Prepared for:
**Port of Seattle**
**Seattle, Washington**

# Summary Report – 2008 Investigations and Data Gap Evaluation
# Lora Lakes Apartments

AECOM, Inc.
September 2009
**Document No.: 054820256000**

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# 1.0 Introduction

AECOM Environment[1] (AECOM) performed environmental site investigation work at the Lora Lake Apartments (Site) for the Port of Seattle (Port) from March to December 2008. The site is owned by the Port and is located at 15001 Des Moines Memorial Drive in Burien, Washington (Figure 1-1). The site investigation work yielded information sufficient to make a preliminary characterization of potential risks to human health and the environment from exposure to chemicals in soil, groundwater and soil vapor. Further, the work provides the foundation for a remedial investigation and feasibility study (RI/FS) under the Model Toxics Control Act (MTCA) in accordance with Agreed Order DE 6703 between the Port and the Washington State Department of Ecology (Ecology).

This document summarizes available information on historical land use, removal actions, and investigations conducted at the site and presents the results of 2008 sampling events. This information is used to develop a preliminary Conceptual Site Model (CSM) describing potential source areas, the nature and extent of chemicals of potential concern, their fate and transport in the environment, potential exposure pathways, and receptors. Finally, the document discusses data gaps and a generalized scope of work to address those data gaps.

## 1.1 Background

### 1.1.1 Site Location, Surrounding Land Use and Site History

The Site is located at 15001 Des Moines Memorial Drive in Burien, Washington, King County Assessor's Parcel No. 2023049105. The Site is 8.29 acres in size and contains an unoccupied residential apartment complex. Directly adjacent to and north of the property is State Highway 518. Land use north of the highway is residential and limited commercial. Des Moines Memorial Drive flanks the eastern boundary of the site. Further east is land owned by the Port and designated in the Natural Resource Mitigation Plan for Seattle Tacoma International Airport (Airport) as Miller Creek/Lora Lake Upland Buffer and Flood Plain Zones. Immediately south of the site are open lots which were recently cleared of commercial development (Auto Service Station, Seattle City Light Substation and a commercial shopping center). West of the site is Eighth Avenue South and an area of residential land use.

Prior to 1940, the site was both an orchard and private residence (1936 photo; Appendix A). From approximately 1940 to the mid-1980s, the site was used for industrial purposes. Operators at the site included Novak Barrel Cleaning Company during the 1940s and 1950s and Burien Auto Wrecking from the 1960s until the 1980s. A series of aerial photographs spanning the years from 1936 – 2004 are provided in Appendix A. The photograph dated 1946 shows a building and possible waste pond present when the Novak Barrel Cleaning Company occupied the property. The 1985 aerial photograph shows numerous vehicles and areas of darkened soil when the property was occupied by Burien Auto Wrecking. The later photographs show the site's transition to the LLA complex and changes to surrounding properties.

It is important to note the changes in property use adjacent to and within the LLA current property line. The aerial photographic history shows that from the 1940s to 1985, there were homes present along the northern boundary of both the Novak and Burien Auto Wrecking property line. In approximately 1987, these homes

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[1] AECOM Environment is the new environmental business line of AECOM Technology Corporation. ENSR changed its name to AECOM Environment on November 10, 2008. AECOM Environment leverages the full environmental resources of ENSR, Earth Tech, STS, and Metcalf & Eddy.

were removed and this land incorporated into what is now the LLA property boundary. East across Des Moines Memorial Drive the 1936 photo shows that Lora Lake is not present. Sometime between 1936 and 1946 peat mining began in the future footprint of Lora Lake[2] and by 1946 a small lake is visible. In the 1985 aerial photo the current-day Lora Lake is present and is surrounded by residential buildings. The 1992 photo shows the completed LLA complex; across Des Moines Memorial Drive, Lora Lake is still surrounded by residential buildings. Then, in the 2004 aerial photo, the residential buildings are no longer present around Lora Lake and the area has been re-graded.

In the mid-1980s, the Mueller Group purchased the property. The LLA buildings were constructed in 1987. The initial complex was comprised of 22 buildings, each three stories in height.

In 1998, the Port acquired the apartment complex from Pacific Gulf Properties, Inc., for conversion to airport support (industrial) use. Due to litigation-driven delays in Third Runway construction, in May 2000, the City of Burien (City), the Port and the King County Housing Authority (KCHA) entered into a Housing Cooperation Agreement transferring ownership of the apartment complex to KCHA. The agreement called for the complex to be returned to the Port by mid-2005. In July 2004, the agreement with KCHA was extended for another two years.

The Port reacquired the property on July 20, 2007 after the apartments were vacated. Later that year, to comply with Federal Aviation Administration (FAA) flight path requirements for the Third Runway, six of the apartment buildings were demolished. At the same time, KCHA initiated a condemnation action against the Port to secure ownership of the portion of the property not required for FAA flight path requirements. KCHA's planed to return the latter portion of the property to residential use. The Port agreed to transfer the property to KCHA. However, in July 2008 after further site investigations KCHA and the Port entered into a final settlement agreement, dismissing the condemnation action and reconveying the property to the Port.

### 1.1.2 Investigative, Regulatory and Cleanup History

In 1986, Golder Associates (Golder) conducted a geotechnical investigation at the site on behalf of the Mueller Group (Golder, 1986). The intent of the investigation was to determine soil conditions prior to the development of the multi-building LLA complex. During the investigation a waste pit containing visually contaminated soils was discovered. Metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (sVOCs) were detected in a composite sample of contaminated soil.

In March 1987, Chemical Waste Management, on behalf of the Mueller Group, performed a targeted excavation of impacted soil and removed approximately 140 cubic yards of soil as well as a concrete sump discovered during excavation activities. Confirmation samples indicated the excavation had removed the impacted soils but impacted soils were identified in another area adjacent to the excavation, approximately 400 feet square. In April 1987, Golder returned to conduct additional characterization and found that the on-site contractor had graded and removed an additional 4.5 feet of soil from the 400 feet square area and constructed formwork for placement of stemwall footings for the LLA Recreation Building in the area. The excavated soil had been moved to an on-site stockpile. Golder excavated several exploratory test pits in the 400-square-foot area and encountered a small concrete sump with visibly stained soil, which they removed. They collected four confirmation soil samples from the test pits. Golder reported that the analytical results indicated slightly elevated levels of zinc and lead in samples but all other analytes were not detected. The Mueller Group submitted Golder's 1987 *Investigation and Clean-Up Report* to Ecology summarizing the cleanup action (Golder, 1987). In December 1987, Ecology responded with a letter to the Mueller Group

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[2] Peat mining was conducted by Hi-Line Leaf Mold Products during the 1940s and 1950s (Rigg,1958).

stating that the Golder cleanup had been performed "…in a professional manner using environmentally sound criteria which will protect the public. At this time, no additional investigation is required."

In 2007, the Port performed a limited soil and groundwater investigation to obtain information necessary to support redevelopment planning for the site. The Port focused the investigation on the area that was believed to be the location remediated previously by the Mueller Group in 1987. On behalf of the Port, GeoScience Management installed nine temporary soil borings and a single groundwater monitoring well (February 2008 investigation; GeoScience Management, 2008). The location of the borings (LLP-1 through LLP-9) and well (MW-1) are noted on Figure 1-2. The area the Mueller Group remediated as determined by GeoScience Management is also presented on Figure 1 -2.

The Port's focused site investigation revealed no visual, olfactory, or instrumental evidence of contamination in shallow soil and no shallow soil samples were collected for laboratory analysis. Soil samples collected at depth and groundwater samples from MW-1 contained petroleum hydrocarbons, VOCs, and sVOCs

Following this focused investigation, the Port and KCHA jointly applied to the Washington State Department of Ecology Voluntary Cleanup Program and the Port contracted with ENSR (now AECOM) to conduct a more detailed site investigation. ENSR prepared a site investigation work plan titled *Site Investigation Work Plan – Lora Lake Apartments* dated March 24, 2008, which included a detailed scope for soil, groundwater, and sub-slab vapor investigations across the site. Data were collected during three separate sampling events (March-April, August, and December); each event was conducted to supplement data gathered during the previous event. Soil, groundwater, and sub-slab vapor samples were collected in the first event. Groundwater and a limited number of soil samples were collected in the August and December events.

The March - April 2008 investigation confirmed soil was impacted in the central portion of the site near the vicinity of the Recreation Building. Impacted soil was also identified to the east, toward the site boundary. The sub-slab soil vapor investigation showed that, though contamination was present on-site, it was not impacting soil vapors present directly below the site buildings in excess of EPA sub-slab screening levels. Groundwater was impacted in the vicinity of the Recreation Building and extending downgradient, to the east, toward the LLA property line. To resolve whether groundwater contamination was present offsite beyond the eastern Site boundary, additional wells were installed and sampled in August 2008 and in December 2008. As described in this report the contamination does not appear to have migrated off site at levels of concern.

# 2.0 2008 Soil, Groundwater and Sub-slab Vapor Investigation

Soil and groundwater sampling and analytical procedures for the March-April 2008 investigation are described in the *Site Investigation Work Plan – Lora Lake Apartments*, March 24, 2008 (ENSR, 2008). A modified version of this document, referred to here in as the “Work Plan,” is provided in Appendix C. The document was modified to include activities conducted during the second and third sampling events and reflects changes in sample locations and analytical methods. Table 2-1 summarizes all soil and groundwater sample locations and the rationale for each location. Table 2-2 summarizes analytical methods used on soil and groundwater sampling for each event.

The sequence of investigation events is as follows:

- **First Sampling Event (March – April)**
  - *March 17, 2008 –* A limited access hollow-stem auger (HSA) was used to collect soil samples in locations completed as groundwater monitoring wells (MW-1 through MW-6).
  - *March 27, 2008 –* The first round of groundwater sampling was conducted on six wells (MW-1 through MW-6).
  - *April 3, 2008 –* Geoprobe and hand-auger soil sample collection was conducted.
  - *April 11-15, 2008 –* Sub-slab vapor sample collection was conducted.
- **Second Sampling Event (August)**
  - *August 12, 2008 –* Monitoring wells MW-8 through MW-11 were installed and soil samples were collected from each well and archived
  - *August 19-20, 2008 –* The second round of groundwater sampling was conducted on seven wells: MW-3, MW-4, MW-5, MW-8, MW-9, MW-10 and MW-11.

Monitoring well MW-7 was installed October 22, 2008 and one soil sample was collected and archived.

- **Third Sampling Event (December)**
  - *December 3, 2008 –* The third round of groundwater sampling was conducted on four wells: MW-2, MW-6, MW-7, and MW-10.

Specific details regarding soil and groundwater sample collection are described in the sections below. Details regarding sub-slab vapor collection are described in Appendix B.

## 2.1 Soil Sampling

The first sampling event conducted in March and April 2008 included the collection of 44 shallow and deep soil samples from twelve locations. The rationale for each sample location is described in Table 2-1. The soil samples were collected using a hand auger, a limited access geoprobe rig, and limited access HSA in accordance with the Work Plan. On March 17, 2008 the limited access HSA was used to collect soil samples in locations completed as groundwater monitoring wells (MW-2 through MW-6) and on April 3, 2008 geoprobe and hand-auger sample collection was completed. All sample locations are illustrated on Figure 1-3; boring logs are located in Appendix D.

All sample collection locations were cleared of surface debris and grass (or weeds). In areas covered by mulch (e.g., play area), the loose wood fragments were brushed aside until firm soil was exposed. When grass was encountered, an intact one foot diameter circle of grass was removed to expose firm soil. The intact grass was replaced, consistent with grade, after sample collection.

Individual soil samples were collected from depths of 0 – 0.5 foot and 1.5 – 2.0 feet below ground surface (bgs) at all twelve locations. These samples provided information on the nature and extent of near-surface soil contamination. The 0 - 0.5 foot interval was selected based on Ecology guidance that defines the depth interval that children will typically encounter when engaged in outdoor play (Ecology, 2007). The 1.5 – 2.0 foot interval represents a reasonable maximum that could be encountered during residential gardening or landscaping activities. At eight of the locations soil samples were also collected from depths of approximately 7 feet and 14 feet. The samples collected at the 7 and 14 foot depths provided general site characterization data and were collected based on impacts observed at depth during the previous investigation performed by GeoScience Management.

Throughout the sampling process, the field geologist recorded lithology and photo ionization detector (PID) readings. While the 0 – 0.5 and 1.5 – 2.0 foot intervals were consistently sampled, there was variation in the depth of the deeper samples. Samples were collected at depth based on olfactory, visual, and/or PID readings. The 7- and 14-foot depth intervals were sampled by default if no sign of contamination was present at depth. The samples were collected using SPT methods (ASTM D 1586). All samples were labeled, placed on ice, and submitted along with chain-of-custody documentation to Columbia Analytical in Kelso, WA for analysis. The soil samples were analyzed for total metals, VOCs, sVOCs, PCBs, total petroleum hydrocarbons (TPH) and dioxin and furans. Table 2-2 lists sample analytical methods

During the second and third sampling events, an HSA was used to install monitoring wells MW-8 through MW-11, and MW-7, respectively. Soil samples were collected from the borings advanced for monitoring well installation in order to log soil characteristics and field screen for indications of contamination. The soil samples were collected from each boring at five-foot intervals starting at 5 feet bgs and continuing to the total depth of the boring. The samples were collected using SPT methods (ASTM D 1586). Each sample was field-screened using a photoionization detector (PID) and visually inspected to determine if contamination was present in any of the samples. There were no obvious signs of contamination in any of the samples. One soil sample was collected from the groundwater interface in each well and archived at Columbia Analytical Services in Kelso, WA at -18 degrees Celsius for future use.

All samples were labeled, placed on ice, and submitted along with chain-of-custody documentation to Columbia Analytical in Kelso, WA for analysis. Table 2-2 lists sample analytical methods.

## 2.2 Monitoring Well Installation

Five monitoring wells (MW-2 through MW-6) were installed at the site on March 17, 2008 using a HSA drilling rig operated by Cascade Drilling, Inc. of Woodinville, WA. Five additional monitoring wells were installed east of the site in August 2008 (MW-8 through MW-11) and in October 2008 (MW-7). Monitoring well installation activities were conducted in accordance with the standards for monitoring well construction and installation described in the Work Plan. Material specifications and completion depths were recorded during well construction and documented in well completion logs. The boring logs are located in Appendix D. Field notes of the well development are included in Appendix E.

The location of each well installed on site was based on local topography and information from previous hydrogeologic work that indicated a generally south easterly groundwater flow direction (GeoScience Management, 2008). Well placements were selected to yield one upgradient well (MW-2), three downgradient wells (MW-3, MW-4, and MW-5) and one cross gradient (MW-6).

Groundwater monitoring wells (MW-7 through MW-11) were installed downgradient and adjacent to the LLA property boundary to determine if impacted groundwater had migrated beyond Site boundaries. Monitoring well MW-7 was installed downgradient of MW-6 within the Washington Department of Transportation (WADOT) Right-of-Way (ROW) east of Des Moines Memorial Drive. MW-8 through MW-11 were located on a 10-foot strip of Port of Seattle-owned property east of Des Moines Memorial Drive and outside of the Port's Lora Lake Mitigation Site fence line.

Installation of monitoring wells (MW-2 through MW-6) included soil sampling to determine lithology and nature and extent of contamination of site soils and groundwater. The soil observations were performed continuously from 0 - 3 feet and then at 2.5 foot intervals below 3 feet while drilling each well. Analytical soil samples were collected as described in Section 2.1. Monitoring wells MW-7 through MW-11 were installed to determine the extent of impacted groundwater beyond site boundaries. Soil sample observations were performed at 5 foot intervals while drilling each well. One analytical soil sample was collected from each well at the groundwater interface and archived as described in Section 2.1.

Monitoring wells were constructed with 2-inch, Schedule 40 polyvinyl chloride (PVC) casing and ten feet of screen (0.020-slot). The placement of the top of the screen varied from 5 to 13 feet bgs and depended on conditions encountered during drilling and location of groundwater. Blank PVC casing extended from the top of the screen to approximately ground surface. A clean, washed 10/20 silica sand pack was placed in the annulus between the well screen and the borehole wall from the bottom of the boring, and extending to approximately 2 feet above the top of the screen. An annular seal consisting of 3/8" bentonite pellets was placed above the sand pack to just below the ground surface and hydrated to create a seal. All monitoring wells were completed with flush-mount monuments and lockable well caps.

The wells were developed as described in the Work Plan. Purge water, decontamination water, and soil cuttings were placed in 55-gallon drums, labeled, and staged at the site. After installation, the top of the PVC casing of each monitoring well was surveyed by a surveyor licensed by the Port of Seattle. The horizontal survey datum used by the surveyor was from the Seattle-Tacoma International Airport (STIA) grid, and the vertical datum was NGVD-29.

## 2.3 Groundwater Sampling

The first round of groundwater sampling was conducted on March 27, 2008 for wells MW-1 through MW-6. A duplicate sample was collected from MW-5. A trace amount (approximately 0.01 feet) of hydrocarbon was noted on the groundwater in well MW-1. Measurements of the hydrocarbons at 0.01 feet or less using field instruments are not accurate and are considered trace. No hydrocarbon sheen was noted in samples from other wells at the site.

The second groundwater sampling event was conducted on August 19-20, 2008. Samples were collected from the seven wells; MW-3, MW-4, and MW-5 on the LLA property and MW-8, MW-9, MW-10 and MW-11 on the property to the east, across Des Moines Memorial Drive. A duplicate sample was collected from MW-9. Monitoring well MW-6, located on the LLA property, was scheduled for sampling but could not be sampled because there was insufficient groundwater in the well (0.19 inches of water). All groundwater samples were analyzed for those analytes detected in up gradient wells at concentrations exceeding MTCA Method B clean up levels (CUL) or with method detection limits above MTCA CULs during the March – April 2008 investigation. The analytes consisted of TPH-Dx, priority pollutant metals[3], pentachlorophenol (PCP), carcinogenic polycyclic aromatic hydrocarbons (cPAH) and dioxin and furans. Two alternate analytical

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[3] Antimony, arsenic, beryllium, cadmium, chromium, cooper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

methods were used to achieve lower reporting limits for PCP and cPAH during the August 2008 investigation. See Table 2-2 for a list of analytical methods used during this event.

The third and last round of groundwater sampling was conducted on December 3, 2008. Samples were collected from four wells on the LLA property (MW-2 and MW-6) and two wells bordering the eastern LLA property (across Des Moines Memorial Drive; MW-7 and MW-10). MW-6 was sampled, but due to insufficient water in the well (2.4 feet of water) the well was sampled before groundwater parameters equalized. A duplicate sample was collected from MW-7. The analytes consisted of TPH-Dx, TPH-Gx, priority pollutant metals, PCP, dioxins and furans.

For all groundwater sampling, a low-flow sampling method was used; PVC tubing was placed down into the screened interval of the well and then groundwater was slowly purged using a peristaltic pump at a rate not exceeding 0.5-liters per minute until groundwater parameters equalized. The information was recorded on a ground-water sampling form (Appendix E). The pump was decontaminated between each well using a soap-water wash and tap-water rinse. All water generated during sampling was placed in a DOT-approved, properly labeled 55-gallon metal drum and staged onsite prior to disposal. More detailed procedures regarding groundwater sampling can be found in Appendix C.

All groundwater samples were labeled, placed on ice, and submitted along with appropriate chain-of-custody documentation to Columbia Analytical in Kelso, WA for analysis of the parameters listed in Table 2-2.

## 2.4 Soil, Groundwater and Sub-slab Vapor Analytical Results

The analytical results, tables, and figures for each sampling event are in Appendix F. Evaluation of these three data sets is discussed in Section 4.0 Field Analytical Results and Discussion.

The analytical results, tables and figures for the sub-slab vapor sampling are in Appendix B. Further discussion of sub-slab vapor is not included in the results and discussion section because analytical results suggest that existing sub-slab vapor conditions do not translate into unacceptable risks.

## 2.5 Data Quality

Data validation was performed on all laboratory analytical data produced for this project to assure the quality assurance and quality control (QA/QC) procedures as stipulated in the Work Plan were met. If the QA/QC protocol was not met it was flagged and qualified to ensure it was used appropriately. The analytical data were validated following a Level III B Category evaluation. This level is used primarily in support of engineering studies, using standard EPA-approved procedures. Three validation reports were completed; one for each sampling event. A brief overview of the qualified data is provided below. The complete data validation reports are in Appendix F.

The data validation report for samples collected during the March-April 2008 event stated that overall precision, accuracy, method compliance, and completeness of the data set were acceptable for all methods reported. Only a limited number of select data points were rejected or missing. All non-rejected data were suitable for their intended use with the qualification and clarifications noted. Notable validations are as follows:

- Not all analyses requested on the chain of custody were analyzed. NWTPH-Dx analysis was not completed on sample LL08-1.5-2 due to insufficient sample volume.
- Hold time was exceeded by one day for NWTPH-Dx analysis on soil samples collected on 3/18/08. All DRO and RRO results for these samples were qualified with a U or NJ qualifier.
- Hold time was exceeded by 20-21 days for mercury analysis on three soil samples (MW-5-1.5-2, MW-4-9-10.5, and MW-2-0-0.5). The reported mercury concentrations were J qualified.

