LOWER DUWAMISH WATERWAY SUPERFUND SITE
TERMINAL 117 EARLY ACTION AREA

Draft
Soil Boring and Groundwater Monitoring Report
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and
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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirements
bgs	below ground surface
CAS	Columbia Analytical Services
CLARC	cleanup levels and risk calculation
EAA	early action area
EE/CA	engineering evaluation and cost analysis
EPA	U.S. Environmental Protection Agency
MCL	Maximum contaminant levels
MTCA	Model Toxics Control Act
NTCRA	non-time-critical removal action
NTU	Nephelometric turbidity units
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photoionization detector
PVC	Polyvinyl chloride
QAPP	quality assurance project plan
SVOC	semivolatile organic compound
T-117	Terminal 117
TPH	total petroleum hydrocarbon
VOC	volatile organic compound
WQC	Water quality criteria

1 INTRODUCTION

In August 2010, on behalf of the City of Seattle, Integral Consulting Inc. (Integral) installed two groundwater monitoring wells and analyzed soil and groundwater samples from these wells within the Terminal 117 (T-117) Early Action Area (EAA), located in Seattle, Washington. As set forth in the August 19, 2010, revised T-117 Quality Assurance Project Plan (QAPP) addendum (Integral 2010), the two wells were installed on Dallas Avenue S. within the T-117 EAA non-time-critical removal action (NTCRA) boundary. The objectives of this work were as follows:

- Provide additional data on groundwater quality at the downgradient edge of the Adjacent Streets and Residential Yards Study Area of the NTCRA EAA (USEPA 2005)
- Provide a baseline of existing groundwater conditions (i.e., hydraulic and water quality) in this area
- Evaluate the potential for recontamination of the T-117 upland and sediments following the NTCRA.

The subject wells will be incorporated into the ongoing T-117 groundwater monitoring program, and soils information from the borings will be incorporated into the engineering design phase of the NTCRA.

This report provides a summary of the well installation and sampling activities, a summary of soil and groundwater screening results, and recommendations for future quarterly groundwater monitoring events.

2 SAMPLING AND WELL INSTALLATION ACTIVITIES

Sampling and wells installation activities took place from August 24 to 26, 2010, and consisted of advancing soil borings, soil sampling, groundwater profiling, groundwater sampling, installing two groundwater monitoring wells (MW-14 and MW-15), and developing the monitoring wells. Surveying of the monitoring wells took place on September 9, 2010. A description of each activity is presented in the following subsections.

2.1 SOIL BORING AND SOIL SAMPLING

The soil borings were advanced on August 24 and 25, 2010, using a direct push (Geoprobe) drill rig driving a 4.5-in. probe rod. At least two soil borings were advanced within 3 ft of each other at each of two locations in order to collect both soil and groundwater samples. The first borings, used to collect soil samples and log soil/geology conditions, were advanced to a depth of 24 ft. Although till was encountered prior to depths of 24 ft, the first borings were advanced into the till layer to allow for collection of till samples and were based on the length of the sampling probe. The final borings were used to evaluate the vertical groundwater profile of the upper aquifer (above the till layer), to collect groundwater samples, and to install groundwater monitoring wells, as discussed in Section 2.2. Well MW-14 was installed in one of two borings in the street near 8603 Dallas Avenue S., adjacent to former Boring P66. Well MW-15 was installed in one of three borings in the street near 8601 Dallas Avenue S., adjacent to former Boring CPT-3 (Figure 1). An additional boring, advanced to 10 ft, was needed at MW-15 to allow for adequate soil sample volume.

Soil samples were collected from each borehole to support characterization of soil stratigraphy, field screening, and laboratory analysis. The soil was collected using decontaminated stainless steel samplers equipped with new plastic liners driven ahead of the Geoprobe in 4-ft increments as the borings were advanced. Once the sampler was advanced 4 ft, it was withdrawn from the borehole, the sample and liner were removed, and the sample and liner were placed on clean aluminum foil where the liner was split apart for logging and sampling. The boring logs for MW-14 and MW-15 are provided in Appendix A.

