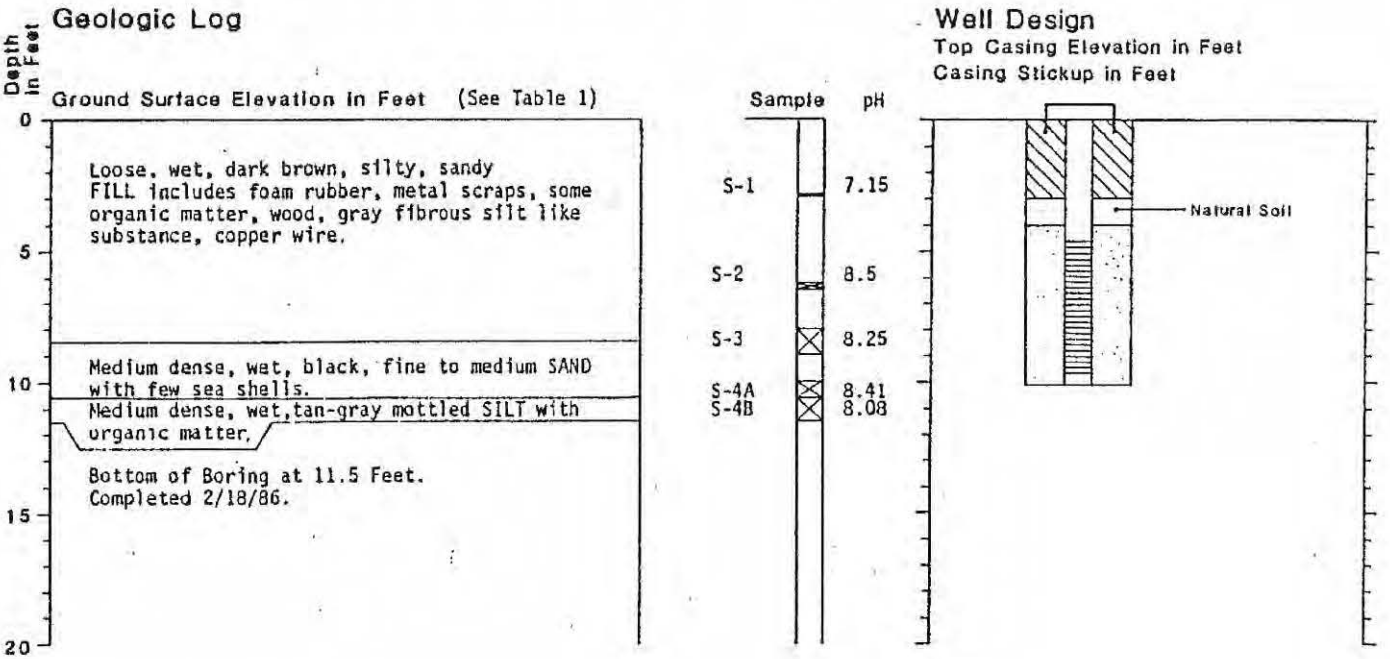
Figure 2

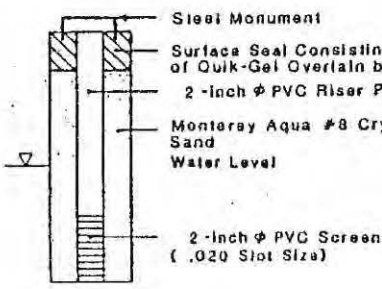
MW-3
MW-4
HART CROWSER

Boring Log and Construction Data for Well MW-3



Boring Log and Construction Data for Well MW-4





2-inch O.D. Split Spoon Sample

* No Sample Recovery

N Standard Penetration Resistance, Blows per foot

GS Grain Size Analysis

K Permeability Test

pH Test for pH of Soil Slurry Consisting of 50% Soil and 50% Distilled Water

NOTES:

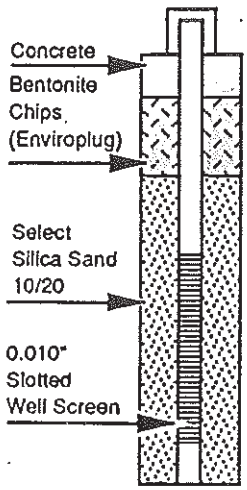
1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level is for date indicated and may vary with time of year. ATD:At Time of Drilling

J-1615-03 March 1986

HART-CROWSER & associates, inc.

Figure 3

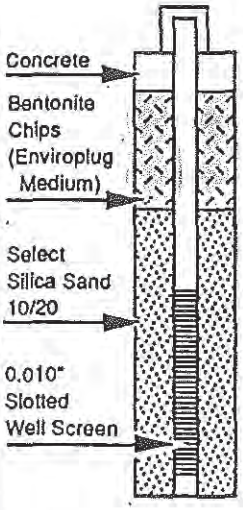
BORING NO. SB-1A	ELEVATION: 11.91 ft
LOCATION:	DATE STARTED: 3/28/91
DRILLING AGENCY: Soil Sampling Service	DATE COMPLTED: 3/28/91
DRILLING EQUIPMENT: All-terrain CME-50	DRILLER: W. Lindholm / LOGGED BY: K. Teague / D. Walker
DRILLING METHOD: 4" ID HSA	SAMPLER:



DEPTH (FEET)	BLOWS / 6 IN.	SAMPLE	GRAPHIC LOG	DESCRIPTION
5				Note: Not Sampled. Stratigraphic information from Well SB-1 except as noted (*) (2.3 - 4.0) Loose, saturated, brown, medium grained sand (SP) (FILL)
10				* (10.5) Clay encountered

Project No. 91C0191A	Sithe Energies, U.S.A., Inc. Tacoma Cogeneration Project	LOG OF BORING SB-1A	SHEET 5 of 7
Woodward-Clyde Consultants			

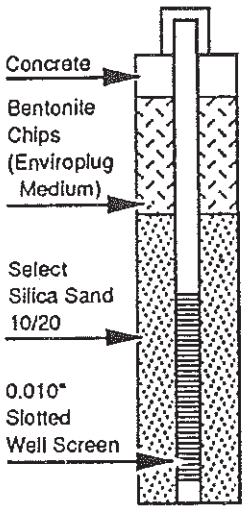
BORING NO. SB-2A		ELEVATION: 11.78 ft	
LOCATION:		DATE STARTED: 3/29/91	
DRILLING AGENCY: Soil Sampling Service		DATE COMPLTED: 3/29/91	
DRILLING EQUIPMENT: All-terrain CME-50		DRILLER: W. Lindholm	LOGGED BY: K. Teague / D. Walker
DRILLING METHOD: 4" ID HSA		SAMPLER:	



DEPTH (FEET)	BLOWS / 6 IN.	SAMPLE	GRAPHIC LOG	DESCRIPTION
5				Note: Not Sampled. Stratigraphic information from Well SB-2, except as noted (*) (3.5 - 5.5) Loose, wet to saturated, dark gray to brown fine to medium sand (SP), trace of silt, trace of clayey blebs to 4mm diameter (FILL) *(7.0 - 8.5) Refuse encountered
10				(8.5 - 10.5) Soft, saturated, gray-brown clay (CL) with abundant roots and rootlets

Screened in clay 8.5 - 10.5'

BORING NO. SB-3A	ELEVATION: 13.26 ft
LOCATION:	DATE STARTED: 3/29/91
DRILLING AGENCY: Soil Sampling Service	DATE COMPLTED: 3/29/91
DRILLING EQUIPMENT: All-terrain CME-50	DRILLER: W. Lindholm / LOGGED BY: K. Teague / D. Walker
DRILLING METHOD: 4" ID HSA	SAMPLER:



DEPTH (FEET)	BLOWS / 6 IN.	SAMPLE	GRAPHIC LOG	DESCRIPTION
				Note: Not Sampled. Stratigraphic information from Well SB-3 (3.5 - 5.5) Loose to medium, dense, saturated, medium sand (SP) trace of fine sand (FILL)
5				
10				(8.5 - 10.5) Very soft, saturated, gray-tan clay (CL) with some darker gray vertically oriented streaks

screen in clay 8.5-10.5' (at least)

Project No. 91C0191A	Sithe Energies, U.S.A., Inc. Tacoma Cogeneration Project	LOG OF BORING SB-3A	SHEET 7 of 7
Woodward-Clyde Consultants			

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT CHEMPRO, Tacoma Plant

Location See figure 1

Boring No. CTMW-1

Surface Elevation 26.5 ft.

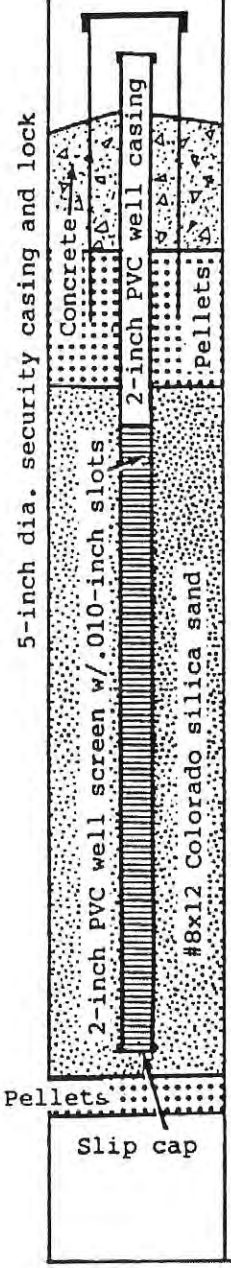
Drilling Method Hollow Stem Auger

Total Depth 11.2 ft.

Drilled By Tacoma Pump & Drilling

Date Completed 6/3/87

Logged By SRS



PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
	0				SW	Gravelly SAND, gray to black, fine to coarse, trace silt; moist.	
	2						
20-20-20		1	SB		SP	2.0-3.5'. SAND, black, fine to medium, trace silt; very moist at 3.5 ft.; oil odor.	oily
	4						
	6						
3-4-6	8	2	SS		SP	7.0-8.5'. SAND, gray to brown gray, fine to medium, with scattered interbeds of silty SAND; saturated; slight odor.	slighty oily
	10	3	SS		ML	10.4-11.2'. SILT, gray brown to light gray, scattered roots and grasses; very moist	
3-2-1	12						

SEA-300-02a

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BORING LOG

PROJECT CHEMPRO, Tacoma Plant

Location See figure 1

Boring No. CTMW-5

Surface Elevation 27.2 ft.

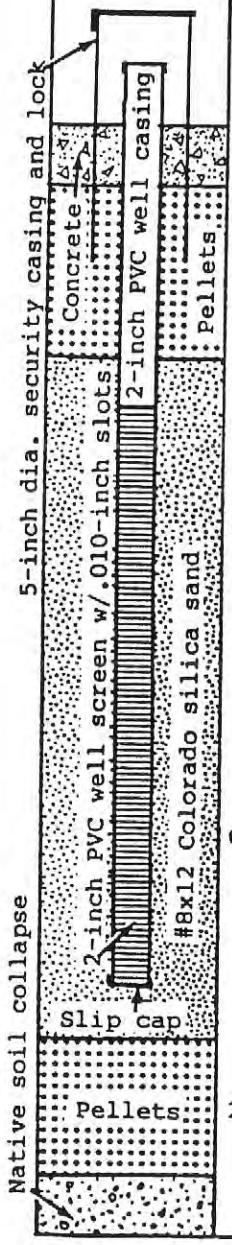
Drilling Method Hollow Stem Auger

Total Depth 13.0

Drilled By R Tacoma Drilling & Pump

Date Completed 5/29/87

Logged By DEM



WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		0						
						SW	0-1.5'. Gravelly SAND, light brown, fine to medium, abundant wood debris, trace gravel & cobbles, dry.	
		2						
	15-14-14		1	SB		SM	2.0-2.5'. Silty SAND, dk. brown, fine to medium, abundant plant roots, moist.	
		4				SM	4.0-4.5'. Silty SAND, brown to black, fine, trace fine gravel, moist.	
	4-6-8		1A	SS		SP		
		6					4.5-5.5'. SAND, gray, fine to medium, scattered red fragments, saturated.	
	6-5-5	8	2	SS		SP	7.0-8.5'. SAND, gray, fine to medium, saturated.	
		10					Solvent(?) odor	
	2-1/2-1/2		3	SS				
		12	4	SS		CL	Clayey SILT, see following pages for description	

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT CHEMPRO, Tacoma Plant

Boring No. CTMW-5

Native soil collapse

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
	Pushed 1.5 ft.	12	4	SS			11.5-13.0'. Clayey SILT, light gray, abundant plant roots, indistinct bedding, moist.	
		14						

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Location See Figure 2.1 **Boring No.** CTMW-7

Surface Elevation _____ **Drilling Method** Cable Tool

Total Depth 32.5' **Drilled By** Tacoma Pump & Drilling

Date Completed 11/25/87 **Logged By** KGL

WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
5-inch diam. security casing and lock; concrete; 2-inch PVC Well Casing; Bentonite Chips		0						
						GP	0-1' GRAVEL, 3/4" crushed rock	
		2				SM	1-2' SILTY SAND, brown, fine to coarse, some fine gravel, trace clay, med. dense, moist.	
		4					2-7' SOLID WASTE (Auto Debris) Brown to black, misc. man-made fill intermixed with sand and gravel, med. dense, moist to wet, slight odor.	
		6						
		8				SM/ SP	7-11' SAND, gray brown, medium grained, bluish sheen, med. dense, trace to some silt, oil odor.	
		10					heaving sand	CHnu=50ppm, Poly Draeger Tube = 4mm
	10-32-8		1	SS				
		12				ML	11-12' SILT, dark brown, trace to some med. sand, trace fine gravel, soft, wet.	

SEA-300-02a

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-7

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
Bentonite Pellets; 2-inch PVC Well Casing		12				SP	12-26' SAND, dark gray to black, fine to med., trace coarse, trace silt, med. dense to soft, wet, no odor.	
		14						
		16						
		18					some gravel from 18-20'	
		20						
	9-11-50 /4"		2	SS				Hnu=4ppm Poly Draeger Tube=4mm
		22				SP		
		24					heaving sand	
2-inch PVC Well Screen w/0.010-inch slots; Stainless Steel Centralizer; #8x12 Colorado Silica Sand		26						
							26-32.5' INTERBEDDED SILT AND SAND description on following page	

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-7

WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
Stainless Steel Centralizer; #8x12 Colorado Silica Sand		26				SM/ ML	26-32.5' INTERBEDDED SILT AND SAND organic rich lenses, thinly laminated to lenses several inches thick, med. dense to soft, wet, no odor.	
		28						
		30						
6"	10-15-30	32	3	SS			Terminate boring at 31' 11/24/87	Hnu=150ppm, Poly Draege Tube=Zero, Duplicate Sample
		34						
		36						
		38						
		40						

Sweet, Edwards & Associates, Inc.

BORING LOG

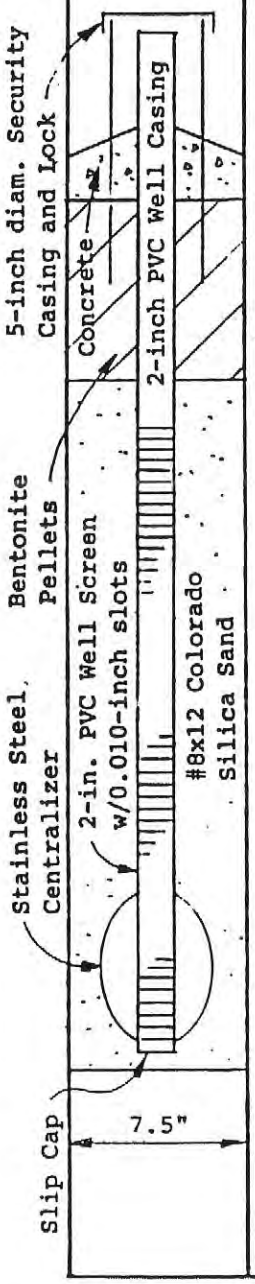
PROJECT Chempro, Tacoma Plant

Location See Figure 2.1 **Boring No.** CTMW-8

Surface Elevation **Drilling Method** Hollow Stem Auger

Total Depth 10 ft. **Drilled By** Tacoma Pump and Drilling

Date Completed 11/27/87 **Logged By** KGL



WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		0				GP	0-1' GRAVEL, 3/4" crushed rock	
		2					1-9.5' LIME WASTE, blue gray, some silty sand and fine gravel, stickey, med. dense to dense, moist to wet.	
		4						
		6					wet cuttings at 5'	
		8						
		10				ML	9.5-10' CLAYEY SILT, brown, organic rich, medium plasticity, soft, wet.	
		12					Terminate boring at 10', 11/27/87	

SEA-300-02a

Sweet, Edwards & Associates, Inc.