- Contamination was present in laboratory blanks for selected analytes in the following analyses: Method 8260B for soils, Method 8270C for soils and groundwater, NWTPH-Gx for soils and groundwater, NWTPH-Dx for soil and groundwater, and Method 8290 for soils and groundwater. Qualifiers were assigned based on concentration of contaminant relative to the method reporting limit.
- Additional qualifiers were assigned to select data due to the following criteria: laboratory control sample recoveries outside of control limits; matrix spike recoveries outside of control limits; laboratory duplicates or serial dilutions outside control limits; internal standards outside method criteria for GC/MS or ICP-MS analyses; not all system performance criteria was met for ICP-MS tunes; and not all qualitative/quantitative criteria for organic target analyte identification were met.

The data validation report for samples collected during the August 2008 event stated that overall precision, accuracy, method compliance, and completeness of the data set were acceptable for all methods reported. The majority of the data were unqualified and no data were missing or rejected. All the reported data were suitable for their intended use with the qualification and clarifications noted. Notable validations are as follows:

- Hold time for pH analysis was exceeded by 1 day for six samples. The reported pH value was J-flagged.
- Contamination was present in laboratory blanks for selected analytes for the following analyses: NWTPH-Dx for groundwater, and Method 8290 groundwater. Qualifiers were assigned based on concentration of contaminant relative to the method reporting limit.
- Additional qualifiers were assigned to select data due to the following criteria: laboratory control sample recoveries outside of control limits; not all system performance criteria were met for ICP-MS tunes; and not all qualitative/quantitative criteria for organic target analyte identification were met.

The data validation report for samples collected during the December 2008 event stated that overall precision, accuracy, method compliance, and completeness of the data set were acceptable for all methods reported. The majority of the data were unqualified and no data were missing or rejected. All the reported data were suitable for their intended use with the qualification and clarifications noted. Notable validations are as follows:

- Hold times for pH analysis was exceeded by five or less hours. The reported pH value was J-flagged.
- Contamination was present in laboratory blanks for selected analytes for the following analyses: Method 8151 modified for groundwater, NWTPH-Dx for groundwater, and Method 8290 groundwater. Qualifiers were assigned based on concentration of contaminate relative to the method reporting limit.

**Table 2-1 Sample Location and Purpose**

| Location ID | Approximate Location | Rationale |
|---|---|---|
| *Groundwater* | | |
| MW-1 | Approximate center of property in location of known historic impacts | Validate previously collected groundwater data |
| MW-2 | Northwest corner of the property by Building Q | Characterize groundwater entering property |
| MW-3 | South side of the property by Buildings E and F | Characterize groundwater leaving property |
| MW-4 | Eastern property boundary by former Buildings C and D | |
| MW-5 | Eastern property boundary by former Buildings A and C | |
| MW-6 | Eastern property boundary by former Buildings W and X | Characterize groundwater in NE corner of property |
| MW-7 | East of Des Moines Memorial Drive downgradient of MW-6 | Characterize groundwater beyond property line |
| MW-8 | East of Des Moines Memorial Drive downgradient of MW-1 | |
| MW-9 | East of Des Moines Memorial Drive downgradient of MW-5 | |
| MW-10 | East of Des Moines Memorial Drive downgradient of MW-4 | |
| MW-11 | East of Des Moines Memorial Drive downgradient of MW-3 | |
| *Soil* | | |
| LL-01 | East side of the Rec. building | Potential high-use area;<br>Previous MTCA exceedances at depth |
| MW-2 | Northwest corner of the property by Building Q | Likely point of influx of groundwater to site;<br>Achieve site-wide coverage |
| MW-3 | South side of the property by Buildings E and F | Achieve site-wide coverage |
| MW-4 | East side of property by Buildings C and D | Achieve site-wide coverage |
| MW-5 | East side of the property by former Building A | Achieve site-wide coverage |
| MW-6 | Northeast corner of the property by former Buildings X and W | Achieve site-wide coverage |
| LL-07 | West side of the property by Building N | Achieve site-wide coverage |

| Location ID | Approximate Location | Rationale |
|---|---|---|
| *Soil (continued)* | | |
| LL-08 | Boneyard / Play area | Potential high-use area; adjacent to former off-site transformer location |
| LL-09 | Northeast corner of the property by former Buildings U and V | Achieve site-wide coverage |
| LL-10 | North side of the Rec. building | Potential high-use area;<br>Adjacent to previous MTCA exceedances |
| LL-11 | South side of the Rec. building | |
| LL-12 | Near the basketball court / pool | Potential high-use area |
| *Soil Vapor* | | |
| LL-SV-RB | Recreation building | Achieve site-wide coverage |
| LL-SV-D | Building D | Achieve site-wide coverage |
| LL-SV-F | Building F | Achieve site-wide coverage |
| LL-SV-H | Building H | Achieve site-wide coverage |
| LL-SV-N | Building N | Achieve site-wide coverage |
| LL-SV-Q | Building Q | Achieve site-wide coverage |
| LL-SV-R | Building R | Achieve site-wide coverage |
| LL-SV-T | Building T | Achieve site-wide coverage |
| LL-SV-AA (Background) | Carport on west side of property | Determine background air values |

**Table 2-2 Soil and Groundwater Sampling Events**

| *Soil* | | | Sampling Details | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well ID | Sample ID | Date | Metals | PCB | VOC | | SVOC | | Total Petr. Hydr. | | Dioxin/ Furans | TSS | TOC | Hard-ness | pH | Turbidity |
| | | | SW-846 6020/7471A | EPA 3545/ 8280 | SW-846 8260B | SW-846 8270CSIM | SW-846 8270C | SW-846 8151M | NWTPH -Dx | NWTPH-Gx | SW-846 2890 | EPA 160.2 | ASTM 4129-82M | EPA 130.2 | EPA 150.1 | |
| LL01 | LL01-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL01-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL01DUP02-040308 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| LL07 | LL07-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL07-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| LL08 | LL08-0-0.5 | 4/3/2008 | X | X | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL08-1.5-2 | 4/3/2008 | X | X | X | — | X | — | — | X | X | — | — | — | — | — |
| | LL08-2-4 | 4/3/2008 | X | X | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL08DUP01-040308 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL08-13-15 | 4/3/2008 | X | X | X | — | X | — | X | X | X | — | — | — | — | — |
| LL09 | LL09-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL09-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL09-6-8 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL09-13-15 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| LL10 | LL10-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL10-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| LL11 | LL11-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL11-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| LL12 | LL12-0-0.5 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL12-1.5-2 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL12-6-8 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | LL12-13-15 | 4/3/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| MW-2 | MW-2-0-0.5 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-2-1.5-2 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-2-6.5-8 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-2-14-15.5 | 3/19/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-2-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | — | — | X | — | — | — |
| MW-3 | MW-3-0-0.5 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-3-1.5-2 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-3-6.5-8 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-3-14-15.5 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| MW-4 | MW-4-0-0.5 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-4-1.5-2 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-4-9-10.5 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-4-14-15.5 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |

| *Soil* | | | Sampling Details | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well ID** | **Sample ID** | **Date** | **Metals** | **PCB** | **VOC** | | **SVOC** | | **Total Petr. Hydr.** | | **Dioxin/ Furans** | **TSS** | **TOC** | **Hard-ness** | **pH** | **Turbidity** |
| | | | **SW-846 6020/7471A** | **EPA 3545/ 8280** | **SW-846 8260B** | **SW-846 8270CSIM** | **SW-846 8270C** | **SW-846 8151M** | **NWTPH -Dx** | **NWTPH-Gx** | **SW-846 2890** | **EPA 160.2** | **ASTM 4129-82M** | **EPA 130.2** | **EPA 150.1** | |
| MW-5 | MW-5-0-0.5 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-5-1.5-2 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-5-6.5-8 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-5-11.5-13 | 3/17/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| MW-6 | MW-6-0-0.5 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-6-1.5-2 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-6-11.5-13 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-6-19-21.5 | 3/18/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-6-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | — | — | X | — | — | — |
| MW-7 | MW-70-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | — | — | X | — | — | — |
| | MW-7-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | — | — | X | — | — | — |
| MW-10 | MW-10-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | — | — | X | — | — | — |

| *Groundwater* | | | Sampling Details | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well ID** | **Sample ID** | **Date** | **Metals** | **PCB** | **VOC** | | **SVOC** | | **Total Petr. Hydr.** | | **Dioxin/ Furans** | **TSS** | **TOC** | **Hard-ness** | **pH** | **Turbidity** |
| | | | **SW-846 6020/7471A** | **EPA 3545/ 8280** | **SW-846 8260B** | **SW-846 8270CSIM** | **SW-846 8270C** | **SW-846 8151M** | **NWTPH -Dx** | **NWTPH-Gx** | **SW-846 2890** | **EPA 160.2** | **EPA 415.1** | **EPA 130.2** | **EPA 150.1** | |
| MW-1 | MW-1-0308 | 3/28/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| MW-2 | MW-2-0308 | 3/28/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-2-120308 | 12/3/2008 | — | — | — | — | — | X | — | — | X | X | — | — | X | — |
| MW-3 | MW-3-0308 | 3/27/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-3-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| MW-4 | MW-4-0308 | 3/27/2008 | X | — | X | — | X | | X | X | X | — | — | — | — | — |
| | MW-4-082008 | 8/20/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| MW-5 | MW-5-0308 | 3/27/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-5-DUP-1-0308 | 3/27/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-5-082008 | 8/20/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| MW-6 | MW-6-0308 | 3/28/2008 | X | — | X | — | X | — | X | X | X | — | — | — | — | — |
| | MW-6-120308 | 12/3/2008 | X | — | — | — | — | X | X | — | X | X | — | — | X | — |
| MW-7 | MW-70-120308 | 12/3/2008 | X | — | — | — | — | X | X | — | X | X | — | — | X | — |
| | MW-7-120308 | 12/3/2008 | X | — | — | — | — | X | X | — | X | X | — | — | X | — |
| MW-8 | MW-8-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| MW-9 | MW-9-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| | MW-9-DUP-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| MW-10 | MW-10-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |
| | MW-10-120308 | 12/3/2008 | — | — | — | — | — | — | — | — | X | X | — | — | X | — |
| MW-11 | MW-11-081908 | 8/19/2008 | X | — | — | X | — | X | X | — | X | — | — | X | X | X |

# 3.0 Site Geology and Hydrogeology

The regional geology and hydrogeology of the Des Moines 7.5' Quadrangle, where the LLA site is located, has been studied in detail (Aspect, 2005). The Lora Lake area consists of glacial and non glacial deposits overlying volcanic and sedimentary bedrock. The glacial and non-glacial deposits vary in thickness, but are generally several hundred feet thick. Cross-sections indicate that, in the vicinity of Lora Lake, these deposits are approximately 500 feet thick and include alternating layers of coarse and fine grained units.

Investigations at the LLA site have focused on the shallow soil, the localized fill and the Fraser Glacial Deposits (the Vashon Drift). This unit includes recessional lacustrine and outwash deposits, till and underlying advance outwash deposits and is on the order of 100 feet thick near the LLA site. Data collected from the site soil borings were used to develop cross sections representing the subsurface conditions at the site (Figure 3.1). Cross section A-A' is generally oriented in northeast to southwest direction over the eastern portion of the site (Figure 3-2). Cross section B-B' is generally oriented in a northwest to southeast direction over the central portion of the site (Figure 3-3). In general, the site geology is comprised of a discontinuous fill (reworked soil) layer that is underlain by sand and sand with gravel and occasional discontinuous silt and very fine grained sand lenses.

The fill layer varies in thickness across the site and is absent across much of the northern portion of the property. The fill is absent in the northwest corner near MW-2 and the northeast corner near MW-6 and is approximately 15 feet thick on the southeast side of the site near MW-4 and MW-5. The fill layer is a brown, medium dense to dense, fine to coarse-grained sand with fine to coarse-grained rounded gravel. Underlying the fill layer, native non-reworked soils consist of very dense sand with gravel and occasional discontinuous silt and very fine-grained sand lenses ranging from 0.5 inches thick to 0.75 feet thick extending to at least a depth of 28 feet below ground surface. The sand in the native non-reworked soil is generally fine to coarse-grained and dense to very dense. This layer primarily consists of sand but also contains fine to coarse gravels up to 2 inches in diameter.

An additional cross section was developed with data collected during installation of monitoring wells MW -7, MW-8, MW-9, MW-10 and MW-11 (cross section C-C', Figure 3-4). Cross section C-C' is generally oriented in a northeast to southwest direction and is located east of Des Moines Memorial Drive. The geology, based on well borings, is fill (reworked soil) from the ground surface down to approximately 10 to 12 feet bgs. The fill layer is typically comprised of brown, orange-brown or dark brown, medium dense to very dense, fine to coarse-grained, poorly graded to well graded sand with occasional fine to coarse-grained rounded gravel. Organic material was occasionally encountered consisting of roots and rootlets within the upper 10 to 12 feet. Based on the differences in color and gravel percentage, this fill material appears different from the fill material encountered on the LLA property.

Underlying the fill layer is native non-reworked soil consisting of very dense sand with gravel and occasional discontinuous silt and very fine-grained sand lenses extending to at least the total well depth of 20.5 feet bgs. The sand in the native non-reworked soil is generally fine to coarse-grained and dense to very dense. This native layer primarily consists of sand but also contains fine to coarse gravels.

Regionally, groundwater in the Lora Lake area includes perched groundwater and regional aquifers. The Perched groundwater is found in isolated, laterally discontinuous zones near the surface (in the upper 50 feet) in otherwise unsaturated soils. The uppermost aquifer occurs in the Vashon glacial advance outwash sediments. Underlying strata include glacial and/or non-glacial aquifer units alternating with finer gained aquitard units. Groundwater flow direction in the regional aquifers is to the south and southwest in the Lora Lake area (Aspect, 2005).

Groundwater depth and flow direction at the site was determined by gauging depth-to-water (DTW) in each of the site groundwater monitoring wells and then using the well survey data to determine the groundwater elevation at each well. Gauging was conducted on March 27-28, on August 19-20 and on December 3, 2008 during the groundwater sampling events. Table 3-1 summarizes groundwater elevations; Figures 3-5, 3-6, and 3-7 are the groundwater contour maps for each sampling event.

Shallow groundwater flows to the south east at the site based on gauging results from all three sampling events. Depth to groundwater ranges from 6.5 feet to 21.0 feet bgs in on-site wells MW-1 through MW-6, and 11 to 14 feet bgs in off-site wells MW-7 through MW-11. Groundwater elevations range from 264.05 to 293.38 ft NGVD-29. The groundwater gradient ranges across the site from 0.015 ft/ft (MW-2 to MW-1) to 0.138 ft/ft (MW-4 to MW-10).

Shallow groundwater at the LLA site occurs in the fill and Vashon Drift. The shallow groundwater may be perched or have some degree of connection with the upper aquifer (Vashon Advance Outwash). However, the south easterly direction of groundwater flow at the LLA site differs from that of the regional aquifer, which is south to southwest, suggesting that finer-grained units inhibit direct connection of the shallow LLA Site groundwater to the regional aquifer, and that localized topography affects local groundwater flow. Cross sections in the area (Aspect 2005) also indicate that the upper regional aquifer is separated from the lower regional aquifer beneath the LLA site by a finer grained aquitard (transition beds and pre-Frasier fine-grained deposits). Based on currently available well logs, the finer grained aquitard pinches out east of the LLA site, in the vicinity of Lora Lake.

**Table 3-1 Summary of Groundwater Elevations**

| Well Number | PVC Pipe Survey Elevation | Date | DTW | DTP | PT | GW Elevation |
|---|---|---|---|---|---|---|
| MW-1 | 301.76 | 3/27/2008 | 16.29 | 16.28 | 0.01 | 285.48 |
| | | 12/3/2008 | 19.92 | | | 281.84 |
| MW-2 | 299.89 | 3/27/2008 | 6.51 | 16.28 | 0.01 | 293.38 |
| | | 12/3/2008 | 8.08 | | | 291.81 |
| MW-3 | 300.36 | 3/27/2008 | 17.38 | 16.28 | 0.01 | 282.98 |
| | | 8/19/2008 | 18.63 | | | 281.73 |
| | | 12/3/2008 | 18.42 | | | 281.94 |
| MW-4 | 294.56 | 3/27/2008 | 15.81 | 16.28 | 0.01 | 278.75 |
| | | 8/19/2008 | 16.81 | | | 277.75 |
| | | 12/3/2008 | 17.92 | | | 276.64 |
| MW-5 | 295.15 | 3/27/2008 | 20.31 | 16.28 | 0.01 | 274.84 |
| | | 8/19/2008 | 21.19 | | | 273.96 |
| | | 12/3/2008 | 21.33 | | | 273.82 |

| Well Number | PVC Pipe Survey Elevation | Date | DTW | DTP | PT | GW Elevation |
|---|---|---|---|---|---|---|
| MW-6 | 291.08 | 3/27/2008 | 12.35 | 16.28 | 0.01 | 278.73 |
| | | 8/19/2008 | 14.61 | | | 276.47 |
| | | 12/3/2008 | 13.14 | | | 277.94 |
| MW-7 | 287.907 | 12/3/2008 | 14.09 | 16.28 | 0.01 | 273.817 |
| MW-8 | 282.29 | 8/19/2008 | 6.51 | 16.28 | 0.01 | 275.78 |
| | | 12/3/2008 | 10.95 | | | 271.34 |
| MW-9 | 283.34 | 8/19/2008 | 17.38 | 16.28 | 0.01 | 265.96 |
| | | 12/3/2008 | 13.21 | | | 270.13 |
| MW-10 | 284.15 | 8/19/2008 | 15.81 | 16.28 | 0.01 | 268.34 |
| | | 12/3/2008 | 13.95 | | | 270.20 |
| MW-11 | 284.36 | 8/19/2008 | 20.31 | 16.28 | 0.01 | 264.05 |
| | | 12/3/2008 | 11.84 | | | 272.52 |

# 4.0 Field Analytical Results and Discussion

## 4.1 Identification of Applicable Preliminary Screening Concentrations

Site zoning, adjacent property information, and characteristics of the affected media were considered in the selection of applicable screening concentrations. The screening concentrations are not site cleanup levels. Screening concentrations are conservative levels used to assess whether site impacts pose a risk to human health or the environment. The site clean-up levels and/or remediation levels will be determined during the RI/FS. The screening concentrations used for this investigation were obtained from the Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 WAC. Both Method A and Method B Cleanup Levels (CULs) were used as preliminary screening concentrations for soil and groundwater. Method A CULs were obtained from Table 720-1 Method A Cleanup Level for Ground Water and Table 740-1 Method A Cleanup Levels for Unrestricted Land Uses and consider both direct contact and leaching to groundwater pathways. For chemicals not included on the Method A tables (and with the exception of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins and furans), Method B CULS for soil (direct contact) and groundwater were obtained from the Cleanup Levels and Risk Calculations (CLARC) on-line database developed and maintained by the Washington Department of Ecology (Ecology). All screening values are included in the analytical data tables for easy reference and comparison.

The Method B screening levels for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins and furans in soils were obtained following WAC173-340-740 (3)(B)(II) for carcinogenic effects of soil ingestion. In order to compare the cPAH analytical results to the screening level, the analytical results are multiplied by their individual toxic equivalency factors (TEF) to obtain the toxic equivalent (TEQ) of benzo(a)pyrene (BAP). The total cPAH TEQ concentration for each sample was compared to the BAP screening concentration of 137 µg/kg. For dioxin/furan in soil, the analytical results for each congener are multiplied by their individual TEF values to obtain the TEQ of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The total TEQ concentration for each sample was then compared to the TCDD screening concentration of 11 ng/kg.

The Method B screening level for cPAHs in groundwater was obtained following WAC173-340-720 (4)(B) for carcinogens in potable water. Again, the analytical results are multiplied by their individual TEF to obtain the TEQ of BAP. Then the total cPAH TEQ concentration for each sample was compared to the BAP screening concentration of 0.012 µg/L. The Modified Method B screening level for dioxin/furan compounds in groundwater was obtained following WAC 173-340-720 (4)(c)(iv). The analytical results from each sample are multiplied by their individual TEF to obtain the TEQ of TCDD. Then the total TCDD TEQ concentration for each sample was compared to the TCDD screening concentration of 5.83 pg/L.

## 4.2 Summary of Results

AECOM field investigations confirm the presence of residual contamination at the LLA site. The sources of contamination are tied to historical operations that occurred at the site before the apartment complex was constructed. The removal actions that took place in advance of apartment construction (pre-MTCA) targeted the source(s) of contamination and higher concentration deposits of impacted material but left material in place that exceeds current cleanup screening levels. Grading of the site in preparation for construction of the apartments may have displaced contaminated material from the original point(s) of contamination.

### 4.2.1 Soil Results

Based on the available data, the highest chemical concentrations in near-surface soil (0 to 2 feet) are near the Recreation Building and in the vicinity of Buildings A, C and D on the east side of the property. The chemicals detected above screening levels in near-surface soil were lead, arsenic, PAHs, pentachlorophenol, dioxins and furans. Neither VOCs nor TPH were detected in near-surface soil above protective levels. Arsenic was present at concentrations consistent with area background values for the central Puget Sound region (~5 to 10 mg/kg), and did not suggest a notable overprint of arsenic from ASARCO Tacoma stack emissions (Ecology, 2002). Lead was detected slightly in excess of the MTCA Method A screening level of 250 mg/kg (there is no published value for a MTCA Method B level) on the eastern side of the site near Buildings A, C and D. Pentachlorophenol and cPAH were detected in the same area at a concentrations above the MTCA Method B direct contact screening levels. Dioxins and furans exist above MTCA Method B screening levels more broadly across the site than the aforementioned chemicals. However, the highest concentrations of dioxins and furans are, again, located near Buildings A, C, and D.