As stated in the revised QAPP addendum (Integral 2010), a total of four soil samples were collected for analytical testing: one at the 6 to 8 ft and one at the 8 to 10 ft intervals in each boring, which were based on the depth of the removal prism in the areas of approximately 6 ft below ground surface (bgs). Because field observations indicating impacted soil, such as obvious contamination or field screening indicators (odor, sheen, and photoionization detector [PID] response above background levels), were not present, all other 2-ft intervals from the surface to the bottom of the borings were sampled to be archived at the analytical laboratory. One sample was also collected from each boring at the top of the till layer for grain size analysis in order to estimate the hydraulic permeability of the till.

Representative samples for analysis of volatile organic compounds (VOCs) and headspace screening were collected directly from each of the sample intervals selected for analysis as soon as possible after splitting apart the sample liner while following U.S. Environmental Protection Agency (EPA) 5035A methods for collecting soil samples for VOC analyses. Headspace screening was performed using a PID and readings were recorded on the boring logs (Appendix A).

In addition to analysis of VOCs, the intervals selected for testing were also submitted to Columbia Analytical Services (CAS) in Kelso, Washington, for the following analyses:

- Polychlorinated biphenyl (PCB) aroclors
- Total petroleum hydrocarbons (TPH) (NWTPH-Gx, NWTPH-Dx)

- Semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbons (PAHs)
- Total arsenic
- Dioxins/furans.

The analytical methods used, full analyte list (including VOCs and TPH), method detection limits, and reporting limits are included in the revised QAPP addendum (Integral 2010). Additional soil volume was collected from these intervals for archiving purposes when sufficient sample material was available.

Copies of the chain of custody forms for all samples collected are included in Appendix B.

All non-dedicated equipment used for soil sampling, including stainless steel sampling bowls, spoons, and push rods[1], was thoroughly decontaminated between samples. The decontamination procedure was:

1. Wipe/wash equipment of gross solids.
2. Wash equipment with non-phosphate detergent, scrubbing off residues.
3. Rinse generously with tap water.
4. Rinse with laboratory-grade deionized water.

2.2 GROUNDWATER PROFILING AND SAMPLING

As previously stated, the final borings advanced at each of the two locations were used to evaluate the vertical groundwater profile of the upper aquifer (above the till layer), to collect groundwater samples, and to install groundwater monitoring wells MW-14 and MW-15. Groundwater profiling was performed by collecting groundwater samples in 2-ft intervals below the water table in each boring using a screen point groundwater sampler. The sampler used was 41 in. long with a 1.6-in. outer diameter. The probe was pushed to the bottom of the sampling interval and then drawn up 2 ft to expose the screen. Water was then pumped directly into sampling containers with a peristaltic pump using low-flow methods (ENSR/AECOM 2008). For each sampling interval, the well was surged and water was pumped until the following field parameters stabilized:

- Temperature
- Turbidity
- pH
- Conductivity

[1] For push rods, rinsing was done with a pressure washer only (i.e., step 4 was omitted).

- Oxidation-reduction potential
- Dissolved oxygen.

Stabilization of field parameters was reached for each 2-ft interval when the criteria set forth in the T-117 monitoring well QAPP (ENSR/AECOM 2008) were met during periodic measurement.

Based on depths to groundwater and till of 14.7 and 21 ft bgs, respectively, at the MW-14 borehole prior to well installation, the intervals profiled included 15 to 17, 17 to 19, and 19 to 21 ft bgs. At the MW-15 borehole prior to well installation, groundwater and till were encountered at 14.8 and 19 ft bgs, respectively. However, the intervals profiled included only 14 to 16 and 16 to 18 ft bgs. The 18- to 20-ft interval initially intended to be the lowest interval profiled for MW-15 was not profiled due to very low groundwater production at the 16- to 18-ft interval.[2] Completed monitoring well development forms for each interval sampled are provided in Appendix A. Final (stabilized) field parameters for each of the intervals measured for MW-14 and MW-15 are shown in Table 1.

