

Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Remedial Investigation

DATA AND ANALYSIS REPORT: POREWATER SAMPLING OF LOWER DUWAMISH WATERWAY FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

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Prepared by:  WindWard
environmental LLC

200 West Mercer Street, Suite 401 ♦ Seattle, Washington ♦ 98119

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Supporting Documentation

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Appendix B: Proposed Porewater Sampling Methods

Appendix C: Toxicity Data for Evaluation of Volatile Organic Compounds Detected in Porewater

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Acronyms

Acronym	Definition
ARI	Analytical Resources Inc.
COC	chain of custody
EC50	effect concentration for 50% of a test population
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
FAV	final acute value
FCV	final chronic value
GC/MS	gas chromatography/mass spectrometry
GWI	Great Western International
HQ	hazard quotient
ID	identification
LC50	lethal concentration for 50% of a test population
LC100	lethal concentration for 100% of a test population
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc.
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LOEC	lowest observed effect concentration
MLLW	mean lower low water
MS/MSD	matrix spike/matrix spike duplicate
NAD83	North American horizontal datum 1983
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observed effect concentration
NTU	nephelometric turbidity unit
PDT	Pacific Daylight Time
QAPP	quality assurance project plan
QC	quality control
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
VOC	volatile organic compound
Windward	Windward Environmental LLC

1.0 Introduction

This data report presents the results of the chemical analysis of porewater samples collected from the Lower Duwamish Waterway (LDW) as part of the Phase 2 Remedial Investigation (RI). The LDW RI data needs memorandum (Windward 2003) identified the need to collect porewater samples for analysis of volatile organic compounds (VOCs) to assess risk to benthic invertebrates. To address this need, the Phase 2 RI work plan (Windward 2004) stated that porewater samples would be collected in areas where VOCs have been historically detected in groundwater at upland properties immediately adjacent to the LDW. In the porewater quality assurance project plan (QAPP) (Windward 2005a), available data for VOCs in groundwater at 11 sites along the LDW were reviewed to determine which sites had the highest potential for VOC concentrations in porewater and should therefore be included in the porewater sampling described in this report. The two sites selected for sampling were Great Western International (GWI) and Boeing Plant 2/Jorgensen Forge.

The remainder of this report is organized into the following sections:

- ◆ Section 2 – Porewater collection methods
- ◆ Section 3 – Laboratory methods
- ◆ Section 4 – Results
- ◆ Section 5 – Data analysis
- ◆ Section 6 – References

The text of this report is supported by the following appendices:

- ◆ Appendix A – Data tables
- ◆ Appendix B – Proposed Porewater Sampling Methods
- ◆ Appendix C – Toxicity Data for Evaluation of Volatile Organic Compounds Detected in Porewater
- ◆ Appendix D – Data validation report
- ◆ Appendix E – Laboratory form 1s
- ◆ Appendix F – Collection forms and field notes
- ◆ Appendix G – Chain-of-custody forms

Appendices D through G, which include a detailed data validation report and scanned original field and laboratory documents for this data and analysis report, may be viewed online at http://www.ldwg.org/rifs_docs.htm; the links to these resources are found in the Data Report section of that Web page under the heading **Task 10: Results of Phase 2 fieldwork**. These materials are also available on compact disk upon request

and will be provided to the US Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

2.0 Porewater Collection Methods

This section describes the methods used to collect porewater samples. Additional details regarding the porewater collection methods are presented in the QAPP (Windward 2005a). Copies of field notes, porewater collection forms, and protocol modification forms are presented in Appendix F. Copies of the completed chain-of-custody (COC) forms that were used to track sample custody are presented in Appendix G.

2.1 SAMPLE IDENTIFICATION SCHEME

Each porewater sampling location was assigned a unique alphanumeric sample identification (ID) number. The first three characters of the location ID were "LDW" to identify the Lower Duwamish Waterway project area. The next two characters were "PW" to identify the medium sampled (porewater), followed by "G" or "B" to identify GWI or Boeing Plant 2/Jorgensen Forge, followed by "PZ" or "PE" to signify piezometer or peeper. The last two characters were consecutive numbers, beginning with 01, to identify the specific location within the LDW area for each collection device. For example, the sample ID of the peeper sample collected at location 01 at GWI was LDW-PW-G-PE-01.

Field replicates were identified using sample numbers starting with 201. For example, the first field replicate sample collected with a peeper at GWI was identified as LDW-PW-G-PE-201.

2.2 FIELD QUALITY CONTROL SAMPLES

Four types of field quality control (QC) samples were collected. These samples included: 1) rinsate blanks for the sampling equipment, 2) field replicate samples, 3) trip blanks, and 4) one equipment blank for the peeper material. Each type of sample is described below.

- ◆ Rinsate blanks. These samples were created by collecting deionized water that was rinsed through a piezometer with attached tubing. One rinsate blank was collected for each of the piezometer models used.
- ◆ Field replicates. These samples were collected at two peeper locations, LDW-PW-G-PE-08 and LDW-PW-B-PE-10. Porewater samples were collected from two replicate peepers (in addition to the primary peeper) deployed at each of the two locations, for a total of three peepers at each of those two locations.
- ◆ Trip blanks. These samples consisted of deionized water sealed in a VOC sample container prepared by the laboratory, Analytical Resources Inc. (ARI). Each cooler with field samples included one trip blank. These blank samples

were transported from the laboratory to the field and then returned to the laboratory, unopened, with the field samples.

- ◆ Equipment blank. This sample was collected to determine if any of the materials used in the construction of the peeper may have contributed VOCs to the sample. The equipment blank consisted of a peeper filled with deionized water placed into a 1-liter container with deionized water. After 72 hours, the water was collected from this peeper with the same method used in the field.

2.3 SAMPLE LOCATIONS

The rationale for selecting porewater locations is presented in the QAPP (Windward 2005a). Piezometer samples were collected from 12 sampling locations (Table 2-1), and peeper samples were collected from 16 sampling locations (Table 2-2). The sampling locations at GWI and Boeing Plant 2/Jorgensen Forge are shown in Figures 2-1 and 2-2, respectively.

Table 2-1. Piezometer sampling locations and conditions

SAMPLE LOCATION ID	TARGET COORDINATES ^a		ACTUAL COORDINATES ^a		PIEZOMETER TYPE ^b	DATE	TIME (PDT) ^c	DEPTH BELOW MUDLINE (ft) ^d	MUDLINE ELEVATION RELATIVE TO MLLW (ft)	ESTIMATED TIDAL STAGE RELATIVE TO MLLW (ft) ^e	ESTIMATED WATER DEPTH (ft) ^f
	X	Y	X	Y							
GW sampling locations											
LDW-PW-G-PZ-01	1271176	200360	1271175	200362	EPA	6/22/05	1140	1	-5.0 ^g	-3.6	1.4
LDW-PW-G-PZ-02	1271018	200284	1271017	200286	EPA	6/23/05	1115	2	-10.1	-3.9	6.2
LDW-PW-G-PZ-03	1270937	200219	1270938	200221	EPA	6/23/05	0940	1	-14.9	2.0	16.9
LDW-PW-G-PZ-04	1271247	200314	1271248	200312	EPA	6/22/05	1106	1.5	-5.2	-3.2	2.0
LDW-PW-G-PZ-05	1271102	200185	1271078	200199	EPA	6/23/05	0850	1	-10.4	4.8	15.2
LDW-PW-G-PZ-06	1271064	200124	1271063	200121	EPA	6/23/05	1215	2	-15.4	-2.6	12.8
Boeing Plant 2/Jorgensen Forge sampling locations											
LDW-PW-B-PZ-07	1275711	195752	1275710	195750	EPA	6/22/05	1020	1	-5.9	-2.0	3.9
LDW-PW-B-PZ-08	1275691	195746	1275690	195745	MHE	6/21/05	1101	1	-11.1	-2.9	8.2
LDW-PW-B-PZ-09	1275664	195739	1275665	195739	MHE	6/21/05	1005	1	-15.1	-2.3	12.8
LDW-PW-B-PZ-10	1275750	195716	1275751	195719	MHE	6/22/05	0916	1	-5.3	0.8	6.1
LDW-PW-B-PZ-11	1275732	195704	1275730	195707	MHE	6/22/05	0820	1	-9.7	3.9	13.6
LDW-PW-B-PZ-12	1275702	195685	1275702	195685	MHE	6/21/05	0856	1	-15.4	0.2	15.6

^a Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US survey ft).