The distribution of impacts in deeper soil (i.e., > 2 feet bgs) is generally consistent with the near-surface soil. In general, the highest concentrations are located on the east side of the site near Buildings A, C, and D. The only chemicals that exceeded screening levels in deeper soil from this area were cPAHs and dioxins and furans. Dioxins and furans were also detected in excess of the screening levels in the play area (near Building M). The soil sampling conducted by GeoScience Management demonstrated that soil impacted with petroleum hydrocarbons and PAHs remain at depth near the Recreation Building. The area near the Recreation Building is understood to be approximately co-located with the source of contamination originally investigated and subjected to a clean-up action associated with apartment complex construction in 1986-1987.

### 4.2.2 Groundwater Results

As discussed in Section 3.0, groundwater flows easterly across the site. Groundwater from MW-1 contains arsenic, TPH-Dx, PCP, cPAHs, and dioxins and furans above screening levels. This well is approximately located in the source area that was the focus of the removal action in 1987. Downgradient, in monitoring wells MW-5 and MW-4, groundwater concentrations are below screening criteria with the exception of PCP in MW-5. PCP was detected below screening levels further east of MW-5 in monitoring well MW-9, a location just off-site and downgradient of MW-5.

Petroleum hydrocarbons detected in groundwater at monitoring well MW-1 (in the center of the site) and in monitoring well MW-6 (in the northeast corner of the site) have different chemical signatures (as discussed in Appendix F), suggesting unrelated sources (see Figure 4-1). This analytical evidence is consistent with the differing land uses in the two areas. Land in the vicinity of MW-6 was in residential use until the mid-1980s. The area near MW-1 was used for industrial purposes by Novak Barrel Cleaning and Burien Auto Wrecking.

Tetrachloroethene, trichloroethane and 1,2-dichloroethene originally detected in groundwater samples collected from geoprobes installed during the GeoScience Management investigation and listed as groundwater contaminants on the Voluntary Cleanup application, were either not detected or detected below screening levels in groundwater samples collected from site monitoring wells.

### 4.2.3 Non-Aqueous Phase Liquid (NAPL)

Investigative work to date has yielded no evidence that either light NAPL (LNAPL) or dense NAPL (DNAPL) non-aqueous phase liquids are present at the site.

Well MW-1 was located near and downgradient of the source area for the specific purpose of providing information on near-source soil and groundwater impacts. This well would be expected to contain evidence of LNAPL if it were present. A measurable layer of LNAPL was not present in MW-1, however a trace was observed on groundwater in this well (March 27, 2008). A trace is a layer detected by field equipment below a reliably measure thickness (≤ 0.01 feet) and is indicative of significant soil and groundwater contamination.

Past barrel cleaning and auto-wrecking operations at the site may have involved the use or disposal of chlorinated solvents. Chlorinated solvents can, in sufficient quantity, form DNAPL. Chlorinated solvent compounds were not found in soil at depth in any of the investigations. A composite sample of contaminated material from the waste pit had low concentrations of chlorinated solvents (Golder, 1986):

- **Methylene chloride:** 0.23 ppm
- **1,1,2,2,tetrachloroethene:** 14 ppm
- **Trichloroethylene:** 0.61 ppm.

The waste pit, 140 cubic yards of soil surrounding the waste pit, and another sump identified in close proximity to the first were removed as part of the initial site cleanup in 1987.

Additional chlorinated solvent concentration data for soil and groundwater were obtained during the ENSR/ AECOM investigations described in this report. Chlorinated solvent compounds were detected, but the concentrations were below screening levels for soil and groundwater. In addition, chlorinated solvent compounds were detected in groundwater in the site's upgradient well (MW-2), indicating diffuse low-level groundwater contamination possibly associated with offsite sources. Finally, chlorinated solvent compounds in groundwater near the source area (MW-1) were well below one percent of their respective pure phase aqueous solubility and below one percent (10,000 mg/kg) in soil. Site concentrations are below these conservative threshold values that indicate a potential for DNAPL (C.K. Smoley, 1993).

# 5.0 Conceptual Site Model

Data collected during the 1987 investigation and remedial activities, and the 2007 – 2008 investigations provide information on the site history, geology, hydrogeology, and potential nature and extent of contamination. With this information, the potential exposure to human health and environment can be evaluated. This section synthesizes the available data into a conceptual site model (CSM) of contaminant location, movement, and potential exposure. The CSM presented herein is primarily qualitative in nature and serves to translate available physical and chemical data into a narrative and graphical representation of site conditions. The model serves as a useful aid in identifying data gaps and developing the future RI/FS work plan. As additional data are gathered and understanding of the site increases, this site conceptual model will be reexamined and refined.

## 5.1 Sources

There are no continuing primary sources of hazardous substance at the site. It appears that most of the existing contamination is from historical releases that occurred associated with historic industrial activities. A barrel cleaning facility and an auto wrecking yard occupied the site between the 1940s and 1980s. The Novak Barrel Cleaning Company operated a waste pit (1946 aerial photograph in Appendix A). Usage of the pit during the later Burien Auto Wrecking operations is uncertain. However, aerial photographs show vehicles stored throughout the auto wrecking yard and stained soil (the auto wrecking yard included all but the northern portion of the LLA complex). A concrete sump structure believed to be the waste pit and some surrounding soil were removed by The Mueller Group in 1987. The Mueller Group also completed site grading in preparation for the construction and landscaping of the LLA complex. It is believed that the LLA Recreation Building occupies the location of the former waste pit and excavation activities conducted by The Mueller Group in 1987. This location was determined by GeoScience Management in 2007 using a tape measure and following the map provided in the June 1987 Golder Cleanup Report.

Based on the distribution of impacted soil (Section 5.3; Figure 5-1), impacted soil may have been spread eastward from the waste pit area toward Des Moines Memorial Drive during grading activities. While the 1987 removal appeared to be designed to address the site soil with the highest then-known contaminant concentrations, the soil that remained onsite in the vicinity of the waste pit continues to act as a secondary source of hazardous substances in this area of the site.

The northern portion of the LLA property was in residential use until The Mueller Group purchased the land around 1987. Petroleum hydrocarbons are present in groundwater at the northeast corner of the property. The source of these petroleum hydrocarbons is unclear. They may originate from activities associated with historical residential use in vicinity and/or the adjacent Highway 518.

## 5.2 Contaminants Exceeding Screening Levels

The location and concentration of chemicals of concern at the site are largely defined by sampling activities. Documentation regarding chemical handling and use at the barrel cleaning and auto salvage operations is not available. Given the property use for auto salvage operations and the stained soil apparent on aerial photographs, some petroleum hydrocarbon contamination would be expected at the site. . Based on reported soil and groundwater impacts, the contaminants exceeding screening levels are petroleum hydrocarbons, cPAH, PCP, lead, arsenic, and dioxins and furans. Chlorinated solvents have been detected at low levels in soil but do not exceed screening levels.

Soil and groundwater data were compared to the screening levels discussed in Section 4.1 to define chemicals of potential concern (COPC). Tables 5-1 and 5-2 summarize data from GeoScience Management and ENSR/AECOM sampling events, presenting sample locations and concentrations that exceed screening values. The COPCs and the media in which they were identified are listed in Table 5-3. Appendix I discusses the mobility and persistence of the COPCs, and their physical properties (degradation, attenuation, mobility, volatility, etc.). Summary information related to the site specific characteristics are described below.

**Table 5-1 Summary of COPCs Exceeding Screening Levels – Soil Investigation 2008**

| Contaminant | Screening Concentration | Depth (ft) | Location | Concentration |
|---|---|---|---|---|
| cPAHs (TEQ) | 137 µg/Kg BaP (Method B Carcinogenic) | 0 - 0.5 | MW-4 | 149 |
| | | 0 - 0.5 | MW-5 | 243 |
| | | 2 - 4 | LL-8 | 156 |
| | | 11.5 - 13 | MW-5 | 144 |
| Dioxins/Furans (TEQ) | 11 ng/Kg TCDD (Method B Carcinogenic) | 0 - 0.5 | MW-2 | 30.2 |
| | | 0 - 0.5 | MW-4 | 2575 |
| | | 0 - 0.5 | MW-5 | 3098 |
| | | 0 - 0.5 | LL-01 | 493 |
| | | 0 - 0.5 | LL-10 | 155 |
| | | 0 - 0.5 | LL-11 | 57 |
| | | 0 - 0.5 | LL-12 | 234 |
| | | 1.5 - 2 | MW-4 | 31.2 |
| | | 1.5 - 2 | MW-5 | 24 |
| | | 1.5 - 2 | LL-1 | 1588 |
| | | 1.5 - 2 | LL-7 | 33.8 |
| | | 1.5 - 2 | LL-8 | 43.7 |
| | | 1.5 - 2 | LL-10 | 2603 |
| | | 2 - 4 | LL-8 | 650/504 |
| | | 6.5 - 8 | MW-5 | 572 |
| | | 9 - 10.5 | MW-4 | 126 |
| | | 11.5 - 13 | MW-5 | 89.7 |
| Lead | 250 mg/Kg (Method A Unrestricted) | 0 - 0.5 | MW-4 | 370 |
| | | 0 - 0.5 | MW-5 | 294 |
| PCP | 8300 µg/Kg (Method B Carcinogenic) | 0 - 0.5 | MW-4 | 15000 |
| Gasoline Range Organics[1] | 100 mg/Kg (Method A Unrestricted) | 14.5 | LLP-4 | 1,900 |
| | | 14 | MW-1 | 1,000 |
| Diesel Range Organics[1] | 2,000 mg/Kg (Method A Unrestricted) | 14.5 | LLP-4 | 6,000 |
| | | 14 | MW-1 | 8,900 |
| Oil Range Organics[1] | 2,000 mg/Kg (Method A Unrestricted) | 6.5 | LLP-2 | 9,800 |
| | | 14.5 | LLP-4 | 17,000 |
| | | 14 | MW-1 | 12,000 |

[1] GeoScience Management, 2008

## Table 5-2 Summary of COPCs Concentrations – 2008 Groundwater Investigation

| Contaminant | Screening Concentration | Location | March 2008 Concentration | August 2008 Concentration | December 2008 Concentration |
|---|---|---|---|---|---|
| cPAHs (TEQ) | 0.012 µg/L BaP (Method B Carcinogenic) | MW-1 | 1.00 [1] | | |
| | | MW-2 | 0.06 [1] | | |
| | | MW-3 | 0.17 [1] | <0.016 [2] | |
| | | MW-4 | 0.07 [1] | <0.016 [2] | |
| | | MW-5 | 0.06 [1] | <0.016 [2] | |
| | | MW-5 dup | 0.07 [1] | | |
| | | MW-8 | | <0.016 [2] | |
| | | MW-9 | | <0.016 [2] | |
| | | MW-9 dup | | <0.016 [2] | |
| | | MW-10 | | <0.016 [2] | |
| | | MW-11 | | <0.016 [2] | |
| Dioxins/Furans (TEQ) | 5.83 pg/L TCDD (Method B Carcinogenic) | MW-1 | 234/234 [3] | | |
| | | MW-2 | 0.87/0.023 [3] | | 0.30 |
| | | MW-3 | 0.72/0.00052 [3] | 0.556 | |
| | | MW-4 | 0.72/0.33 [3] | 1.26/0.032 [3] | |
| | | MW-5 | 0.65/0.012 [3] | 1.64/0.481 [3] | |
| | | MW-5 dup | 0.60/0.00076 [3] | | |
| | | MW-6 | 0.7/0.017 [3] | | 0.37 |
| | | MW-7 | | | 0.27 |
| | | MW-7 dup | | | 0.45 |
| | | MW-8 | | 1.30 | |
| | | MW-9 | | 1.11/0.482 [3] | |
| | | MW-9 dup | | 1.26/0.015 [3] | |
| | | MW-10 | | 14.04/12.97 [3,4] | 0.32 |
| | | MW-11 | | 0.52 | |
| TPH-Dx (DRO/RRO) | 500 µg/L (Method A Residential) | MW-1 | 6300/8300 | | |
| | | MW-2 | <39/73 | | |
| | | MW-3 | <18/34 | <25/44 | |
| | | MW-4 | <19/43 | <22/64 | |
| | | MW-5 | <57/46 | | |
| | | MW-5 dup | <130/100 | <48/59 | |
| | | MW-6 | 7300/890 | | 3600/710 |
| | | MW-7 | | | <13/37 |
| | | MW-7 dup | | | <19/48 |
| | | MW-8 | | <34/85 | |
| | | MW-9 | | <29/110 | |
| | | MW-9 dup | | <24/64 | |
| | | MW-10 | | <21/38 | |
| | | MW-11 | | <23/69 | |

| Contaminant | Screening Concentration | Location | March 2008 Concentration | August 2008 Concentration | December 2008 Concentration |
|---|---|---|---|---|---|
| PCP | 0.73 µg/L (Method B Carcinogenic) | MW-1 | 16 [1] | | |
| | | MW-2 | <0.95 [1] | | 0.16 [2] |
| | | MW-3 | <0.99 [1] | <0.5 [2] | |
| | | MW-4 | <0.97 [1] | <0.5 [2] | |
| | | MW-5 | <0.97 [1] | 1.5 [2] | |
| | | MW-5 dup | 1.1 [1] | | |
| | | MW-6 | <5 [1] | | 0.091 [2] |
| | | MW-7 | | | 0.5 [2] |
| | | MW-7 dup | | | 0.5 [2] |
| | | MW-8 | | <0.5 [2] | |
| | | MW-9 | | <0.58 [2] | |
| | | MW-9 dup | | <0.56 [2] | |
| | | MW-10 | | <0.5 [2] | |
| | | MW-11 | | <0.5 [2] | |
| Arsenic | 5 µg/L (Method A Residential) | MW-1 | 10.5 | | |
| | | MW-2 | <0.33 | | |
| | | MW-3 | <1.39 | 0.77 | |
| | | MW-4 | <1.38 | 0.66 | |
| | | MW-5 | 3.44 | 2.76 | |
| | | MW-5 dup | 3.58 | | |
| | | MW-6 | 1.66 | | 0.73 |
| | | MW-7 | | | 0.6 |
| | | MW-7 dup | | | 0.7 |
| | | MW-8 | | 0.92 | |
| | | MW-9 | | 0.32 | |
| | | MW-9 dup | | 0.22 | |
| | | MW-10 | | 0.59 | |
| | | MW-11 | | 0.33 | |

**Notes:**

[1] Analytical methods for cPAHs and PCP: SW-846 8270C (reporting limit: 0.2-2 µg/L)

[2] Analytical methods for cPAH: SW-846 8270 SIM (reporting limit: 0.02 µg/L) and for PCP: SW-846 8151 (reporting limit: 0.5 µg/L)

[3] First value is TEQ using 1/2 detection limit for non-detects. Second value is TEQ using zero for detection limit

[4] Reported TEQ concentration is suspect due blank contamination. TEQ concentration in follow-up sampling (December 2008) is below screening levels.

Shaded concentration value exceeded screening levels.

**Table 5-3 Chemicals of Potential Concern**

| COPC | Identified in Soils above Screening Levels | Identified in Groundwater above Screening Levels |
|---|---|---|
| Arsenic | | X |
| cPAH | X | X |
| Dioxin and Furans | X | X |
| Lead | X | |
| Pentachlorophenol | X | X |
| Total Petroleum Hydrocarbons (Gasoline, Diesel and Residual Range Organics) | X | X |

### 5.2.1 Arsenic

Arsenic is a metalloid and is commonly treated as a metal. Arsenic forms various complexes depending on the prevailing soil and groundwater geochemistry. Arsenic comes from both natural and anthropogenic sources and under most conditions arsenic tends to adsorb to soil, forming relatively insoluble and immobile complexes with iron, aluminum, and magnesium oxides. However, under reducing conditions commonly associated with petroleum-impacted groundwater plumes, arsenic becomes more soluble and may be mobilized. The factors most strongly influencing arsenic mobility in water include Eh, pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, distribution and composition of the biota, season, and the nature and concentration of natural organic matter.

### 5.2.2 Carcinogenic Polycyclic Aromatic Hydrocarbons

cPAHs are a specific group of petroleum hydrocarbons that tend to be analyzed separately due to their toxicity. The transport and fate of PAHs in the environment are largely determined by their physical and chemical properties (e.g., Henry's law constant and $K_{oc}$). These properties are approximately correlated to their molecular weights; the low and medium molecular weight compounds constitute the non-carcinogenic PAHs (nPAHs), while the high molecular weight compounds, with the exception of benzo[g,h,i]perylene (nPAH), constitute the carcinogenic PAHs. PAHs have moderate to strong soil sorption capacity and low water solubility; therefore, they are fairly immobile in soil and do not readily leach to groundwater. The principal process for degradation of PAHs in soil is microbial metabolism. Degradation rates are affected by the degree of contamination, environmental factors, the soil organic content, the soil structure and particle size, characteristics of the microbial population, the presence of contaminants toxic to microorganisms, and the physical and chemical properties of the PAHs (ATSDR, 2007).

### 5.2.3 Dioxins and Furans

Dioxins and furans are two classes of similar chemicals that both contain two carbon benzene ring structures. All dioxins include two oxygen atoms, while all furans include one oxygen atom. They can be anthropogenically and naturally produced as trace impurities or incidental byproducts in chlorophenols, chlorinated herbicides, and commercial Aroclor (PCB) mixtures, bleached paper production or combustion (ASTDR 2007). Dioxins are characterized by extremely low vapor pressures, high log $K_{ow}$, high organic-carbon coefficients ($K_{oc}$), and extremely low water solubilities. These factors indicate a strong affinity for soil, particularly soil with high organic content. Their strong adsorption to soil, low water solubilities, and high $K_{oc}$ values indicate that the rate of transport from unsaturated zone soils to the water table via rain infiltration would be extremely low. Once sorbed to particulate matter or bound in the sediment organic phase, they exhibit little potential for leaching or volatilization. The only environmentally significant transformation process for these congeners is believed to be photodegradation of chemicals not bound to particles in the gaseous phase or at the soil or water air interface. Bacterial degradation of dioxins and furans is possible, but is a very slow process.

### 5.2.4 Lead

Lead is a naturally occurring metal. However, where lead levels are elevated, the source is generally anthropogenic. Lead compounds are used as a pigment in paints, dyes, and ceramic glazes, in caulk, and in leaded gasoline (discontinued in the 1980s). Lead exists in various forms and tends to be relatively immobile. Common forms of lead are strongly sorbed to organic matter in soil, and very little is transported through runoff to surface water or leaching to groundwater except under acidic conditions.

### 5.2.5 Pentachlorophenol

Pure pentachlorophenol (PCP) exists as colorless crystals. PCP was widely used as a pesticide and wood preservative, but since 1984, the purchase and use of pentachlorophenol has been restricted. It is no longer available to the general public due to the chemical's hazardous nature, abundance in the environment, and low biodegradation rates. The sorption or mobility of PCP in soils is controlled primarily by soil pH and the amount of PCP sorbed at a given pH increases with increasing organic content of the soil. The presence of cosolvents such as alcohols or petroleum hydrocarbons decreases the adsorption of pentachlorophenol to soils by increasing its effective solubility. The mobile phase is more likely to leach to groundwater where it could partition into the aqueous phase. PCP readily degrades in the environment by chemical, microbiological, and photochemical processes (ASTDR 2007). In soils, reductive dehalogenation appears to be the most significant PCP degradation pathway ultimately leading to ring cleavage, liberation of chloride, and carbon dioxide evolution.

### 5.2.6 Total Petroleum Hydrocarbons

Petroleum hydrocarbons are commonly measured in bulk using TPH analyses. These analyses provide limited information about the actual compounds present, but provide a general indication of the range of petroleum hydrocarbons (e.g, light, volatile, short-chained organic compounds versus heavy, long-chained, branched compounds). Petroleum products include automotive gasoline, Stoddard solvent, jet fuel, diesel fuel, fuel oils, mineral oils, lubricants, and asphalt. In general, petroleum products will migrate through the soil as bulk oil by gravity and capillary action. Bulk oil may be retained by the soil as it flows as "residual saturation," and individual compounds that comprise the TPH may dissolve into air or water (ATSDR, 2007). The majority of petroleum products are less dense than water and, if present in sufficient volume, the free-phase petroleum product will essentially float on the groundwater table; denser petroleum products may sink through the groundwater. A free-phase petroleum layer (LNAPL) has not been encountered at the site. Petroleum hydrocarbons at the site are dominantly moderate to heavy, long chained hydrocarbons (diesel-range and residual-range hydrocarbons). The diesel and residual range hydrocarbons have low volatility, relatively low solubility and tend to sorb to soils. Hydrocarbons biodegrade in the environment and the rate of degradation depends on the type of hydrocarbons (shorter chain hydrocarbons degrade faster) and several environmental factors (oxygen content, pH, moisture content, temperature, nutrient concentrations, and microbes) (ATSDR, 2007).

## 5.3 Contaminant Distribution

Figures 5-1 through 5-4 illustrate the chemical distribution of contaminants present in Site soil and groundwater. Figures 5-1 and 5-2 are aerial depictions and Figures 5-3 and 5-4 are cross sections. The following sections describe the distribution of each chemical or group of chemicals present above screening levels.