BORING LOG

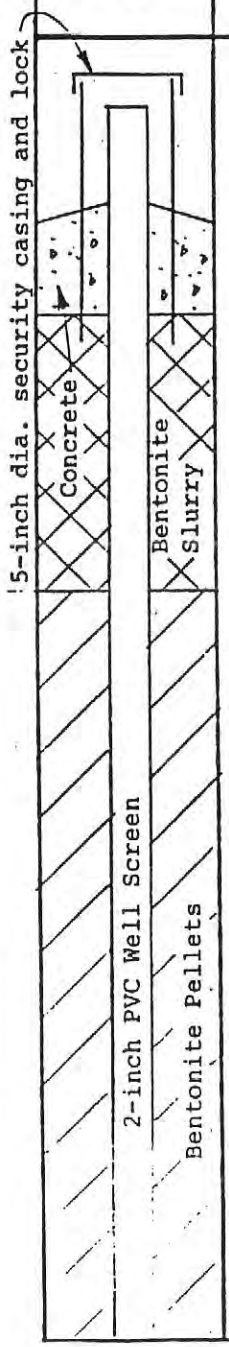
PROJECT Chempro, Tacoma Plant

Location See Figure 2.1 **Boring No.** CTMW-9

Surface Elevation _____ **Drilling Method** Hollow Stem Auger

Total Depth ~~40~~ 30 ft. **Drilled By** Tacoma Pump and Drilling

Date Completed 11/27/87 **Logged By** KGL



WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		0						
						GP	0-1' GRAVEL, 3/4" crushed rock.	
		2					1-9.5' LIME WASTE, blue gray, some silty sand and fine gravel, stickey, med. dense to dense, moist to wet.	
		4						
		6						Hnu=14ppm
		8						
							9.5-14' CLAYEY SILT, brown, organic rich, med. plasticity, soft, wet.	
		10				ML		
		12						

SEA-300-02a

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-9

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		12				ML	CLAYEY SILT (description on previous page)	
		14					14-27' SAND, dark gray to black, med., some coarse, abundant shell fragments, trace silt, med. dense to loose, wet.	
		16				SP	grades to less silt with depth	
		18						
		20						
	10-10-25		1	SS				
		22						
		24				SP		
		26						

Bentonite Pellets

2-inch PVC Well Casing

Stainless Steel Centralizer

2-inch PVC Well Screen w/0.010-inch Slots

#8x12 Colorado Silica Sand

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-9

WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
Stainless Steel Centralizer; #8x12 Colorado Silica Sand; Slough; 6"	6-12-16	26	2	SS		SP	SAND (description on previous page)	Hnu=13ppm
		28				SM/ ML	27-31.5' INTERBEDDED SILT AND SAND, dark gray, fine grained, low plasticity silt, thinly laminated to lenses several inches thick, med. dense to soft, wet, no odor.	
		30						
		32					Terminate boring at 30' 11/28/87	
		34						
		36						
		38						
		40						

SEA-300-02b

Sweet, Edwards & Associates, Inc.

BORING LOG

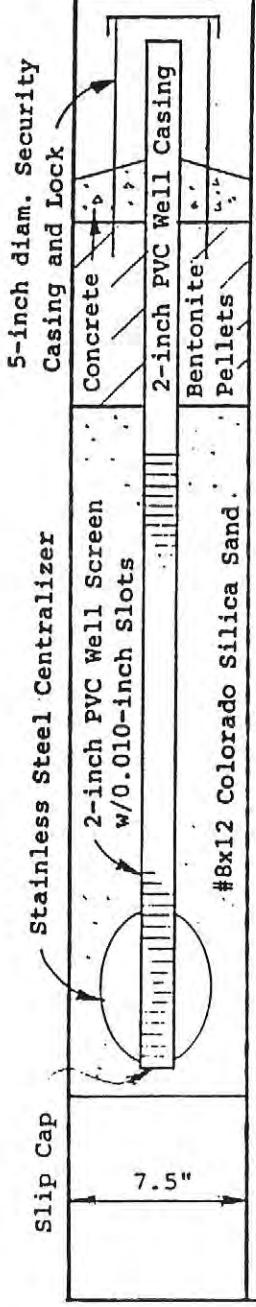
PROJECT Chempro, Tacoma Plant

Location See Figure 2.1 **Boring No.** CTMW-10

Surface Elevation **Drilling Method** Hollow Stem Auger

Total Depth 10' **Drilled By** Tacoma Pump and Drilling

Date Completed 11/27/87 **Logged By** KGL



WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		0				SM/ML	0-1' SANDY SILT (Top Soil), brown.	
		2				SM	1-3' SANDY SILT, light blue gray, some lime waste, med. to coarse, some fine gravel, med. dense, moist.	
		4				ML	3-5.25' SILT, brown, organic fragments, med. plasticity, moist, strong oil odor, wet cuttings at 4'.	Hnu=5ppm
	12-10-9	6	1	SS		SP	5.25-10' SAND, black, fine to med., some shell fragments, med. dense, saturated.	Hnu=7.5ppm
		8						
		10					Terminate boring at 10' 11/27/87	
		12						

SEA-300-02a

LOG OF CTMW-11(R2)

PROJECT: TWAAFA	COORDINATES: N 712465.1 E 1170801.5 (NAD83)	
LOCATION: Tacoma, WA	SURFACE ELEV. (NAVD88): 21.0 ft	TOC ELEV. (NAVD88): 20.77 ft
DRILLING CONTRACTOR: Cascade Drilling	DATE: 10/23/2021	
DRILLING EQUIPMENT: CME 75	TOTAL DEPTH OF BORING: 16.5ft	ECOLOGY I BMM-968
DRILLING METHOD: 4" Hollow Stem Auger	LOGGED BY: D.Cooper	
SAMPLING METHOD: 3"x18" SPT 300# auto	RESPONSIBLE PROF.: D.Cooper	REG. NO.: 1600

NOTES:

DEPTH (feet)	SAMPLES: Lab Sample	SAMPLES: Sample Recovery	SAMPLES: Blow Counts	SAMPLES: PID (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors	BORING AND WELL CONSTRUCTION DETAILS
1					Surface - Crushed Rock	8" Morris Flush-Mount Well Box
2					**POORLY GRADED SAND WITH SILT (SM):** brown to gray (7.5YR-5/3-5/1) , moist to wet 80% sand, 15% silt, 5% gravel	2-inch Diameter SCH 40 PVC Casing TOC elev. 20.77' North rim
3			21/50-6"	0.0		Concrete 0-2.0'
4						
5						Hydrated medium Bentonite Chip 2.0-5.0'
6			20/21/20	0.0		
7						
8			1/2/1	0.0		#2-12 Monterey Silica Sand 5.0-16.0'
9					**SLUDGE (ML):** white (7.5YR 8/1), wet, pasty, non-plastic, with limestone fragments No odor	
10						
11			2/3/3	0.0		
12						2-inch Diameter SCH 40 PVC Screen 0.010" slot 5.5-15.5' 0.4' end cap Total well depth: 15.9'
13			1/2/2	0.0		
14						
15						
16			3/3/4	0.1	**SILT (ML)**	

Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Location See Figure 2.1 **Boring No.** CTMW-12

Surface Elevation _____ **Drilling Method** Cable Tool

Total Depth 35.5 ft. **Drilled By** Tacoma Pump & Drilling

Date Completed 11/27/87 **Logged By** KGL

WELL DETAILS	PENE-TRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERME-ABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
5-inch diam. Security Casing and Lock; Concrete; Bentonite Pellets; 2-inch PVC Well Screen; Bentonite Chips		0						
						GP	0-1' GRAVEL, 3/4" crushed rock.	
		2				SM	1-4.5' SILTY SAND, brown, fine to medium, some gravel, trace cobbles, med. dense, moist, no odor.	
		4					encounter ground water	
		6					4.5-14' SOLID WASTE (Lime Waste ?) greenish white, "chalkey", creamy consistency, appears greasy, slight effevescence with dilute HCl, very soft, wet.	
		8						
		10						
		12						

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-12

WELL DETAILS	PENETRATION TIME/ RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
		12					SOLID WASTE description on previous page	
		14					14.5-20' CLAYEY SILT, brown to gray, bedded to thinly laminated, abundant organics, med. to low plasticity, soft, wet, organic-rich odor.	
		16				ML		
		18						
		20					20-31' SAND, dark gray to black, fine to med., trace coarse, med. dense to loose, trace silt, wet, no odor.	
		22				SM/SP	heaving sand	
		24						
	18-25-34		1	SS				
		26						

Stainless Steel Centralizer

2-inch PVC Well Casing

Bentonite Chips

2-inch PVC Well Screen w/0.010-inch slots

#8x12 Colorado Silica Sand

Sweet, Edwards & Associates, Inc.

BORING LOG

PROJECT Chempro, Tacoma Plant

Boring No. CTMW-12

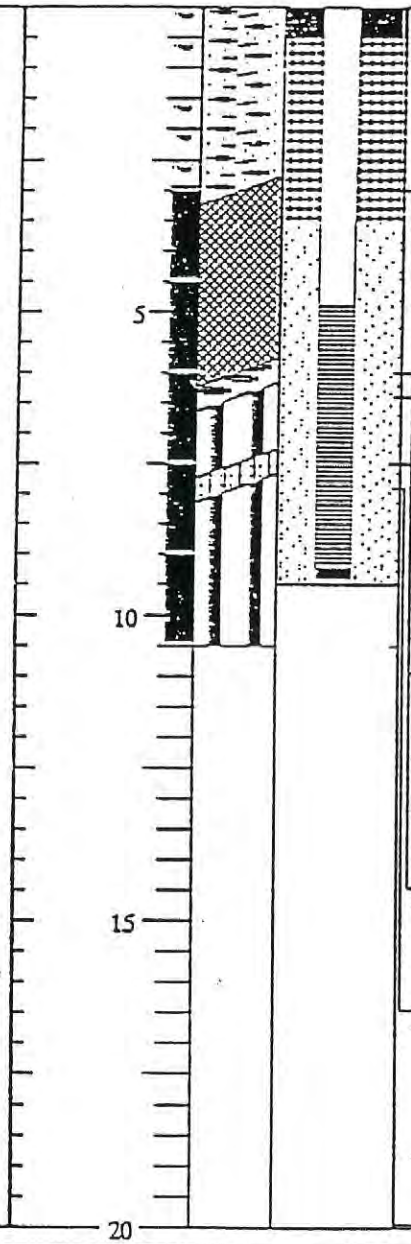
WELL DETAILS	PENETRATION TIME/RATE	DEPTH (FEET)	SAMPLE NO.	SAMPLE TYPE	PERMEABILITY TESTING	SYMBOL	LITHOLOGIC DESCRIPTION	WATER QUALITY
2-in. PVC Well Screen w/0.010-inch slots; Stainless Steel Centralizer; #8x12 Colorado Silica Sand; Slough; 6"	18 30 50	26 28 30 32 34 36 38 40	2	SS		SM/SP SM/ML	SILTY SAND TO SAND (description on previous page) 31-35.5 SAND WITH INTERBEDDED SILT, dark gray to black, fine grained, some med., low plasticity silt, med. dense to loose, wet, no odor. heaving sand Terminate boring at 34' 11/27/87	

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors, Inc.	BORING NO.	CTMW-14
LOCATION	Tacoma, Parcels B & C	PAGE	1 OF 2
DRILLED BY	Hokkaido Drilling	REFERENCE ELEV.	25.50'
DRILL METHOD	H.S. Auger	TOTAL DEPTH	10.50'
LOGGED BY	Anne Udaloy	DATE COMPLETED	5/12/89

SAMPLE NUMBER/ INTERVAL	SAMPLE TYPE	BLOW COUNT PER 6"/ % TOTAL RECOVERY
0-1.5	GRAB	
0.5	GRAB	
1.5-3	GRAB	
2.5	GRAB	
3-4.5	SS	4-30-28 30%
4.5-6	SS	5-3-3 0%
6-7.5	SS	2-4-4 100%
7.5-9	SS	3-4-3 30%
9-10.5	SS	2-2-2 100%

GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOLOGIC COLUMN | WELL DETAILS



LITHOLOGIC DESCRIPTION

0 - 3.0 feet: SANDY GRAVEL with cobbles (FILL); light brown, 40% medium sand, 60% subangular to subrounded gravel to 3 inches in diameter, trace cobbles to 6 inches in diameter, very dense, difficult to sample. Dry. (GW)

— @ 0.4 - 0.7 foot: SAND; light brown, <15% subrounded gravel to 2 inches in diameter, loose, dry. (SP)

3.0 - 6.0 feet: LIME WASTE (FILL); light brown with white splotches, 10-15% fines, 70% medium sand, <20% subrounded to subangular gravel 1/4 to 1 inch in diameter. White splotches effervesce in dilute HCl. Dry. No recovery from 4.5-6.0 feet. (FILL)

6.0 - 6.4 feet: SANDY GRAVEL (FILL); light grey, 30% sand, 70% subrounded and subangular gravel to 1 inch in diameter, loose, saturated. (GP-GM)

— @ 6.3 - 6.4 feet: SAND (FILL); black with red grains, 90% medium sand. (SP)

6.4 - 7.5 feet: CLAYEY SILT (FILL); light grey with red sand grains, 70-95% silt, trace to 30% fine sand, roots common, fines downward. Plastic. Saturated. (MH-OH)

7.5 - 7.9 feet: SAND (FILL); black with red grains and white shell fragments. 15% fines, 85% coarse sand, saturated, loose. (SM)

7.9 - 10.5 feet: CLAYEY SILT; light grey with tan streaks, 80-95% silt, trace to 20% fine and medium sand, common roots, plastic, saturated. (MH-OH)

— @ 9.7 - 9.9 feet: PEAT; light brown and black. (PT)

REMARKS

1) All SAMPLE NUMBERS are prefaced by "CTMW-14-". 2) Elevations are referenced to City of Tacoma datum.

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors, Inc.	BORING NO.	CTMW-14
LOCATION	Tacoma, Parcels B & C	PAGE	2 OF 2
DRILLED BY	Hokkaido Drilling	REFERENCE ELEV.	25.50'
DRILL METHOD	H.S. Auger	TOTAL DEPTH	10.50'
LOGGED BY	Anne Udaloy	DATE COMPLETED	5/12/89

SAMPLE NUMBER/ INTERVAL	SAMPLE TYPE	BLOW COUNT PER 6"/ % TOTAL RECOVERY	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHO-LOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
				25				Boring terminated at 10.5 feet. WELL CONSTRUCTION DETAILS: Total assembly length: 11.2 feet. Casing stickup: 1.6 feet. Screened interval: 4.9-9.4 feet. Filter pack: 3.5-9.5 feet, Colorado 8x12 Silica Sand. Seal: 0.5-3.5 feet, Enviroplug medium bentonite chips. Surface seal: 0-0.5 foot, concrete.
				30				
				35				
				40				

REMARKS

1) All SAMPLE NUMBERS are prefaced by "CTMW-14-". 2) Elevations are referenced to City of Tacoma datum.

SWET-EDWARDS/EMCON

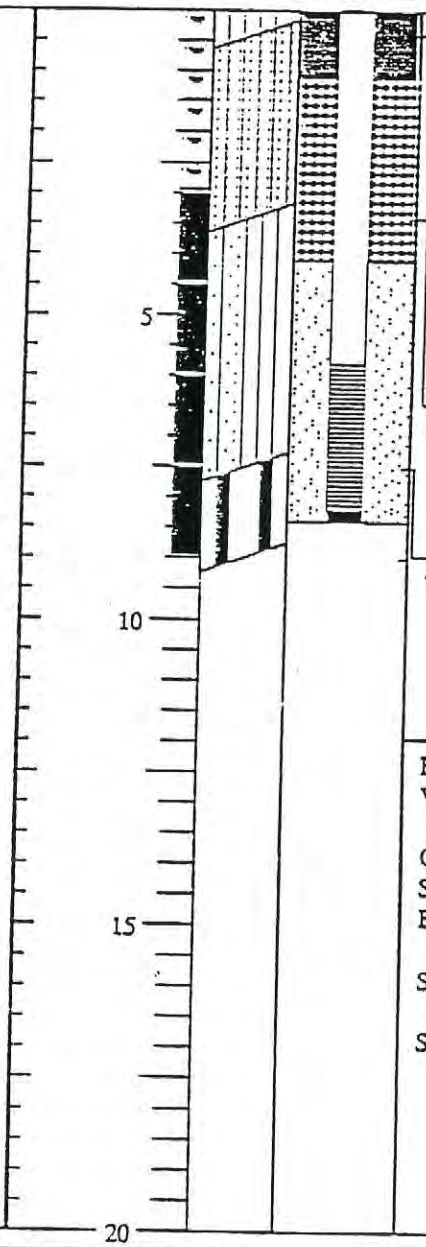
594-03.10 CHEMB C.IF 08/17/90

LOG OF EXPLORATORY BORING

PROJECT NAME	Chemical Processors, Inc.	BORING NO.	CTMW-15
LOCATION	Tacoma, Parcels B & C	PAGE	1 OF 1
DRILLED BY	Hokkaido Drilling	REFERENCE ELEV.	24.60'
DRILL METHOD	H.S. Auger	TOTAL DEPTH	9.50'
LOGGED BY	Anne Udaloy	DATE COMPLETED	5/16/89

SAMPLE NUMBER/ INTERVAL	SAMPLE TYPE	BLOW COUNT PER 6"/ % TOTAL RECOVERY
0-1.5	GRAB	
0.5	GRAB	
1.5-3	GRAB	
2.5	GRAB	
3-4.5	SS	1-1-1 40%
4.5-6	SS	1-2-3 30%
6-7.5	SS	2-2-4 10%
7.5-9	SS	2-3-4 100%

GROUND WATER LEVELS | DEPTH IN FT. | SAMPLES | LITHOLOGIC COLUMN | WELL DETAILS



LITHOLOGIC DESCRIPTION

0 - 0.4 feet: GRAVELLY SANDY SILT (FILL); light grey and tan, 55% silt, 25% medium to fine sand, 20% 1/4 to 1/2 inch diameter gravel. Moist, slightly plastic, no odor. (ML)

0.4 - 3.4 feet: SILTY SAND; dark brown, 20-25% silt, 70% medium to fine sand, < 5% subrounded gravel to 2 inches in diameter. Moist. (SM)

— @ 3.3 - 3.4 feet: PEAT; dark brown, < 20% silt or coarser, roots abundant. (PT)

3.4 - 7.5 feet: SANDY SILT/SILTY SAND; light grey, 25-80% silt, 20-75% fine and medium sand, slightly plastic, saturated. (SM/ML).

7.5 - 9.0 feet: CLAYEY SILT; light brown and light grey, light grey with black splotches to 1/8 inch in diameter from 7.5 to 7.9 feet. 90% silt or finer, < 10% fine sand; plastic, not sticky, saturated. (MH-OH)

Boring terminated at 9.0 feet.