^b MHE – model developed by Mark Henry Enterprises, EPA –modified MHE model developed by EPA

^c Samples were collected during the 4 hours before low tide when groundwater discharge was expected to be the greatest.

^d Depth below the mudline at which the screened section of the piezometer was placed; as stated in Sections 3.1.2.3 and 3.1.3.3 of the QAPP (Windward 2005a), the target depth of the sample was 1 ft (30 cm) below the mudline, or as shallow as possible below 1 ft if a 1-ft-deep sample was not retrievable.

^e Estimated using observed tide at Elliott Bay corrected for the LDW at Eighth Ave. S [i.e., assumes LDW tides are 10.5 minutes later and 96% of the height at Elliott Bay (NOAA 2005)].

^f Calculated as the difference between the tidal stage and the mudline elevation.

^g Estimated value because no bathymetry data are available for PZ-01.

MLLW – mean lower low water

PDT – Pacific Daylight Time

Table 2-2. Peeper sampling locations and conditions

SAMPLE LOCATION ID	TARGET COORDINATES ^a		ACTUAL COORDINATES ^a		DEPLOYMENT ^b		RETRIEVAL		MUDLINE ELEVATION RELATIVE TO MLLW (ft)
	X	Y	X	Y	DATE	TIME (PDT)	DATE	TIME (PDT)	
GWJ sampling locations									
LDW-PW-G-PE-01	1271185	200394	1271196	200394	7/19/05	1022	8/1/05	1050	0 to -2 ^c
LDW-PW-G-PE-02	1271181	200379	1271179	200380	7/19/05	1432	8/1/05	1044	0 to -2 ^c
LDW-PW-G-PE-03	1271241	200390	1271228	200353	7/19/05	1415	8/1/05	1030	-4
LDW-PW-G-PE-04	1271234	200337	1271232	200336	7/19/05	1414	8/1/05	1025	-4
LDW-PW-G-PE-05	1271277	200365	1271249	200358	7/19/05	1036	8/1/05	1110	0 to -2 ^c
LDW-PW-G-PE-06	1271263	200355	1271244	200366	7/19/05	1047	8/1/05	1230	0 to -2 ^c
LDW-PW-G-PE-07	1271290	200325	1271290	200323	7/19/05	1054	8/1/05	1237	0 to -2 ^c
LDW-PW-G-PE-08 ^d	1271280	200304	1271286	200327	7/19/05	1109	8/1/05	1255	0 to -2 ^c
Boeing Plant 2/Jorgensen Forge sampling locations									
LDW-PW-B-PE-09	1275752	195780	1275752	195780	7/19/05	0827	8/1/05	1430	0
LDW-PW-B-PE-10 ^d	1275718	195765	1275719	195762	7/19/05	1221	8/1/05	0920	-2
LDW-PW-B-PE-11	1275774	195762	1275772	195761	7/19/05	0849	8/1/05	1435	0
LDW-PW-B-PE-12	1275747	195749	1275747	195750	7/19/05	1230	8/1/05	0915	-3
LDW-PW-B-PE-13	1275783	195739	1275784	195737	7/19/05	0851	8/1/05	1440	0
LDW-PW-B-PE-14	1275766	195731	1275768	195731	7/19/05	1235	8/1/05	0907	-2
LDW-PW-B-PE-15	1275792	195720	1275792	195718	7/19/05	0844	8/1/05	1445	0
LDW-PW-B-PE-16	1275776	195708	1275775	195707	7/19/05	1241	8/1/05	0900	-3

^a Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US survey ft).

^b All peepers were deployed with their upper surfaces 10 cm below the mudline.

^c Estimated value because no bathymetry data are available.

^d Two field replicate peepers were deployed and retrieved at each of these locations.

MLLW – mean lower low water

PDT – Pacific Daylight Time

2.4 SAMPLE COLLECTION METHODS

This section describes the methods used to collect porewater samples with piezometers and peepers. Additional details on the collection equipment are presented in Section 3.2.3 of the QAPP (Windward 2005a).

A porewater reconnaissance survey was conducted on June 6 and 7, 2005, to test the field equipment and probe the target locations in order to assess sediment type. The reconnaissance survey was also used to determine which type of piezometer would be used to collect the sample, based on sediment type, and the best method to collect a sample 1 ft (30 cm) below the mudline, or as shallow as possible below 1 ft if a 1-ft-deep sample could not be retrieved. Trials of both diver-assisted and deployment-by-boat methods were conducted during the reconnaissance survey. In addition, various methods were tested to collect incrementally deeper samples to a maximum depth of 6 ft (180 cm) below the mudline. The results of the reconnaissance survey were summarized in a memorandum to EPA and Ecology (Appendix B), which documented the methods used, types of piezometer deployed, and targeted sampling depths below the mudline for the sampling event that occurred the week of June 20, 2005.

2.4.1 Piezometers

Piezometer sampling was conducted from June 21 to 23, 2005, during the 4 hours before low tide, when groundwater discharge was expected to be the greatest. Sampling was conducted using either a stainless steel PushPoint mini-piezometer designed by MHE Products or an aluminum EPA-designed mini-piezometer (referred to as a modified MHE). The EPA design has a longer screened interval and wider inner diameter than that of the MHE sampler. At each location, the screened section of the piezometer was inserted to a minimum of 1 ft below the mudline. Once the piezometer had been inserted into the sediment, the internal rod was removed and tubing was attached to the top of the piezometer.

At locations where the water depth was >5 ft (150 cm) below mean lower low water (MLLW), piezometers were inserted into the sediment by a diver. At locations where the water depth was ≤ 5 ft, the piezometer was deployed directly from the boat.

Tubing from the piezometer was attached to a peristaltic pump to collect sufficient water volume to measure conventional water quality parameters prior to collecting the VOC sample. When the turbidity readings indicated that the initial turbid water had been flushed, the other water quality parameters were recorded. Water quality parameters were measured using a Hydrolab Series 4a MiniSonde® surveyor, which was immersed in a container that contained porewater. The Hydrolab was allowed to equilibrate before measurements were taken for conductivity, temperature, dissolved oxygen, and pH; turbidity was measured using a portable turbidimeter. These water quality parameters were also measured just above the sediment surface and just below

the water surface at each sampling location, and were recorded on the porewater collection forms (Appendix F).

After measurement of the water quality parameters, the VOC sample was collected, also using the peristaltic pump. The pump withdrew a steady stream of water that did not incorporate air into the sample. The porewater was dispensed into three 40-mL vials with septa caps (pre-preserved with hydrochloric acid). The sample vial was filled leaving no headspace and was visually inspected to ensure that no air bubbles were trapped in the vial. The samples were then placed in a cooler on ice prior to delivery to ARI on the same day.

2.4.2 Peepers

Porewater samples were collected using peepers according to the specifications presented in the porewater QAPP (Windward 2005a). Peepers were pre-filled with deionized or site water and deployed at GWI and Boeing Plant 2/Jorgensen Forge on July 19, 2005, and were retrieved 13 days after deployment, on August 1, 2005. Peepers were placed at the 16 sampling locations described in Table 2-2. Peepers were deployed so that the upper surface of the peeper was approximately 4 inches (10 cm) below the mudline. Depending on the sediment conditions, peepers were either pushed directly into soft sediment or placed by digging a hole with a hand-held shovel and then covering the peeper with sediment. At locations PE-01, PE-05, PE-06, PE-07, PE-08, PE-09, PE-11, PE-12, PE-13, PE-14, and PE-15, peepers were deployed by personnel on the shoreline. At locations PE-02, PE-03, PE-04, PE-10, and PE-16, peepers were deployed by a diver. Each peeper was either secured to an anchored line that extended across the sediment surface to a fixed object on the shoreline or was secured directly to a fixed object.

All peepers were retrieved underwater by a diver. The diver removed each peeper from the sediment and placed it into a slightly larger container filled with ambient water and then covered the container with a screw-cap lid. The diver immediately brought each container to the surface, where the crew on the boat extracted the porewater sample from the peeper.

The extraction method was modified from the method described in the QAPP to minimize the porewater and ambient water exchange. Porewater samples were extracted by siphoning water out of both the peeper and the outer container at the same rate so that the surface tension on the mesh screen was not disturbed. This method was tested prior to use in the field by using dye to color the water outside of the peeper. Only trace amounts of dye were observed in the water siphoned from the inside of the peeper using this method.