### 5.3.1 Metals Distribution

Lead and arsenic are the only metals identified above screening levels. Lead is present above screening levels in surface soil (0.0 -0.5 feet bgs) on the east side of the site, extending from the former source area (historical location of the waste pit and current location of the Recreation Building area) to the eastern portions of the site (likely from regrading). Lead concentrations are below screening levels in groundwater. Concentration of arsenic in soil is consistent with area background values for the central Puget Sound region; however arsenic is present above screening levels in groundwater near the former source area (Recreation Building area). Both metals are co-located with cPAHs, PCP and dioxins and furans. The presence of arsenic at higher dissolved concentrations near the former source area is likely related to reducing conditions caused by the presence of hydrocarbons.

### 5.3.2 Petroleum Hydrocarbon Distribution

Petroleum hydrocarbons in the gas, diesel, and oil ranges were identified in soils at depth (6 feet and 14 bgs) in the vicinity of the former source area (GeoScience Management, 2008). They are not present in soil above screening levels in any other location sampled. Diesel range hydrocarbons are also present in groundwater in this same area but attenuate prior to reaching the downgradient wells on the east side of the property.

Diesel range hydrocarbons have also been identified in groundwater at the northeast corner of the site. Impacted soil has not been encountered in this area and the source of hydrocarbons in groundwater is currently unknown. Groundwater flows from the west northwest toward this area. Based on the direction of the hydraulic gradient and the fact that the petroleum hydrocarbon chromatogram images found in the center of the site differ from the petroleum hydrocarbon images in this location, the sources are different.

### 5.3.3 Pentachlorophenol Distribution

Pentachlorophenol (PCP) is present in shallow (0.0 – 0.5 feet bgs) soil above screening levels on the east side of the site. It is also present below screening levels in shallow and deep (11.5 – 13 feet bgs) soil in the former source area and on the east side of the site. Groundwater is impacted with PCP above the screening level near the source area however the PCP concentrations reduce down gradient to below screening levels adjacent to the site across Des Moines Memorial Drive.

### 5.3.4 cPAH Distribution

Carcinogenic polycyclic aromatic hydrocarbons (cPAH) are present in shallow (0.0 – 0.5 feet bgs) and deep (11.5 – 13 feet bgs) soil on the east side of the site, likely extending from the former source area or related to auto wrecking operations. The cPAHs were not identified above screening levels in soil near the source area of the site, but cPAHs are present in groundwater above screening levels in the source area. The cPAHs are co-located with all other Site contaminants at this location.

### 5.3.5 Dioxin and Furan Distribution

Dioxins and furans are present in shallow soil (0.0 – 0.5 feet bgs) across much of the site. These compounds are not present above screening criteria in shallow soil on the south west side of the site but are present at 1.5 - 4 feet bgs in this area. Dioxin and furans are also not present on the extreme northeast and southeast sides of the property. Dioxins and furans are present in the surface soil and at depth in the center and east side of the site.

Dioxins and furans were detected in groundwater from MW-1. MW-1 is located in the suspected source area, but as discussed in Section 5.2.3 and Appendix H Section 5.0, the transport rate of dioxins and furans from unsaturated zone soils to the water table is extremely low and once the dioxins and furans sorb to particulate matter or are bound in the sediment organic phase, they exhibit little potential for leaching or volatilization

(ATSDR 2007). Dioxins and furans were not detected in other site ground water wells above screening levels with the exception of one sample collected from monitoring well MW-10; and due to method blank contamination the results of the analysis were suspect. Follow-up sampling and analysis of monitoring well MW-10 did not detect dioxins and furans above screening levels. Based on the analytical data and published information on dioxins and furans characteristics, dioxin and furan impacted groundwater does not extend beyond MW-1 and the suspected source area.

### 5.3.6 NAPL

LNAPL and DNAPL are immiscible in water and, if present, exist as distinct mobile phases in the subsurface. The term “light” refers to the fluid having a specific gravity <1 such that, when present, the substance resides near the water table. A trace was detected at MW-1 which is located near the source area. However, a measurable LNAPL layer was not present (<0.01 feet thick). No evidence of LNAPL or LNAPL sheen was observed in other wells at the site. DNAPL has not been encountered at the site. Concentrations of DNAPL-related chemicals are very low, less than one percent of the pure phase solubility or effective solubility of DNAPL-related chemicals in groundwater and less than one percent concentration (10,000 mg/kg) of DNAPL-related chemicals in soil. These concentrations indicate that DNAPL is not present at the site (C.K. Smoley, 1993).

## 5.4 Potential Migration Pathways

Contaminants present in soil and groundwater can be transported through natural mechanisms and lead to a potential exposure to receptors. Figure 5-5 illustrates the conceptual site model and potential migration and exposure pathways. These mechanisms are described below.

### 5.4.1 Vapor Migration

Contaminants in soil and groundwater can volatilize into soil vapor and migrate up to the soil surface. Analytical testing of soil identified trace levels of VOCs. The sub-slab vapor results collected from select locations across the site during the investigation were below the EPA screening levels set forth in the EPA *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, Table 2a (USEPA, 2002).

Based on this evidence, the vapor migration pathway is not complete and need not be further investigated during the RI.

### 5.4.2 Soil to Groundwater

Groundwater contamination at the site stems from releases that occurred during historic industrial site uses. Information on subsurface soil and groundwater quality discussed in Section 2.0 suggests continued partitioning of contaminants between soil and groundwater. The soil to groundwater pathway is complete and will be evaluated further in the RI/FS.

### 5.4.3 Groundwater to Surface Water

Lora Lake is located east of the site, across Des Moines Memorial Drive. Shallow groundwater flows off-site southeast towards Lora Lake. Groundwater sample concentrations from monitoring wells located east of and parallel to Des Moines Memorial Drive (i.e., between the LLA site and Lora Lake), are below human health screening levels.

Groundwater data in wells located adjacent to the site and across Des Moines Memorial Drive and immediately upgradient of the lake were reviewed and compared directly to Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A-240) for total metals (Appendix F 4-5). Metals that were detected in groundwater samples did not exceed the surface water criteria.

Pentachlorophenol (PCP) and dioxins (as TCDD toxicity equivalents) were also detected in wells MW-8, -9, -10, and -11 (Appendix F, Figures F4-4 and F4-6). PCP did not exceed the surface water quality standard (WAC 173-201A-240) in any well based on the pH range of 6.10 to 7.72 measured in the field . There is no applicable Washington State or federal surface water standard available for dioxins. However, based on the dioxin and furan concentrations found in the wells (ranging from 0.27 pg/L TCDD to 1.30 pg/L TCDD), the distance to the lake (greater than 100 feet), the high affinity for dioxins and furans to sorb to particles, and the extremely low water solubility of dioxins and furans, the groundwater to surface water pathway is considered incomplete.

### 5.4.4 Surface Soil to Surface Water

Surface soil has the potential to reach surface water via direct runoff down slope or migration via a stormwater system. Prior to construction of the LLA complex, stormwater infrastructure did not exist at the site and the site was largely unpaved. Presumably the majority of storm water infiltrated through the ground surface. As part of the construction of the LLA complex stormwater infrastructure was installed and the site was re-graded. Most stormwater at the site is now discharged through this infrastructure.

Precipitation not conveyed by the stormwater infrastructure would flow down slope, following the topography. The topography of the eastern portion of the site was steepened during construction of the residential complex. While vegetation on this slope minimizes the potential for erosion, there is a potential for stormwater runoff and soil erosion and redeposition onto the shoulder of Des Moines Memorial Drive. However the roadway itself acts as a physical barrier that precludes direct discharge of site storm water runoff to Lora Lake. Therefore, overland runoff to the surface water body is considered incomplete.

With regard to the storm drain pathway, a storm drain system was first installed at the site during construction of the apartment complex in 1987. The system consists of a King County main line, and a local, site-specific drainage system. First, King County installed a main line through the undeveloped site to convey drainage from surface streets and residential areas to the west and north of the site (Appendix G). This line crosses under Des Moines Memorial Highway and discharges to Lora Lake. Before completion of the apartment complex, there were no catch basins or laterals on the LLA site to receive and convey on-site drainage. By the time apartment complex construction was complete, the current local site-specific system was in place and operational, tied into the King County main line.

At completion, the surface of the LLA site was covered with buildings, pavement, or stabilized (landscaped) surface soil. The LLA storm drain system collects runoff from many of the buildings and site paved areas. This water discharges to Lora Lake via the municipal main that runs through the site. Stormwater not captured by the drainage infrastructure infiltrates through the landscaped surfaces. Approximately 65% of the site is covered by concrete foundations, buildings, and asphalt parking areas. The remaining 35% of the site is landscaped.

Apartment construction drawings acquired from King County included construction, erosion and sediment control plan details that specified use of various best management practices (e.g., filter fabric fences, temporary sediment dispersion trenches, a storm water retention pond, and catch basin filters) during the construction activity itself. As documented at the time, these management practices were designed to: 1) minimize runoff of surface soil from unpaved portions of the construction site; and 2) filter stormwater running off paved surfaces and entering the newly constructed storm drain system (i.e., catch basins and laterals connecting to the main).

Based on the site development and stormwater infrastructure history, and the documented construction activity requirements, transport of site contaminants to surface water (i.e., Lora Lake) via the stormwater system is not a complete pathway.

## 5.5 Potential Receptors

The LLA complex, including apartment building, building foundations, parking areas and landscaping are all currently intact except for the above ground features of buildings A, C, U, V, W and X which were demolished to comply with Federal Aviation Administration requirements for the Third Runway operation. Foundations of these buildings remain intact. Future use by the Port of Seattle will be commercial/light industrial and will be almost certainly comprised of buildings and asphalt paved parking. Potential receptors and exposure pathways are described in following sections, based on the planned property reuse and configuration.

### 5.5.1 Human Health Exposures

There is no residential use of the site expected in the future. Instead, the site will be redeveloped for commercial/light industrial use consistent and compatible with the use of the adjacent property as a major commercial airport. Maintenance, construction, and utility workers may be exposed to contaminated surface soil, subsurface soil and groundwater while excavating or working around utilities in impacted areas. Direct contact, inhalation, and incidental ingestion are the potential means of worker exposure to contaminated media.

Exposure to impacted groundwater could occur through potable water use. However, exposure via this pathway is unlikely because potable water is provided by local public water supply systems rather than drinking water wells. In addition, installation of future groundwater withdrawal systems is unlikely in the Miller Creek basin based on the restrictions set forth under the Instream Resource Protection Program – Green Duwamish River Basin, Water Resource Inventory Area (WRIA) 9 (WAC 173-509). Miller Creek is part of the Green Duwamish River Basin. In addition, groundwater shown to be in continuity with regulated surface water bodies is also regulated under this program. Shallow groundwater below the LLA is believed to be in continuity with Lora Lake which in turn drains to Miller Creek.

There is no recreational use of the site. Neither the LLA property nor the open space east of the site surrounding Lora Lake is used for public recreation. Lora Lake is part of the Miller Creek/Lora Lake Vacca Farm Mitigation Area where public recreation is restricted. The entire area is fenced and the restrictive covenants placed on the property prohibit use by recreational users or the general public.

### 5.5.2 Terrestrial /Ecological Exposures

The characteristics of the site were considered in the context of the Terrestrial Ecological Evaluation (TEE) Process (Ecology, 2009) to assess potential habitat and wildlife that may occur in association with the site. Based on qualitative assessment of the site characteristics including ground cover, current and anticipated future land use and surrounding land use, the site meets the exclusion criteria in WAC 173-340-7491 (b). The rationale for the exclusion is provided in Table 5-4 and discussed in additional detail below.

Little potential ecological habitat is present at the site under current conditions. Although soil impacts have been documented at the site, impacts are in many cases located beneath impermeable surface cover (e.g., pavement, buildings) and available habitat is limited in quality, size, and continuity throughout the site. The majority of the site is occupied by buildings and/or building foundations and paved parking areas. Discontinuous areas of apartment complex landscaping -- grass lawn, shrubs, medium-height young trees, and taller mature trees -- provide some potential, albeit limited resources to urban-adapted wildlife species. Significant ecological habitat is not present at the site.

Directly east of the site is the Miller Creek/Lora Lake Upland Buffer and Flood Plain Zone, which lies directly beyond the end of Sea-Tac Runway 34L/16R. This area is actively managed and maintained by the Port of Seattle and provides a noise and safety buffer for the benefit of the surrounding community. This area is managed according to a comprehensive wildlife management program (POS, 2008) intended to deter certain wildlife species that may interfere with aviation safety especially large birds and those that form large flocks. Management is comprehensive and includes excluding wildlife from the airfield with specialized fencing and limiting vegetation that may serve as potential food sources for undesirable species (e.g., raptors) that may interfere with aviation operations. The area is fenced with wildlife deterrent fencing, which extends below ground to limit terrestrial (mammalian) wildlife access.

Based on current and reasonably anticipated future conditions the site does not constitute important ecological habitat and, as such, all habitat and receptor criteria meet Ecology's TEE exclusion criteria in WAC 173-340-7491 (b) indicating that no further ecological assessment is warranted at the site. Consequently, further ecological evaluation in a simplified or site-specific terrestrial ecological evaluation is not required. No further action is indicated.

**Table 5-4 Terrestrial Ecological Evaluation (TEE) Primary Exclusion Analysis**

| Exclusion Number | Regulation | Exclusion Detail | Yes or No? | Rationale for Exclusion | Are ICs Required if the Exclusion Applies? |
|---|---|---|---|---|---|
| 1 | WAC 173-340-7491(a) | Will soil contamination located at least 6 feet beneath the ground surface and less than 15 feet? | Yes / **No** | Impacts have been observed in surficial and subsurface soil samples obtained at the site. | Yes |
| | WAC 173-340-7491(a) | Will soil contamination located at least 15 feet beneath the ground surface? | Yes / **No** | | No |
| | WAC 173-340-7491(a) | Will soil contamination located below the conditional point of compliance? | Yes / **No** | | Yes |
| 2 | WAC 173-340-7491(b) | Will soil contamination be covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed? | **Yes** / No | The majority of the site is occupied by buildings and/or building foundations and paved parking areas. Discontinuous areas of grass lawn, shrubs, and medium height mature trees provide some potential, albeit limited resources to urban-adapted wildlife species. The lawns and other landscaped vegetation are currently maintained by periodic mowing or trimming. Exposure to wildlife and native/non-native vegetation is not complete and/or is not significant. | Yes |

| Exclusion Number | Regulation | Exclusion Detail | Yes or No? | Rationale for Exclusion | Are ICs Required if the Exclusion Applies? |
|---|---|---|---|---|---|
| 3 | WAC 173-340-7491 (c)(i), (ii), (iii) | Is there less than 1.5 acres of contiguous undeveloped land on the site, or within 500 feet of any area of the site affected by hazardous substances **other than** those listed in the table of Hazardous Substances of Concern?<br>*and*<br>Is there less than 0.25 acres of contiguous undeveloped land on or within 500 feet of any area of the site affected by hazardous substances **listed in** the table of Hazardous Substances of Concern? | Yes / **No**<br>Yes / **No** | Contiguous undeveloped land does not occur at the site. However, adjacent land that serves as part of the SEATAC International Airport natural resource mitigation plan (Miller Creek/Lora Lake Upland Buffer and Flood Plain Zone) lies within 500 feet of site impacts. The area directly adjacent to the site is disturbed and recovering old field: this area was previously zoned residential and residential homes were present prior to transfer of ownership to the Port of Seattle. The homes have since been removed and the area is dominated by perennial weeds and grasses (early successional vegetation) under current conditions. | Other factors determine |
| 4 | WAC 173-340-7491(d) | Are concentrations of hazardous substances in the soil less than or equal to natural background concentrations of those substances at the point of compliance? | Yes / **No** | | No |

**Notes:**

ICs: Institutional controls

Table is adapted from Washington State Department of Ecology (Ecology) Primary Exclusion Documentation Form. Available on-line at: http://www.ecy.wa.gov/programs/TCP/policies/terrestrial/Forms_PrimaryExclusions.htm

# 6.0 Identification of Data Gaps

Based on the preceding review of the existing site data and in consideration of the CSM, there are four data gaps to be filled to adequately define the nature and extent of impacted media and enable completion of the RI.

- *Subsurface soil impacts in the central portion of the site:* Based on existing data, subsurface soil impacts are primarily located in the central (former source area) and eastern portions of the site (Figures 5-1 and 5-2). The vertical and horizontal extent of contamination in these areas is known only in a general sense and additional soil borings concentrated in the vicinity of the Recreation Building, Buildings A, B, and C and the property line are needed to delineate subsurface soil contamination in this area. Analytical methods should be used in order to screen site contaminants against MTCA Method B protection of groundwater values in addition to the direct contact values; specifically, pentachlorophenol due to its high solubility in water.
- *Petroleum-impacted soil and groundwater on northeastern portion of the site:* Impacted groundwater has been encountered in the northeast corner of the site. The source of this petroleum is unknown at this time. Additional groundwater and soil investigation in the northeastern corner of the property will help identify this source. Investigation into locations of historical septic tanks, drain fields, or subsurface heating oil tanks is warranted in this area, specifically upgradient and along the northern property boundary.
- *Dioxin and furan contamination in surface soil:* Dioxin and furans are common in urban soil and are known to occur in the urban landscape of Washington State in concentrations ranging from 0.13 parts per trillion (pptr) to 19.0 pptr (Ecology, 1999).Onsite concentrations are elevated above these levels, and associated with historic industrial land use. The distribution of dioxins and furans in surface soil may be associated with construction grading undertaken for development of the LLA complex. Additional on-site shallow soil sampling is appropriate at selected locations within and along the site property lines to better understand the distribution of surface soil impacts.
- *Hydraulic properties of the perched ground water zone in the vicinity of the Lora Lake Apartments:* Testing to date indicates that shallow groundwater migrates south eastward and that contaminant concentrations attenuate prior to reaching the property boundary. Evaluation of hydraulic conductivities of site soils will improve the understanding of groundwater migration and attenuation processes. Information of sufficient quality can be collected by conducting slug tests in selected site wells.
- *Additional groundwater quality information:* Several groundwater wells have been sampled three or fewer times. Additional groundwater monitoring data from existing site monitoring wells is needed to confirm sampling results to date that indicate that groundwater contamination above screening levels does not extend offsite and to capture any seasonal variability, and confirm natural attenuation processes.

Collection of data to address these data gaps will strengthen the CSM and provide a strong foundation for evaluating potential cleanup options under MTCA.

# 7.0 Conclusions and Recommendations

Results of the recent field investigation work presented in this document, combined with findings of a preceding investigation (GeoScience, 2008), demonstrate that soil and shallow groundwater contaminant concentrations at the LLA site exceed MTCA Method B cleanup concentrations for unrestricted (i.e., residential) land use. Releases responsible for the existing contamination are tied to previous industrial uses of the land for barrel cleaning and auto salvage. The previous clean-up actions undertaken before construction of the apartments were not sufficient in the context of the current MTCA regulation.

The COPCs identified by the recent site investigations are arsenic, lead, PCP, dioxin and furans, cPAHs, and TPH. Existing sampling data has defined the general distribution of soil impacts and the downgradient distribution of groundwater impacts sourced in the central portion of the site. Impacted groundwater and a trace amount of hydrocarbons were found in the main source area (in the center of the site near MW-1). Chemical concentrations in groundwater are attenuating through a number of natural chemical and biological processes (dispersion, absorption, biodegradation) as groundwater moves downgradient. Data gaps remain in the delineation of the depth and lateral extent of impacted soil and groundwater associated with the central portion of the site and the source, and extent of impacts of petroleum in groundwater in the northeastern portion of the site. Based on this information additional on-site soil and/or groundwater characterization should be conducted to address three remaining gaps: delineation of surface dioxin and furan impacts on site, delineation of COPC at depth near the eastern site boundary, and identification of the petroleum source and the distribution of associated impacted media in the north east corner of the site. Additional characterization of groundwater is warranted to confirm existing data.

These additional suggested investigations will be planned and implemented in consideration of future site development. The Port plans to demolish remaining above-ground structures at the site in 2009. Long-term plans for the site are being developed by the Port and the City of Burien, and will not include residential use. While development planning has not yet been completed, the redevelopment will consist of uses compatible with adjacent commercial airport operations, likely light industrial and/or commercial land uses. Elements of the redevelopment could play a material role in cleanup of the site (e.g., paved areas serving as a cap) and will be explored in the feasibility study.