WELL CONSTRUCTION DETAILS: Total assembly length: 7.1 feet.
Casing stickup: -0.7 feet.
Screened interval: 5.3-8.2 feet.
Filter pack: 4.1-8.2 feet, Colorado 8x12 Silica Sand.
Seal: 1.1-4.1, Enviroplug medium bentonite chips.
Surface seal: 0-1.1 feet, concrete.

REMARKS

1) All SAMPLE NUMBERS are prefaced by "CTMW-15-". 2) Elevations are referenced to City of Tacoma datum.

SWEET-EDWARDS/EMCON

594-03.10 CHEVR C IS 08/17/89

LOG OF EXPLORATORY BORING

PROJECT NAME	Chempro, Tacoma	BORING NO.	CTMW-17
LOCATION	Parcel A	PAGE	1 OF 1
DRILLED BY	Tacoma Pump & Drilling	REFERENCE ELEV.	30.20'
DRILL METHOD	H.S. Auger	TOTAL DEPTH	15.50'
LOGGED BY	P. Rowland	DATE COMPLETED	04/08/91

SAMPLE NUMBER	PHOTO FRAME NUMBER	BLOW COUNT (per six inches)	GROUND WATER LEVELS	DEPTH IN FT.	SAMPLES	LITHOLOGIC COLUMN	WELL DETAILS	LITHOLOGIC DESCRIPTION
CT-4 91-4	10	7, 13, 15						0.5 to 7.8 feet: GRAVELLY SAND, (SW-GW); gray to brown, fine to coarse sand, fine to coarse gravel to 1 1/2-inches, trace of silt, subangular to rounded. (FILL)
	11	13, 10, 14						
	12	10, 12, 20						
CT-4 91-5	13	20, 30, 26		5				@ 5.5 feet: sand bed.
	14	46, 30, 32						
	15	20, 34, 36						7.8 to 15.0 feet: SAND AND GRAVEL, (SW-GW); dark gray to black, fine to coarse sands and gravels; wood fibers; plastic; rubber; wire; metal fragments; oil and grease; sheen on grains; saturated. (AUTOFLUFF-FILL)
CT-4 91-6	16	3, 3, 3		10				
	17	20, 64, 60						
	18	27, 11, 20						
	19	6, 3, 5		15				15.0 to 15.5 feet: SILTY CLAY, (ML); gray, soft, plastic; wood root fibers. Former soil surface.
				20				Bottom of boring at 15.5 feet.

REMARKS

Well Construction details: 2-inch diameter PVC Screen and riser. Factory slotted screen 0.010-inch diameter slots. 10-20 silica sand. Reference elevation is ground surface. Top of PVC elevation is 30.16. Blow counts are per 6-inches penetration using a 140 -pound hammer with a 30-inch stroke. Surface monument is flush mounted.

PSC

Location: Tacoma
Project Number: 11071
Permit No.: AGJ983

Site Id: CTMW-17D

Elevation: 16.90' | Datum: NGVD 1929
Date Started: 01/11/01 | Date Completed: 01/11/01
Total Depth: 31.50'
Static Water Level: 3.00'
Logged By: C. Johnson
Remarks:

Borehole Dia.: 14.25in
Contractor: Cascade Drilling, Co
Drilling Method: Hollow Stem Auger
Consulting Firm: PSC
Certified By:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
							(FILL) GRAVEL	MP. El. 16.64
2							WATER 3.00'	
4			100	5 7 19	0.00 ppm		(ML) SILT, Silt Lens olive gray, wet, with woody debris.	
							(GW) GRAVEL, medium brown/olive, loose, wet, poorly sorted, small amount of sandy silt.	
6			0	12 19 21	0.00 ppm			
8			100	18 12 14	0.00 ppm			
			50	19 20 20	0.00 ppm			
10			100	25 25 25	0.00 ppm			
12			75	24 19 16	0.00 ppm			
14			100	25				

PSC

Location: Tacoma

Project Number: 11071

Measuring Point: 16.64'

Site Id: CTMW-17D

Remarks:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
				24 32	0.00 ppm			
16			25	7 10 10				
			100	10 5 5	0.00 ppm		(GW) Gravel, Olive gray, pebble sized, loose, wet, poorly sorted.	
18								
			100	4 4 4			(ML) SILT, Olive gray, well sorted, soft to medium stiff.	
20								
22								
			0	60				
			100	50 50 60	1.2 ppm		(SW) SAND Brownish black w/red, white, and transparent grains, fine to medium, dense, wet, poorly sorted.	
24							4" thick silt stringer at 24'bgs.#	
26								
			100	34 50	0.1 ppm			
28								
30								

PSC

Location: Tacoma

Project Number: 11071

Measuring Point: 16.64'

Site Id: CTMW-17D

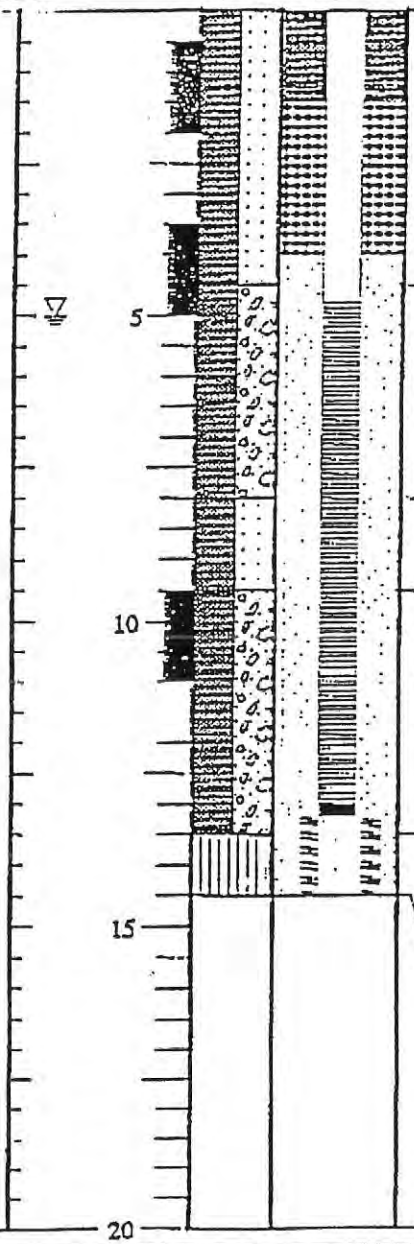
Remarks:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
32								
34								
36								
38								
40								
42								
44								
46								

LOG OF EXPLORATORY BORING

PROJECT NAME	Chempro, Tacoma	BORING NO.	CTMW-18
LOCATION	Parcel A	PAGE	1 OF 1
DRILLED BY	Tacoma Pump & Drilng	REFERENCE ELEV.	30.93'
DRILL METHOD	H.S.Auger	TOTAL DEPTH	15.50'
LOGGED BY	P. Rowland	DATE COMPLETED	04/09/91

SAMPLE NUMBER	PHOTO FRAME NUMBER	BLOW COUNT (per six inches)
CT-4 91-1	1	6
		10
		11
	2	10
		22
		27
CT-4 91-2	3	11
		38
		36
	4	19
		22
		50
	5	10
		15
		10
	6	5
		5
		5
CT-4 91-3	7	10
	8	22
		25
		22
		23
		15
	9	3
		5
		3



0.5 to 4.5 feet: SAND, (SW); brown to gray, fine to coarse sand, trace to 10 percent gravel, well rounded; wood fragments at 3 feet; dry.

4.5 to 8.0 feet: GRAVELLY SAND, (SW-GW); gray, fine to medium sand, fine to medium gravel; up to 15 percent silt beds of gravel at 5 and 7.6 feet. Saturated below 5.5 feet. (FILL)

8.0 to 9.5 feet: SAND, (SW); gray, fine to medium sand, trace of gravel, trace of silt. (FILL)

9.5 to 13.5 feet: GRAVELLY SAND, (SW-GW); gray, fine to coarse sand, fine to coarse gravel to 1-inch diameter, rounded; shell fragments at 12 feet; saturated. (FILL)

13.5 to 14.5 feet: SILT/CLAYEY SILT, (ML); gray; root fibers; odorous. Fomer soil surface.

Bottom of boring at 14.5 feet.

REMARKS

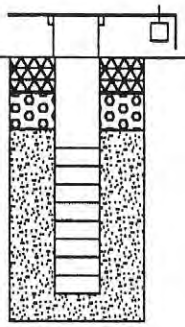
Well Construction details: 2-inch diameter PVC Screen and riser. Factory slotted screen 0.010-inch diameter slots. 10-20 silica sand. Reference elevation is ground surface. Top of PVC elevation is 33.35. Blow counts are per 6-inches penetration using a 140 -pound hammer with a 30-inch stroke.

PSC	Site ID: CTMW-18	Location: Tacoma	Date(s): 04/09/91
	Permit No.:		Well Depth (ft bgs): 13.00' Boring Depth (ft bgs): 14.50'
	Purpose: Monitoring Well, Shallow		Borehole Diameter: NA From (feet bgs): NA To (feet bgs): NA
Geologist: P.Rowland Chempro	Contractor: Tacoma Pump & Drill		
Drilling Method: Hollow Stem Auger	Drilling Fluid Used: NA Drilling Fluid Type: NA		Wellbox Type: Standpipe w/ Locking Cap

Type / Material			Depth (feet bgs) From:	To:	Length (ft)	Volume (ft^3)	Comments:
Conductor Casing:	0.00in		0.00'	0.00'	0.00'	##	PVC Joint:
Well Casing:	2.00in PVC		-2.4'	5.00'	7.40'	##	PVC Joint: Threaded
Screens:	2.00in Slotted	0.010in	5.00'	13.00'	8.00'	##	PVC Joint: Threaded
Annular Fill Materials:	Concrete Grout		0.00'	2.00'	2.00'	##	Poured
	Bentonite Chips		2.00'	4.00'	2.00'	##	Tremied
	Sand #2/20		4.00'	14.50'	10.50'	##	Tremied

Elevation (ft)	Depth (ft)	Recovery	Sample No.	Blow Count	Graphic Log	Geological Description:
10	10					(SP) SAND, Brown to gray, fine to coarse, dry, some organic debris.
						(SW) GRAVELLY SAND, Gray, fine to medium, saturated below 7.6 feet bgs.
						(SP) SAND, Gray, fine to medium, trace of gravel, trace of silt.
						(SW) GRAVELLY SAND, Gray, fine to coarse to 1" dia., saturated, some organic debris.
0	20					(ML) SILT, Gray, some organic debris.
-10	30					
-20	40					
-30	50					
-40						

Well Construction Diagram (Not To Scale)



* All measurements are in feet bgs.

PSC

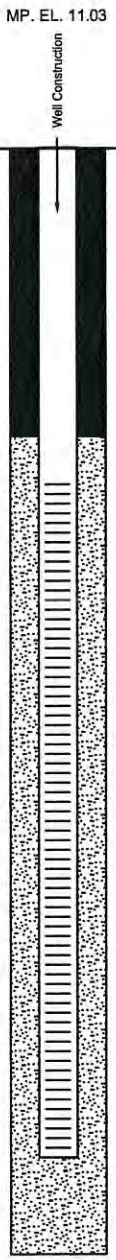
Location: Tacoma
Project Number: 11071
Permit No.: AFF965

Site Id: CTMW-20

Elevation: 11.70' | Datum: NGVD 1929
Date Started: 06/20/00 | Date Completed: 06/20/00
Total Depth: 11.50'
Static Water Level: 2.00'
Logged By: T. Gray
Remarks:

Borehole Dia.: 9.00in
Contractor: Cascade Drilling, Co
Drilling Method: Hollow Stem Auger
Consulting Firm: PSC
Certified By:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description
0							(FILL) GRAVEL
2			60	18 29 32	15.4 ppm		WATER ~2.00' (SP) SAND, Dusky yellowish brown, dense, moist, poorly sorted, medium to fine grained, and medium coarse sand dense, moist.
4							
6							
8			60	11 12 8	2.2 ppm		
10			60	2 2 2	11.8 ppm		(SM) SILTY SAND, Yellowish brown w/ black specks, soft, fine to medium, moist, poorly sorted. (OL) SILT, Olive gray w/ black specks, wet, very fine grained, soft, well sorted.
12							
14							

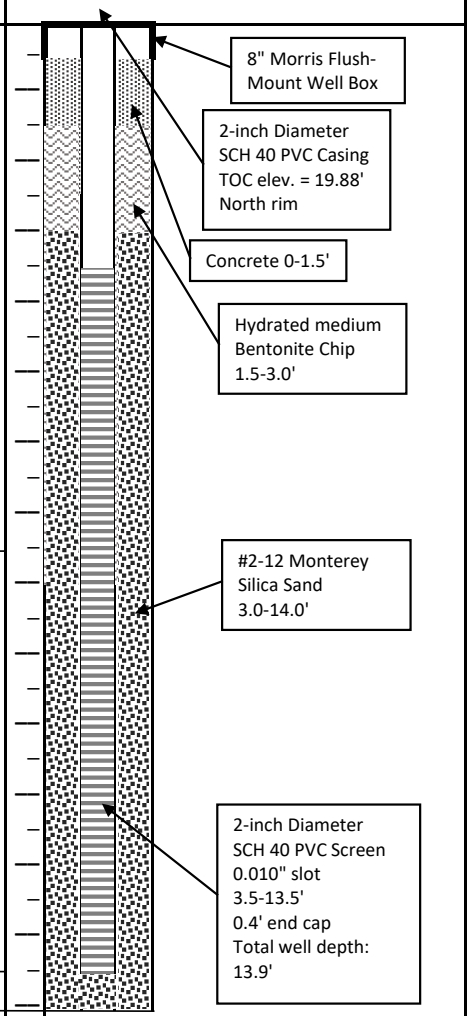


LOG OF CTMW-23(R)

PROJECT: TWAAFA	COORDINATES: N 712347.6 E 1170753.5 (NAD83)	
LOCATION: Tacoma, WA	SURFACE ELEV. (NAVD88): 21.1 ft	TOC ELEV. (NAVD88): 19.88 ft
DRILLING CONTRACTOR: Cascade Drilling	DATE: 10/23/2021	
DRILLING EQUIPMENT: CME 75	TOTAL DEPTH OF BORING: 14.0ft	ECOLOGY I BMM-969
DRILLING METHOD: 4" Hollow Stem Auger	LOGGED BY: D.Cooper	
SAMPLING METHOD: 3"x18" SPT 300# auto	RESPONSIBLE PROF.: D.Cooper	REG. NO.: 1600

NOTES:

DEPTH (feet)	SAMPLES: Lab Sample	SAMPLES: Sample Recovery	SAMPLES: Blow Counts	SAMPLES: PID (ppm)	VISUAL SOIL DESCRIPTION	BORING AND WELL CONSTRUCTION DETAILS
1					Surface - Crushed Rock	
2					**POORLY GRADED SAND WITH GRAVEL (SP):** medium brown, moist to wet	
3			50-6"	0.0		
4						
5						
6			26/28/30	0.0		
7						
8			2/4/2	0.0		
9					**SLUDGE (ML):** white, wet, pasty, non-plastic, with limestone fragments No odor	
10						
11			1/1/1	0.0		
12						
13			3/4/6	0.0		
14					**SILT (ML)**	
15						
16						



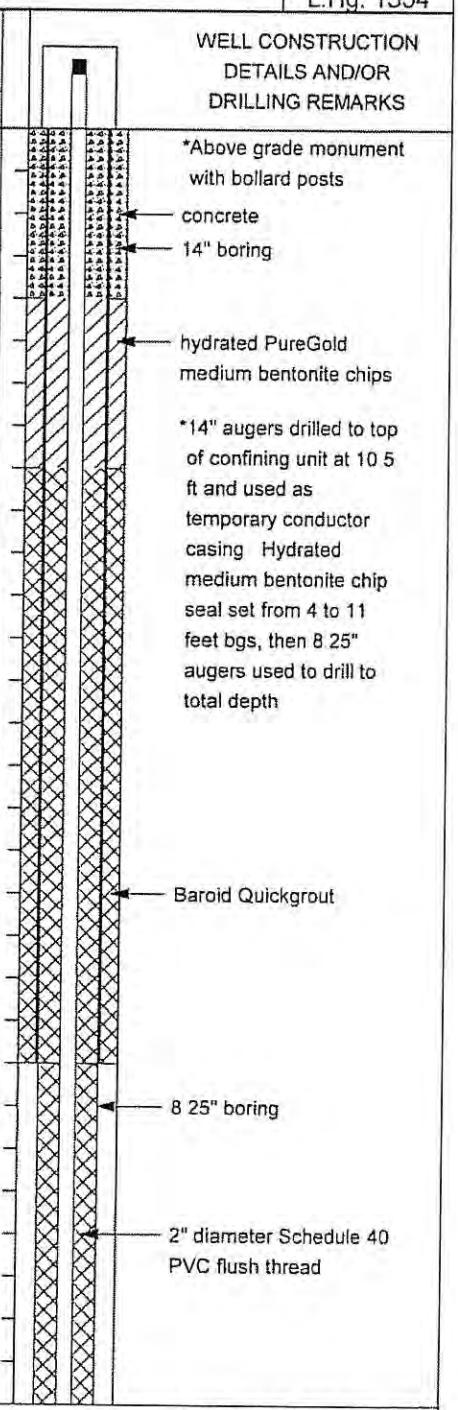
Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

PROJECT: PSC Tacoma Tacoma, Washington	**Log of Well No. CTMW-24**
BORING LOCATION: 1649 E Alexander (N 712293.1; E 1170515.8)	TOP OF CASING ELEVATION AND DATUM: 16.35 feet (NGVD 1929)
DRILLING CONTRACTOR: Cascade Drilling, Inc.	DATE STARTED: 8/16/05 / DATE FINISHED: 8/16/05
DRILLING METHOD: Hollow-stem auger	TOTAL DEPTH (ft.): 11.0 / SCREEN INTERVAL (ft.): 5.5 - 10.3
DRILLING EQUIPMENT: CME-75	DEPTH TO WATER (ft.): FIRST / COMPL ~6.5 / CASING: 2" Sched. 40 PVC
SAMPLING METHOD: NA	LOGGED BY: T. Gray
HAMMER WEIGHT: NA / DROP: NA	RESPONSIBLE PROFESSIONAL: J. Long / REG NO. L.Hg. 1354