Porewater was extracted from the peeper in the field as follows. The lid of the outer container was opened, and a drill was used to make a small hole in the top of the peeper in order to insert a siphon tube. A siphon tube was also placed into the outer container, and then both siphons were started simultaneously with syringes. The

porewater siphoned from the peeper was collected in three VOC vials per location. Between vials, the siphoning was halted by pinching both tubes simultaneously; siphoning was then restarted simultaneously once the next vial was in place. After all three vials were filled, the remaining porewater in the peeper was collected in a container filled with enough water to immerse the Hydrolab for water quality measurements (conductivity, temperature, dissolved oxygen, pH, and oxidation-reduction potential). Water quality parameters were measured as described in Section 3.2.3 of the QAPP (Windward 2005a). At several locations within each area, water quality parameters were also measured in LDW water collected just above the sediment where the peeper was buried.

2.5 FIELD DEVIATIONS FROM THE QAPP

Field methods were conducted in accordance with the QAPP (Windward 2005a), except for the following modifications to collection methods and sampling locations. These field deviations did not affect the data quality. EPA was consulted on all deviations. The deviations were as follows:

- ◆ The QAPP did not state that rinsate blanks would be collected from the piezometers. However, based on discussions in the field with EPA, two rinsate blank samples were collected: one from the MHE model and the other from the EPA-modified MHE model.
- ◆ Sample location PZ-05 was approximately 29 ft from the target location because the diver sampled from an incorrect marker. After discussion with EPA, it was determined that the new sample location was still representative of the target location.
- ◆ During field sampling, some of the GWI target peeper locations shown in Figure 3-6 of the QAPP and in Figure 2-1 of this report were not occupied because incorrect coordinates for those locations were presented in Table 3-3 of the QAPP. At the first GWI peeper deployment location (PE-01), it was not apparent that the QAPP coordinates were incorrect in relation to the target seep (S-2) because of high seepage observed throughout that general area. Therefore, the peeper location was inadvertently placed 23 ft west along the shoreline from the actual location of seep S-2. At the next peeper location, PE-05, it was apparent that the QAPP coordinates were incorrect because the location was mapping on land, so the peeper was placed visually in relation to seep S-13 according to the description in Section 3.1.2.4 of the QAPP. Other peepers that were visually placed in relation to seeps S-13 and S-1 because the target coordinates in the QAPP were apparently incorrect included PE-07, PE-08, and PE-03. In summary, the distances of the actual locations from their target locations are as follows (see Figure 2-1):
 - ◆ PE-01 and PE-02 were located 23 and 25 ft west of their target locations, respectively

- ◆ PE-03 and PE-04 were located 9.5 and 5.1 ft north of their target locations, respectively
- ◆ PE-05 and PE-06 were located 11 and 3.3 ft west of their target locations, respectively
- ◆ PE-07 and PE-08 were located 5.5 and 9.4 ft southeast of their target locations, respectively

The locations that were visually placed were identified with the approval of the EPA oversight.

- ◆ Section 3.2.3.2 of the QAPP stated that a syringe would be inserted through the end of the peeper cap to extract the porewater. This extraction method was modified as discussed in Section 2.4.2 of this report to minimize the porewater and site water exchange.
- ◆ Because of time constraints, only certain locations where peepers were deployed were selected for LDW water quality measurements. The locations selected were considered most representative of the area based on water depth and distance to peepers.
- ◆ Oxidation-reduction potential was not measured during the piezometer sampling because the particular Hydrolab used during that sampling event did not have a probe with that capability.
- ◆ LDW surface water was used to fill peepers at PE-02, PE-03, PE-4, PE-08, PE-10, PE-12, PE-14, and PE-16 because an insufficient volume of deionized water was available. Because this water was equilibrated with porewater for two weeks during peeper deployment, use of site water should not have affected the results

3.0 Laboratory Methods

Chemical analyses were conducted by ARI. All samples were analyzed using gas chromatography/mass spectrometry (GC/MS) for 71 VOCs according to EPA SW 846 method 8260B. There were no laboratory deviations from the methods and procedures as described in the porewater QAPP (Windward 2005a).

4.0 Results

This section presents the results of the chemical analyses conducted on porewater samples as well as the conventional parameters analyzed in the field for both porewater and LDW water. The results of the data validation, conducted by LDC, are discussed in Section 4.2, and are also presented in full in Appendix D.

Complete data tables and raw laboratory data are presented in Appendices A and E, respectively. The number of significant figures shown for each concentration in all

tables in this data report was specified by the analytical laboratory. There was no additional manipulation of significant figures.

4.1 RESULTS OF VOC ANALYSIS

The results of VOC analysis of porewater samples collected using piezometers and peepers are presented in this section. These results are compared to toxicity data from the literature in Section 5.0. All results are presented in Appendix A.

4.1.1 Piezometer results

VOCs were not detected in any of the 12 porewater samples collected using piezometers. Table 4-1 presents a list of the VOC analytes and their reporting limits.

Table 4-1. Detection frequency and reporting limits for VOCs analyzed in porewater samples collected using piezometers at GWI and Boeing Plant 2/Jorgensen Forge

ANALYTE	UNIT	DETECTION FREQUENCY	REPORTING LIMIT	
			MINIMUM	MAXIMUM
1,1,1,2-Tetrachloroethane	µg/L	0/12	0.2	1.0
1,1,1-Trichloroethane	µg/L	0/12	0.2	1.0
1,1,2,2-Tetrachloroethane	µg/L	0/12	0.2	1.0
1,1,2-Trichloroethane	µg/L	0/12	0.2	1.0
1,1,2-Trichlorotrifluoroethane	µg/L	0/12	0.2	1.0
1,1-Dichloroethane	µg/L	0/12	0.2	1.0
1,1-Dichloroethene	µg/L	0/12	0.2	1.0
1,1-Dichloropropene	µg/L	0/12	0.2	1.0
1,2,3-Trichlorobenzene	µg/L	0/12	0.5	2.5
1,2,3-Trichloropropane	µg/L	0/12	0.5	2.5
1,2,4-Trichlorobenzene	µg/L	0/12	0.5	2.5
1,2,4-Trimethylbenzene	µg/L	0/12	0.2	1.0
1,2-Dibromo-3-chloropropane	µg/L	0/12	2.0	10
1,2-Dibromoethane (EDB)	µg/L	0/12	0.2	1.0
1,2-Dichlorobenzene	µg/L	0/12	0.2	1.0
1,2-Dichloroethane	µg/L	0/12	0.2	1.0
1,2-Dichloropropane	µg/L	0/12	0.2	1.0
1,3,5-Trimethylbenzene	µg/L	0/12	0.2	1.0
1,3-Dichlorobenzene	µg/L	0/12	0.2	1.0
1,3-Dichloropropane	µg/L	0/12	0.2	1.0
1,4-Dichlorobenzene	µg/L	0/12	0.2	1.0
2,2-Dichloropropane	µg/L	0/12	0.2	1.0
2-Chloroethyl vinyl ether	µg/L	0/12	0.5	2.5
2-Chlorotoluene	µg/L	0/12	0.2	1.0
2-Hexanone	µg/L	0/12	1.0	5.0
4-Chlorotoluene	µg/L	0/12	0.2	1.0