# 8.0 References

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# Appendix A

# Historical Aerial Photographs

# Appendix B

# Sub-slab Vapor Investigation

# Appendix C

# Modified Sampling and Analysis Plan for Soil and Groundwater Investigation

# Appendix D

# Boring and Well Logs

# Appendix E

# Groundwater Sampling Forms

# Appendix F

# Soil and Groundwater Analytical Results

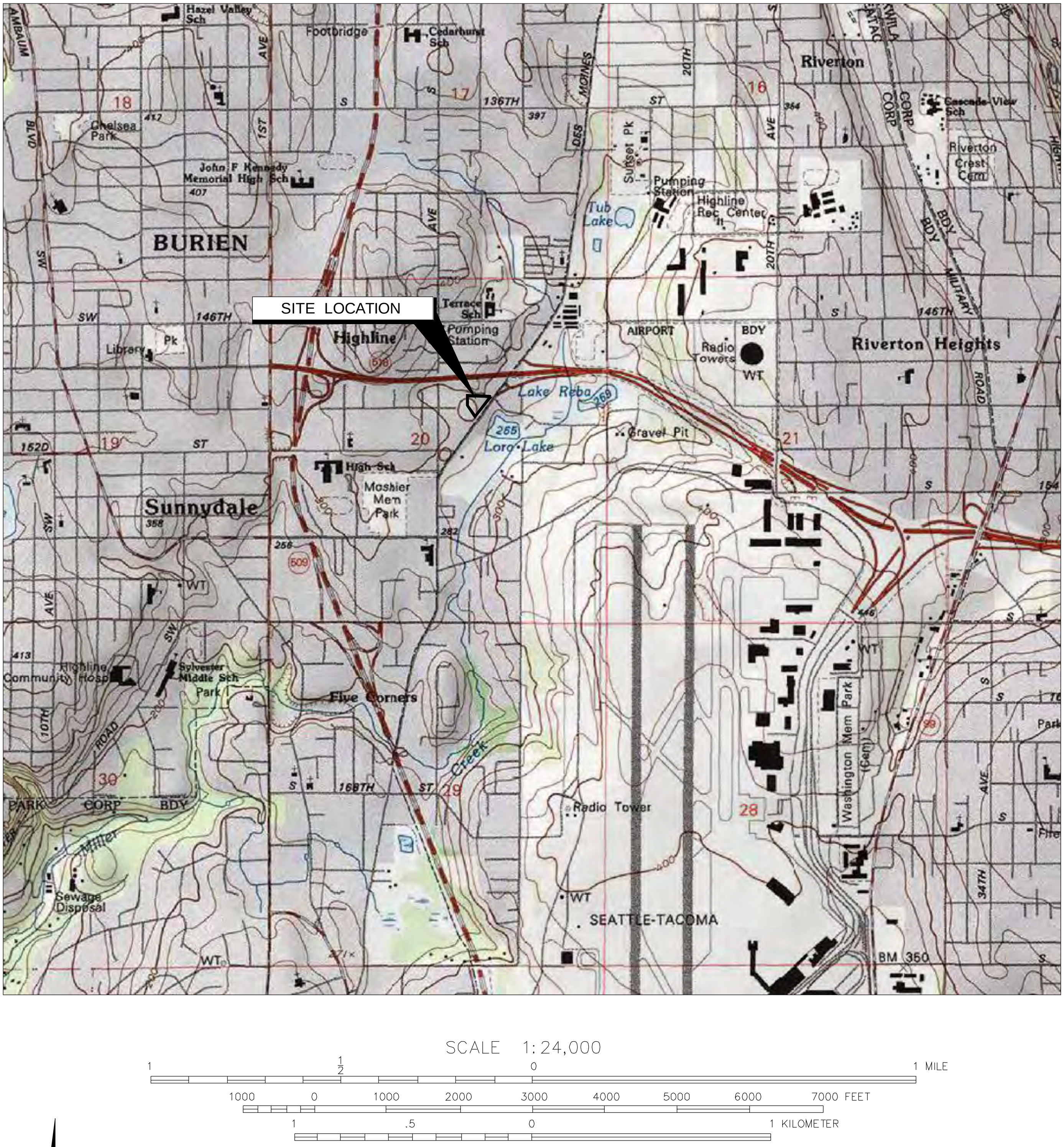
# Appendix G

# City of Burien Storm Drain System Plan View

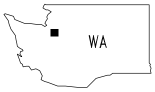
# Appendix H

# Chemicals of Potential Concern

File: J:\ENSR\BP\Port of Seattle\Lora Lake Apartment Site\05482025-200\P0S08-05482025-200_A1.dwg Layout: ANSI_AV1-LJ User: smexia Plotted: Jun 18, 2008 - 1:28pm Xref's:



Portion of 7.5-minute Series (Topographic) Map
United States Department of the Interior
Geological Survey
Burien, Washington Quadrangle 1981



QUADRANGLE LOCATION

ENSR | AECOM

LORA LAKE APARTMENT
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**VICINITY MAP**

DATE: 2/28/08
DRWN: S.MEXIA

**FIGURE 1-1**

File: L:\Lora Lake\sample_locations(D).dwg Layout: FIG 1-2 User: marshalle Plotted: Aug 03, 2009 - 1:30pm Xref's:

AECOM

LORA LAKE APARTMENT
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**LOCATION OF SOIL BORINGS AND MW-1 INSTALLED 2007**

DATE: 7/29/09
DRWN: E.M./SEA

**FIGURE 1-2**

File: L:\Lora Lake\SAMP_LOCATIONS.dwg Layout: fig 1-2 User: emarshall Plotted: Jun 24, 2008 - 2:53pm Xref's:

▆ BUILDING STRUCTURES
▆ OTHER STRUCTURES
▆ PAVEMENT
▆ FOUNDATION ONLY
⌖ MONITORING WELLS
◎ GEOPROBE LOCATIONS
▲ SUBSLAB VAPOR SAMPLE LOCATIONS
— — PROPERTY BOUNDARY
🟩 APPROXIMATE LOCATION OF REMEDIAL ACTION CONDUCTED BY GOLDER IN MARCH/APRIL 1987
🟦 APPROXIMATE AREA OF GEOSCIENCE MANAGEMENT FOCUSED ENVIRONMENTAL SITE ASSESSMENT

ENSR | AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**SAMPLE LOCATION MAP**

DATE: 5/1/08
DRWN: E.M./SEA

**FIGURE 1-3**

HORIZONTAL SURVEY DATUM: STIA GRID ASSUMED COORDINATE SYSTEM
VERTICAL DATUM: NGVD29

AECOM

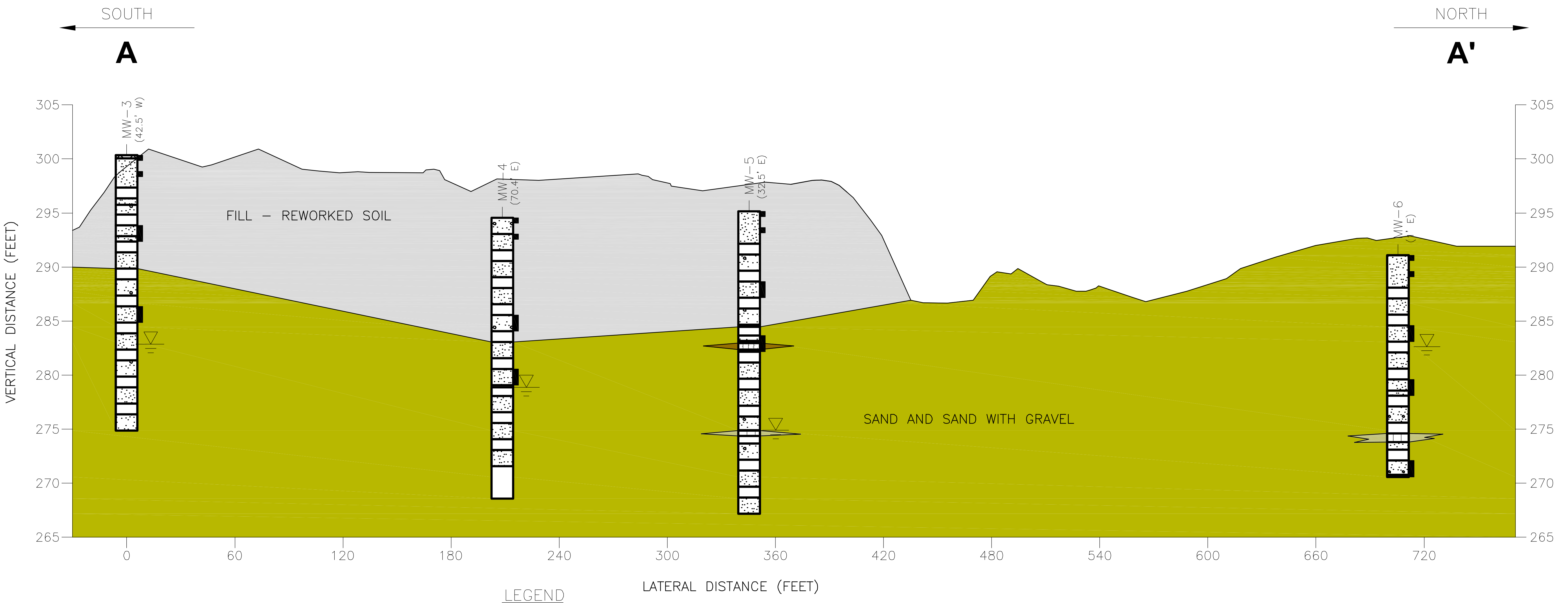
LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**CROSS SECTION LOCATIONS**
**OCTOBER, 2008**

DATE: 7/29/09 | DRWN: E.M./SEA

**FIGURE 3-1**

File: L:\Lora Lake\x-sect-locs.dwg Layout: fig 3-1 User: MarshallE Plotted: Sep 03, 2009 – 8:31am Xref's:



LEGEND

- ML Silt
- SM Silty sand
- SW Well-graded sand
- SP Poorly-graded sand
- Mulch
- ■ Sample Location
- ▽ WL Groundwater elevation collected on March 27, 2008

30 0 60

1"=60'

Vertical Exaggeration: 6x

AECOM

NOTE: Section is projected.
Fill contact determined by silt lenses.

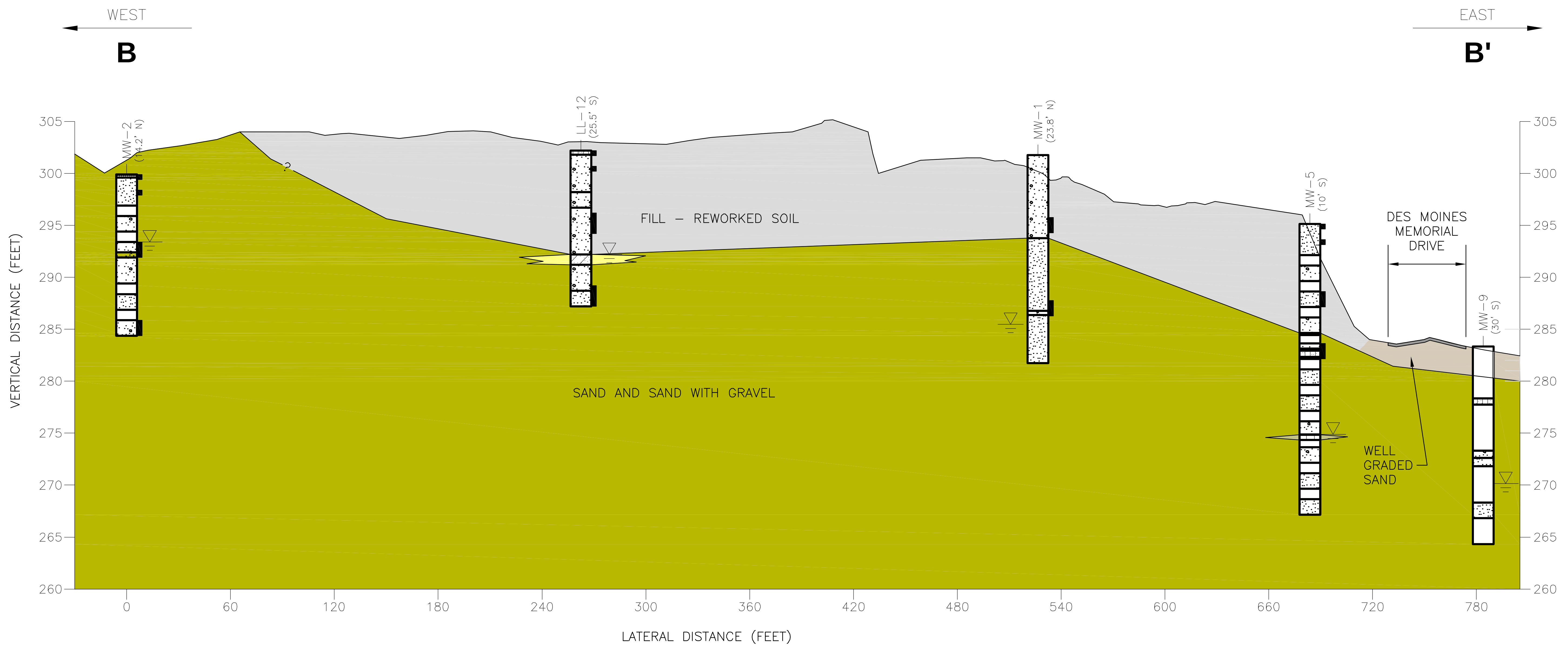
**LORA LAKE APARTMENT**
**15001 DES MOINES MEMORIAL DRIVE**
**BURIEN, WASHINGTON**

**CROSS SECTION A-A'**

DATE: 7/29/09
DRWN: E.M./SEA

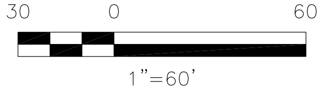
**FIGURE 3-2**

File: L:\Lora Lake\x-sect-a(b).dwg Layout: FIG 3-2 User: MarshallE Plotted: Jul 29, 2009 – 12:49pm Xref's:



LEGEND

| | | |
|---|---|---|
| ▥ | ML | Silt |
| ▨ | SM | Silty sand |
| ▨ | SW | Well–graded sand |
| ▨ | SP | Poorly–graded sand |
| ∿ | | Mulch |
| ■ | | Sample Location |
| ▽ | WL | Groundwater elevation collected on March 27, 2008 |



1"=60'
Vertical Exaggeration: 6x

AECOM

NOTE: Section is projected.
Fill contact determined by silt lenses.

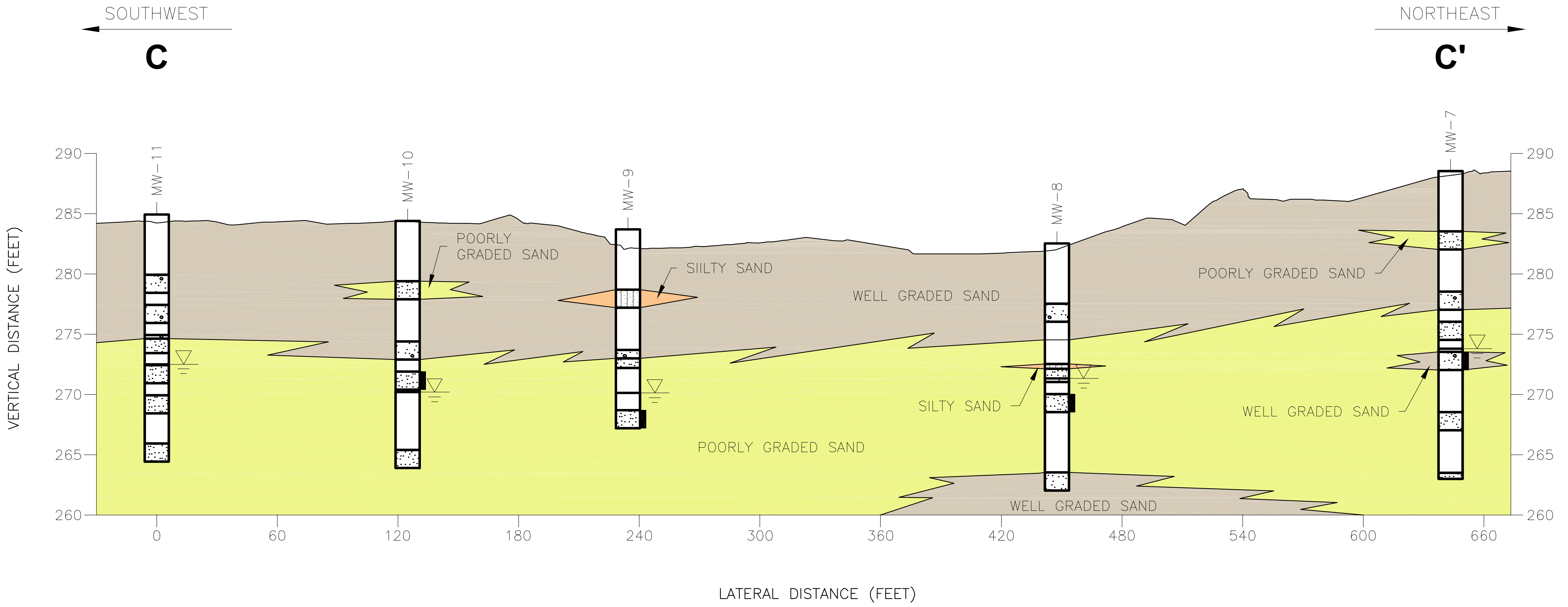
**LORA LAKE APARTMENTS**
**15001 DES MOINES MEMORIAL DRIVE**
**BURIEN, WASHINGTON**

**CROSS SECTION B-B'**

DATE: 3/24/09
DRWN: E.M./SEA

**FIGURE 3-3**

File: L:\Lora Lake\x-sect-b(b).dwg Layout: FIG 3-3 User: MarshallE Plotted: Sep 03, 2009 - 8:41am Xref's:



LEGEND

- ▨ SP
- ▥ SM
- ▨ SW
- ☐ Not sampled for lithology
- ■ Sample Location
- ▽ WL Groundwater elevation collected on December 3, 2008

30 0 60

Horizontal Scale in feet

Vertical Exaggeration: 6

NOTE: Section is not projected, it is shown as direct distance

AECOM

**LORA LAKE APARTMENT**
**15001 DES MOINES MEMORIAL DRIVE**
**05482-025-5000**

DATE: 3/24/09
DRWN: E.M./SEA

**CROSS SECTION C-C'**
**DECEMBER 2008**

**FIGURE 3-4**

File: L:\Lora Lake\MW-7_11 X-SECT.dwg Layout: FIG 3-4 User: MarshallE Plotted: Mar 24, 2009 - 8:46am Xref's:

AECOM

HORIZONTAL SURVEY DATUM: STIA GRID ASSUMED COORDINATE SYSTEM
VERTICAL DATUM: NGVD29

40 0 80
1"=80'

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**GROUNDWATER CONTOUR MAP**
**MARCH 17-18, 2008**

DATE: 7/29/09
DRWN: E.M./SEA

**FIGURE 3-5**

File: L:\Lora Lake\GW_CTRS_3-08.dwg Layout: fig 3-5 User: MarshallE Plotted: Sep 04, 2009 - 10:36am Xref's:

HORIZONTAL SURVEY DATUM: STIA GRID ASSUMED COORDINATE SYSTEM
VERTICAL DATUM: NGVD29

AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

DATE: 7/29/09
DRWN: E.M./SEA

**GROUNDWATER CONTOUR MAP**
**AUGUST, 2008**

**FIGURE 3-6**

File: L:\Lora Lake\gw-ctrs_8-08.dwg Layout: fig 3-6 User: marshalle Plotted: Aug 03, 2009 - 1:43pm Xref's:

File: L:\Lora Lake\GW_CTRS_12-08.dwg Layout: FIG 3-7 User: marshalle Plotted: Aug 03, 2009 - 1:44pm Xref's:

AECOM

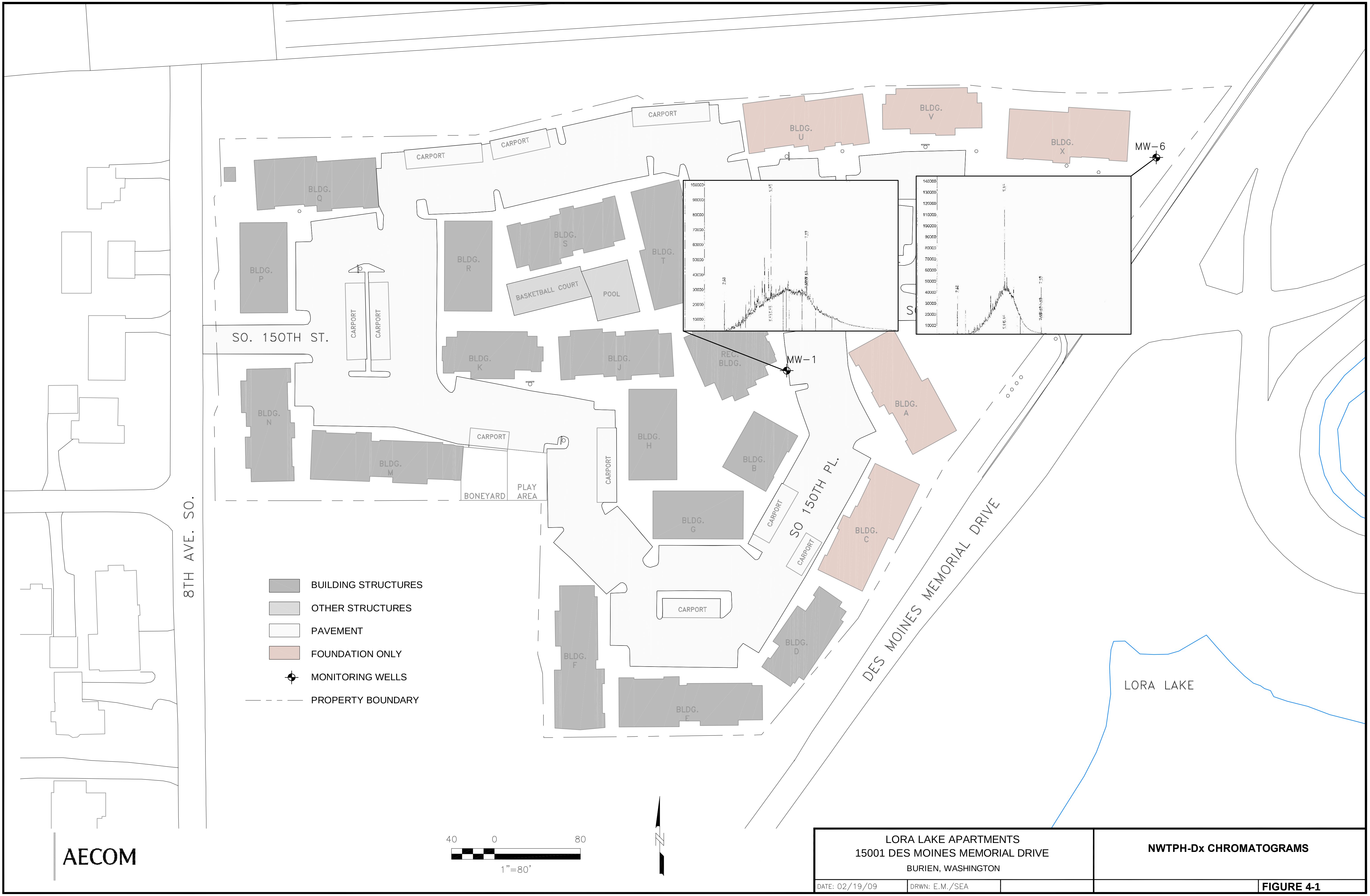
HORIZONTAL SURVEY DATUM: STIA GRID ASSUMED COORDINATE SYSTEM
VERTICAL DATUM: NGVD29