DEPTH (feet)	SAMPLES: Sample No.	SAMPLES: Sample	SAMPLES: Blows/ Foot	OVM Reading	DESCRIPTION NAME (USCS): color, moist. % by wt., plast density, structure, cementation, react w/HCl, geo inter Surface Elevation: 14 00 feet (NGVD 1929)	WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS
1						*Above grade monument with bollard posts
2						concrete
3						PureGold hydrated medium bentonite chips
4						2" diameter Schedule 40 PVC flush thread
5						2/12 Monterey sand
6					See CTMW-24D log for lithology as this well is located ~5 feet away from well CTMW-24D	8 25" boring
7						
8						Schedule 40 PVC well screen, 0.010" slot
9						
10						
11					End of boring at 11.0 feet	0 30' PVC end cap
12						
13						
14						
15						

PROJECT: PSC Tacoma Tacoma, Washington	**Log of Well No. CTMW-24D**
BORING LOCATION: 1649 E. Alexander (N 712297 2; E 1170515 4)	TOP OF CASING ELEVATION AND DATUM: 16.39 feet (NGVD 1929)
DRILLING CONTRACTOR: Cascade Drilling, Inc	DATE STARTED: 8/16/05 / DATE FINISHED: 8/16/05
DRILLING METHOD: Hollow-stem auger	TOTAL DEPTH (ft.): 24.5 / SCREEN INTERVAL (ft.): 19 - 23.8
DRILLING EQUIPMENT: CME-75	DEPTH TO WATER (ft.): FIRST / COMPL ~6.5 / CASING: 2" Sched. 40 PVC
SAMPLING METHOD: SPT split spoon drive sampler [18" x 2 5"]	LOGGED BY: T. Gray
HAMMER WEIGHT: 300 lb / DROP: 30 in	RESPONSIBLE PROFESSIONAL: J. Long / REG NO L.Hg. 1354

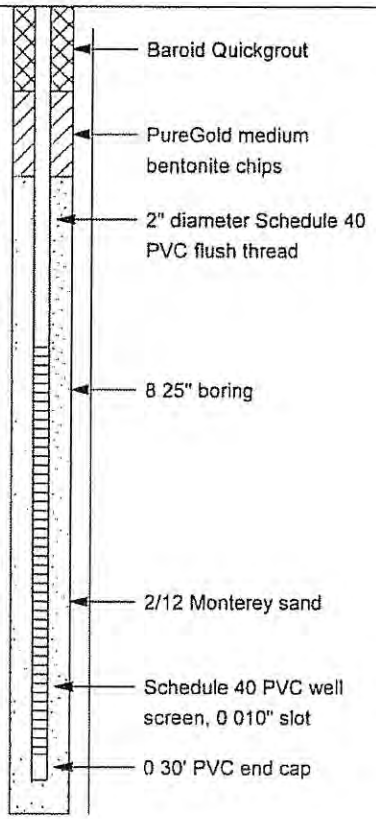
DEPTH (feet)	SAMPLES: Sample No.	SAMPLES: Sample	SAMPLES: Blows/ Foot	OVM Reading	DESCRIPTION NAME (USCS): color, moist, % by wt., plast density. structure, cementation, react w/HCl, geo inter Surface Elevation: 14 00 feet (NGVD 1929)
1	CTMW-24D-0805		53	0	POORLY GRADED SAND with GRAVEL (SP): dark yellowish brown (10YR 4/6), dry, 80% fine to medium sand, 20% gravel
2			23		
3				0	
4			38	0	POORLY GRADED SAND (SP): dark gray (2 5Y 4/1), wet, 95% fine to medium sand, 5% nonplastic fines fabric layer POORLY-GRADED SAND with GRAVEL (SP)
5			29	0	POORLY GRADED SAND with SILT (SP-SM): dark gray (2 5Y 4/1), moist, 85% fine to medium sand, 15% nonplastic fines, trace gravel
6			9		POORLY GRADED SAND (SP): very dark grayish brown (10YR 3/2), moist, 95% fine to medium sand, 5% nonplastic fines
7				0	wet fine to coarse sand content (95%)
8			2		POORLY GRADED SAND with SILT (SP-SM): very dark grayish brown (10YR 3/2), moist, 85% fine to coarse sand, 15% nonplastic fines
9			3	0	SILTY SAND (SM): very dark grayish brown (10YR 3/2), wet, 80% fine sand, 20% nonplastic fines SILT (ML) fines increase to 30%
10				0	
11			3	0	ORGANIC SILT (OL): very dark grayish brown (10YR 3/2), with black streaking, wet, 95% fines, 5% sand, low plasticity, soft, abundant organic material, peaty
12					
13			4		
14					SILT (ML): very dark grayish brown (10YR 3/2), wet, 95% fines, low plasticity, soft
15			4		



PROJECT: PSC Tacoma
Tacoma, Washington

Log of Well No. CTMW-24D (cont'd)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/ Foot	OVM Reading	DESCRIPTION NAME (USCS): color, moist, % by wt., plast density. structure, cementation, react w/HCl, geo inter	WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS
16			8		SILT (ML): (cont'd)	
17					SILT with SAND (ML): very dark grayish brown (10YR 3/2), wet, 75% fines, 25% fine sand, firm, some sand and silt stringers	
18			14		POORLY GRADED SAND (SP): black (10YR 2/1), wet, 95% fine sand, 5% nonplastic fines	
19			8			
20						
21						
22						
23						
24						
25					End of boring at 24 5 feet	
26						
27						
28						
29						
30						
31						
32						
33						



PROJECT: PSC Tacoma Tacoma, Washington	**Log of Well No. CTMW-25D**
BORING LOCATION: 1801 E. Alexander (N 711774.1; E 1170888.6)	TOP OF CASING ELEVATION AND DATUM: 13.06 feet (NGVD 1929)
DRILLING CONTRACTOR: Cascade Drilling, Inc	DATE STARTED: 8/19/05 / DATE FINISHED: 8/19/05
DRILLING METHOD: Hollow-stem auger	TOTAL DEPTH (ft.): 21.0 / SCREEN INTERVAL (ft.): 15.5 - 20.3
DRILLING EQUIPMENT: CME-75	DEPTH TO WATER (ft.): FIRST / COMPL 6 / CASING: 2" Sched. 40 PVC
SAMPLING METHOD: SPT split spoon drive sampler [18" x 2.5"]	LOGGED BY: T. Gray
HAMMER WEIGHT: 300 lb / DROP: 30 in	RESPONSIBLE PROFESSIONAL: J. Long / REG NO L.Hg. 1354

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	Blows/ Foot	OVM Reading	DESCRIPTION NAME (USCS): color, moist, % by wt., plast density, structure, cementation, react. w/HCl, geo inter Surface Elevation: 10 91 feet (NGVD 1929)
1					POORLY GRADED SAND with GRAVEL (SP): dark yellowish brown (10YR 4/6), dry, 80% fine to coarse sand, 20% gravel with cobbles up to 3 inches, backfilled portion from utility line excavation
2					SILTY SAND (SM): very dark grayish brown (10YR 3/2), moist, 80% fine sand, 20% nonplastic fines
3			9		
4				6	
5			6	3	
6	CTMW-25D-0805				SILT (ML) wet
7			2		wood fragments up to 1" SILT (ML)
8			2	0	POORLY-GRADED SAND (SP)
9					ORGANIC SILT (OL): very dark grayish brown (10YR 3/2), moist, 95% fines, 5% sand, abundant organic debris, glass pieces, black streaking, nonplastic, firm, peaty texture
10					
11			4	0	SILT (ML): very dark grayish brown (10YR 3/2), wet, 95% fines, 5% sand, nonplastic, soft, some organic debris
12					few organic debris
13			3	0	POORLY-GRADED SAND (SP)
14			18	0	POORLY GRADED SAND (SP): black (10YR 2/1), wet, 95% fine sand, 5% nonplastic fines SILT (ML)
15					

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS

- *Above grade monument with bollard posts concrete
- PureGold hydrated medium bentonite chips
- 14" boring
- *14" augers drilled to top of confining unit at 9 ft and used as temporary conductor casing Hydrated medium bentonite chip seal set from 4 to 9 5 feet bgs. then 8 25" augers used to drill to total depth
- Baroid Quickgrout
- 8 25" boring
- 2" diameter Schedule 40 PVC flush thread
- PureGold hydrated medium bentonite chips
- 2/12 Monterey sand

PROJECT: PSC Tacoma
Tacoma, Washington

Log of Well No. CTMW-25D (cont'd)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/ Foot	OVM Reading	DESCRIPTION NAME (USCS): color, moist, % by wt., plast density, structure, cementation, react w/HCl, geo inter	WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS
16			5		POORLY GRADED SAND (SP): (cont'd) sand is fine to medium	2/12 Monterey sand
17			14			Schedule 40 PVC well screen, 0 010" slot
18					SILT (ML)	
19						
20						8 25" boring
21					End of boring at 21 0 feet	0 30' PVC end cap
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						

BURLINGTON ENVIRONMENTAL

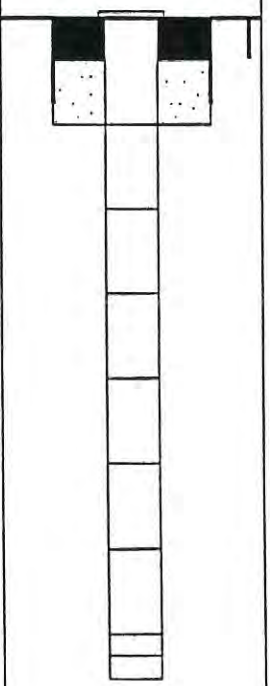
Project: Tacoma RFI	Consulting Firm: Burlington	Date(s):03/17/94 – 03/17/94	
	Drilling Contractor: Burlington	Casing Elevation: 13.77	
	Drilling Method: RECON	Datum: NGVD 1929	
	Logged By: K. Tahghighi	Approved By:	
Identification: PZ–1	Total Depth 7.00 ft		
	Borehole Diameter: 2.20 in		
State Permit # R09293 Permit Date:	Well Casing: 1.56" PVC	From 0.0 to 1.00 ft	
Remarks: Pilot hole to 7.5 ft bgs Driven Piezometer Flush mount monument, with security bolts	Screen: PVC Slot Size: 0.020in	From 1.00 to 7.00 ft	
	Annular Fill: Bentonite	From 0.00 to 0.5 ft	

ELEVATION (feet)	DEPTH (feet)	GRAPHIC LOG	Material Description	Well Construction
13.77	0		(SW) Brown medium to fine to coarse SAND, trace SILT (0.0'– 0.5') Fill Material	
			(SW) Brown medium to fine to coarse SAND, trace SILT, trace fine GRAVEL (0.5'– 1.5') Fill Material	
			(FI) Dark gray medium to fine to coarse SAND and SILT, trace fine GRAVEL, trace miscellaneous FILL (AUTO FLUFF) (1.5'– 5.5') Fill Material	
8.77	5		(SP) Dark gray medium to fine SAND, trace SILT (from 5.5')	
			Total Depth = 7.0 feet bgs	
3.77	10			

BURLINGTON ENVIRONMENTAL

	Consulting Firm: Burlington	Date(s):03/17/94 – 03/17/94
	Drilling Contractor: Burlington	Casing Elevation: 12.86
	Drilling Method: RECON	Datum: NGVD 1929
Project: Tacoma RFI	Logged By: K. Tahghighi	Approved By:
	Total Depth 7.20 ft	
Identification: PZ–5	Borehole Diameter: 2.20 in	
State Permit # R09293 / Permit Date:	Well Casing: PVC Diameter: 1.56 in	From 0.00 to 1.2 ft
Remarks: Pilot hole to 8.5' bgs Driven piezometer Flush mount monument with security bolts	Screen: PVC Slot Size: 0.01 in	From 1.20 to 7.20 ft
	Annular Fill: Bentonite	From 0.00 to 0.5 ft

ELEVATION (feet)	DEPTH (feet)	GRAPHIC LOG	Material Description	Well Construction
12.86	0			
			Nearest known boring/well: CTMW–8	
7.86	5			
			Total Depth = 7.2 feet bgs	
2.86	10			



PSC

Location: Tacoma
Project Number: 11071
Permit No.:

Site Id: PZ-7

Elevation: 18.66' | Datum: NGVD 1929
Date Started: 01/10/01 | Date Completed: 01/10/01
Total Depth: 18.00'
Static Water Level: 6.75
Logged By: T. Gray

rehole Dia.: 9.25in
Contractor: Cascade Drilling, Co
Drilling Method: Hollow Stem Auger
Consulting Firm: PSC
Certified By:

Remarks:
Permanent Piezometer
Water Elevation Measurement Point

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
0			60	8 12 21	0.00 ppm		(FILL) SANDY GRAVEL, Olive orange brown, medium dense, poorly sorted, moist to dry.	
			30	9 13 19	0.2 ppm			
2			60	19 20 12	0.00 ppm		(FILL) Auto-fluff	
4			60	30 30 30	0.00 ppm			
6			60	15 19 30	0.00 ppm		(SM) SILTY SAND, Olive gray to brown, medium sand with silt, poorly sorted, wet, some wood debris and auto-fluff present. WATER ~6.75'	
			60	18 23 18	0.7 ppm			
8			60	10 14 10	5.9 ppm			
10			100	9 17	0.00 ppm		(ML) SILT Silt lens.	
			60	50 22 17	0.00 ppm			
12							(ML) SILT Silt lens with wood debris.	
14			18	12				

PSC

Location: Tacoma

Project Number: 11071

Measuring Point: 20.97'

Site Id: PZ-7

Remarks:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
				9 12				
			18	9 9 7				
16								
			60	4 3 4			(ML) SILT, Olive gray, medium stiff, moist, well sorted.	
18								
20								
22								
24								
26								
28								
30								

PSC

Location: Tacoma
Project Number: 11071
Permit No.:

Site Id: PZ-8

Elevation: 11.65' | Datum: NGVD 1929
Date Started: 01/09/01 | Date Completed: 01/09/01
Total Depth: 12.00'
Static Water Level: 4.50'
Logged By: T. Gray

Borehole Dia.: 9.25in
Contractor: Cascade Drilling, Co
Drilling Method: Hollow Stem Auger
Consulting Firm: PSC
Certified By:

Remarks:
Permanenet Piezometer
Water Elevation Measuring Point

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description
0			60	15 50			(FILL) Gravel, Surface Debris, and Organic Debris.
			60	24 26 30	2.8 ppm		(SW) GRAVELLY SAND, Orange brown, medium dense, poorly sorted, dry to moist, some organic debris.
2			20	9 6 9			
4			60	6 12 19	2.4 ppm		WATER ~4.50' (SP) SAND, Brownish black with red grains, fines, medium dense, poorly sorted, medium wet, shell debris.
6			60	11 16 18	0.00 ppm		
			60	10 12 15	0.00 ppm		
8			60	2 2 2	0.00 ppm		
10			60	5 5 9	0.00 ppm		(OL) SILT, Olive brown with black streaks, stiff, moist to wet, some wood debris.
12							
14							

Well Construction

PSC

Location: Tacoma
Project Number: 11071
Permit No.:

Site Id: PZ-9

Elevation: 12.42' | Datum: NGVD 1929
Date Started: 01/09/01 | Date Completed: 01/09/01
Borehole Dia.: 9.25in
Total Depth: 11.50'
Contractor: Cascade Drilling, Co
Static Water Level: 4.00'
Drilling Method: Hollow Stem Auger
Logged By: T. Gray
Consulting Firm: PSC
Remarks:
Permanenet Piezometer
Water Elevation Measuring Point
Certified By:

Depth (bgs)	Sample No.	Recovery	Recovery (percent)	Blow Count	Headspace (ppm)	Graphic Log	Material Description	Well Construction
0			100	48 50	0.00 ppm		(FILL) Gravel, Orange brown, loose.	
			100	42 50	0.00 ppm		(SW) GRAVELLY SAND, Olive green gray, medium to coarse, loose, dry to moist, poorly sorted.	
2			100	18 60				
					0.00 ppm			
4							WATER ~4.00'	
6							Rocky debris.	
			60	6 9	0.00 ppm			
8			0	38 7 7				
10			60	4 4 10	0.00 ppm		(OL) SILT, Olive gray, medium stiff, soft, very wet, well sorted, with wood and root debris.#	
12								
14								

Geologic Borehole Log

MAUL FOSTER ALONG

Project Number	Well Number	Sheet
M0615.20.001	TWA-1	1 of 1

Project Name	Taylor Way TWAAFA Site	TOC Elevation (feet)	14.78
Project Location	1514 Taylor Way, Tacoma, WA	Surface Elevation (feet)	14.9
Start/End Date	12/14/21 to 12/14/21	Northing	712993.9
Driller/Equipment	Holt Drilling Services, Inc./Hollow Stem Auger	Easting	1171335.1
Geologist/Engineer	C. Wise & C. Sifford	Total Depth of Borehole	17.0 feet
Sample Method	Split Spoon	Outer Hole Diam	9 inch

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
1								3.7		0.0 to 3.0 feet: GRAVELLY SAND (SW); dark grayish brown (10YR 4/2); 5% fines; 60% sand, fine to medium; 35% gravel, fine to coarse, subangular to subrounded; loose; trace cobbles up to 3-inches in size, subrounded to rounded; no odor; moist.
2										@ 0.5 feet: Rusty metal rivet or bolt, 1.5-inches by 0.5-inches in size.
3				67	SPT		2 5 3	4.2		
4								5.6		3.0 to 5.0 feet: SAND WITH SILT (SP-SM); light olive brown (2.5Y 5/3); 10% fines; 90% sand, very fine; medium dense; trace gravel, fine, subrounded; no odor; moist.
5		▽								@ 4.0 feet: Rusty metal fragment 0.5-inches in size.
6				72	SPT		2 4 4	6.1		5.0 to 17 feet: SAND (SP); black (7.5YR 2.5/1); 100% sand, fine to medium; medium dense; no odor; moist. @ 5.0 feet: Water encountered during drilling.
7								4.4		@ 5.9 feet: Silt lamina; 0.3-inches thick; tan; 100% fines, medium plasticity; soft; orange rind present; moist.
8				67	SPT		1 1 1	6.3		@ 6.1 feet: Silty sand lamina; 0.5-inches thick; 40% fines, low plasticity; 60% sand, fine; firm; moist. @ 7.0 feet: Decrease in density to very loose.
9								6.6		@ 8.8 feet: Decrease in sand grain size to fine.
10										
11				100	SPT		0 4 6			@ 10.7 to 11.0 feet: Silt lens; medium dark gray (10YR 3/1); 95% fines, medium plasticity; 5% sand, fine; medium dense; moist.
12										@ 11.0 to 11.2 feet: Laminations of silt and sand.
13				100	SPT		4 4 5	5.9 7.3		@ 12.5 to 13.2 feet: Moisture increases to wet. @ 13.2 to 13.5 feet: Silt lens; very dark gray (10YR 3/1); 95% fines, medium plasticity; 5% sand, fine; firm; moist.
14										
15				100	SPT		3 5 14	5.8		
16				100	SPT		6 15 25	6.6		@ 16.0 to 17.0 feet: Density increases to hard.
17								4.2		

Total Depth = 17.0 feet bgs

NOTES:

1. bgs = below ground surface. 2. Depths are relative to feet below ground surface. 3. ID = identification. 4. PID = photoionization detector. 5. ppm = parts per million. 6. SPT = standard penetration test.