ANALYTE	UNIT	DETECTION FREQUENCY	REPORTING LIMIT	
			MINIMUM	MAXIMUM
Acetone	µg/L	0/12	1.0	6.2
Acrolein	µg/L	0/12	5.0	25
Acrylonitrile	µg/L	0/12	1.0	5.0
Benzene	µg/L	0/12	0.2	1.0
Bromobenzene	µg/L	0/12	0.2	1.0
Bromochloromethane	µg/L	0/12	0.2	1.0
Bromodichloromethane	µg/L	0/12	0.2	1.0
Bromoethane	µg/L	0/12	0.2	1.0
Bromoform	µg/L	0/12	0.2	1.0
Bromomethane	µg/L	0/12	0.2	1.0
Carbon disulfide	µg/L	0/12	0.2	1.0
Carbon tetrachloride	µg/L	0/12	0.2	1.0
Chlorobenzene	µg/L	0/12	0.2	1.0
Chloroethane	µg/L	0/12	0.2	1.0
Chloroform	µg/L	0/12	0.2	1.0
Chloromethane	µg/L	0/12	0.2	1.0
cis-1,2-Dichloroethene	µg/L	0/12	0.2	2.0
cis-1,3-Dichloropropene	µg/L	0/12	0.2	1.0
Dibromochloromethane	µg/L	0/12	0.2	1.0
Dibromomethane	µg/L	0/12	0.2	1.0
Dichloromethane	µg/L	0/12	0.3	1.5
Ethylbenzene	µg/L	0/12	0.2	1.0
Hexachlorobutadiene	µg/L	0/12	0.5	2.5
Iodomethane	µg/L	0/12	0.2	1.0
Isopropylbenzene	µg/L	0/12	0.2	1.0
Methyl ethyl ketone	µg/L	0/12	1.0	5.0
Methyl isobutyl ketone	µg/L	0/12	1.0	5.0
Naphthalene	µg/L	0/12	0.5	2.5
n-Butylbenzene	µg/L	0/12	0.2	1.0
n-Propylbenzene	µg/L	0/12	0.2	1.0
p-Cymene	µg/L	0/12	0.2	1.0
sec-Butylbenzene	µg/L	0/12	0.2	1.0
Styrene	µg/L	0/12	0.2	1.0
tert-Butylbenzene	µg/L	0/12	0.2	1.0
Tetrachloroethene	µg/L	0/12	0.2	1.0
Toluene	µg/L	0/12	0.2	1.0
trans-1,2-Dichloroethene	µg/L	0/12	0.2	1.0
trans-1,3-Dichloropropene	µg/L	0/12	0.2	1.0
trans-1,4-Dichloro-2-butene	µg/L	0/12	1.0	5.0
Trichloroethene	µg/L	0/12	0.2	1.0
Trichlorofluoromethane	µg/L	0/12	0.2	1.0

ANALYTE	UNIT	DETECTION FREQUENCY	REPORTING LIMIT	
			MINIMUM	MAXIMUM
Vinyl acetate	µg/L	0/12	0.2	1.0
Vinyl chloride	µg/L	0/12	0.2	1.6
Xylene (meta and para)	µg/L	0/12	0.4	2.0
Xylene (ortho)	µg/L	0/12	0.2	1.0

Preliminary data were provided to EPA and Ecology on July 6, 2005, prior to validation, in order to discuss the need for any additional peeper locations. Based on discussions with EPA and Ecology, no additional peeper locations were deemed necessary.

4.1.2 Peeper results

Table 4-2 presents a summary of the results for the 20 porewater samples collected using peepers. Of the 71 VOCs analyzed, 16 VOCs were detected in at least one sample. The highest concentrations were reported for cis-1,2-dichloroethene and vinyl chloride at GWI.

Table 4-2. Detection frequency, range of detected concentrations, and reporting limits for VOCs analyzed in porewater samples collected using peepers at GWI and Boeing Plant 2/Jorgensen Forge

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION			REPORTING LIMIT ^a	
			MINIMUM	MAXIMUM	MEAN ^b	MINIMUM	MAXIMUM
1,1,1,2-Tetrachloroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
1,1,1-Trichloroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
1,1,2,2-Tetrachloroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
1,1,2-Trichloroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
1,1,2-Trichlorotrifluoroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
1,1-Dichloroethane	µg/L	9/20	0.3	16	6	0.2	0.2
1,1-Dichloroethene	µg/L	3/20	0.3	4.9	2	0.2	0.4
1,1-Dichloropropene	µg/L	0/20	nd	nd	nd	0.2	0.4
1,2,3-Trichlorobenzene	µg/L	0/20	nd	nd	nd	0.5	1.0
1,2,3-Trichloropropane	µg/L	0/20	nd	nd	nd	0.5	1.0
1,2,4-Trichlorobenzene	µg/L	0/20	nd	nd	nd	0.5	1.0
1,2,4-Trimethylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
1,2-Dibromo-3-chloropropane	µg/L	0/20	nd	nd	nd	2.0	4.0
1,2-Dibromoethane (EDB)	µg/L	0/20	nd	nd	nd	0.2	0.4
1,2-Dichlorobenzene	µg/L	3/20	0.5	1.2	0.8	0.2	0.4
1,2-Dichloroethane	µg/L	2/20	7.4	15	11	0.2	0.4
1,2-Dichloropropane	µg/L	2/20	1.7	2.5	2.1	0.2	0.4
1,3,5-Trimethylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
1,3-Dichlorobenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
1,3-Dichloropropane	µg/L	0/20	nd	nd	nd	0.2	0.4

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION			REPORTING LIMIT ^a	
			MINIMUM	MAXIMUM	MEAN ^b	MINIMUM	MAXIMUM
1,4-Dichlorobenzene	µg/L	2/20	0.3	0.3	0.3	0.2	0.4
2,2-Dichloropropane	µg/L	0/20	nd	nd	nd	0.2	0.4
2-Chloroethyl vinyl ether	µg/L	0/20	nd	nd	nd	0.5	1.0
2-Chlorotoluene	µg/L	0/20	nd	nd	nd	0.2	0.4
2-Hexanone	µg/L	0/20	nd	nd	nd	1.0	2.0
4-Chlorotoluene	µg/L	0/20	nd	nd	nd	0.2	0.4
Acetone	µg/L	0/20	nd	nd	nd	2.6	71
Acrolein	µg/L	0/20	nd	nd	nd	5.0	10
Acrylonitrile	µg/L	0/20	nd	nd	nd	1.0	2.0
Benzene	µg/L	1/20	9.4	9.4	9.4	0.2	4.7
Bromobenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
Bromochloromethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Bromodichloromethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Bromoethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Bromoform	µg/L	0/20	nd	nd	nd	0.2	0.4
Bromomethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Carbon disulfide	µg/L	5/20	0.2	0.7	0.3	0.2	0.4
Carbon tetrachloride	µg/L	0/20	nd	nd	nd	0.2	0.4
Chlorobenzene	µg/L	4/20	0.3	1.4	0.7	0.2	0.4
Chloroethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Chloroform	µg/L	0/20	nd	nd	nd	0.2	0.4
Chloromethane	µg/L	0/20	nd	nd	nd	0.2	0.4
cis-1,2-Dichloroethene	µg/L	17/20	0.2	2,900	200	0.2	0.2
cis-1,3-Dichloropropene	µg/L	0/20	nd	nd	nd	0.2	0.4
Dibromochloromethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Dibromomethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Dichloromethane	µg/L	0/20	nd	nd	nd	0.3	0.6
Ethylbenzene	µg/L	0/20	nd	nd	nd	0.2	1.3
Hexachlorobutadiene	µg/L	0/20	nd	nd	nd	0.5	1.0
Iodomethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Isopropylbenzene	µg/L	2/20	0.2	0.3	0.3	0.2	0.4
Methyl ethyl ketone	µg/L	0/20	nd	nd	nd	1.0	2.4
Methyl isobutyl ketone	µg/L	0/20	nd	nd	nd	1.0	2.0
Naphthalene	µg/L	0/20	nd	nd	nd	0.5	1.0
n-Butylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
n-Propylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
p-Cymene	µg/L	0/20	nd	nd	nd	0.2	0.4
sec-Butylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
Styrene	µg/L	0/20	nd	nd	nd	0.2	0.4
tert-Butylbenzene	µg/L	0/20	nd	nd	nd	0.2	0.4
Tetrachloroethene	µg/L	2/20	0.4	1.1	0.8	0.2	0.4

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION			REPORTING LIMIT ^a	
			MINIMUM	MAXIMUM	MEAN ^b	MINIMUM	MAXIMUM
Toluene	µg/L	5/20	0.3	3.5	1	0.2	0.4
trans-1,2-Dichloroethene	µg/L	7/20	0.3	21 J	6	0.2	0.4
trans-1,3-Dichloropropene	µg/L	0/20	nd	nd	nd	0.2	0.4
trans-1,4-Dichloro-2-butene	µg/L	0/20	nd	nd	nd	1.0	2.0
Trichloroethene	µg/L	6/20	0.2	2.5	0.8	0.2	0.4
Trichlorofluoromethane	µg/L	0/20	nd	nd	nd	0.2	0.4
Vinyl acetate	µg/L	0/20	nd	nd	nd	0.2	0.4
Vinyl chloride	µg/L	12/20	0.4	2,500	200	0.2	0.2
Xylene (meta and para)	µg/L	0/20	nd	nd	nd	0.4	0.8
Xylene (ortho)	µg/L	0/20	nd	nd	nd	0.2	1.3

^a RL range for nondetect samples

^b Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nd – nondetect

J – estimated concentration

Table 4-3 presents the concentrations of the 16 VOCs detected in at least one porewater sample collected using peepers at GWI locations. Vinyl chloride and cis-1,2-dichloroethene were detected at all eight locations. Porewater from LDW-PW-G-PE-06 had the highest concentrations of VOCs, with concentrations of vinyl chloride and cis-1,2-dichloroethene of 2,900 and 2,500 µg/L, respectively. This peeper was adjacent to seep S-13 (Figure 2-1), where vinyl chloride was previously detected in seep water at a concentration of 1,600 µg/L and cis-1,2-dichloroethene was detected at a concentration of 5,400 µg/L (Windward 2005a).