At the lowest interval profiled for each monitoring well borehole, a sample was collected for VOC analysis following groundwater profiling of that interval. This sample was collected using a "tubing-bottom check valve," or solid tubing fitted with a check valve at the bottom, to minimize VOC loss that can be experienced with suction pumping with a peristaltic pump. The tubing was lowered through the Geoprobe rod and screen to the middle of the 2-ft sampling interval and the check valve was released. The tubing was then withdrawn and the water sample was placed directly into laboratory-prepared sample bottles for volatile organics.

The groundwater VOC samples were submitted to CAS in Kelso, Washington, along with the soil samples collected. The VOC analyte list, method detection limits, and reporting limits for water samples are included in the revised QAPP addendum (Integral 2010). Copies of the chain of custody forms for all samples collected are included in Appendix B.

2.3 MONITORING WELL INSTALLATION

Following groundwater profiling, final borings advanced at each of the two locations were used to install groundwater monitoring wells MW-14 and MW-15. The wells were constructed with well casings consisting of 2-in. diameter Schedule 40 polyvinyl chloride (PVC) piping with flush-threaded couplings. Ten-ft sections of 0.010-in. slot PVC well screen with threaded end plugs were installed at the bottom of the wells and across the observed water table. Solid casing was extended from the top of the screened intervals to the ground surface. The well screens were factory-packed with 20/40 grade sand.

[2] The decision not to sample the 18- to 20-ft interval was discussed with and approved by EPA personnel in the field (Zavala 2010).

The annular space was backfilled with No. 10–20 Colorado silica sand to approximately 1 ft above the top of the well screen. A bentonite chip seal was poured on top of the sand filter pack to approximately 1 ft bgs as the probe was retracted. The seal was hydrated with clean, potable water supplied by the drillers until sufficiently hydrated. A concrete surface seal was then poured on top of the bentonite seal from approximately 1 ft bgs to the ground surface, surrounding an 8-in. diameter flush-mount, watertight surface monument. A locking cap was then installed on the top of the well casing.

As stated in the revised QAPP addendum (Integral 2010), the locations of the screened intervals and the depths of the wells were determined in the field based on the observed water table depth and the depth to till. Groundwater and till were encountered at 14.3 and 21 ft bgs, respectively, at MW-14. Therefore, MW-14 was advanced to a total depth of 21 ft bgs, and the screened interval was installed from 11 to 21 ft bgs. The well screen straddles the water table but is limited to approximately 3 ft above the observed water table. This will accommodate future downward (dry season) water level fluctuations, while providing sufficient room for a proper sand filter and surface seal between the top of the well screen and the ground surface.

At MW-15, groundwater and till were encountered at 14.6 and 19 ft bgs, respectively. However, the final total well depth and depth of the bottom of the well screen were set to 18 ft bgs due to decreasing soil permeability with depth. The screened interval was installed from 8 to 18 ft bgs.

MW-14 and MW-15 were installed on August 24 and August 25, 2010, respectively. Well construction details are presented in Appendix A.

2.4 MONITORING WELL DEVELOPMENT

Monitoring well development was conducted on August 25 and 26, 2010, the day following installation of each well. Development consisted of over-pumping each well using a 1.5-in. diameter submersible pump. The wells were repeatedly pumped (approximately 5 gallons per cycle) and then surged with the submersible pump. The same water quality parameters recorded during groundwater profiling (temperature, turbidity, pH, conductivity, oxidation-reduction potential, and dissolved oxygen) were measured periodically and recorded on a field form. Over-pumping continued until at least 10 well casing volumes were removed and field parameters were stabilized per the T-117 monitoring well QAPP (ENSR/AECOM 2008). Turbidity measurements (below 5 nephelometric turbidity units [NTUs] over three consecutive readings) were the main guide for the completion of the well development. Approximately 37 well casing volumes were removed during development of MW-14, while approximately 12 well casing volumes were removed from MW1-5.