Borehole Completion Details

0 to 1.0 feet: Concrete.
1.0 to 4.0 feet: Bentonite chips hydrated with potable water.
4.0 to 15.0 feet: 10/20 silica sand.
15.0 to 17.0 feet: Slough.

Monitoring Well Completion Details

Washington State Department of Ecology Well No. BNN191.
Traffic-grade, flush-mounted, monitoring well vault.
0 to 5.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride riser pipe.
5.0 to 15.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride, 0.010 machine slot, prepacked well screen with threaded polyvinyl chloride end cap.
Total well completion depth is approximate.

▽ **Water level at approximately 5.0 feet bgs at time of drilling.**

Geologic Borehole Log

MAUL FOSTER ALONG

Project Number	Well Number	Sheet
M0615.20.001	TWA-2	1 of 1

Project Name	Taylor Way TWAAFA Site	TOC Elevation (feet)	11.69
Project Location	1514 Taylor Way, Tacoma, WA	Surface Elevation (feet)	12.0
Start/End Date	12/13/21 to 12/13/21	Northing	712881.6
Driller/Equipment	Holt Drilling Services, Inc./Hollow Stem Auger	Easting	1171602.8
Geologist/Engineer	C. Wise	Total Depth of Borehole	11.5 feet
Sample Method	Split Spoon	Outer Hole Diam	9 inch

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
1								0.0		0.0 to 5.0 feet: GRAVELLY SAND (SW); dark grayish brown (10YR 4/2); 5% fines; 65% sand, fine to medium; 30% gravel, fine to coarse, subangular to subrounded; medium dense; trace cobbles, up to 3-inches in size, subrounded to rounded; no odor; moist.
2								0.0		
3			SPT	33			16 6 7	0.0		
4		▽						0.0		@ 4.0 feet: Water.
5			SPT	42			4 4 1	0.0		5.0 to 10.5 feet: SANDY GRAVEL (GW); dark grayish brown (10YR 4/2); 5% fines; 45% sand, fine to coarse; 50% gravel, fine to coarse, angular to subrounded; very loose; no odor; wet.
6										
7										
8			SPT	28			0 0 0	0.0		@ 7.5 feet: Gravel increases to 70%.
9										
10			SPT	100			0 1 2	0.0		@ 10.0 feet: About 2-inches of heave.
11								0.0		10.5 to 11.5 feet: SILT (ML); gray (10YR 5/1); 95% fines, medium plasticity; 5% sand, very fine; soft; trace organics (rootlets); no odor; wet.

Total Depth = 11.5 feet bgs

NOTES:

1. bgs = below ground surface. 2. Depths are relative to feet below ground surface. 3. ID = identification. 4. PID = photoionization detector. 5. ppm = parts per million. 6. SPT = standard penetration test.

Borehole Completion Details

0 to 1.0 feet: Concrete.
1.0 to 4.0 feet: Bentonite chips hydrated with potable water.
4.0 to 10.0 feet: 10/20 silica sand.
10.0 to 11.5 feet: Slough.

Monitoring Well Completion Details

Washington State Department of Ecology Well No. BNN190.
Traffic-grade, flush-mounted, monitoring well vault.
0 to 5.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride riser pipe.
5.0 to 10.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride, 0.010 machine slot, prepacked well screen with threaded polyvinyl chloride end cap.
Total well completion depth is approximate.

▽ **Water level at approximately 4.0 feet bgs at time of drilling.**

Geologic Borehole Log

MAUL FOSTER ALONG

Project Number	Well Number	Sheet
M0615.20.001	TWA-3	1 of 1

Project Name	Taylor Way TWAAFA Site	TOC Elevation (feet)	15.48
Project Location	1514 Taylor Way, Tacoma, WA	Surface Elevation (feet)	16.1
Start/End Date	12/14/21 to 12/14/21	Northing	712672.7
Driller/Equipment	Holt Drilling Services, Inc./Hollow Stem Auger	Easting	1172087.7
Geologist/Engineer	C. Wise & C. Sifford	Total Depth of Borehole	11.5 feet
Sample Method	Split Spoon	Outer Hole Diam	9 inch

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
1–5										0.0 to 7.5 feet: SAND WITH GRAVEL (SW); brown (7.5YR 4/3); 5% fines; 80% sand, very fine to medium; 15% gravel, fine to medium, subangular to subrounded; loose to dense; no odor; dry to wet.
5–7				6	SPT		3 4 3	1.6		
7		▽								
7–9				44	SPT		2 2 2	2.0		7.5 to 8.0 feet: GRAVEL (GP); gray (10YR 5/1); 10% sand, fine to medium; 90% gravel, medium to coarse, angular; loose; no odor; no sheen; wet. 8.0 to 10.5 feet: SILTY SAND (SM); brown (7.5YR 4/3); 20% fines; 80% sand, very fine to medium; firm; no odor; no sheen; wet.
10–11				94	SPT		0 0 1	2.1 2.8		10.5 to 11.5 feet: SILT (ML); very dark gray (10YR 3/1); 100% fines, medium plasticity; soft to firm; trace organics (woody debris); no odor; moist.

Total Depth = 11.5 feet bgs

NOTES:

1. bgs = below ground surface. 2. Depths are relative to feet below ground surface. 3. ID = identification. 4. PID = photoionization detector. 5. ppm = parts per million. 6. SPT = standard penetration test.

Borehole Completion Details

0 to 1.0 feet: Concrete.
1.0 to 3.0 feet: Bentonite chips hydrated with potable water.
3.0 to 10.0 feet: 10/20 silica sand.
10.0 to 11.7 feet: Slough.

Monitoring Well Completion Details

Washington State Department of Ecology Well No. BNN181.
Traffic-grade, flush-mounted, monitoring well vault.
0 to 5.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride riser pipe.
5.0 to 10.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride, 0.010 machine slot, prepacked well screen with threaded polyvinyl chloride end cap.
Total well completion depth is approximate.

▽ **Water level at approximately 7.5 feet bgs at time of drilling.**

DALTON OLMSTED FUGLEVAND

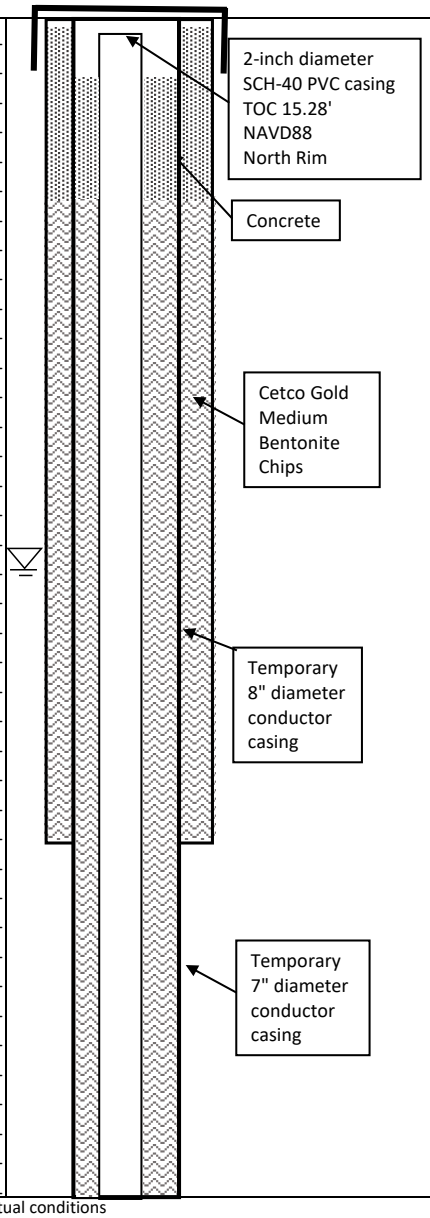
LOG OF TWA-4D

PROJECT: TWAAFA	COORDINATES: N 712176.2 E 1170862.7 (NAD 83)	
BORING LOCATION: Clean Earth - N Trailer Parking Lot	SURFACE ELEV. (NAVD88): 15.6 ft	TOC ELEV. (NAVD88) : 15.28 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 12/7/2021	
DRILLING METHOD: Sonic, with telecoping casing	TOTAL DEPTH: 60'	Ecology Tag # BNW-193
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D.COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: Recovery	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION (Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors)
1					-Asphalt surface
					5/8" minus crushed rock base
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)
2		ns/no		0.0	gray brown, wet, loose, gravelly SAND with silt
3					
4		ns/no		0.0	- wood shavings and sawdust layer 4.0' to 6.5'
5					
6		ns/no		0.9	
7					**POORLY GRADED SAND (SP)**
					saturated, gray, fine to medium sand
8		ns/no		0.0	- wood shavings and sawdust layer 7.5'-8.5'
9					
					- scattered fine organics and trace silts
10		ns/no		0.0	
11					
12		ns/no		0.0	
13					**SILT (ML)**
					wet, gray, firm, rapid dilatency, non-plastic silt with fine sand
					becomes medium plasticity silt with scattered thin roots at 13.0'
14		ns/no		0.0	
15					**POORLY GRADED SAND (SP)**
					wet, dark gray, fine to medium sand with trace silt
16		ns/no		0.2	
17					
18		ns/no		0.1	
19					
20					

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

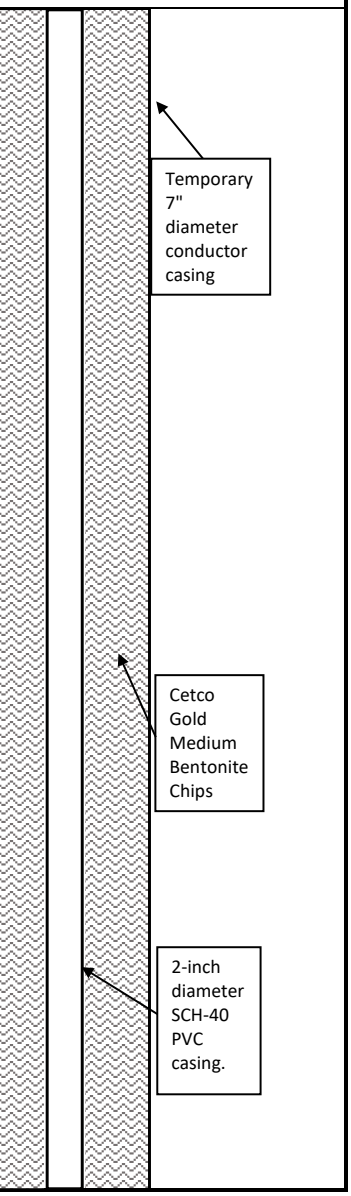
LOG OF TWA-4D

PROJECT: TWAAFA	COORDINATES: N 712176.2 E 1170862.7 (NAD 83)	
BORING LOCATION: Clean Earth - N Trailer Parking Lot	SURFACE ELEV. (NAVD88): 15.6 ft	TOC ELEV. (NAVD88) : 15.28 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 12/7/2021	
DRILLING METHOD: Sonic, with telecoping casing	TOTAL DEPTH: 60'	Ecology Tag # BNW-193
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D.COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: RECOVERY	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION (Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors)
20					**POORLY GRADED SAND (SP)**
21					wet, dark gray, fine to medium sand with trace silt
22		ns/no		0.1	
23					
24		ns/no		0.2	- thin silt layer at 24'
25					
26		ns/no		0	
27					
28		ns/no		0	
29					- increasing silt
30					**SILTY SAND (SM)**
31					- recovery lost between 30 to 35'
32					
33					
34					
35					**SILTY SAND (SM)**
36		ns/no		0.0	saturated, dark gray, silty, very fine sand
37					
38		ns/no		0.0	**POORLY GRADED SAND (SP)**
39					saturated, dark gray, fine sand with trace silt
40					

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

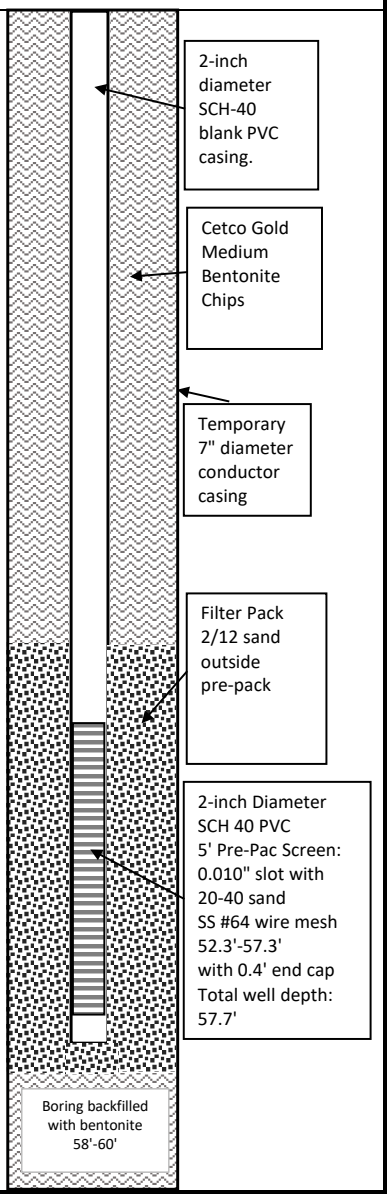
LOG OF TWA-4D

PROJECT: TWAAFA	COORDINATES: N 712176.2 E 1170862.7 (NAD 83)	
BORING LOCATION: Clean Earth - N Trailer Parking Lot	SURFACE ELEV. (NAVD88): 15.6 ft	TOC ELEV. (NAVD88) : 15.28 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 12/7/2021	
DRILLING METHOD: Sonic, with telecoping casing	TOTAL DEPTH: 60'	Ecology Tag # BNW-193
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D.COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SHEEN/ODOR	RECOVERY	PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
40	*GW	ns/no		0.1	**POORLY GRADED SAND (SP)** saturated, dark gray, fine to medium sand with trace silt
41					
42		ns/no		0.2	
43					
44		ns/no		0.1	
45		ns/no		0.1	
46					
47		ns/no		0.1	
48					
49		ns/no		0.1	
50	*GW	ns/no		0.1	***GW** - Groundwater grab sample: TWA-4_50-52_1221 @ 50-52'
51					
52		ns/no		0.1	
53					
54		ns/no		0.1	
55					
56		ns/no		0.0	
57					
58					
59		ns/no		0.0	**SILTY SAND (SM)** saturated, dark gray, silty, fine sand with shell fragments
60		ns/no		0.0	END OF BORING AT 60' Below ground surface

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

Project: Hylebos Marsh	Project Number:	Client: Port of Tacoma	Boring No. TWA-5D
Address, City, State 1212 Taylor Way		Drilling Contractor: Holt	Drill Rig Type: Sonic
Logged By: Nick Waldo	Date Started: 9/24/2019 9:00	Bit Type: Sonic	Diameter: 4
Drill Crew: Holt	Completed: 9/25/2019 14:30	Hammer Type: NA	
USA Ticket Number: 19408678	Backfilled: 9/25/2019	Hammer Weight: NA	Hammer Drop: NA
N: To be measured W: To be measured	Groundwater Depth: 9 feet bgs	Elevation:	Total Depth of Boring: 60 feet

Depth (feet)	Sample Type	Sample Number	Blow Counts (blows/foot)	Graphic Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Recovery %	Odor/Sheen	PID (PPM)
					Surface - grass		No	
					Moist weathered wood fill			
5							No	
10					9' - moist gray clay to 10 feet		No	
					Moist weathered wood fill with occasional gravel and chunks of wood			
15					16' discrete gay clay interbedded with weathered wood fill			
					0.5 to 2 inches thick			
					18.5 - wet gray clay			
20					8" conductor casing set - chipped with 1 bag of bentonite, hydrated, and pulled back about 3"			
					wet gray clayey silt			
					wet gray clayey silt with sea shells (at 23-24.5')			
25					24.5' wet gray med to coarse sand			
	W	TWA-5-1			water sample collected 25-30'			
30	S	TWA-5-30-S			wet gray clayey silt			0