Table 4-3. Peeper samples at GWI with detected VOC concentrations

ANALYTE	UNITS	LDW-PW-G-PE-01	LDW-PW-G-PE-02	LDW-PW-G-PE-03	LDW-PW-G-PE-04	LDW-PW-G-PE-05	LDW-PW-G-PE-06	LDW-PW-G-PE-07	LDW-PW-G-PE-08	LDW-PW-G-PE-203 ^a	LDW-PW-G-PE-204 ^a
1,1-Dichloroethane	µg/L	0.4	0.4	0.2 U	0.2 U	3.7	16	11	6.7	4.0	7.7
1,1-Dichloroethene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	1.1	4.9	0.4 U	0.4 U	0.3	0.2 U
1,2-Dichlorobenzene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.5	0.4 U	0.4 U	0.6	1.2
1,2-Dichloroethane	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	15	7.4	0.4 U	0.4 U	0.2 U	0.2 U
1,2-Dichloropropane	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	2.5	1.7	0.4 U	0.4 U	0.2 U	0.2 U
1,4-Dichlorobenzene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.3	0.4 U	0.4 U	0.2 U	0.3
Benzene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	3	9.4	2.2	3.2	2.4	4.7
Carbon disulfide	µg/L	0.2	0.2 U	0.2 U	0.2 U	0.2 U	0.7	0.4 U	0.4	0.2	0.2
Chlorobenzene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1.4	0.4	0.4 U	0.3	0.6
cis-1,2-Dichloroethene	µg/L	6.1	46	0.5	2.4	630	2,900	18	20	41	27
Isopropylbenzene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2	0.4 U	0.4 U	0.2 U	0.3
Tetrachloroethene	µg/L	0.4	0.2 U	0.2 U	0.2 U	1.1	0.2 U	0.4 U	0.4 U	0.2 U	0.2 U
Toluene	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.5	3.5	0.4 U	0.5	0.3	0.5
trans-1,2-Dichloroethene	µg/L	0.3	3.4	0.2 U	0.2 U	16	21 J	0.4 U	0.5	0.7	0.4
Trichloroethene	µg/L	0.5	2.5	0.2 U	0.2 U	1.1	0.4	0.4 U	0.4 U	0.2 U	0.2 U
Vinyl chloride	µg/L	3.4	11	0.4	1.8	270	2,500	7.2	11	92	86

^a Field replicates from LDW-PW-G-PE-08

J – estimated concentration

U – not detected at reporting limit shown

Table 4-4 presents the concentrations of the four VOCs detected in porewater samples collected using peepers at Boeing Plant 2/Jorgensen Forge. At least one VOC was detected in samples collected from six of the eight locations, at concentrations ranging from 0.2 to 13 µg/L.

Table 4-4. Peeper samples from Boeing Plant 2/Jorgensen Forge with detected VOC concentrations

ANALYTE	UNITS	LDW-PW-B-PE-09	LDW-PW-B-PE-11	LDW-PW-B-PE-12	LDW-PW-B-PE-13	LDW-PW-B-PE-14	LDW-PW-B-PE-201 ^a	LDW-PW-B-PE-202 ^a
1,1-Dichloroethane	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.3	0.2 U	0.2 U
cis-1,2-Dichloroethene	µg/L	0.4	1.7	0.9	0.5	0.2	0.4	1.0
Trichloroethene	µg/L	0.2 U	0.2	0.2 U	0.2 U	0.2 U	0.2 U	0.2
Vinyl chloride	µg/L	0.2 U	13	0.2 U	1.1	0.2 U	0.2 U	0.2 U

^a Field replicates from LDW-PW-G-PE-10

U – not detected at reporting limit shown

4.2 CHEMICAL DATA VALIDATION RESULTS

Independent data validation of all results was conducted by LDC. The complete data validation report is provided in Appendix D. The following sections summarize the results of the data validation but do not list every sample qualified by the validators. Detailed information regarding every qualified sample is available in Appendix D.

4.2.1 Overall data quality

Porewater samples were analyzed in four SDGs. LDC conducted a full validation on the first SDG. All sample results that were not selected for full validation underwent a summary validation, which included an evaluation of all the summary forms for calibration, instrument performance, and internal standards. Table 4-5 presents the number of samples in each SDG, the sampling method, and the level of data validation. The ratio of full to summary validation is consistent with the validation guidelines in the QAPP (Windward 2005a). Based on the information reviewed, the overall data quality was considered acceptable for use in the Phase 2 RI, as qualified. The results of the data validation are summarized in the following subsections.

Table 4-5. Numbers of porewater samples and level of data validation performed for each SDG

SDG	SAMPLING METHOD	VALIDATION LEVEL	NUMBER OF SAMPLES IN SDG
IE76	piezometer	full	4
IE93	piezometer	summary	8
IF11	piezometer	summary	5
II78	peeper	summary	27

4.2.2 Sample transport and holding times

Porewater samples were analyzed within holding times. The chain-of-custody documents were reviewed for verification of cooler temperatures. All cooler temperatures met validation criteria.

4.2.3 Field blank results

Rinsate blanks, trip blanks, and equipment blanks were submitted for analysis. VOCs detected in these blanks are presented in Table 4-6. Concentrations of these VOCs in porewater samples were compared to the concentrations detected in the associated field blank. Detected concentrations that were less than ten times the blank concentration for common laboratory contaminants or less than five times the blank concentration for other contaminants were qualified as nondetected with elevated reporting limits (RLs). Contamination of these blanks warranted the U-qualification of 10 VOCs in select samples as presented in Table 4-7.

Table 4-6. VOC concentrations detected in rinsate, equipment, and trip blanks

ANALYTE	UNITS	LDW-PW-PZ-EPARB ^a	LDW-PW-PZ-MHERB ^b	LDW-PW-PE-01-EB ^c	TRIP BLANK
Acetone	µg/L	5.0	4.6	48	1.2
Benzene	µg/L	0.2 U	0.2 U	1.3	0.2 U
2-Butanone	µg/L	1.0 U	1.0 U	1.5	1.0 U
cis-1,2-Dichloroethene	µg/L	0.9	0.2 U	0.2 U	0.2 U
Ethylbenzene	µg/L	0.2 U	0.2 U	0.4	0.2 U
n-Butylbenzene	µg/L	0.2 U	0.2 U	0.2	0.2 U
n-Propylbenzene	µg/L	0.2 U	0.2 U	0.4	0.2 U
Naphthalene	µg/L	0.5 U	0.5 U	1.4	0.5 U
Toluene	µg/L	0.5	0.4	0.2 U	0.2 U
Trichlorofluoromethane	µg/L	0.3	0.2 U	0.2 U	0.2 U
1,2,4-Trimethylbenzene	µg/L	0.2 U	0.2 U	3.1	0.2 U
1,3,5-Trimethylbenzene	µg/L	0.2 U	0.2 U	1.0	0.2 U
Vinyl chloride	µg/L	0.5	0.2 U	0.2 U	0.2 U
m,p-Xylene	µg/L	0.4 U	0.4 U	1.8	0.4 U
o-Xylene	µg/L	0.2 U	0.2 U	1.5	0.2 U