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

## GROUNDWATER CONTOUR MAP
## DECEMBER, 2008

DATE: 7/29/09
DRWN: E.M./SEA

**FIGURE 3-7**



AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

DATE: 02/19/09
DRWN: E.M./SEA

**NWTPH-Dx CHROMATOGRAMS**

**FIGURE 4-1**

File: L:\Lora Lake\CHROMATOGRAMS.dwg Layout: fig 5-3 User: MarshallE Plotted: Feb 19, 2009 - 3:43pm Xref's:

File: L:\Lora Lake\IMPACT_LOCATIONS.dwg Layout: SOIL User: MarshallE Plotted: Mar 11, 2009 - 10:30am Xref's:

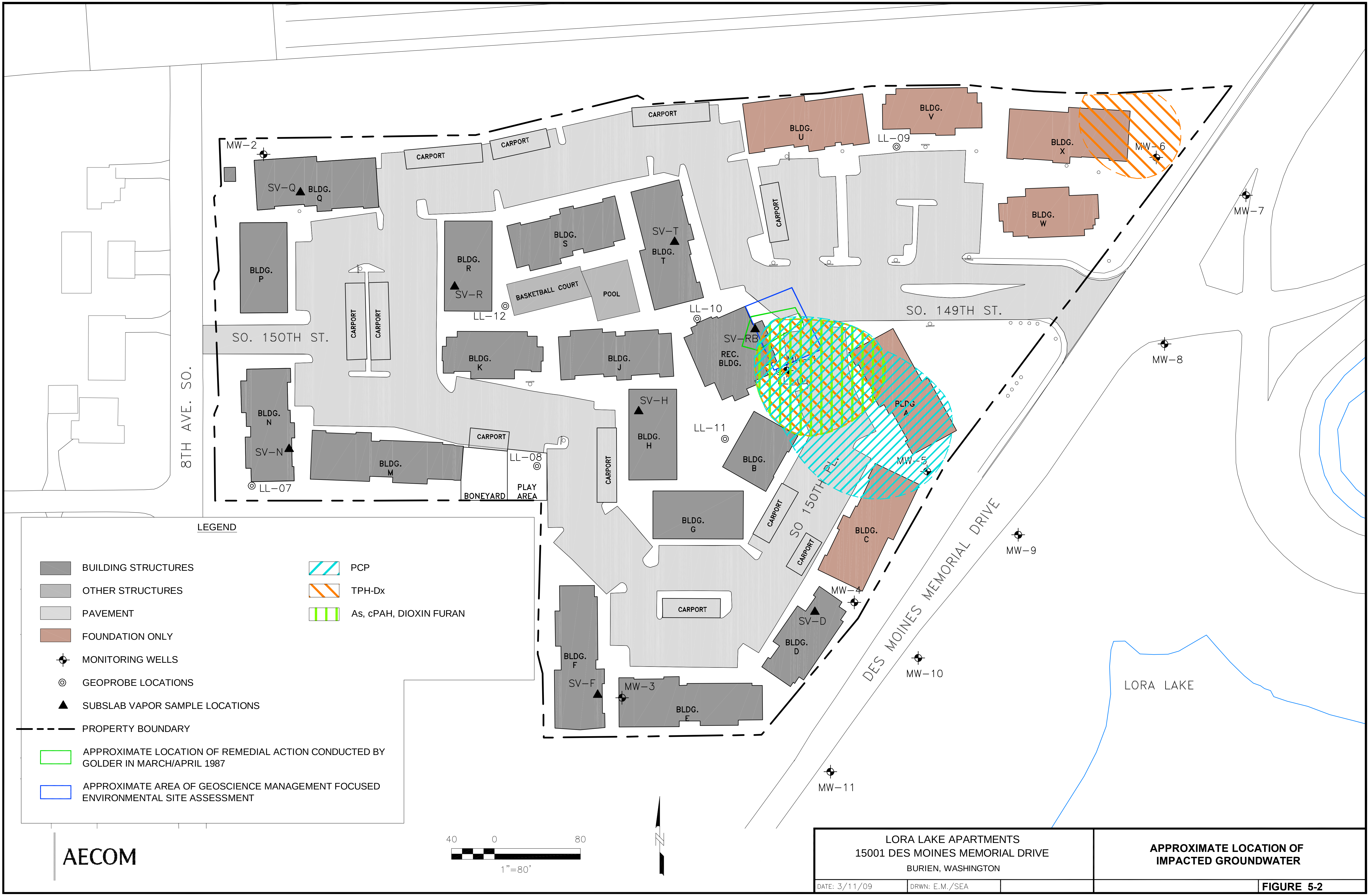
AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**APPROXIMATE LOCATION OF IMPACTED SOIL**

DATE: 3/11/09
DRWN: E.M./SEA

**FIGURE 5-1**



AECOM

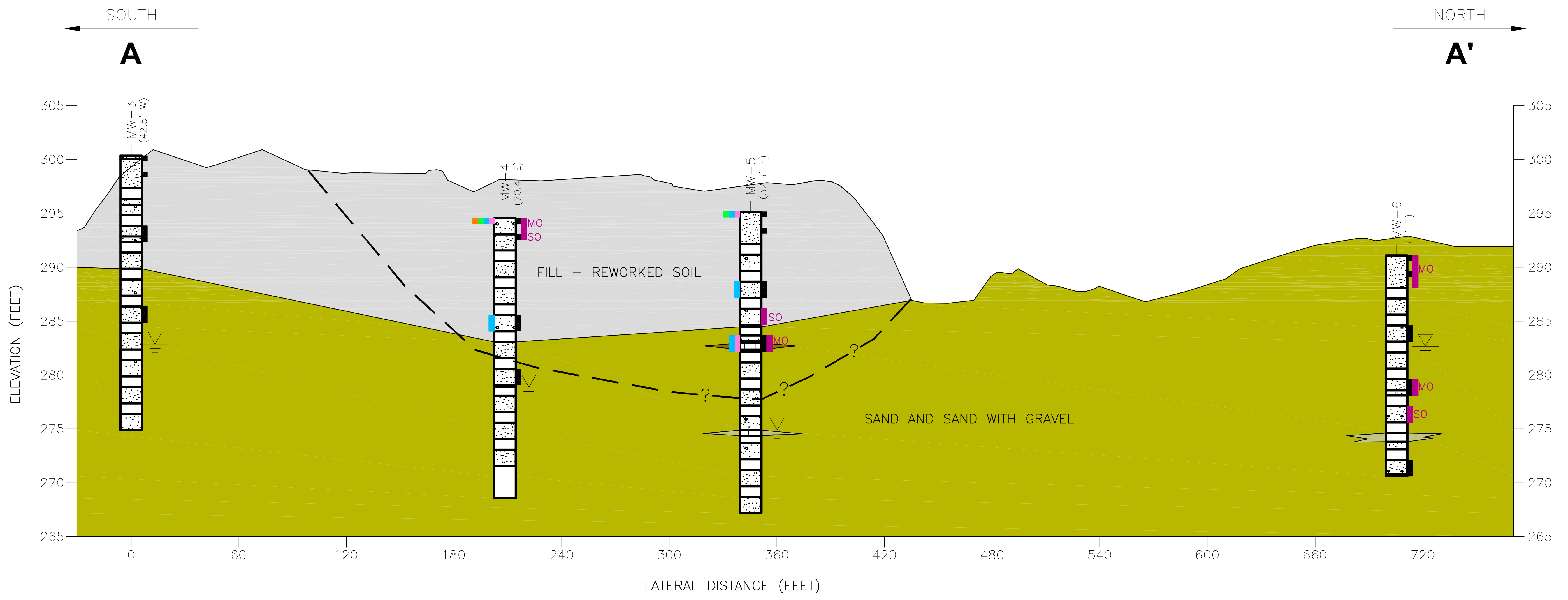
LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**APPROXIMATE LOCATION OF IMPACTED GROUNDWATER**

DATE: 3/11/09 | DRWN: E.M./SEA

**FIGURE 5-2**

File: L:\Lora Lake\IMPACT_LOCATIONS.dwg Layout: GROUNDWATER User: MarshallE Plotted: Mar 11, 2009 - 10:30am Xref's:



LEGEND

| | | |
|---|---|---|
| ▥ | ML | Silt |
| ▥ | SM | Silty sand |
| ▨ | SW | Well-graded sand |
| ▨ | SP | Poorly-graded sand |
| ▭ | | Mulch |
| ■ | | Sample Location |
| ▽ | WL | Groundwater elevation measured on March 27, 2008 |

| | |
|---|---|
| ■ | Odor (MO=moderate, SO=slight odor) |
| ■ | CPAHs exceeding screening levels |
| ■ | Dioxins/Furans exceeding screening levels |
| ■ | Lead exceeding screening levels |
| ■ | PCP exceeding screening levels |
| — — — | Approximate extent of impacted soil |

30 0 60

1"=60'

Vertical Exaggeration: 6x

NOTE: Section is projected.
Fill contact determined by silt lenses.

AECOM

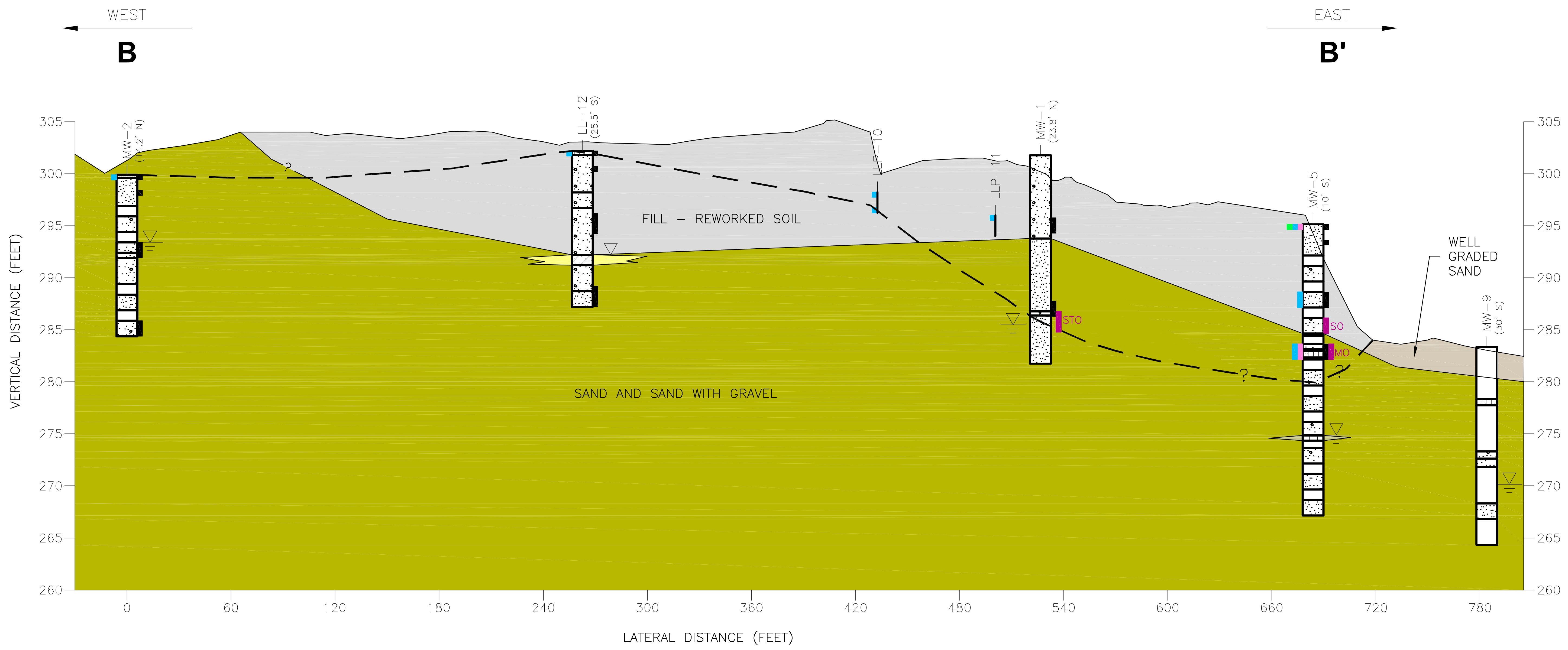
**LORA LAKE APARTMENT**
**15001 DES MOINES MEMORIAL DRIVE**
**BURIEN, WASHINGTON**

**APPROXIMATE EXTENT OF CROSS SECTION A-A'**
**IMPACTED SOIL**

DATE: 03/11/09 DRWN: E.M./SEA

**FIGURE 5-3**

File: L:\Lora Lake\x-sect-a(C).dwg Layout: FIG 5-3 User: MarshallE Plotted: Mar 11, 2009 - 1:57pm Xref's:



LEGEND

| | | |
|---|---|---|
| ▥ | ML | Silt |
| ▦ | SM | Silty sand |
| ⁙ | SW | Well–graded sand |
| ⁙ | SP | Poorly–graded sand |
| ≈ | | Mulch |
| ■ | | Sample Location |
| ▽ | WL | Groundwater elevation collected on March 27, 2008 |

| | |
|---|---|
| 🟪 | Odor (STO=strong, MO=moderate, SO=slight odor) |
| 🟪 | CPAHs exceeding screening levels |
| 🟦 | Dioxins/Furans exceeding screening levels |
| 🟩 | Lead exceeding screening levels |
| — — — | Approximate extent of impacted soil |

30 0 60

1"=60'

Vertical Exaggeration: 6x

NOTE: Section is projected.
Fill contact determined by silt lenses.

AECOM

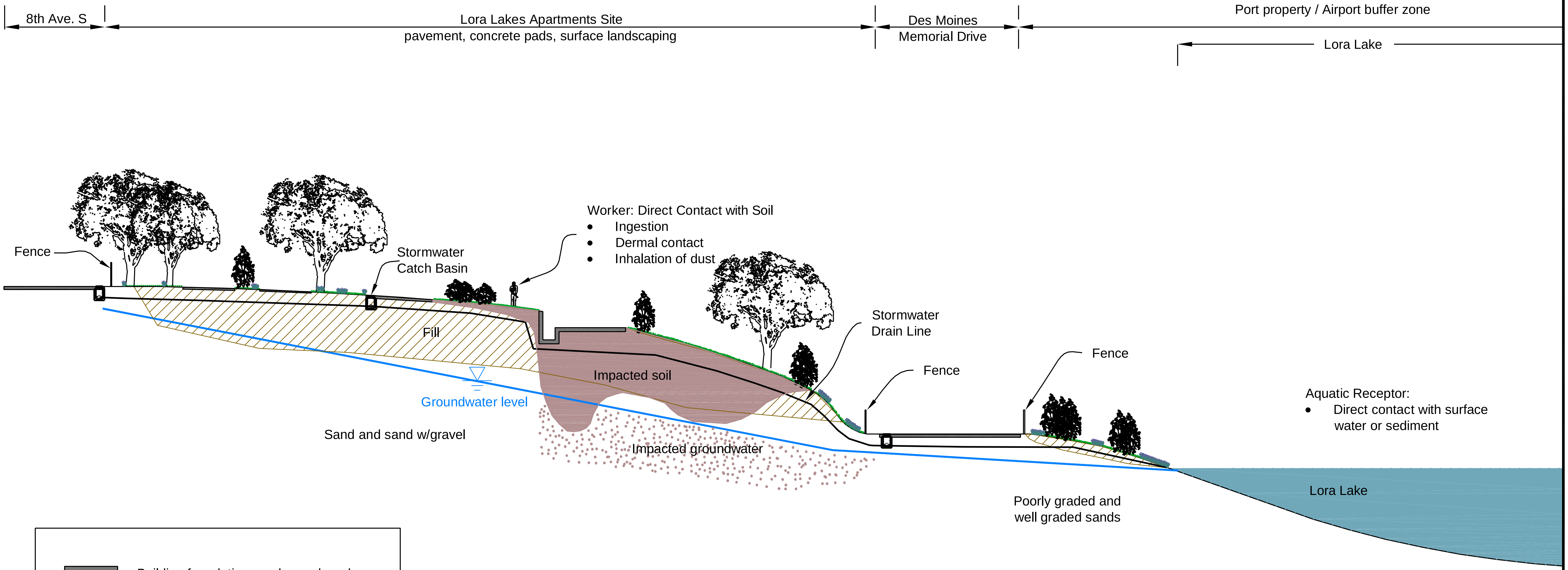
**LORA LAKE APARTMENTS**
**15001 DES MOINES MEMORIAL DRIVE**
**BURIEN, WASHINGTON**

**APPROXIMATE EXTENT OF CROSS SECTION B-B'**
**IMPACTED SOIL**

DATE: 3/24/09 DRWN: E.M./SEA

**FIGURE 5-4**

File: L:\Lora Lake\x–sect–b(C).dwg Layout: FIG 5–4 User: MarshallE Plotted: Mar 24, 2009 – 9:02am Xref's:



| | |
|---|---|
| ▬ | Building foundations and paved roads |
| ♣ | Landscaping and vegetation |
| ■ | Impacted media |
| ▨ | Fill material |
| ▽ | Groundwater level |

Drawing not to scale

AECOM

LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**CONCEPTUAL SITE MODEL SHOWING POTENTIAL MIGRATION AND EXPOSURE PATHWAYS**

DATE: 7/29/09
DRWN: E.M./SEA

**FIGURE 5-5**

*File: P:\CADD\Lora Lake\potential migration graphic-b.dwg Layout: FIGURE 5-5 User: marsholle Plotted: Aug 04, 2009 - 8:30am Xref's:*

File: L:\Lora Lake\AERIAL_PHOTOS(b).dwg Layout: 2004 User: MarshallE Plotted: Feb 17, 2009 - 3:31pm Xref's:

🟩 🟩 🟩 🟩 **APPROXIMATE PROPERTY BOUNDARY**

AECOM

LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**AERIAL PHOTOGRAPH 2004**

DATE: 02/16/09
DRWN: E.M./SEA

**FIGURE**

File: L:\Lora Lake\AERIAL_PHOTOS(b).dwg Layout: 1992 User: MarshallE Plotted: Feb 17, 2009 - 3:31pm Xref's:

▬ ▬ ▬ ▬ **APPROXIMATE PROPERTY BOUNDARY**

AECOM

LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**AERIAL PHOTOGRAPH 1992**

DATE: 02/16/09 DRWN: E.M./SEA

**FIGURE**

AECOM

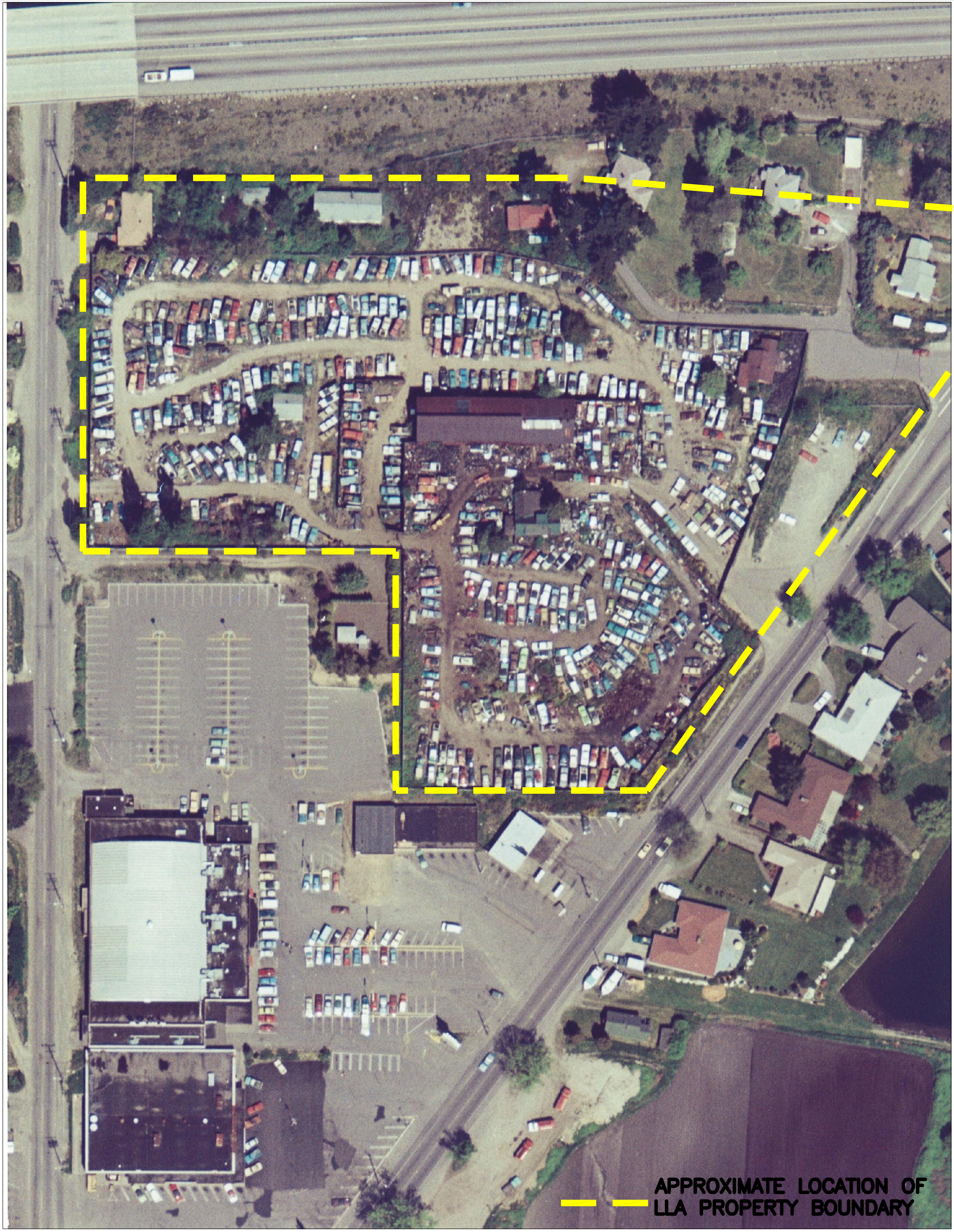
LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