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Project: Hylebos Marsh	Project Number:	Client: Port of Tacoma	Boring No. TWA-5D
Address, City, State 1212 Taylor Way		Drilling Contractor: Holt	Drill Rig Type: Sonic
Logged By: Nick Waldo	Date Started: 9/24/2019 9:00	Bit Type: Sonic	Diameter: 4
Drill Crew: Holt	Completed: 9/25/2019 14:30	Hammer Type: NA	
USA Ticket Number: 19408678	Backfilled: 9/25/2019	Hammer Weight: NA	Hammer Drop: NA
N: To be measured W: To be measured	Groundwater Depth: 9 feet bgs	Elevation:	Total Depth of Boring: 60 feet

Depth (feet)	Sample Type	Sample Number	Blow Counts (blows/foot)	Graphic Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Recovery %	Odor/Sheen	PID (PPM)
30					No recovery, heaving sands.	100	No	0
								0
35							No	0
					Very wet silts and sands, poor recovery	100		
	s	TWA-5-38-s			wet grey clay			0
					wet grey silt			
					39.5 wet grey coarse sand		No	0
40	w	TWA-5-2			water sample collected 35-40'			
					Wet dark grey med to coarse med to coarse sand			0
					1" gray clay lens			
45	w	TWA-5-3			wet dark grey med to coarse Sand			
					water sample collected 45-50'			
50					wet dark grey med to coarse Sand			
55					wet dark grey med to coarse Sand with sea shells			
					57.5 - grey sand with white coarse sand/shell lens			0
					wet grey silt with shells			
	s	TWA-5-59-s						

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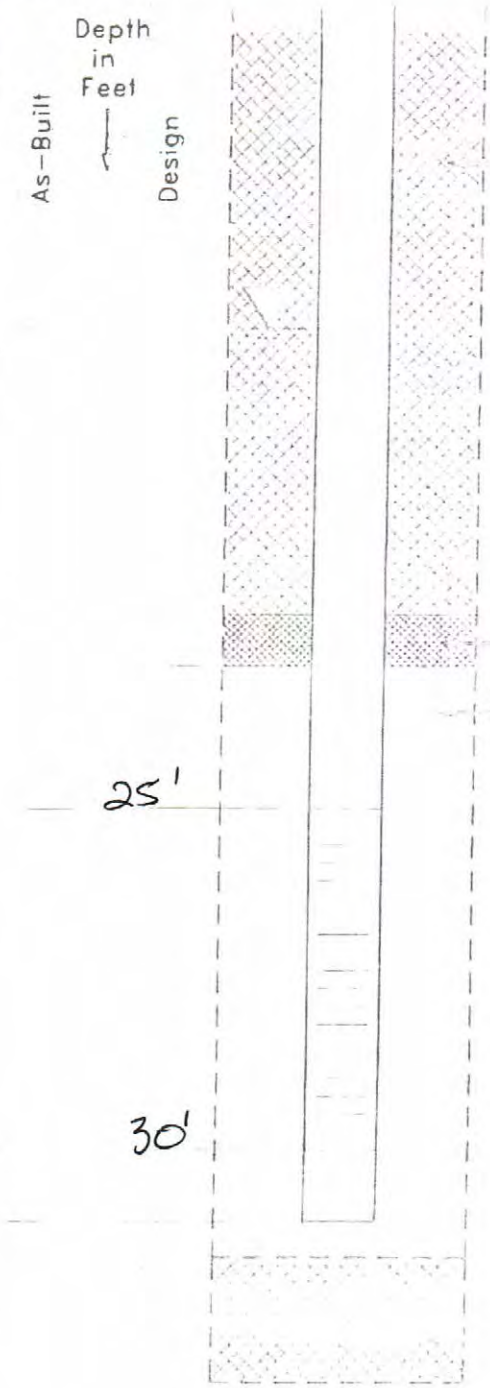
WELL INSTALLATION REPORT

Well No. TWA-5D Date 11.7.2019

Job Well tag ID# BLU-457 Job No.

Observer Waldo Drilling Method Sonic

Draw Appropriate Monument (Flush or Above Ground)



Approx. Elevation

Type of Monument groundwater well

Stickup Monument X Well

0' feet Seal Material

Drillers: Holocene Drilling

Borehole Diameter

Water Level Date ~6.0 11/7/2019

Riser Pipe Diameter 2 inch

Riser Pipe Material schedule 40 PVC

Type of Joints

"O"-Ring Seals? (Yes) No

Seal Material Bentonite to surface

Filter Pack Material 2/12 silica sand

Filter Pack Size

Screen Diameter 2 inch

Screen Material

Screen Slot Size 0.010 inch slotted

Screen Construction: Milled / Wire Wound

Tail Pipe Diameter 2"

Tail Pipe Length 4"

Tail Pipe Material

Bottom Seal Type

CONSULTING, INC

conductor casing set to 20' to seperate shallow and deep groundwater

Project: Hylebos Marsh	Project Number:	Client: Port of Tacoma	Boring No. TWA-6D
Address, City, State 1212 Taylor Way		Drilling Contractor: Holt	Drill Rig Type: Sonic
Logged By: Nick Waldo	Date Started: 9/24/2019 9:00	Bit Type: Sonic	Diameter: 4
Drill Crew: Holt	Completed: 9/25/2019 14:30	Hammer Type: NA	
USA Ticket Number: 19408678	Backfilled: 9/25/2019	Hammer Weight: NA	Hammer Drop: NA
N: To be measured W: To be measured	Groundwater Depth: 6 feet bgs	Elevation:	Total Depth of Boring: 60 feet

Depth (feet)	Sample Type	Sample Number	Blow Counts (blows/foot)	Graphic Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Recovery %	Odor/Sheen	PID (PPM)
					Surface - grass		No	
					Moist brown medium grain sand (SP)			
							No	
5					Moist dark gray sand with some shells (SP)			
					Wet layers of gray silts and sand			
					0.5 ' layer of wet gray clay (CL)			
					Moist brown and gray silts and clay with organics			
					Wet gray silt Clay with lots of embedded organics		No	
10					8" conductor casing set at 12- chipped with 1 bag of bentonite, hydrated, and pulled back about 3"			
					Gray Clay (CL)			
15	W	TWA-6-1			Water sample collected 15-20'			
					at 17' some sand mixed with clay			
					Gray clay			
					Gray clay with sandy silt			
					Wet dark gray medium sand.			
20	S	TWA-6-21-S			Wet gray sandy silt, 0.5 thick.			
					Wet dark gray medium sand.			
	W	TWA-6-2			Water collected at 25-30			
25					Wet dark gray medium sand.			
					Wet dark gray silty fine to medium sand.			
30								0

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Project: Hylebos Marsh	Project Number:	Client: Port of Tacoma	Boring No. TWA-6D
Address, City, State 1212 Taylor Way		Drilling Contractor: Holt	Drill Rig Type: Sonic
Logged By: Nick Waldo	Date Started: 9/24/2019 9:00	Bit Type: Sonic	Diameter: 4
Drill Crew: Holt	Completed: 9/25/2019 14:30	Hammer Type: NA	
USA Ticket Number: 19408678	Backfilled: 9/25/2019	Hammer Weight: NA	Hammer Drop: NA
N: To be measured W: To be measured	Groundwater Depth: 6 feet bgs	Elevation:	Total Depth of Boring: 60 feet

Depth (feet)	Sample Type	Sample Number	Blow Counts (blows/foot)	Graphic Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Recovery %	Odor/Sheen	PID (PPM)
30					Wet gray fine to medium sand.	100	No	0
								0
	W	TWA-6-3			water sample collected 35-40'		No	0
35						100		
					Wet gray layer of sand, silt and clay (0.5' thick)			
					Wet gray fine to coarse sand.			0
							No	0
40					Wet gray medium sand.			
								0
	W	TWA-6-4			water sample collected 45-50'			
45								0
	S	TWA-6-48-S			Wet dark gray silty fine sand			0
					Wet gray medium to coarse sand.			
50								
55								
					Wet sand with coarse sand- white intact shells - 2" clay layer at 57.5			0
					Wet medium sand with shells			

Civil Engineering

Boring Log: Sheet 2 of 2

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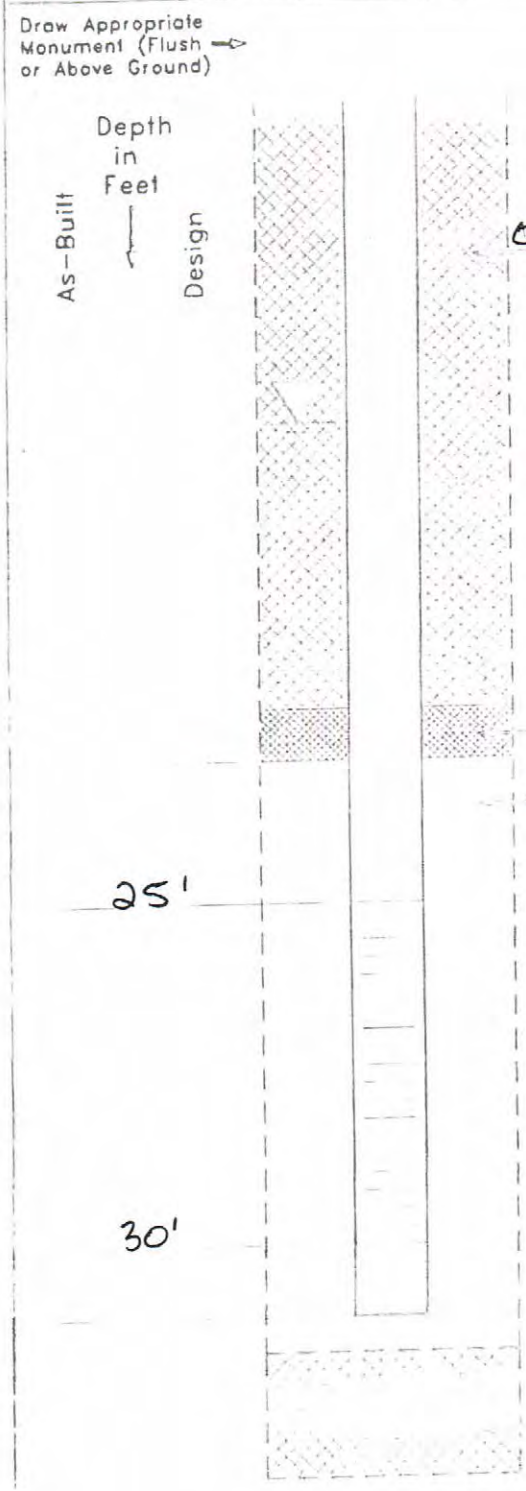
WELL INSTALLATION REPORT

Well No. TWA-6D
Job well tag ID # BLU-456
Date 11.7.2019
Job No.
Observer Waldo
Drilling Method Sonic



Approx. Elevation
Type of Monument groundwater well
Stickup Monument — X — Well
Seal Material
Borehole Diameter
Drillers: Holocene Drilling
Water Level Date ~6.5 ~~6.7~~ 11.7.2019
Riser Pipe Diameter 2 inch
Riser Pipe Material schedule 40 PVC
Type of Joints
"O"-Ring Seals? (Yes) No
Seal Material Bentonite to surface
Filter Pack Material 2/12 silica sand
Filter Pack Size —
Screen Diameter 2 inch
Screen Material —
Screen Slot Size 0.010-inch slotted
Screen Construction: Milled / Wire Wound
Tail Pipe Diameter 2"
Tail Pipe Length 4"
Tail Pipe Material
Bottom Seal Type

CONSULTING, INC

conductor set at 9.5 to 12.5' to seperate shallow and deep groundwater

DALTON OLMSTED FUGLEVAND

LOG OF TWA-7D

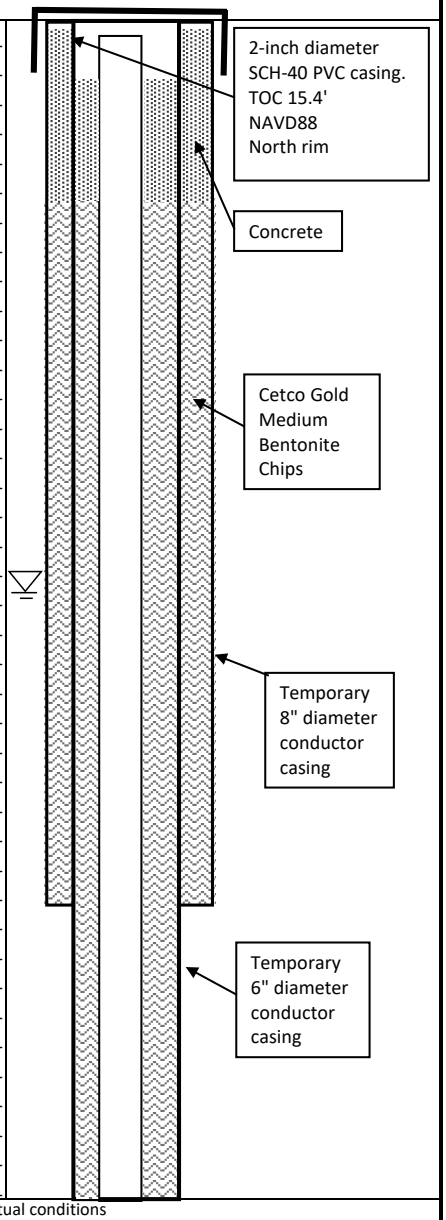
PROJECT: TWAAFA	COORDINATES: N 711980.5 E 1170617.8 (NAD 83)	
BORING LOCATION: Clean Earth - S Employee Parking Lot	SURFACE ELEV. (NAVD88): 15.7 ft	TOC ELEV. (NAVD88): 15.40 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 1/26/2022	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-082
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D. COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: Recovery	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION (Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors)
1					ashphalt surface
2					**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)**
3		ns/no		0.0	wet, mottled gray-brown, gravelly, sand with silt
4		ns/no		0.0	
5					
6		ns/no		0.9	- white, lime-like sludge materal mixed with gravel at 6.0'
7					**POORLY GRADED SAND (SP)**
8		ns/no		0.0	wet, gray, fine to medium sand , with trace gravel and silt
9					
10		ns/no		0.0	poor recovery - clean out showed:
11					**SILT (ML)**
12		ns/no		0.0	wet, brown, firm, medium-plastic silt with fine sand
13					
14		ns/no		0.0	
15					- becomes sandy
16		ns/no		0.2	**no recovery**
17					
18		ns/no		0.1	
19					
20					

BORING AND WELL CONSTRUCTION DETAILS

Morris Heavy Duty Flush-mount 8-inch dia. monument with 3-bolt cover.



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

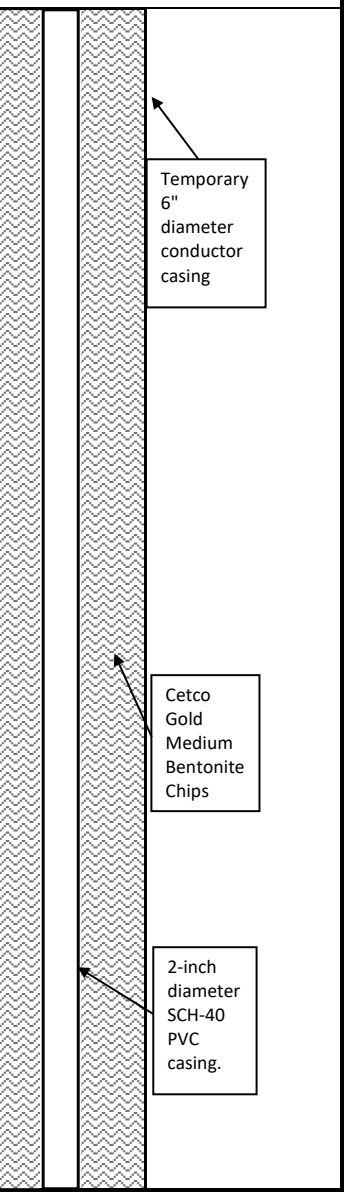
LOG OF TWA-7D

PROJECT: TWAAFA	COORDINATES: N 711980.5 E 1170617.8 (NAD 83)	
BORING LOCATION: Clean Earth - S Employee Parking Lot	SURFACE ELEV. (NAVD88): 15.7 ft	TOC ELEV. (NAVD88): 15.40 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 1/26/2022	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-082
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D.COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: RECOVERY	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION (Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors)
20					**POORLY GRADED SAND (SP)** saturated, dark gray, fine sand with trace silt and scattered shell fragments
22		ns/no		0.1	
24		ns/no		0.2	
26		ns/no		0	
28		ns/no		0	
30					- becomes silty
32					**SILT (ML)** wet, brown, medium plastic silt
34					**POORLY GRADED SAND WITH SILT (SP)** saturated, dark gray, silty, fine sand
36		ns/no		0.0	
38		ns/no		0.0	**POORLY GRADED SAND (SP)** saturated, dark gray, fine sand with trace silt
40					- increasing silt with depth