^a rinsate blank of EPA piezometer (modified MHE) tubing

^b rinsate blank of MHE piezometer tubing

^c peeper equipment blank

U – not detected at reporting limit shown

Table 4-7. Sample results qualified because of blank contamination

ANALYTE	TYPE OF BLANK	ASSOCIATED SDG	NUMBER OF SAMPLES QUALIFIED	LOWEST MODIFIED FINAL REPORTING LIMIT (µg/L)	HIGHEST MODIFIED FINAL REPORTING LIMIT (µg/L)
Acetone	TB, MHERB, EPARB, EB	IE76, IE93, IF11, II78	29	1.3	71
Benzene	EB	II78	8	0.4	4.7
2-Butanone	EB	II78	1	2.4	2.4
cis-1,2-Dichloroethene	EPARB	IE93, IF11	2	1.4	2.0
Ethylbenzene	EB	II78	3	0.2	1.3
Trichlorofluoromethane	EPARB	IE93, IF11	1	0.2	0.2
1,2,4-Trimethylbenzene	EB	II78	3	0.2	0.3
Vinyl chloride	EPARB	IE93, IF11	1	1.6	1.6
m,p-Xylene	EB	II78	1	0.7	0.7
o-Xylene	EB	II78	5	0.3	1.3

TB – trip blank

MHERB – rinsate blank of MHE piezometer tubing

EPARB – rinsate blank of EPA piezometer tubing

EB – peeper equipment blank

4.2.4 Laboratory quality assurance/quality control

Calibration

The initial calibration was conducted correctly, and all system performance check compounds were adequate. The percent relative standard deviations and/or coefficient of determination for all analytes were within QC limits for all compounds, as applicable.

The relative response factors were below acceptable limits, resulting in the UJ-qualification of nondetect results for acrolein, 2-chloroethyl vinyl ether, and methyl isobutyl ketone in piezometer samples and 1,2-dibromochloropropane in peeper samples.

Continuing calibration verifications were conducted at the required frequencies. The only compounds with a percent difference higher than 25% in the continuing calibration relative to the initial calibration were acrolein and acetone in SDGs IE76 and IE93; bromomethane, iodomethane, and dibromochloromethane in SDG IF11; and chloromethane, 2-chloroethyl vinyl ether, and bromomethane in SDG II78.

Nondetected results for these analytes in associated samples were UJ-qualified. A subset of the relative response factors in the continuing calibration verifications were also < 0.05 for acrolein, acetone, 2-chloroethyl vinyl ether, and 1,2-dibromo-3-chloropropane, resulting in the UJ-qualification of associated non-detected results.

Blanks

No VOCs were detected in the method blanks, with the exception of methylene chloride in SDGs IE76 and IE93 and acetone in SDG IF11. Methylene chloride was not detected in any porewater samples. Acetone was detected in four samples and a trip blank at less than 10 times the blank concentration. Therefore, acetone results in the four samples were qualified as nondetect (U-qualified) with elevated RLs.

Surrogate recovery

Surrogates were added to all samples and blanks as required by the method. All surrogate recoveries were within QC limits.

Matrix spike

MS/MSD results were reviewed, and several analytes were outside QC limits. Low spike recoveries for chloromethane, bromomethane, vinyl chloride, and iodomethane in SDG IE93 resulted in UJ-qualification for sample LDW-PW-B-PZ-10. Sample LDW-PW-B-PE-201 was UJ-qualified for low spike recoveries for chloromethane, bromomethane, hexachlorobutadiene, and n-butylbenzene in SDG II78.

Laboratory control samples and standard reference material

Laboratory control sample results were reviewed, and percent recoveries and relative percent difference (RPD) results were within QC limits for all analytes, with the following exceptions. In SDG IF11, bromomethane and iodomethane were below QC limits; chloromethane and bromomethane recoveries were below QC limits in SDG II78; and the hexachlorobutadiene RPD was outside QC limits in SDGs IE76 and IE93. As a result, the associated results for these VOCs, which were not detected in any porewater samples, were UJ-qualified. Standard reference material was analyzed at the required frequencies, and all results were within QC criteria.

Internal standards

All internal standard areas and retention times were within validation criteria.

4.3 WATER QUALITY RESULTS FROM FIELD MEASUREMENTS

Water quality parameters were measured in the field using a Hydrolab Series 4a MiniSonde®. The Hydrolab was allowed to equilibrate before measurements were taken for conductivity, temperature, dissolved oxygen, and pH. Turbidity was measured using a DRT-15CE portable turbidimeter. Tables 4-8 and 4-9 present the water quality results from the piezometer and peeper sampling events, respectively.

Table 4-8. Results of water quality measurements collected in the field during piezometer sampling

LOCATION ID	WATER TYPE	TEMPERATURE (°C)	SPECIFIC CONDUCTIVITY (µmhos/cm)	DISSOLVED OXYGEN (mg/L)	pH	TURBIDITY (NTU)
GW1						
LDW-PW-G-PZ-01	porewater	14.32	9857	0.05	8.13	>1000
	LDW surface	15.35	10549	6.68	7.55	7.48
	LDW bottom	15.29	10991	6.58	7.65	13.6
LDW-PW-G-PZ-02	porewater	16.63	42727	0.25	7.28	>1000
	LDW surface	15.17	16465	7.19	7.7	4.02
	LDW bottom	14.95	19526	6.93	7.63	6.28
LDW-PW-G-PZ-03	porewater	13.73	44397	1.16	7.52	294
	LDW surface	14.66	15349	7.23	7.67	2.73
	LDW bottom	13.57	40317	6.58	7.84	13.1
LDW-PW-G-PZ-04	porewater	13.03	41537	0.18	7.38	83.3
	LDW surface	15.07	15838	6.68	7.37	58.7
	LDW bottom	15.03	15764	6.52	7.37	83.5
LDW-PW-G-PZ-05	porewater	13.37	44833	0.47	7.28	9.71
	LDW surface	14.81	14437	7.13	7.51	2.61
	LDW bottom	13.69	39462	6.82	7.84	2.48
LDW-PW-G-PZ-06	porewater	16.25	36442	0.13	7.5	>1000
	LDW surface	15.55	8311	7.82	7.72	5.54
	LDW bottom	14.81	21879	6.62	7.67	9.11
Boeing Plant 2/Jorgensen Forge						
LDW-PW-B-PZ-07	porewater	14.28	40369	0.26	7.36	16.9
	LDW surface	15.5	4200	7.36	7.9	6.98
	LDW bottom	15.32	3881	7.12	7.71	7.26
LDW-PW-B-PZ-08	porewater	17.14	43792	0.44	7.45	8.03
	LDW surface	17.74	2558	7.25	7.58	5.68
	LDW bottom	16.91	11184	6.51	7.64	nm
LDW-PW-B-PZ-09	porewater	17.28	44268	0.5	7.28	81.7
	LDW surface	17.99	3998	7.2	7.76	7.67
	LDW bottom	17.2	35076	5.91	7.58	13.6
LDW-PW-B-PZ-10	porewater	14.54	19943	0.73	8.01	6.67
	LDW surface	15.39	15867	6.96	7.55	4.84
	LDW bottom	15.31	15737	6.62	7.52	5.59
LDW-PW-B-PZ-11	porewater	15.01	43269	1.08	7.4	166
	LDW surface	15.76	13382	7.16	7.12	3.47
	LDW bottom	13.81	40317	6.41	7.73	11.1
LDW-PW-B-PZ-12	porewater	16.39	44539	1.27	7.27	54.2
	LDW surface	14.89	42717	6.13	7.61	15.5
	LDW bottom	17.39	8971	7.6	7.4	nm

nm – not measured

NTU – nephelometric turbidity unit

Table 4-9. Results of water quality measurements collected in the field during peeper sampling