DATE: 02/16/09 DRWN: E.M./SEA

**AERIAL PHOTOGRAPH 1985**

**FIGURE**

File: L:\Lora Lake\AERIAL_PHOTOS(b).dwg Layout: 1985 User: MarshallE Plotted: Feb 17, 2009 - 3:31pm Xref's:



ENSR | AECOM

LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**AERIAL PHOTOGRAPH 1980**
**BURIEN AUTO WRECKING**

DATE: 06/23/08 DRWN: E.M./SEA

**FIGURE**

File: L:\Lora Lake\AERIAL_PHOTOS.dwg Layout: 1980 User: emarshall Plotted: Jun 23, 2008 - 2:23pm Xref's:

▬ ▬ ▬ ▬ **APPROXIMATE PROPERTY BOUNDARY**

AECOM

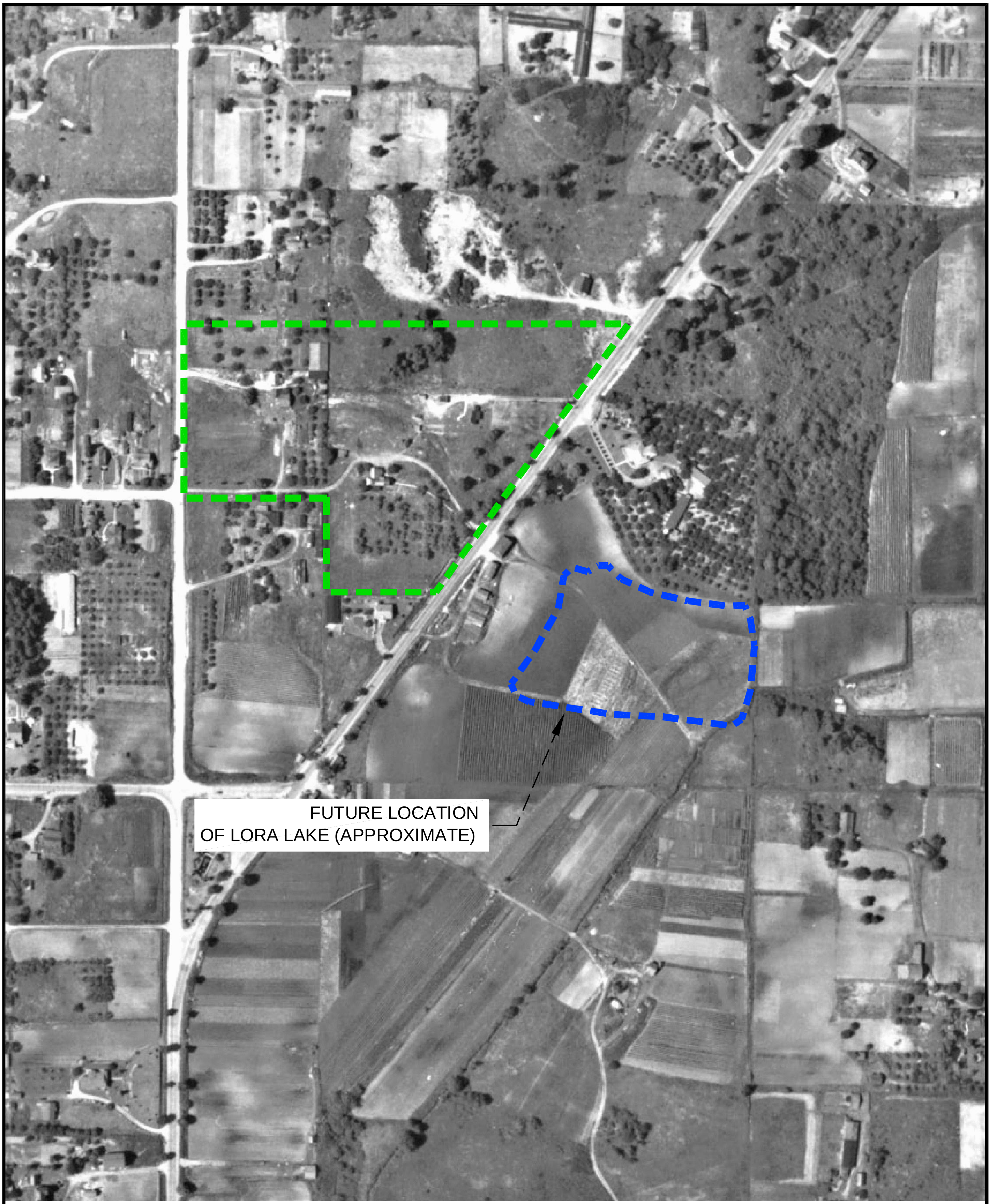
LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**AERIAL PHOTOGRAPH 1946**

DATE: 3/24/09 DRWN: E.M./SEA

**FIGURE**

File: L:\Lora Lake\AERIAL_PHOTOS(b).dwg Layout: 1946 User: MarshallE Plotted: Mar 24, 2009 - 8:25am Xref's:



▬ ▬ ▬ ▬ **APPROXIMATE PROPERTY BOUNDARY**

AECOM

LORA LAKES APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**AERIAL PHOTOGRAPH 1936**

DATE: 5/18/09 | DRWN: E.M./SEA

**FIGURE**

*File: L:\Lora Lake\AERIAL_PHOTOS(b).dwg  Layout: 1936  User: MarshallE  Plotted: May 18, 2009 - 2:34pm  Xref's:*

Prepared for:
Port of Seattle
Seattle, Washington

# Sub-slab Vapor Investigation
## Lora Lakes Apartments

AECOM, Inc.
February 9, 2009
**Document No.: 05482025**

Prepared for:
Port of Seattle
Seattle, Washington

# Sub-slab Vapor Investigation
## Lora Lakes Apartments

__________________________________
Prepared by Stacy Patterson, Project Manager

__________________________________
Reviewed by Merv Coover, Senior Project Manager

AECOM, Inc.
February 9, 2009
**Document No.: 05482-025**

AECOM

# Contents

# List of Tables

# List of Figures

# 1.0 Sample Collection

Sub-slab vapor samples were collected from beneath eight of the 16 buildings at the Lora Lake Apartments site, located at 15001 Des Moines Memorial Drive in Burien, Washington. The sample locations were chosen to provide data from across the site and to assess the potential for vapor intrusion into each of the buildings (Figure B-1). The sample ports were located in paved building entryways to minimize impacts to the building structure.

The vapor sampling method conducted at the site varied slightly from the Work Plan, so the following sections describe the collection method in detail. The sampling event followed guidelines published by the EPA draft SOP (US EPA, 2004) and the New York State Department of Health Guidance for Evaluating Soil Vapor Intrusion (NYSDOH, 2006).

## 1.1 Sample Point Installation

On April 11- 12, 2008, eight sub-slab vapor sampling points (LL-SV-D-0408, LL-SV-F-0408, LL-SV-H-0408, LL-SV-N-0408, LL-SV-Q-0408, LL-SV-R-0408, LL-SV-T-0408, LL-SV-RB-0408) were installed in the entry ways of Buildings D, F, H, N, Q, R, T and the Recreation Building.

Sample boreholes were advanced using an electric rotary hammer drill. The borings were advanced in two stages. First, a 1.5-inch diameter hole was drilled to a depth that partially penetrated the slab (approximately ¾-inch deep). Cuttings were removed using a small brush. Secondly, the rotary hammer drill was used to advance a 7/16-inch diameter hole through the remainder of the slab and approximately 1.5 inches into the sub-slab material.

The vapor sampling probes were constructed of ¼-inch outer diameter (3/16-inch inner diameter) chromatography-grade 316 stainless-steel tubing and stainless-steel compression fittings. The probe tubing was lowered to approximately 3.5 inches above the bottom of the boreholes to prevent clogging with sub-slab material. Quick drying cement was injected into the annular space of the boreholes and allowed to dry for 72 hours before sampling. Approximately 1-inch of tubing remained protruded above the seal. This was fitted with recessed stainless-steel plugs to enable repeat sampling and to prevent the escape of soil vapors.

## 1.2 Equipment

The equipment used for the sub-slab vapor sampling was modeled after the examples illustrated in the EPA draft SOP (US EPA, 2004) and the New York State Department of Health Guidance for Evaluating Soil Vapor Intrusion (NYSDOH, 2006). An example of the sample collection train used is shown in Figure B-2 and consists of the following components:

- Swagelok®-type connectors were used for all connections between tubing and other sampling components, and one Watts®-brand brass needle valve
- Teflon®-lined polyethylene tubing connected to the fittings and sample train
- One flow controller device to limit the flow rate.

All gauges were connected by laboratory-supplied chromatography grade stainless steel tubing. All samples were collected in 100% certified clean 6-liter Summa® canisters provided by Columbia Analytical Services. Each canister was field verified to have a vacuum of at least 25 inches of mercury (25-in Hg) before sampling.

## 1.3 Leak Testing and Purging

Leakage of atmospheric air into the sampling equipment can compromise sample integrity and dilute measured sub-slab contaminant concentrations. Therefore, sampling equipment was thoroughly inspected to ensure tight fittings between all components. When connecting the sample train to a sub-slab sample probe for sampling, the following leak test steps were followed:

- All threaded connections were wrapped with Teflon® tape
- The needle valve connected to the probe and tubing was shut
- Purge canister was opened and initial pressure was documented on the field data log
- Valves were left open for 10 minutes.

The vacuum gauge on the purge canister was checked to ensure. The initial pressure held and there were no leaks in the sampling equipment. If leaks were detected, fittings were tightened and the leak test was conducted again.

Purging was conducted prior to collecting a sub-slab vapor sample to ensure that the vapor sample collected was representative of actual sub-slab vapor concentrations. To minimize the potential for leakage, the purge rate was kept at or less than 0.2 liters per minute. The estimated purge volume is two liters is based on the assumptions provided in the EPA draft SOP (US EPA, 2004).

### 1.4 Helium Tracer

A helium tracer test was performed during sampling to ensure that a representative sample was collected from the sub-slab area. A foam exercise mat with a 1-foot diameter hole was placed over the probe, with the probe in the center of the cut-out hole. An acrylic shroud was affixed around the soil gas assembly on top of the mat and ultra high-purity helium was introduced into the headspace of the shroud until the concentration of helium in the enclosure reached 5 percent. The foam mat minimized leakage of helium out of the shroud. Helium concentration in the enclosure was measured by a dielectric MGD-2002 helium detector and was logged in 2- to 5-minute intervals in the field data collection form. Levels of helium were maintained near 5 percent during the duration of the sampling by periodically pumping helium into the enclosure as needed.

The samples were analyzed for helium in addition to VOCs. If helium concentration in the sample exceeds 10 percent of the shroud concentration, then sample dilution is too great to be reliably corrected for, per guidance set forth in the New York State Department of Health *Guidance for Evaluating Soil Vapor Intrusion* (NYSDOH, 2006).

## 2.0 Sampling and Analyses

Sub-slab vapor sampling was conducted on April 14-15, 2008. Each sample was collected over a period of approximately one-half hour (calculated sampling rate of 0.2 liters per minute). The flow controller connected to the sample train was pre-set by the lab, Columbia Analytical Services, to allow for the proper flow rate (0.2 liters per minute). After the leak test and purging were completed, the valve on the purging canister was closed and the valve on the sampling canister and sample train were opened to allow sub-slab air to flow into the sampling canister. At the end of the one-half hour sampling period, the final canister vacuum was recorded in the field data collection log and the valves to the canister were closed.

In addition to the eight sample locations, a duplicate sample was collected from the Recreation Building. This was done by replacing the purge canister with a 6-liter 100% certified Summa® canister and opening the valves on both cans simultaneously once the purging was completed. This procedure filled both the sample canister and the duplicate canister simultaneously. The Recreation Building sample and duplicate sample were collected over a period of one hour based on a flow rate of 0.2 liters per minute.

A sample could not be obtained from the sample port at Building Q due to irreparable leakage in the sample train.

An ambient air sample was collected on the second day of sampling, April 15. The sample canister was hung between the carports on the far west side of the subject property. The sample was collected in a 100% certified 6-liter Summa® canister over an 8-hour period.

The samples were transported under chain-of-custody to Columbia Analytical Services in Simi Valley, CA. The sub-slab soil vapor sample and the ambient air sample were analyzed for VOCs using EPA Method TO-15, Modified EPA Method 3C for oxygen, carbon dioxide, and methane, and Modified ASTM Method D-1946 for helium.

# 3.0 Analytical Results

Based on the New York State Department of Health *Guidance for Evaluating Soil Vapor Intrusion* (NYSDOH, 2006), samples collected from Building D, H, and N did not meet the QA/QC requirement of less than 10% of the shroud helium concentration. The helium concentrations present in each sample indicated a leak in the sampling apparatus during collection and is therefore, not representative of sub-slab vapor and will not be evaluated further.

The ambient air sample and sub-slab samples collected at the Recreation Building and apartment buildings F, R, T, and Z all passed QA/QC requirements. The laboratory data are summarized in Table B-1.

All results are below the EPA screening levels set forth in the EPA *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, Table 2a (USEPA, 2002). The sample results were also compared directly to MTCA Method B ambient air standards. This is a conservative comparison that does not take into account attenuation of vapor concentrations between sub-slab and building air. Three analytes exceeded the ambient air standards:

- Dichlorodifluoromethane at Buildings F and T
- Methylene chloride at Buildings R and T.

These results suggest that existing sub-slab soil vapor conditions do not translate into unacceptable risks to occupants of the apartment structures located on the site.

# 4.0 References

EPA 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA530-D-02-004. November 2002.

EPA 2004. *Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations.* U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory,

NYSDOH 2006. New York State Department of Health Guidance for Evaluating Soil Vapor Intrusion in the State of New York. October 2006.

# Tables

# Table B-1    Sub-Slab Vapor Sample Results

| | | | Location Name | Building F | Rec Building | Building Z | Building T | Building R | Ambient Air |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Name | **LL-SV-F-0408** | **LL-SV-RB-0408** | **LL-SV-Z-0408** | **LL-SV-T-0408** | **LL-SV-R-0408** | **LL-SV-AA-0408** |
| **Chemical** | **EPA Screening Level for Shallow Soil (µg/m$^3$)*** | **MTCA Method B Air, Carcinogen, Standard Formula Value (µg/m$^3$)** | **MTCA Method B Air, Non-Carcinogen, Standard Formula Value (µg/m$^3$)** | | | | | | |
| 1,2,4-Trimethylbenzene | 60 | NR | 2.7 | <0.77 | <0.77 | <0.77 | **1.6** | **0.89** | <0.70 |
| 1,3,5-trimethylbenzene | 6.0 | NR | 2.7 | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| 2-Butanone (MEK) | 10,000 | NR | 460 | **1.4** | <0.77 | <0.77 | **1.9** | **3.5** | <0.70 |
| 4-Ethyltoluene | NA | NR | NR | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| 2-Propanol (Isopropyl Alcohol) | NA | NR | NR | **0.89** | <0.77 | <0.77 | **0.86** | **1.1** | <0.70 |
| Acetone | 3,500 | NR | NR | **11** | <0.77 | <0.77 | **11 M** | **13 M** | <0.70 |
| Acetonitrile | 600 | NR | 27 | **0.78** | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Acrolein | 3,500 | NR | 0.0091 | <0.77 | <0.77 | <0.77 | <0.81 | ***1.0*** | <0.70 |
| Carbon Disulfide | 7,000 | NR | 320 | **6.4** | **1.2** | **1.6** | **0.96** | <0.76 | <0.70 |
| Chlorobenzene | 600 | NR | 8 | <0.77 | <0.77 | **3.3** | <0.81 | <0.76 | <0.70 |
| Chloroform | 110 | 0.11 | NR | **0.89** | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Chloromethane | NA | 1.4 | NR | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | 0.74 |
| Dichlorodifluoromethane (CFC 12) | 2,000 | NR | 80 | ***420*** | **27** | **27** | ***140*** | **6.4** | **2.4** |
| Ethanol | NA | NR | NR | **9** | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Ethylbenzene | 2,200 | NR | 460 | <0.77 | <0.77 | <0.77 | **1.6** | **0.9** | <0.70 |
| Ethyl Acetate | 32,000 | NR | NR | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | **1.0** |
| m,p-Xylenes | 14,000 [1] | NR | 46 [2] | <1.5 | <1.5 | <1.5 | **3.4** | **1.6** | <1.4 ND |
| Methyl Methacrylate | 7,000 | NR | 320 | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Methylene Chloride | 5,200 | 5 | 1,400 | **2.5** | **2.2** | **2.2** | ***29*** | ***19*** | <0.70 |
| Naphthalene | 30 | NR | 1.4 | <0.77 | <0.77 | <0.77 | <0.81 | **1.3** | <0.70 |
| o-Xylene | 7,000 | NR | 46 | <0.77 | <0.77 | <0.77 | **1.2** | <0.76 | <0.70 |
| Propene | NA | NR | NR | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Styrene | 10,000 | 4.4 | 460 | <0.77 | <0.77 | <0.77 | <0.81 | <0.76 | <0.70 |
| Tetrachloroethene | 810 | 0.42 | 16 | <0.77 | **1.8** | **1.9** | <0.81 | <0.76 | <0.70 |
| Toluene | 4,000 | NR | 2,200 | **3.4** | **2.7** | **2.5** | **5.3** | **3.0** | **0.96** |
| Trichlorotrifluoroethane | NA | NR | NR | <0.77 | **0.85** | <0.77 | <0.81 | <0.76 | <0.70 |
| Trichlorofluoromethane | 7,000 | NR | 320 | **1.3** | **1.2** | **1.2** | **1.2** | **1.2** | **1.2** |

***Bold and Italics*** - Analyte exceeds MTCA Method B Standard Formula Value

**Values from OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils Table 2a (Subsurface Vapor Intrusion Guidance), USEPA, 2002*

[1] Sum of m and p xylenes from EPA guidance document

[2] Value shown is for m-xylenes; p-xylenes have not been researched

Qualifiers
M - Matrix interference due to coelution with a non-target compound; results may be biased high
NA - not applicable
NR - Not Researched

Note: Method B ambient air values are conservative and do not account for the diffusion, advection and attenuation factors that effect sub-slab vapor concentrations before becoming present in ambient air.