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

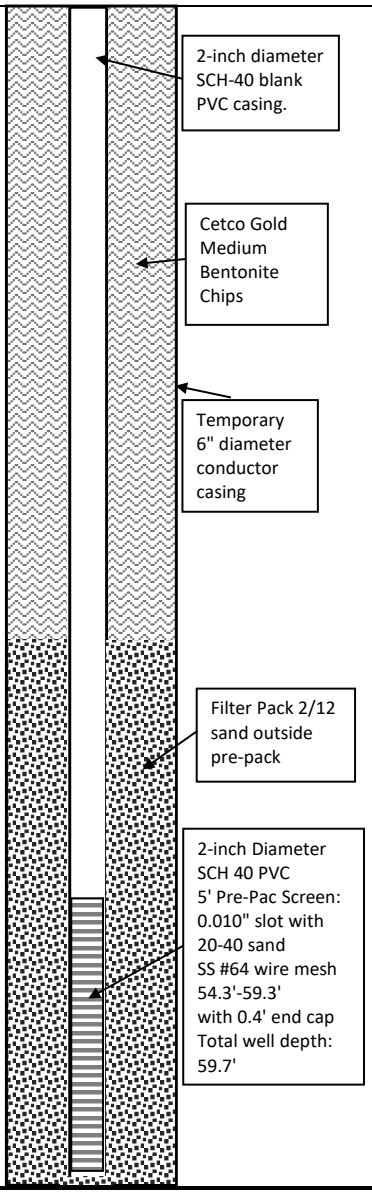
LOG OF TWA-7D

PROJECT: TWAAFA	COORDINATES: N 711980.5 E 1170617.8 (NAD 83)	
BORING LOCATION: Clean Earth - S Employee Parking Lot	SURFACE ELEV. (NAVD88): 15.7 ft	TOC ELEV. (NAVD88): 15.40 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 1/26/2022	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-082
DRILLING EQUIPMENT: Boart Longyear DB100	LOGGED BY: D.COOPER	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D.COOPER	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SHEEN/ODOR	RECOVERY	PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
40	*GW				***GW** - Groundwater grab sample: TWA-7_40-42_1221 @ 40-42'
41					
42		ns/no		0.0	**POORLY GRADED SAND (SP)**
43					saturated, dark gray, fine to medium sand with trace silt
44		ns/no		0.0	
45					
46		ns/no		0.0	
47					
48		ns/no		0.0	
49					
50		ns/no		0.0	
51					**SILTY SAND (SM)**
52		ns/no		0.0	saturated, dark gray, silty, fine to medium sand with scattered shell fragments
53					
54		ns/no		0.0	**POORLY GRADED SAND (SP)** saturated, dark gray, fine to medium sand with trace silt
55					
56	*GW	ns/no		0.0	***GW** - Groundwater grab sample: TWA-7_55-57_1221 @ 55' - 57'
57					
58					
59		ns/no		0.0	**SILTY SAND (SM)** saturated, dark gray, silty, fine sand with shell fragments
60					END OF BORING AT 60' Below ground surface

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

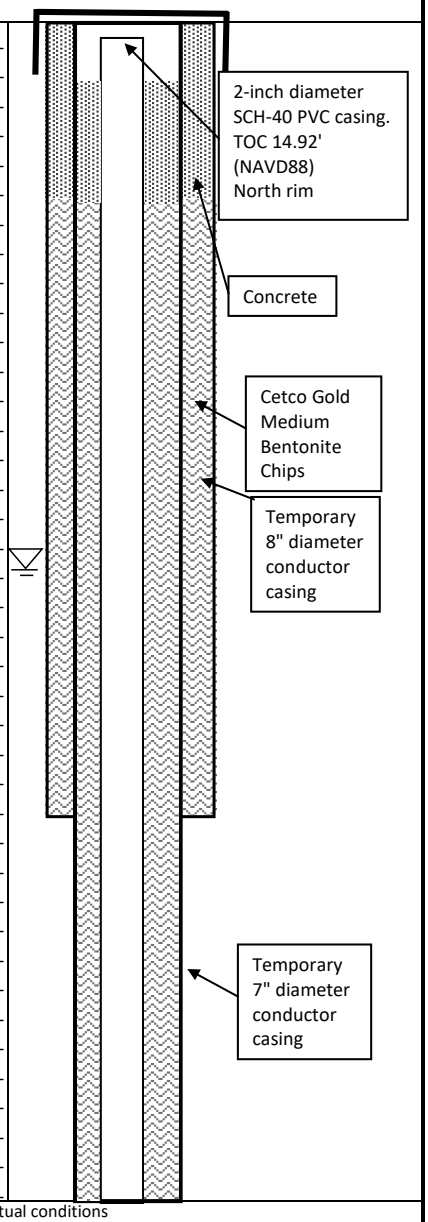
LOG OF TWA-8D

PROJECT: TWAAFA	COORDINATES: N 711983.0 E 1171072.2 (NAD 83)	
BORING LOCATION: PARCEL A	SURFACE ELEV. (NAVD88): 15.0 ft	TOC ELEV. (NAVD88): 14.92 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 10/13/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-164
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: A. CERRUTI	REG. NO.: 21013797

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: Recovery	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
1		ns/no		0.2	grassy surface **POORLY GRADED SAND with trace silt and gravel (SP)** medium brown, loose, moist, fine to medium sand, trace subrounded gravel, silt, and broken shells becomes wet at 2.2'
3		ns/no		0.1	
5		ns/no		0.2	fine roots and organics
7		ns/no		0.8	**POORLY GRADED SAND with silt (SP-SM)** medium gray, medium dense, wet, very fine to medium sand with silt increasing silt content with depth, broken shells throughout
10		ns/no		0.1	
12		ns/no			**SILT (ML)** light gray, firm, slow dilatency, non-plastic silt
13		ns/no		0.3	fine sand interbeds between 11.3' and 12.3'
15		ns/no		0.0	**POORLY GRADED SAND with silt (SP-SM)** gray, medium dense, wet, very fine to medium sand with silt
17		ns/no		0.0	**SILTY SAND (SM)** medium brown, slightly dense, wet, silty, fine to medium sand organic grasses and roots at 16.7' to 16.9'
19		ns/no		0.0	**POORLY GRADED SAND with silt (SP-SM)** medium gray, loose, wet, fine to medium sand with silt

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

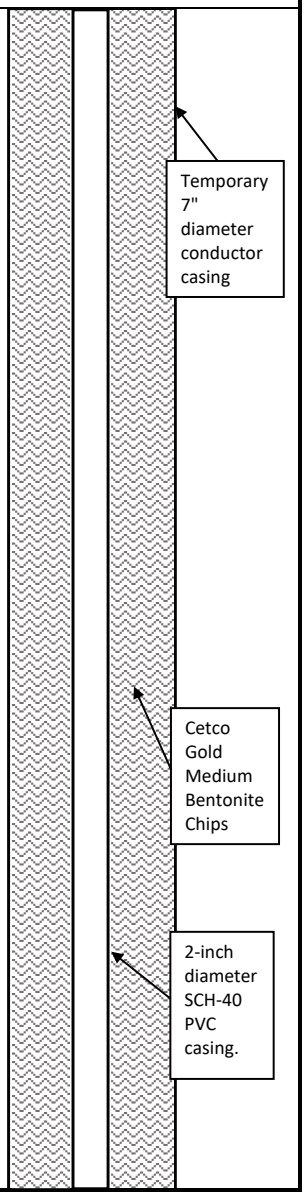
LOG OF TWA-8D

PROJECT: TWAAFA	COORDINATES: N 711983.0 E 1171072.2 (NAD 83)	
BORING LOCATION: PARCEL A	SURFACE ELEV. (NAVD88): 15.0 ft	TOC ELEV. (NAVD88): 14.92 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 10/13/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-164
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: A. CERRUTI	REG. NO.: 21013797

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: RECOVERY	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION (Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors)
20	*GW	ns/no		0.2	***GW - G**roundwater grab sample: TWA-8_20-22_1021 @ 20-22'
21					**POORLY GRADED SAND with silt (SP-SM)**
22		ns/no		0.1	medium gray, loose, wet, fine to medium sand with silt
23					-increasing silt and density
24		ns/no		0.2	
25		ns/no			
26					
27		ns/no		0.0	**SILT with sand (ML)**
28					dark gray, firm, slow dilatency, non-plastic silt with very fine to medium sand
29		ns/no		0.0	**SILTY SAND (SM)**
30		ns/no		0.0	medium gray, medium dense, wet, silty very fine to fine sand with trace organics and broken shells
31					
32		ns/no		0.0	-becomes dark gray, sand content increases
33					
34		ns/no		0.0	
35					-silty laminations at 35.5'
36		ns/no		0.0	
37					
38		ns/no		0.0	**POORLY GRADED SAND (SP)**
39		ns/no			dark gray, medium dense, wet, fine to medium sand with trace silt
40		ns/no		0.0	

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

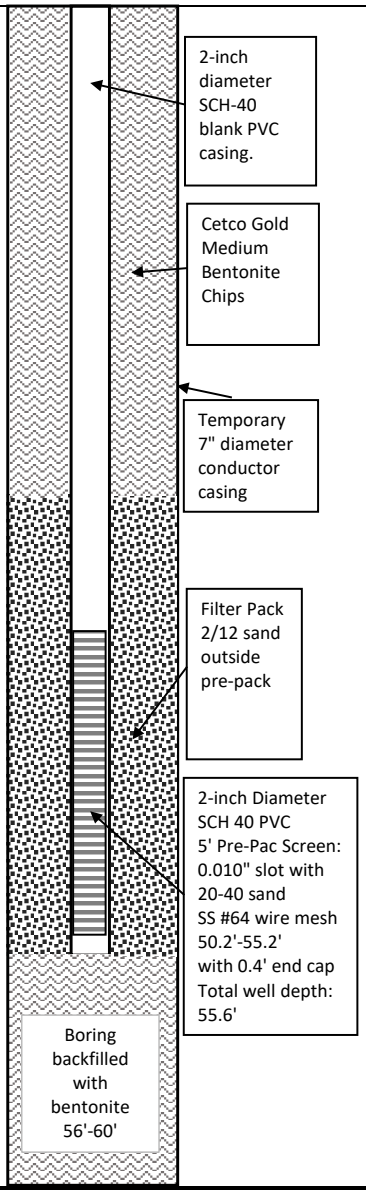
LOG OF TWA-8D

PROJECT: TWAAFA	COORDINATES: N 711983.0 E 1171072.2 (NAD 83)	
BORING LOCATION: PARCEL A	SURFACE ELEV. (NAVD88): 15.0 ft	TOC ELEV. (NAVD88): 14.92 ft
DRILLING CONTRACTOR: CASCADE DRILLING	START/END DATE: 10/13/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-164
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: A. CERRUTI	REG. NO.: 21013797

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SHEEN/ODOR	RECOVERY	PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
40	*GW	ns/no		0.1	***GW** - Groundwater grab sample: TWA-8_40-42_1021 @ 40-42'
41					**POORLY GRADED SAND with SILT (SP)** dark gray, medium dense, wet, fine to medium sand with silt
42		ns/no		0.2	densely laminated with silt stringers and trace broken shells between 42' and 42.7'
43					
44		ns/no		0.1	
45		ns/no		0.1	
46					
47		ns/no		0.1	
48					**POORLY GRADED SAND (SP)** dark gray, loose, wet, fine to medium sand
49		ns/no		0.1	-silt lense/nodule at 48.7'
50		ns/no		0.1	***GW** - Groundwater grab sample: TWA-8_50-52_1021 @ 50-52'
51					
52		ns/no		0.1	**SILTY SAND (SM)** dark gray, dense, wet, silty, very fine to medium sand. broken shells throughout, fine to medium sand lense at 51.8' to 52.1'
53					
54		ns/no		0.1	**POORLY GRADED SAND (SP)** dark gray, loose, wet, fine to medium sand with trace silt
55					-54.4' organic mat
56		ns/no		0.0	-silty nodules and fine rounded gravel at 56.7'
57					
58		ns/no		0.0	**POORLY GRADED SAND with silt (SP-SM)** dark gray, medium dense, wet, very fine to medium sand with silt,
59					
60		ns/no		0.0	END OF BORING AT 60' Below ground surface

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

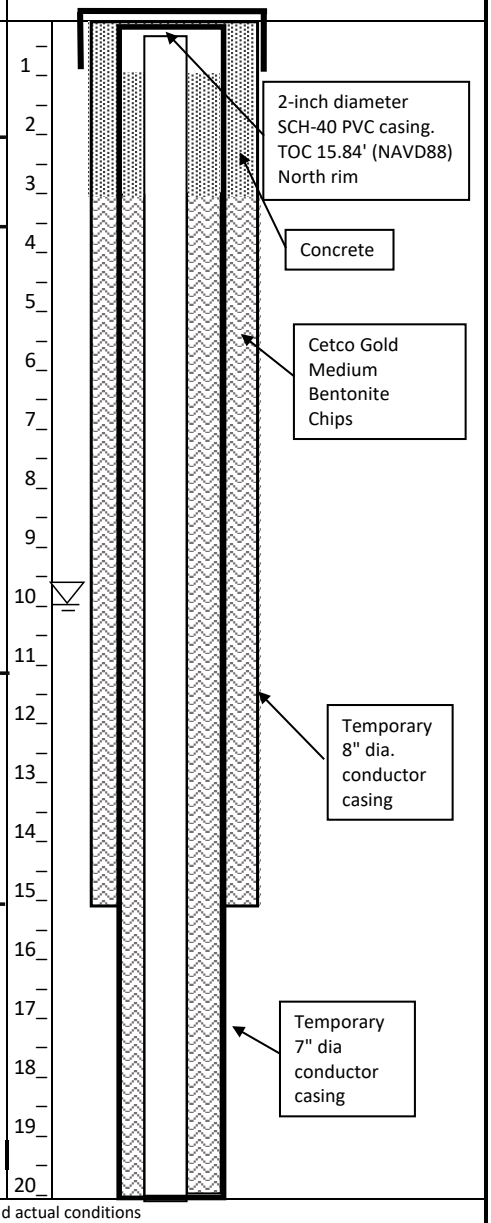
LOG OF TWA-9D

PROJECT: TWAAFA	COORDINATES: N 712482.8 E 1171238.6 (NAD 83)	
BORING LOCATION: Clean Care Property	SURFACE ELEV. (NAVD 88): 15.6 ft	TOC ELEV. (NAVD 88): 15.84 ft
DRILLING CONTRACTOR: Cascade Drilling	START/END DATE: 10/11/2021 - 10/12/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-163
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D. Cooper	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SAMPLES: SHEEN/ODOR	SAMPLES: RECOVERY	SAMPLES: PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
1		ns/no		3.6	- 2" asphalt, 4" crushed gravel base **WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** medium brown, loose, moist, medium to coarse sand, fine to coarse
2		ns/no		4.8	sub-rounded gravel, and silt.
3		ns/slo		140	**POORLY GRADED GRAVEL WITH SAND (GP)** light gray to medium gray, loose, moist, fine to medium subrounded gravel with medium to coarse sand and wood chips
4					**WOOD WASTE with sand** medium to dark brown, fibrous wood waste with sand and broken brick
5					- becomes very dark brown
6		ms/so		232	
7					
8					
9					
10					
11		ns/no		7.8	**POORLY GRADED SAND WITH SILT (SP-SM)** medium brown, loose, saturated, fine to medium sand with silt
12		ns/no		0.9	**SILT (ML)** light to medium gray, medium stiff, wet, high dilatency, non-plastic
13					with very fine to fine sand sand content decreases between 11.8' and 14.5', low dilatency
14				1.1	and thin roots, root casts
15					-sand content increases between 14.5' to 15'
16		ns/so		0.2	**SILTY SAND (SM)** dark gray, medium dense, saturated, silty, fine sand
17		ns/no		0.1	
18					
19					
20					

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DALTON OLMSTED FUGLEVAND

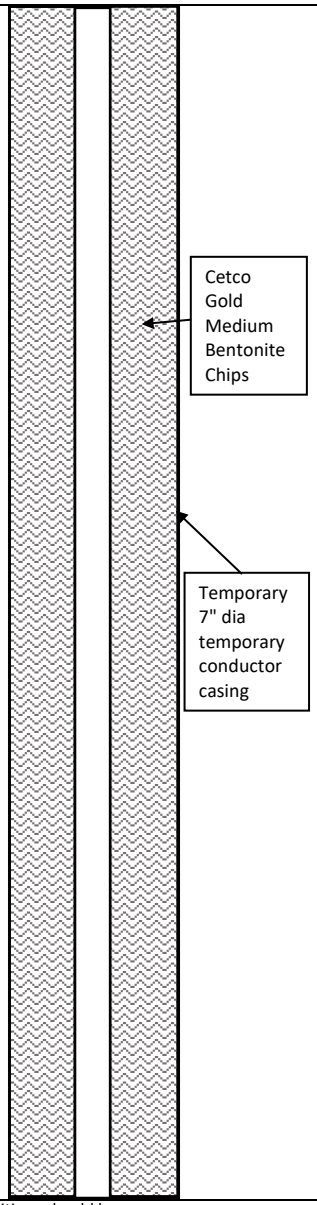
LOG OF TWA-9D

PROJECT: TWAAFA	COORDINATES: N 712482.8 E 1171238.6 (NAD 83)	
BORING LOCATION: Clean Care Property	SURFACE ELEV. (NAVD 88): 15.6 ft	TOC ELEV. (NAVD 88): 15.84 ft
DRILLING CONTRACTOR: Cascade Drilling	START/END DATE: 10/11/2021 - 10/12/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-163
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D. Cooper	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SHEEN/ODOR	RECOVERY	PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
20		ns/no		0.2	**POORLY GRADED SAND (SP)** dark gray, loose, saturated, fine to medium sand with trace silt -silty inclusion at 20' to 20.3'
21					
22		ns/no		0.2	
23					
24		ns/no		0.2	
25		ns/no		0.7	
26					-silty interbed at 26'
27		ns/no		0.5	
28					
29		ns/no		0.0	
30					
31		ns/no		0.0	
32					
33					
34					
35					
36		ns/no		0.0	**SILT (ML)** medium gray, medium firm, wet, slow dilatency, non-plastic silt
37					-becomes firm 36' with fibrous organics between 36.3' and 38.8'
38		ns/no		0.0	
39					
40					