Well development forms are included in Appendix A. Final (stabilized) field parameters for each MW-14 and MW-15 following well development are shown in Table 2. Sampling of the developed monitoring wells has been incorporated into the T-117 quarterly groundwater sampling program and is discussed in Section 4.

2.5 MONITORING WELL SURVEYING AND GROUNDWATER LEVELS

The locations and top-of-casing elevations of MW-14 and MW-15 were surveyed on September 9, 2010, to a common horizontal and vertical datum by representatives of Hebrank, Steadman, and Associates, Inc., of Seattle, Washington. After each well was surveyed, the surveying point at the top of each well casing was marked on the outside of the casing to allow for future consistent water level readings. The wells were surveyed to NAD 83 Washington State Plane North and the North American Datum NAVD 88 geographical datum. These survey data are necessary for determining and mapping the direction and horizontal gradient of groundwater flow across the site, which will be discussed in the next quarterly groundwater monitoring report. Survey data are contained in Appendix A.

Depth to groundwater was measured for six monitoring wells on August 26, 2010, within a period of 30 min. These wells were selected for measurement based on their proximity to the work being done and their accessibility. The measured water levels and associated well casing elevations are shown in Table 3.

3 ANALYTICAL RESULTS AND COMPARISONS TO SCREENING LEVELS

This section presents the analytical results for the soil and groundwater samples collected during the installation of groundwater monitoring wells MW-14 and MW-15. Soil and groundwater analytical results were also compared to published screening levels.

3.1 DEVELOPMENT OF SCREENING LEVELS

Screening levels used to evaluate the soil and groundwater sample results are provided in Tables 4 and 5. For a majority of soil analytes (Table 4), screening levels specific to the Adjacent Streets and Residential Yards Study Area of the NTCRA EAA were adopted from Appendix E-3 of the Engineering Evaluation/Cost Analysis (EE/CA) (Windward et al. 2010). For soil analytes not included in Appendix E-3 of the EE/CA, screening levels were derived on the basis of Model Toxics Control Act (MTCA) Method B equation values for direct contact with soil (WAC 173-340-740, Equations 740-1 and 740-2), with one exception.[3] Screening levels were obtained from Ecology's Cleanup Levels and Risk Calculation (CLARC) database (Ecology 2010). If screening levels for both noncancer effects (MTCA Equation 740-1) and cancer effects (MTCA Equation 740-2) were available in the CLARC database, the minimum of the two values was selected for protection of soil.

Screening levels for groundwater analytes specific to the Adjacent Streets and Residential Yards Study Area of the NTCRA EAA were not included in the EE/CA (Windward et al. 2010). Groundwater screening levels were derived by reviewing applicable state and federal laws (i.e., applicable or relevant and appropriate requirements [ARARs]) for protection of drinking water and protection of surface water and evaluating the minimum ARARs to determine if they are sufficiently protective under MTCA. The following ARARs were included in the evaluation:

- Drinking water
  - Maximum contaminant levels (MCLs) established under the Safe Drinking Water Act (40 CFR 141)
  - MCLs established by the State Board of Health (246-290 WAC)
- Surface water
  - Water quality criteria (WQC) for freshwater and saltwater aquatic organisms published by the State of Washington (173-201A WAC)
  - WQC for freshwater and saltwater aquatic organisms and human health, ingestion of organisms only, under Section 304 of the Clean Water Act
  - WQC for freshwater and saltwater aquatic organisms and human health, ingestion of organisms only, established under the National Toxics Rule (40 CFR Part 131)

WQC for protection of human health did not include ingestion of water because the Lower Duwamish Waterway is not rated for drinking water (173-201A WAC).