LOCATION ID	WATER TYPE	TEMPERATURE (°C)	SPECIFIC CONDUCTIVITY (µmhos/cm)	DISSOLVED OXYGEN (mg/L)	pH	OXIDATION REDUCTION POTENTIAL (mV)
GW1						
LDW-PW-G-PE-01	porewater	16.8	14817	3.42	6.2	99
	LDW bottom	17.97	19396	6.58	6.95	107
LDW-PW-G-PE-02	porewater	16.72	14848	3.66	6.09	111
LDW-PW-G-PE-03	porewater	16.76	26578	2.06	6.23	118
LDW-PW-G-PE-04	porewater	17.1	29162	3.13	6.32	155
	LDW bottom	18.07	21047	7.55	7.13	159
LDW-PW-G-PE-05	porewater	17.67	17979	3.83	5.74	181
LDW-PW-G-PE-06	porewater	16.59	15461	3.08	5.99	155
	LDW bottom	17.74	23058	4.93	6.91	167
LDW-PW-G-PE-07	porewater	16.46	21292	3.04	6.38	50
LDW-PW-G-PE-08	porewater	17.43	18775	3.73	6.22	37
	LDW bottom	17.75	23910	5.39	6.92	47
LDW-PW-G-PE-203 ^a	porewater	17.61	14506	3.18	6.32	41
LDW-PW-G-PE-204 ^a	porewater	16.69	20651	2.33	5.94	72
Boeing Plant 2/Jorgensen Forge						
LDW-PW-B-PE-09	porewater	17.85	31741	2.32	6.1	88
	LDW bottom	16.86	32753	6.54	7	88
LDW-PW-B-PE-10	porewater	19.27	22370	3.3	5.35	170
	LDW bottom	19.84	8552	7.5	6.97	175
LDW-PW-B-PE-201 ^b	porewater	19.03	22769	3.28	6.05	173
LDW-PW-B-PE-202 ^b	porewater	19.14	19373	3.12	6.34	169
LDW-PW-B-PE-11	porewater	18.62	24173	2.62	6.02	94
LDW-PW-B-PE-12	porewater	18.77	19407	3.01	5.67	158
LDW-PW-B-PE-13	porewater	17.75	28243	2.52	5.74	111
LDW-PW-B-PE-14	porewater	18.6	18845	2.79	5.58	191
LDW-PW-B-PE-15	porewater	17.19	34467	3.28	5.88	116
	LDW bottom	15.78	37198	5.9	6.69	109
LDW-PW-B-PE-16	porewater	18.84	17630	4.04	3.7	219

^a Field replicates of LDW-PW-G-PE-08

^b Field replicates of LDW-PW-B-PE-10

na – not applicable

5.0 Data Analysis

This section presents a comparison of the piezometer and peeper sample results to relevant aquatic toxicity data from the literature. This comparison is being conducted to estimate the potential for adverse effects on benthic invertebrates, in accordance with the Phase 2 RI work plan (Windward 2004), to assess the need for additional porewater sampling in the LDW.

5.1 TOXICITY DATA

A draft technical memorandum was submitted to EPA and Ecology on June 3, 2005 (Windward 2005b), proposing VOC toxicity data for use in evaluating VOC concentrations in porewater for the purposes of this data report.¹ In the draft technical memorandum, toxicity data were proposed for 14 VOCs of interest at GWI and Boeing Plant 2/Jorgensen Forge (Table 5-1). These 14 chemicals were identified as VOCs of interest because they were previously detected in seeps, Gore-Sorber® modules, or groundwater wells closest to the LDW at either GWI or Boeing Plant 2/Jorgensen Forge, as summarized in the porewater QAPP (Windward 2005a). EPA and Ecology approved the toxicity data presented in the draft technical memorandum for 12 of the 14 VOCs. For the remaining two VOCs (1,1-dichloroethane and vinyl chloride), limited toxicity studies were available, so an alternative approach was recommended by EPA and Ecology. This approach and other revisions to the draft document have been incorporated into the final version of the technical memorandum, which is presented as Appendix C. The remainder of this section briefly summarizes the approaches for deriving toxicity data for the 14 VOCs of interest.

Table 5-1. List of VOCs of interest

VOC	GWI	BOEING PLANT 2/ JORGENSEN FORGE
1,1,1-Trichloroethane	X	
1,1,2-Trichloroethane	X	
1,1-Dichloroethane	X	X
1,1-Dichloroethene	X	
1,2-Dichloroethane	X	
1,2-Dichloroethene (cis or trans)	X	X
Acetone	X	X
Benzene	X	X
Chlorobenzene	X	
Tetrachloroethene	X	
Toluene	X	

¹ EPA and Ecology may request modification of the toxicity data presented in this report for use in the Phase 2 ERA.

VOC	GWI	BOEING PLANT 2/ JORGENSEN FORGE
Trichloroethene	X	X
Vinyl chloride	X	X
Xylene	X	X

To derive toxicity data, a literature search was conducted for relevant aquatic toxicity studies using two databases, ECOTOX and BIOSIS. Studies with aquatic invertebrate species were preferred because the purpose of the porewater sampling is to evaluate risk to benthic invertebrates. Appendix C presents the database search methods and criteria for selecting the most relevant toxicity data from the results of the search. In many cases, the available toxicity data were uncertain because lowest observed effect concentrations (LOECs) were rarely reported, no observed effect concentrations (NOECs) were dependent on the chosen test dilution series, and very few studies reported both effect and no-effect concentrations for a single species and endpoint. Rather than assigning uncertainty factors to the toxicity data, reported results (e.g., NOECs, LOECs, lethal concentrations for 50% of a test population [LC50s]) were presented for the purposes of this data report. Table 5-2 summarizes the toxicity values that were identified for each of the 14 VOCs.

Table 5-2. Selected toxicity data for VOCs in porewater

ANALYTE	UNIT	NOEC	LC50
1,1,1-Trichloroethane	µg/L	1,300	2,400 ^a
1,1,2-Trichloroethane	µg/L	1,000	15,000
1,1-Dichloroethane	µg/L	7,800 ^b	39,600 ^c
1,1-Dichloroethene	µg/L	2,400	11,600
1,2-Dichloroethane	µg/L	na	6,927
1,2-Dichloroethene (cis or trans)	µg/L	na	6,785
Acetone	µg/L	na	33,830
Benzene	µg/L	180	1,100 ^d
Chlorobenzene	µg/L	1,400	2,500 ^e
Tetrachloroethene	µg/L	331	332
Toluene	µg/L	737	14,700
Trichloroethene	µg/L	2,200	14,000
Vinyl chloride	µg/L	12,800 ^b	65,300 ^c
Xylene	µg/L	1,168	2,973

^a Concentration is a LOEC (lowest observed effect concentration).

^b Concentration is an FCV (final chronic value) based on the narcosis model.

^c Concentration is an FAV (final acute value) based on the narcosis model.

^d Concentration is an LC100 (lethal concentration for 100% of a test population).

^e Concentration is an EC50 (effect concentration for 50% of a test population).

LC50 – lethal concentration for 50% of a test population

NOEC – no observed effect concentration

na – not available

5.2 COMPARISON OF VOC CONCENTRATIONS TO TOXICITY DATA

No VOCs were detected in porewater collected using piezometers at GWI and Boeing Plant 2/Jorgensen Forge. All reporting limits for the 14 VOCs of interest were well below any of the toxicity data presented in Table 5-2.

Table 5-3 summarizes the concentrations of the 14 VOCs of interest collected using peepers deployed at GWI and Boeing Plant 2/Jorgensen Forge and the toxicity data from Table 5-2. All detected concentrations were lower than the corresponding toxicity values. In addition, all reporting limits associated with nondetected values were lower than the corresponding toxicity values.

NOECs were not available for four compounds (acetone, 1,2-dichloroethane, cis-1,2-dichloroethene, and trans-1,2-dichloroethene). Acetone was never detected in the peeper samples; the maximum reporting limit was well below the LC50. The maximum detected concentrations of 1,2-dichloroethane and trans-1,2-dichloroethene were well below their LC50 values. Cis-1,2-dichloroethene was detected at a maximum concentration of 2,900 µg/L relative to an LC50 of 6,785 µg/L, and a final chronic value of 5,400 µg/L for this compound was calculated using the narcosis model from DiToro et al. (2000). Therefore, there is some uncertainty in estimating risk to benthic invertebrates at GWI near peeper LDW-PW-G-PE-06. Although the detected concentrations of cis-1,2-dichloroethene were lower than available effect concentration, the detected concentration at LDW-PW-G-PE-06 was within a factor of 2.5 of the available effect concentration.