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

DOF DALTON OLMSTED FUGLEVAND

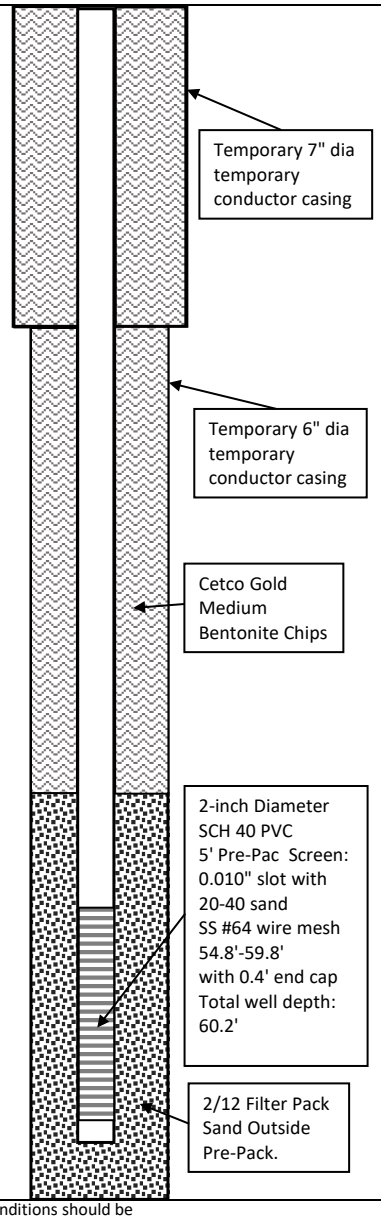
LOG OF TWA-9D

PROJECT: TWAAFA	COORDINATES: N 712482.8 E 1171238.6 (NAD 83)	
BORING LOCATION: Clean Care Property	SURFACE ELEV. (NAVD 88): 15.6 ft	TOC ELEV. (NAVD 88): 15.84 ft
DRILLING CONTRACTOR: Cascade Drilling	START/END DATE: 10/11/2021 - 10/12/2021	
DRILLING METHOD: Sonic, with telescoping casing	TOTAL DEPTH OF BOREHOLE: 60'	Ecology Tag # BNW-163
DRILLING EQUIPMENT: TerraSonic TSI 150CC	LOGGED BY: A. CERRUTI	
SAMPLING METHOD: Soil - 4" Core Barrel sampler, 5' drive length	RESPONSIBLE PROF.: D. Cooper	REG. NO.: 1600

NOTES: Groundwater grab samples collected during drilling using 24" x 2" dia. 0.010"-slot, retractable, SS wire-wrap screen

DEPTH (FT)	SAMPLES: SAMPLE	SHEEN/ODOR	RECOVERY	PID READING (ppm)	VISUAL SOIL DESCRIPTION Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
40		ns/no		0.0	**SILT (ML)** medium gray, firm, slow dilatency, non-plastic silt with trace very fine sand
41					
42		ns/no		0.1	
43	***SS**				***SS** - Soil sample: TWA-9_43_1021 @ 43'
44		ns/no		0.1	**SILTY SAND (SM)** medium gray, medium dense, saturated, silty, very fine to fine sand
45					
	***GW**				***GW** -Groundwater grab sample: TWA-9_45-47_1021 @ 45-47'
46		ns/no		0.0	
47		ns/no		0.1	
48					-silty interbeds between 47' to 49'
49					dark gray, loose, saturated, fine to medium sand
50		ns/no		0.0	
51					
52		ns/no		0.0	
53					-trace silt between 53' to 54'
54		ns/no		0.0	-broken shells at 54'
55					
	***GW**				***GW** - Groundwater grab sample: TWA-9_55-57_1021 @ 55-57'
56		ns/no		0.0	-woody debris at 56'
57					
		ns/no		0.0	
58				0.0	**SILTY SAND (SM)**
59		ns/no		0.0	medium gray, dense, saturated, silty, very fine to medium sand broken shell lenses throughout
60					END OF BORING AT 60' Below ground surface

BORING AND WELL CONSTRUCTION DETAILS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

Geologic Borehole Log

MAUL FOSTER ALONG

Project Number	Well Number	Sheet
M0615.20.001	TWA-10D	1 of 3

Project Name	Taylor Way TWAAFA Site	TOC Elevation (feet)	15.97
Project Location	1514 Taylor Way, Tacoma, WA	Surface Elevation (feet)	13.7
Start/End Date	12/9/21 to 12/14/21	Northing	712271.8
Driller/Equipment	Holt Drilling Services, Inc./Sonic	Easting	1171674.7
Geologist/Engineer	C. Wise & A. Bixby	Total Depth of Borehole	60.0 feet
Sample Method	Core Barrel	Outer Hole Diam	inch

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
1					CB			0.1		0.0 to 1.5 feet: GRAVEL WITH SAND (GW); very dark grayish brown (10YR 3/2); 5% fines; 15% sand, fine to coarse; 80% gravel, fine to coarse, subangular to rounded; loose; no odor; moist. **---- 0 to 12.5 feet: 10-inch casing.**
2								0.2		1.5 to 4.5 feet: SILTY SAND (SM); dark brown (10YR 3/3); 25% fines, low plasticity; 50% sand, fine to coarse; 25% gravel, fine to coarse, subangular to subrounded; medium dense; trace organics (rootlets, grass); no odor; moist.
3				100				0.5		@ 3.0 feet: Color changes to very dark gray (10YR 3/1).
4										@ 4.2 to 4.4 feet: Silt laminae; dark gray brown (10YR 4/2). @ 4.4 to 4.5 feet: Peat laminae; black (10YR 2/1).
5								1.2		4.5 to 10.0 feet: SAND WITH SILT (SP-SM); very dark gray (10YR 3/1); 10% fines, low plasticity; 90% sand, fine to medium; loose; no odor; small orange grains present; moist.
6					CB			0.7		
7								0.9		
8				100						**---- 7.4 to 12.5: Bentonite seal set at base of 10-inch casing.**
9								0.3		
10								0.4		@ 8.7 feet: Silt laminae with trace organics (wood); dark yellowish brown (10 YR 4/4). @ 9.7 feet: Silt laminae; dark yellowish brown (10YR 4/4).
11					CB			0.5		10.0 to 12.5 feet: SILT (ML); very dark gray (10YR 3/1); 100% fines, medium plasticity; soft; no odor; moist. @ 10.0 to 10.6 feet: 15% organics (woody debris).
12				100						@ 11.4 to 11.5 feet: Woody debris.
13								0.6		@ 12.4 feet: Density changes to firm. **---- 12.5 to 40 feet: 8-inch casing.**
14				0	CB					12.5 to 15.0 feet: NO RECOVERY.
15								0.3		15.0 to 20.0 feet: SILTY SAND (SM); gray (5Y 5/1); 40% fines, low plasticity; 60% sand, fine to medium; loose; no odor; small orange grains present; moist.
16										
17								0.9		
18				100						
19								0.8		
20										
21				100	CB			2.1		20.0 to 30.0 feet: SAND WITH SILT (SP-SM); black (5Y 2.5/1); 10% fines, low plasticity; 90% sand, fine to medium; loose; no odor; small orange grains present; moist.
22										

CDA BOREHOLE W/WELL W:\GINT\GINTW\PROJECTS\0615.20.01\DEC2021_MONITORING_WELL_INSTALL.GPJ 03/29/22

MAUL FOSTER ALONG

Geologic Borehole Log

Project Number	Well Number	Sheet
M0615.20.001	TWA-10D	2 of 3

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
23					GW	TWA-10_20-25_1210		1.6		
24				100				1.7		
25					CB			4.1		
26										
27								4.6		
28				100						
29								4.3		
30					CB			3.6		30.0 to 31.0 feet: SILT (ML); dark gray (10YR 4/1); 90% fines, low plasticity; 10% sand, fine; soft; trace shell fragments; no odor; moist.
31										31.0 to 34.0 feet: SILTY SAND (SM); very dark gray (10YR 3/1); 40% fines, low plasticity; 60% sand, fine to medium; medium dense; trace trace organics (rootlets, grass); no odor; moist.
32								5.0		
33				100	GW	TWA-10_30-35_1210				
34								4.1		
35								5.4		34.0 to 35.3 feet: SAND WITH SILT (SP-SM); black (10YR 2/1); 10% fines, low plasticity; 90% sand, fine to medium; loose; no odor; small orange grains present; moist.
36					CB			2.7		@34.1 to 34.3 feet: Silt laminae; dark grayish brown (10YR 4/2). **---- 34.5 to 40 feet: Bentonite seal set at base of 8-inch casing.** 35.5 to 45.0 feet: SILT WITH SAND (ML); very dark gray (10YR 3/1); 90% fines, low plasticity; 10% sand, fine; firm; no odor; moist.
37								5.7		@ 35.5 to 36.0 feet: Shell fragments.
38				100				6.4		@ 36.0 feet: Sand laminae.
39								4.6		@ 38.0 feet: Woody debris.
40					CB	TWA-10_39-40_1210		6.8		
41					CB			0.0		**---- 40 to 60 feet: 7-inch casing.**
42										
43				100				0.0		
44										
45										@ 44.0 to 45.0 feet: Small lenses of sand; ~1-inch width; black (10YR 2/1); 10% fines, low plasticity; 90% sand, fine to medium; loose; no odor; small orange grains present; moist.
46				100	CB			0.0		45.0 to 48.0 feet: SAND (SP); black (10YR 2/1); 5% fines; 95% sand, fine to medium; loose; no odor; small orange grains present; moist.

CDA BOREHOLE W/WELL W:\GINT\GINTW\PROJECTS\0615.20.01\DEC2021_MONITORING_WELL_INSTALL.GPJ 03/29/22

Geologic Borehole Log

MAUL FOSTER ALONG

Project Number	Well Number	Sheet
M0615.20.001	TWA-10D	3 of 3

Depth (feet, bgs)	Well Details	Water Levels	Sample Data: Interval	Percent Recovery	Collection Method	Sample ID	Blows/6"	PID (ppm)	Lithologic Column	Soil Description
47								0.0		
48			100		GW	TWA-10_45-50_1213				48.0 to 50.0 feet: SILTY SAND (SM); very dark gray (10YR 3/1); 40% fines, low plasticity; 60% sand, very fine; firm; no odor; abundant bivalve shells present; moist.
49								0.0		
50					CB					50.0 to 54.0 feet: SAND (SP); black (10YR 2/1); 5% fines; 95% sand, fine to medium; loose; trace shells; no odor; small orange grains present; moist to wet.
51								12.8		
52			100							@ 52.5 feet: Increase in shell fragments.
53								6.9		
54					GW	TWA-10_51-56_1213				54.0 to 55.0 feet: SILTY SAND (SM); very dark gray (10YR 3/1); 40% fines, low plasticity; 60% sand, very fine; firm; no odor; abundant bivalve shells present; moist to wet.
55					CB			2.9		55.0 to 57.0 feet: SAND (SP); black (10YR 2/1); 5% fines; 95% sand, fine to medium; loose; trace shells; no odor; small orange grains present; moist to wet.
56										
57								2.8		57.0 to 59.0 feet: SILTY SAND (SM); very dark gray (10YR 3/1); 40% fines, low plasticity; 60% sand, very fine; firm; no odor; abundant bivalve shells present; wet.
58			100							
59								2.7		59.0 to 60.0 feet: SILTY SAND (SM); very dark gray (10YR 3/1); 30% fines, low plasticity; 70% sand, fine to medium; loose; no odor; abundant bivalves; moist.
60										

Total Depth = 60.0 feet bgs

NOTES:

1. bgs = below ground surface. 2. Depths are relative to feet below ground surface. 3. ID = identification. 4. PID = photoionization detector. 5. ppm = parts per million. 6. CB = core barrel. 7. GW = groundwater sample.

Borehole Completion Details

0 to 3.0 feet: Concrete.
3.0 to 50.0 feet: Bentonite chips hydrated with potable water.
50.0 to 58.0 feet: 10/20 silica sand.
58.0 to 60.0 feet: Slough.

Monitoring Well Completion Details

Washington State Department of Ecology Well No. BNN188.
Traffic-grade, above ground monument with 3 bollards, 3 foot stickup.
+2.5 to 52.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride riser pipe.
52.0 to 57.0 feet: 2-inch diameter, schedule 40, polyvinyl chloride, 0.010 machine slot, well screen with threaded polyvinyl chloride end cap.
Total well completion depth is approximate.

Appendix B

DOF STANDARD OPERATING PROCEDURE – 130

(DOF SOP-130)

PFAS Groundwater Sampling Procedure

Revision Date: 11/03/2023

This SOP contains seven sections:

1. PURPOSE

This SOP serves to provide field personnel with the specific information needed to consistently collect and document representative groundwater samples for laboratory analyses of Per- and Poly Fluoroalkyl Substance (PFAS).

The purpose of this SOP is to identify groundwater sampling techniques and precautions to be taken when groundwater samples are to be collected for PFAS analysis.

2. REFERENCES

Washington State Department of Ecology. June 2023. Guidance for Investigation and Remediating PFAS Contamination in Washington State. Toxics Cleanup Program Publication No. 22-09-058. https://apps.ecology.wa.gov/publications/documents/2209058.pdf

Michigan Department of Environmental Quality. October 2018. General PFAS Sampling Guidance. https://www.michigan.gov/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/General.pdf?rev=5fb24f7dabf0468b9415679b60681503

3. ASSOCIATED TWAAFA SOPS

SOP-110 - Measuring Water and NAPL Levels and Total Depths

SOP-115 – Low-Flow Groundwater Sampling Procedure

SOP-120 - Equipment Decontamination Procedure

4. PFAS CROSS CONTAMINATION POTENTIAL SOURCES

In accordance with the Michigan Department of Environmental Quality General PFAS Sampling Guidance referenced by the Washington State Department of Ecology Guidance for Investigating and Remediating PFAS Contamination in Washington State, the following items and materials are **prohibited:**

- Items containing fluoropolymers:
    - Polytetrafluoroethylene (PTFE), that includes the trademarks Teflon® and Hostaflon®
    - Polyvinylidene fluoride (PVDF), that includes the trademark Kynar®
    - Polycholotrifluoroethylene (PCTFE), that includes the trademark Neoflon ®
    - Ethylene-tetrafluoro-ethylene (ETFE), that includes the trademark Tefzel®
    - Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP
- New or unwashed clothing; anything made with Gore-Tex™ or other water-resistant synthetics
- Any clothing applied with or recently washed with:
    - Fabric softeners, fabric protectors, including UV protection, insect resistant chemicals, water, dirt, and/or stain resistant chemicals.
- Any personal care products (PCPs), sunscreen, and insect repellant (applied day of sampling).

The following materials are **allowable**:

Pumps, Tubing, and Sampling Equipment

- High-density polyethylene (HDPE)
- Low-density polyethylene (LDPE)
- Polypropylene
- Silicone
- Stainless-steel
- Any items used to secure sampling bottles made from:
    - Natural rubber
    - Nylon (cable ties)
    - Uncoated metal springs
    - Polyethylene

Sample Storage and Preservation

- Glass jars
- Laboratory-provided PFAS-Free bottles:
    - HDPE or polypropylene
- Regular wet ice
- Thin HDPE sheeting
- LDPE resealable storage bags (i.e. Ziploc®) that will not contact the sample media

Field Documentation

- Loose paper (non-waterproof, nonrecycled)
- Rite in the Rain® notebooks

- Aluminum, polypropylene, or Masonite field clipboards
- Ballpoint pens, pencils, and Fine or Ultra-Fine Point Sharpie® markers

Clothing, Boots, Rain Gear, and PPE

- Powderless nitrile gloves
- Well-laundered (6 times) synthetic or 100% cotton clothing, with most recent launderings not using fabric softeners
- Made of or with:
    - Polyurethane
    - Polyvinyl chloride (PVC)
    - Wax coated fabrics
    - Rubber / Neoprene
    - Uncoated Tyvek®

Only the allowable materials listed above are approved during performance of PFAS groundwater sampling.

No food should be consumed in the staging or sampling areas, including pre-packaged food or snacks.

- If consuming food on-site becomes necessary, move to the staging area and remove PPE. After eating, wash hands thoroughly and put on new PPE.

5. DECONTAMINATION

All reusable equipment that will contact the well and/or water samples will be decontaminated prior to its use, according to the procedures described in SOP-120. The only surfactants allowed for decontamination are: Alconox®, Liquinox®, or Citranox®.

A final step of rinsing equipment with PFAS-free water will be included during equipment decontamination.

6. PFAS SAMPLING PROCEDURES

6.1. Sampling Preparation

Identify the staging area where field staff will don PPE, decontaminate equipment prior to use, and doff PPE. Personal safety is paramount when conducting work related to environmental investigation and will not be compromised to prevent risk of contamination during PFAS sampling; however, preparation during planning will enable the sample team to adapt equipment and at a minimum identify equipment at risk of containing PFAS. PPE, field clothing, or other materials that are necessary for the sample team to don during sample collection should be recorded in field notes.

Equipment anticipated to come in direct contact with PFAS samples; including sample containers, pumps/tubing/collection equipment, and deionized water should be stored separately from other sampling supplies and handled minimally to reduce the risk of cross contamination from other field

equipment. Hands should be washed and cleaned. Clean, powderless nitrile gloves must be worn on hands during sample collection and while handling sample containers or sampling equipment.

6.2. Sampling Procedure

The sampling procedure will be in accordance with SOP-110 for measurement of water and NAPL Levels; and SOP-115 for low-flow groundwater sampling.

Gloves should be changed frequently and especially before collecting samples into containers. Sample teams will utilize the clean hand/dirt hands approach where practicable, ensuring that non-PFAS free equipment and materials are unlikely to contaminate the sample as it enters the jar.

The following additional steps should be taken during sample collection to prevent contamination:

- The sample cap should not be placed directly on the ground during sampling. If necessary, place the cap on a clean surface (cotton sheeting, HDPE sheeting, triple rinsed cooler lid, etc.).
- New, powderless Nitrile Gloves are required for all sampling activities.
- Regular/thick size markers (Sharpie® or otherwise) are to be avoided.
- Fine and Ultra-Fine point Sharpie® markers are acceptable to label the empty sample container while in the staging area, provided the lid is on the sample container and gloves are changed following labeling.
- Ballpoint pens may be used when labeling sample containers.
- Hands should be well washed and gloved.
- Sample containers should only be opened immediately prior to sampling.
- Sample containers should be capped immediately after collecting the sample.

7. DOCUMENTATION

Monitoring well sampling activities should be documented on the Monitoring Well Sampling Field Sheet. The sheets should be maintained in the project file.