The minimum MCL was evaluated to determine if it was sufficiently protective using MTCA Equations 720-1 and 720-2. It was considered sufficiently protective if the cancer risk did not exceed 1×10^{-5} and the hazard quotient did not exceed 1 (WAC 173-340-720(7)(b)). If the MCL was sufficiently protective, it was used as the drinking water screening level; otherwise, it was adjusted using Equations 720-1 and 720-2 as appropriate to achieve a cancer risk of 1×10^{-5} and a hazard quotient of 1. If there was no MCL for a water analyte, the minimum of the MTCA Equation 720-1 and 720-2 values was used.

[3] For gasoline range TPH (TPH-Gx), the MTCA Method A unrestricted land use cleanup level was used (WAC 173-340-740, Table 740-1).

The minimum WQC was evaluated to determine if it was sufficiently protective using MTCA Equations 730-1 and 730-2. It was considered sufficiently protective if the cancer risk did not exceed 1×10^{-5} and the hazard quotient did not exceed 1 (WAC 173-340-730(5)(b)). If the WQC was sufficiently protective, it was used as the surface water screening level; otherwise, it was adjusted using Equations 730-1 and 730-2, as appropriate, to achieve a cancer risk of 1×10^{-5} and a hazard quotient of 1. If there was no WQC for a water analyte, then the minimum of the MTCA Equation 730-1 and 730-2 values was used.

The final groundwater screening level was selected as the minimum of the screening levels for protecting drinking water and surface water.

3.2 DATA VALIDATION

A full data validation review was conducted by EcoChem, Inc. of Seattle, Washington. Data validation was completed in accordance with the project data quality objectives and laboratory quality control procedures identified in the project QAPPs (ENSR/AECOM 2008; Integral 2010). No laboratory deviations occurred during the handling, analysis, or reporting of the soil or groundwater samples.

Field quality assurance samples were collected for soil and groundwater. One field replicate was collected and analyzed for all parameters of each matrix type (soil and groundwater). The relative percent difference between field replicate results for all detected compounds for both matrices were less than 30, demonstrating that the samples collected were homogeneous.

Two field equipment rinse blanks (one for soil and one for groundwater[4]) and one trip blank were submitted for VOC analysis to determine if cross contamination exists from the sampling equipment and sample handling/shipping process. No VOCs were detected in the field or trip blanks, except for toluene in the groundwater equipment rinse blank at 0.79 μg/L. This did not impact sample results because toluene was not detected in any of the groundwater samples.

Data qualified during data validation include:

- All naphthalene, 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin, and octachlorodibenzo-*p*-dioxin results in soil samples were qualified as non-detects (*U*) due to the presence of these compounds in the laboratory method blank.

[4] A filter wipe sample was collected from decontaminated soil sampling equipment (i.e., stainless steel sampling bowls and spoons) and a rinsate blank sample was collected from the silicon and tygon tubing used for groundwater sampling.

- 1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin in soil sample MWS-14-6-8DUP and 1,2,3,4,6,7,8-heptachlorodibenzofuran in soil samples MWS-14-6-8DUP and MWS-15-6-8 were qualified as non-detects (*U*) due to these compounds not meeting the ion ratio quantitation criteria.

All soil and groundwater data are considered acceptable, as qualified, for site evaluation and risk assessment purposes.

3.3 SOIL RESULTS

Soil results from the four samples collected from MW-14 and MW-15 are listed in Table 4, along with comparisons to the screening levels selected for site soil, as discussed above. Only one detected analyte, arsenic, exceeded screening levels, and no detection limits exceeded screening levels. Soil samples with arsenic concentrations exceeding the screening level included the 8 to 10 ft interval of MW-14 and both the 6 to 8 and 8 to 10 ft intervals of MW-15. However, both the maximum detected arsenic concentration (2 mg/kg) and the arsenic screening level (0.67 mg/kg) are below the natural, background soil arsenic concentration for the Puget Sound region of 7.30 mg/kg (90^{th} percentile; Ecology 1994).