Table 5-3. VOC concentrations in porewater samples collected using peepers at GWI and Boeing Plant 2/Jorgensen Forge compared to toxicity data

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION		REPORTING LIMIT		NOEC	LC50
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM		
1,1,1-Trichloroethane	µg/L	0/20	nd	nd	0.2	0.4	1,300	2,400 ^a
1,1,2-Trichloroethane	µg/L	0/20	nd	nd	0.2	0.4	1,000	15,000
1,1-Dichloroethane	µg/L	9/20	0.3	16	0.2	0.2	7,800 ^b	39,600 ^c
1,1-Dichloroethene	µg/L	3/20	0.3	4.9	0.2	0.4	2,400	11,600
1,2-Dichloroethane	µg/L	2/20	7.4	15	0.2	0.4	na	6,927
Acetone	µg/L	0/20	nd	nd	2.6	71	na	33,830
Benzene	µg/L	1/20	9.4	9.4	0.2	4.7	180	1,100 ^d
Chlorobenzene	µg/L	4/20	0.3	1.4	0.2	0.4	1,400	2,500 ^e
cis-1,2-Dichloroethene	µg/L	17/20	0.2	2,900	0.2	0.2	na	6,785
Tetrachloroethene	µg/L	2/20	0.4	1.1	0.2	0.4	331	332
Toluene	µg/L	5/20	0.3	3.5	0.2	0.4	737	14,700
trans-1,2-Dichloroethene	µg/L	7/20	0.3	21 J	0.2	0.4	na	6,785
Trichloroethene	µg/L	6/20	0.2	2.5	0.2	0.4	2,200	14,000
Vinyl chloride	µg/L	12/20	0.4	2,500	0.2	0.2	12,800 ^b	65,300 ^c

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION		REPORTING LIMIT		NOEC	LC50
			MINIMUM	MAXIMUM	MINIMUM	MAXIMUM		
Xylene (meta & para)	µg/L	0/20	nd	nd	0.4	0.8	1,168	2,973
Xylene (ortho)	µg/L	0/20	nd	nd	0.2	1.3	1,168	2,973

- ^a Concentration is a LOEC (lowest-observed-effect concentration).
- ^b Concentration is an FCV (final chronic value) based on the narcosis model.
- ^c Concentration is an FAV (final acute value) based on the narcosis model.
- ^d Concentration is an LC100 (lethal concentration for 100% of a test population).
- ^e Concentration is an EC50 (effect concentration for 50% of a test population).

LC50 – lethal concentration for 50% of a test population

NOEC – no observed effect concentration

na – not available

5.3 DATA ANALYSIS CONCLUSIONS

The analysis presented in Section 5.2 indicates that VOCs in porewater in LDW sediments collected near GWI and Boeing Plant 2/Jorgensen Forge pose a negligible risk to benthic invertebrates, with the possible exception of porewater from one peeper (PE-06) at GWI, where the cis-1,2-dichloroethene concentration was less than the LC50 but no NOEC was available. Other peepers in the vicinity of PE-06 (PE-03, PE-04, and PE-05) had substantially lower VOC concentrations, so the spatial extent of groundwater discharge of VOCs into porewater appears to be highly localized. This finding is consistent with the proposed conceptual site model for discharge at the GWI site (Windward 2005a).

GWI and Boeing Plant 2/Jorgensen Forge were selected from 11 sites where upland groundwater data have been collected as worst-case areas along the LDW with the highest potential for discharge of VOCs into porewater. The other nine locations have lower VOC concentrations in groundwater, or their upland VOC plumes do not extend to the LDW, and therefore should not result in exposures of benthic invertebrates to VOCs at concentrations expected to pose a risk to benthic invertebrates. Additional porewater sampling in the LDW does not appear to be warranted based on this analysis and the current groundwater data available. These conclusions apply only to the ecological risk assessment (specifically risk to benthic invertebrates) and only to the LDW RI/FS. Several other factors can enter into evaluating risks related to groundwater contamination at upland sites. Therefore, the conclusions for this site do not necessarily apply to ongoing or future upland investigations and cleanup decisions at Boeing Plant 2, Jorgensen Forge, GWI, or other sites along the LDW.

6.0 References

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Figures

- ⊗ Actual peeper location
 - Target peeper location
 - Actual piezometer location
 - Target piezometer location
 - ⊕ Groundwater monitoring location
 - ▲ Seep location for RI/FS (Terra Vac and Floyd/Snider 2000)
 - River mile
- | Bathymetry (feet relative to MLLW) | |
|------------------------------------|-----|
| — | -20 |
| — | -15 |
| — | -10 |
| — | -5 |
| — | 0 |
| — | 5 |



Barges shown in the aerial photo were not present at the time of sampling.

Myrtle St. embayment



Figure 2-1. Phase 2 porewater sampling locations at Great Western International

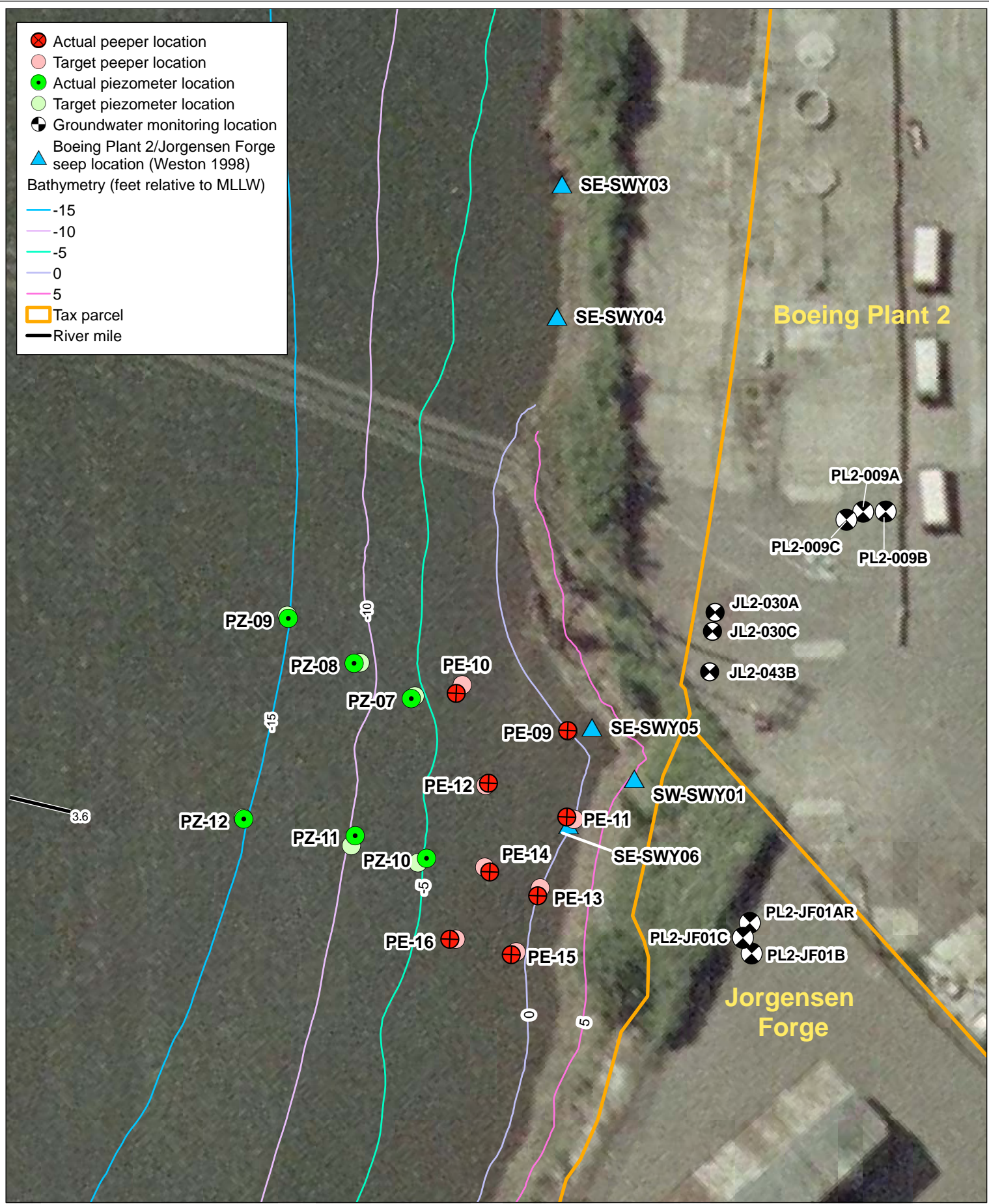


Figure 2-2. Phase 2 porewater sampling locations at Boeing Plant 2/Jorgensen Forge