In addition to arsenic, the following analytes were detected in one or more soil samples, although not in exceedance of screening levels:

- TPH (diesel range and residual range)
- PAHs (15 analytes, including carcinogenic PAHs)
- SVOCs (*bis*(2-ethylhexyl)phthalate, diethyl phthalate, and dimethyl phthalate)
- Aroclor 1260
- Octachlorodibenzofuran.

Grain size results for the one sample collected from each boring at the top of the till layer are also included in Table 4. A grain size distribution plot is also provided for MW-14 and MW-15 as Figures 2 and 3, respectively.

The objective of the grain size analysis was to demonstrate low hydraulic permeability of the till layer. As shown in the grain size distribution plots, most of the soil is in the sand range, thus this test does not confirm low permeability. However, other testing and observations do show that this material exhibits low permeability:

- The cone penetrometer log for CPT-3 (located very near MW-15) is provided in Appendix A. As shown in the logs and text description, the soil becomes very stiff at the contact between the upper sand and underlying till. Material above the contact is generally characterized as silty sand to sandy silt; materials below the contact are characterized as clays and silts. The till layer extends from 20 to at least 30 ft bgs, the maximum depth of the CPT boring.

- As described above, groundwater recovery from the lower intervals at MW-15 was very low.
- At the time of drilling MW-14 and MW-15, the till layer was observed to be dry, in contrast to the saturated sands above.

3.4 GROUNDWATER RESULTS

Groundwater VOC results from the total of two samples from MW-14 and MW-15 are listed in Table 5, along with comparisons to the screening levels selected for site groundwater, as discussed above. Two VOCs (carbon disulfide and tetrachloroethylene) were detected in groundwater. Only carbon disulfide was detected at a concentration (0.84 μg/L) slightly above the screening level (0.81 μg/L).

In addition, the following analytes were reported as non-detect but the detection limits exceeded their respective site-specific screening levels:

- 1,1,1,2-Tetrachlororethane
- 1,2,3-Trichloropropane
- Ethylene dibromide.

4 SUMMARY

Two groundwater monitoring wells were installed to provide additional data on groundwater quality at the downgradient edge of the Adjacent Streets and Residential Yards Study Area of the NTCRA EAA. Analytical and physical testing and results are summarized as follows:

- Soils observed during drilling included an upper sand unit and a lower till unit — The contact between these units was observed at approximately 20 ft bgs. The sand unit was saturated between the contact and the water table at approximately 15 ft bgs. The till was observed to be dry.
- Vertically profiling conventional parameters in groundwater —Although there were differences in field parameter measurements between depth intervals and between the two wells, no systematic trends were observed.

- Groundwater analytical testing for VOCs — Only one VOC, carbon disulfide, was detected above its screening level in water collected from the bottom of the sand aquifer. Carbon disulfide is not a COPC associated with the T-117 NTCRA EAA.
- Soil analytical testing for parameters historically associated with the Adjacent Streets and Yards — No detection of TPH, PAHs, SVOCs, VOCs, PCBs, and dioxins/furans above screening levels were observed. Arsenic was detected above the screening level, but below background levels.
- Grain size analysis of the till unit — Grain size analysis did not conclusively demonstrate low permeability of the till unit, but other lines of evidence, including CPT results and observations while drilling, indicate that the till unit has characteristics of low conductivity and is at least 10 ft thick.

Other objectives for this work included providing a baseline of existing groundwater conditions in this area and evaluating recontaminations potential to T-117 sediments. Groundwater monitoring of the full T-117 analytical suite was included in the quarterly monitoring event conducted in September 2010. The results of that monitoring event are needed to fully address these other objectives. Once the quarterly monitoring has been reported, recommendations for additional evaluations of groundwater beneath Adjacent Streets and Yards Study Area, if any, will be provided.

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