# Figures

▇ BUILDING STRUCTURES

▇ OTHER STRUCTURES

▇ PAVEMENT

▇ FOUNDATION ONLY

⌖ MONITORING WELLS

◎ GEOPROBE LOCATIONS

▲ SUBSLAB VAPOR SAMPLE LOCATIONS

— — PROPERTY BOUNDARY

🟩 APPROXIMATE LOCATION OF REMEDIAL ACTION CONDUCTED BY GOLDER IN MARCH/APRIL 1987

🟦 APPROXIMATE AREA OF GEOSCIENCE MANAGEMENT FOCUSED ENVIRONMENTAL SITE ASSESSMENT

40 0 80

1"=80'

N

ENSR | AECOM

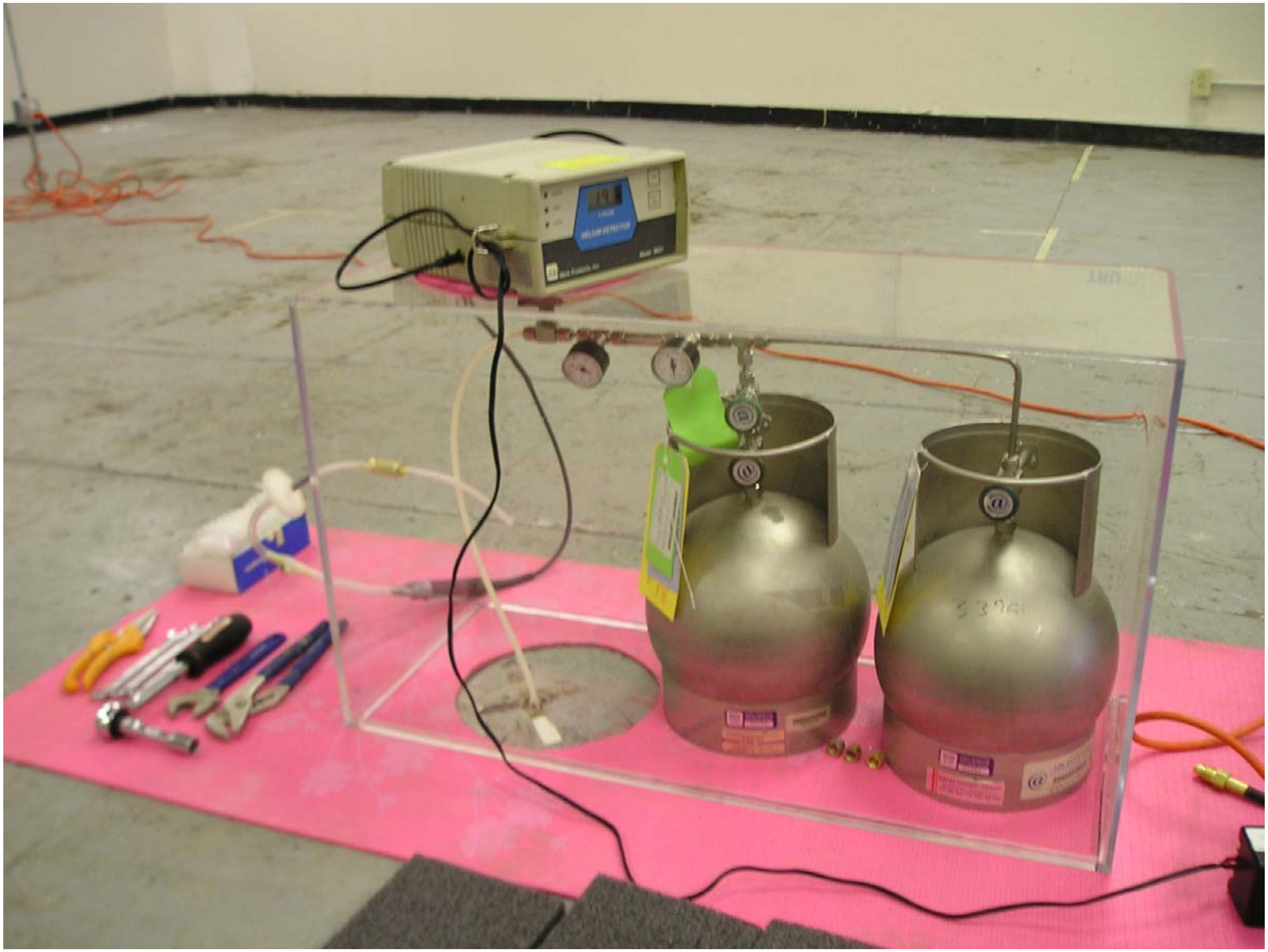
LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**SAMPLE LOCATION MAP**

DATE: 5/1/08
DRWN: E.M./SEA

**FIGURE B-1**

File: L:\Lora Lake\SAMP_LOCATIONS.dwg Layout: fig 1-2 User: emarshall Plotted: Jun 24, 2008 - 2:53pm Xref's:



**LORA LAKE APARTMENTS**
**15001 DES MOINES MEMORIAL DRIVE**
**BURIEN, WASHINGTON**

**Air Sampling Train**

**FIGURE B-2**

Prepared for:
**Port of Seattle**
**Seattle, Washington**

# Modified Sampling and Analysis Plan for Soil and Groundwater Investigation

## Lora Lakes Apartments

AECOM
February 10, 2009
**Document No.: 05482-025**

ENSR | AECOM

Prepared for:
**Port of Seattle**
**Seattle, Washington**

# Modified Sampling and Analysis Plan for Soil and Groundwater Investigation

## Lora Lakes Apartments

Prepared by
Stacy Patterson

Reviewed by
Merv Coover, P.E.

AECOM
February 10, 2009
**Document No.: 05482-025**

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# 1.0 Introduction

The Port of Seattle (Port), is evaluating environmental conditions at the Lora Lake Apartments (LLA) located at 15001 Des Moines Memorial Drive, Burien, Washington. Data collected during the previous soil and groundwater investigation confirmed that industrial operations on the property prior to the construction of the current apartment building complex caused soil and ground water contamination at the LLA.

The original sampling plan titled "*Site Investigation Work Plan – Lora Lake Apartments*" was prepared on March 24, 2008 by AECOM Environment (ENSR, 2008), and reviewed and approved by the Port and KCHA. It was used for the soil, groundwater, and vapor investigations conducted in March 2008.

This document contains the modified version of the sampling and analysis plan, which was used to conduct the groundwater investigation during the August and December sampling events. Two new analytical methods were used to detect semi-volatile organics (PCP and cPAH) during these groundwater investigations, more sensitive methods than those used in the March investigation.

# 2.0 Groundwater Investigation

Ten groundwater wells will be installed using a limited access hollow-stem auger (HSA) as following: wells MW-2 through MW-6 in March 2008, wells MW-8 through MW-11 in August 2008 and well MW-7 in October 2008. The locations will be chosen based on the local topography and supporting information on groundwater flow direction the Port developed for remediation of an adjacent gas station (GeoSciences Management, 2008), and is consistent with the results of a larger scale airport facility groundwater modeling effort (Aspect Consulting, 2005). Well placement, based on the limited information at hand, is intended to yield one upgradient well (MW-2), three wells positioned down-gradient (MW-3, MW-4, and MW-5), one cross-gradient (MW-6) and five wells outside the LLA property (MW-7 through MW-11) to resolve whether groundwater contamination is present offsite past the eastern property line. The proposed locations are illustrated as vicinities, rather than discrete points. Final locations will be selected on-site based on general access considerations and location of utilities. Final locations will be surveyed.

Soil observations will be performed at 5-foot intervals. Soil samples will be collected for analysis during the drilling process and archived (see Section 3.0). Monitoring well screens will be placed at approximately 5 to 10 feet below ground surface at each location, depending on the conditions encountered during drilling.

## 2.1 Pre-Installation Activities

Prior to performing subsurface field work, AECOM will clear the well locations for underground utilities. AECOM will enlist the Washington State “One Call” utility locating service for clearance of utilities on public lands. In addition, AECOM personnel will meet a private locating service (Applied Professional Services, Inc.) to determine clearance of all on-site locations for power, gas, cable, and telephone.

## 2.2 Monitoring Well Installation

Each monitoring well will be completed with 0.01-slot 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) screen with a flush-threaded bottom cap no longer than 6 inches long. Planned screen lengths are 10 feet, but this may change depending on field conditions. Blank Schedule 40 PVC casing will extend from the top of the screen to about 0.5 feet below ground surface for flush mounted wells surface completions.

A sand pack equivalent to 10/20 Silica Sand will be placed in the bottom of the bore hole to two feet above the top of the screen in all monitoring wells. The monitoring well will be surged prior to placement of the bentonite seal to prevent bridging and facilitate settling of the sand pack. A bentonite seal consisting of bentonite chips will be placed directly on the sand pack to a depth of approximately 1.5 feet below grade or less. The depth to the top of the sand pack and the bentonite will be tagged with a weighted tape to ensure well completion materials were installed to the correct depth.

The top of the PVC will be fitted with a standard lockable well plug.

Flush mount well completions will consist of a protective steel casing placed around the PVC and extending from the ground surface to 1 foot below ground surface (bgs). A 2-foot-diameter surface cement pad extending to a depth of 1 to 1.5 feet bgs will be placed around the steel casing. The well shall be labeled with a permanently and clear well identification.

The drilling rods, augers, etc., will be decontaminated between well locations by steam cleaning. AECOM equipment will be decontaminated as per procedures outlined in the decontamination standard operating procedure (SOP) (Appendix A).

## 2.3 Groundwater Well Development

The monitoring wells will be developed prior to gauging or groundwater sampling following procedures outlined in ENSR's SOP for well development (Appendix A). Monitoring wells must be developed for the following reasons:

- To restore the natural permeability of the formation adjacent to the borehole to permit the water to flow into the screen easily;
- To remove the clay, silt, and other fines from the formation so that during subsequent sampling the water will not be turbid or contain suspended matter which can easily interfere with chemical analysis; and
- To remove any formation damage that may have occurred as a result of well drilling.

Before developing the well, water depth, and well depth will be measured using an electronic or mechanical device. Approximately ten well casing volumes (calculated from the length of the water column and the well casing diameter) will be removed from each well during development. The discharge from each well will be continuously monitored until a particulate free discharge is apparent. All materials and equipment used in conjunction with development will be decontaminated prior to use and all provisions made to prevent cross-contamination during development. Well depths will be measured following development to determine whether sand or silt has accumulated in the well.

Regardless of the method employed, any discharges from the wells will be properly disposed. Additionally, all materials and equipment placed into the well in conjunction with development will be decontaminated prior to use.

## 2.4 Surveying

The Port will survey the precise location and elevation of all groundwater monitoring wells. Concurrent to the surveying exercise, AECOM staff will select and mark a water-level measuring point location for each well. The point will be clearly marked on the inner casing (PVC riser) and will coincide with the same point of measurement used by the surveyor. The measuring point will be marked on the north side of the well casing and noted in the project field book.

Monitoring well measurements for total depth and water level will be consistently measured from this reference point so that these data can be used for assessing groundwater elevation trends.

## 2.5 Groundwater Sampling and Analysis

Groundwater sampling will be performed on three different events during 2008. The first round of groundwater samples was conducted on March 2008 for wells MW-2 through MW-6, located in the LLA property. The second groundwater sampling event will be conducted on August 2008 from the eight wells: MW-3, MW-4, MW-5 and MW-6 on the LLA property and MW-8, MW-9, MW-10 and MW-11, across Des Moines Memorial Drive. The third and last round of groundwater samples will be conducted on December 2008 and samples will be collected from four wells, two on the LLA property (MW-2 and MW-6) and two outside the LLA property boundary (MW-7 and MW-10).

Sampling will be performed using Environmental Protection Agency (EPA) approved low-flow methods and will follow the procedures described in the ENSR's groundwater sampling SOP (Appendix A).

### 2.5.1 Well Evaluation

Upon arrival at a monitoring well, the surface seal and well protective casing will be examined for any evidence of frost heaving, cracking, or vandalism. All observations will be recorded in the fluid-level monitoring log or the project field book.

### 2.5.2 Groundwater-Level Measurement

Groundwater level measurements will be made using an electronic or mechanical device. The decontaminated probe will be slowly lowered into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. The exact measurement will be determined by repeatedly raising and lowering the tape or cable to converge on a consistent value. The water-level measurement will be entered in the project field book.

### 2.5.3 Purging and Sample Collection

Purging is required prior to sample collection when using low flow techniques. Purging is considered complete when consecutive measurements of turbidity, dissolved oxygen, oxidation reduction potential (redox), pH, specific conductance, and temperature are within ten percent of the previous measurement, and when consecutive measurements of conductivity are within three percent.

Upon stabilization of parameters, the purge rate will be reduced to approximately 100-200 mL/min. Samples are collected from the discharge tube of the pump into appropriate sample containers. Any non-disposable sample equipment will be decontaminated between sample locations as per ENSR's SOP.

### 2.5.4 Sample Analysis

The selected analytical parameters and their reporting limits are shown in Table C-1 according to the three groundwater sampling events of March, August, and December 2008.

For the March 2008 samples the analytical suite included VOCs, sVOCs, dioxins/furans, total petroleum hydrocarbons (TPH), PCBs and dissolved metals.

The August 2008 analytical suite for groundwater samples will include sVOCs (specifically PAHs and pentachlorophenol), dioxins/furans, diesel range total petroleum hydrocarbons (TPH-Dx), dissolved priority metals, pH and hardness. Two new analytical methods will be used to detect semi-volatile organics (PCP and cPAH) during the August investigation, they are more sensitive methods than those used in the first investigation. The new methods will be SW-846 Method 8270 SIM for cPAHs, which has a method reporting limit of 0.02 μg/L, and SW-846 Method 8151 modified for PCP, which has a method reporting limit of 0.5 μg/L.

In December 2008, the analytical suite will include total petroleum hydrocarbons (TPH-Dx), dioxin/furans, pH, total organic carbon (TOC), priority metals, pentachlorophenol (PCP) and total suspended solids (TSS). The analytical method used to detect PCP will be the same as in the August investigation (SW-846 Method 8151).

The rationale for each sample location is provided in Table C-2.

# 3.0 Soil Investigation

During the March 2008 investigation, soil samples were collected from 12 locations (MW-2 through MW-6, LL-01, LL-07 through LL-12) at the Site (Figure C-1). The proposed soil sample locations are illustrated as vicinities, rather than discrete points. Final locations will be selected based on Site conditions at the time of sampling. Soil was collected from four depths (0 – 6 inches, 18 – 24 inches, and at nominal depths of 7 feet, and 14 feet). Samples were collected at the 0 – 6 inch and 18 – 24 inch intervals at all 12 locations to determine the potential for surface and near-surface exposures. The 0 – 6 inch interval was selected based on Ecology guidance suggesting this is the depth interval that children will typically encounter when playing at the site (Ecology, 2007). The 18 – 24 inch interval represents a reasonable maximum depth interval that could be reached during typical renter residential activities such as gardening and landscaping activity. Samples were collected at the nominal 7 and 14 foot depths at 8 locations to provide general site characterization data. The 7 and 14 foot sample depths were selected based on impacts observed at depth during the previous investigation performed by GeoScience Management.

During August 2008 soil samples will be collected from the five monitoring well locations (MW-2 through MW-6) (Figure C-1). Soil will be collected from the groundwater interface and any location with detected impacts.

## 3.1 Sample Collection Methods

Each sample collection location will be cleared of any surface debris and grass (or weeds). In areas covered by mulch (e.g., play area), the loose wood fragments will be brushed aside until firm soil is exposed. When grass is encountered, an intact one foot diameter circle of grass will be removed to expose firm soil. The intact grass will be replaced, consistent with grade, after sample collection.

Throughout the sampling process, the field geologist will record lithology and photo ionization detector (PID) readings. Based on olfactory, visual, and/or instrumental evidence, the field geologist will sample the most impacted intervals. IF no impacted soil is encountered one soil sample will be collected at the soil water interface.

The soil sample locations and observations of contamination will be recorded on a surface soil sample log. Sufficient sample quantity will be collected to ensure that all appropriate and required data and samples have been collected. All sampling locations will be backfilled to original grade and compacted after sampling and inspections are complete. The backfill will be placed in approximately the same order as the soils were removed. All non-disposable sampling equipment will be decontaminated between each sample interval and sample location as per the decontamination SOP (Appendix A).

### 3.1.1 Hand Tools (March Event Only)

Deep soil samples from location LL-01 had already been analyzed during the GeoScience Management investigation. As such, only the 0 – 6 inch and 18 – 24 inch intervals will be collected at this location.

The 0 – 6 inch sample will be collected in three steps:

1. Collect the first three inches of soil using a clean sampling trowel or spade and place the soil into a stainless steel bowl.

2. Collect soil cores for VOC analysis from the bottom of the collection area (i.e., 3 to 6 in. interval) following the EPA 5035 sampling method.

3. Collect remaining soil in the 3 to 6 in. interval and add to the stainless steel bowl containing the previously removed upper three inches soil. Homogenize the soil in the bowl by hand prior to filling sample containers.

Once the 0 – 6 inch interval has been sampled, a hand auger will be used to drill and expose the 18 - 24 inch interval. The same sample collection procedures will be followed as noted above.

### 3.1.2 Limited Access Hollow-Stem Auger

Shallow and deep soil samples will be collected during the installation of monitoring wells MW-2 through MW-6 in March 2008. In August 2008 monitoring wells MW-8 through MW-11 will be used for soil sample collection, as well as monitoring well MW-7 in December 2008. The samples will be collected using SPT methods (ASTM D 1586). As the borings are advanced, split spoon samples will be obtained at 2.5-foot intervals with a 1.5-inch-diameter split spoon sampler. The samples will be collected by driving the split spoon with a 140-pound hammer falling 30 inches, and recording the blow counts required for each 6-inch drive. The split spoon is advanced through the bottom of the auger to collect the sample. After each sample is collected and the center drill rod installed, the augers will be advanced to the top of the next specified sampling interval. The groundwater borings will be installed to a depth of approximately 25 feet.

### 3.1.3 Limited Access Geoprobe ( March Event Only)

At locations LL-07 through LL-12, shallow soil samples will be collected though use of a limited access geoprobe rig. Deep samples will also be collected at LL-08, LL-09, and LL-12. The borings at these three locations will extend to refusal or to a depth of 20 feet, whichever comes first.

The direct-push method uses a hydraulic hammer to drive a lined drive sampler in front of steel rods. As the drive sampler is advanced, soil is driven into an inner 2-inch diameter, 4-foot long acetate sleeve. After being driven 4 feet, the rods and sampler are removed from the boring. The acetate sleeve containing the soil is then removed from the sample barrel for evaluation and sample processing. After the sampler is decontaminated and a new sleeve is added, the sample barrel is lowered back into the boring with additional sections of rod, and the process is repeated until the next desired depth is reached.

## 3.2 Sample Analysis

The selected analytical parameters and the reporting limits are shown in Table C-1.

For the March 2008 soil samples the analytical suite included total solids, VOCs, sVOCs, dioxins/furans, total petroleum hydrocarbons (TPH), PCBs and dissolved metals. The analytical suite for soil samples of the August 2008 event will include sVOCs (specifically PAHs and pentachlorophenol), dioxins/furans, total petroleum hydrocarbons (TPH-Dx) and dissolved priority metals. In December 2008, the analytical suite will only include total organic carbon (TOC).

The rationale for each sample location is provided in Table C-2.

# 4.0 Sample Nomenclature and Laboratory Details

This section describes the sample nomenclature and laboratory methods used for this investigation.

## 4.1 Sample Nomenclature

Each sample will be assigned a unique alphanumeric identifier. This identifier will facilitate the identification and tracking of each sample. The code is divided into the following designations:

- The first field of the sample code identifies the site: “LL” for Lora Lake.
- The second field of the sample code identifies the location (MW6, MW7).
- The third field of the sample code applies only to soil samples, and delineates depth (i.e., 0-6 or 18-24).

- The fourth field of the sample code identifies date of sample collection

Using the nomenclature scheme described above, sample “MW6-18-24 - 081508” represents a soil sample collected at MW-6 at a depth of 18 to 24 inches on August 15, 2008. Blind field duplicates will be identified as duplicate samples (e.g., DUP-081508).

## 4.2 Analytical Methods, Reporting Limits, Holding Times, and Jar Requirements

Columbia Analytical Services (CAS) will be the analytical laboratory used for all sample analysis tasks. Analytical methods and reporting limits for the project are provided in Table C-1. Standard U.S. Environmental Protection Agency (EPA) methods will be used for all analyses except TPH, which will be analyzed using the NWTPH-Dx methods developed by Ecology.

Holding times and sample container requirements are provided in Table C-3.

# 5.0 Quality Assurance / Quality Control

## 5.1 General Precautions

To prevent sampling interference, sampling personnel will not pump gasoline, wear freshly dry-cleaned clothes or use permanent marking pens during the sampling days. All other similar activities will be avoided and extreme care will be taken to ensure that high quality data are obtained.

## 5.2 Chain of Custody Procedures

Chain-of-custody procedures are intended to document sample possession from the time of collection to disposal. Chain-of-custody procedures are detailed below.

All samples must be packaged so that they do not leak, break, vaporize, or cause cross-contamination of other samples. Each individual sample must be properly labeled and identified. Each shipping container must be accompanied by a chain-of-custody record.

All samples must be clearly identified immediately upon collection. Each sample container label will include the following information:

- Client or project name, or unique identifier, if confidential;
- A unique sample description;
- Sample collection date and time;
- Sampler's name or initials;
- Indication of filtering or addition of preservative, if applicable; and
- Analyses to be performed.

After collection, identification, and preservation (if necessary), the samples will be maintained under chain-of-custody procedures. Transfers of sample custody must be documented by chain-of-custody forms. The chain-of-custody record will include, at a minimum, the following information:

- Client or project name, or unique identifier, if confidential;
- Sample collector’s name;
- Company’s (ENSR) mailing address and telephone number;
- Designated recipient of data (name and telephone number);
- Analytical laboratory's name and city;
- Description of each sample (i.e., unique identifier and matrix);
- Date and time of collection;
- Quantity of each sample or number of containers;
- Type of analysis required; and
- Date and method of shipment.

Additional information may include type of sample containers, shipping identification air bill numbers, etc.

## 5.3 Quality Assurance Objectives

All samples will be collected for laboratory analysis as described in Sections 2 through 3 of this modified SAP. The following quality-control parameters will be evaluated throughout the course of this project:

- Detection limits;
- Data precision;
- Data accuracy;
- Representativeness; and

- Comparability and completeness.

These quality-assessment parameters are described in greater detail in the subsequent paragraphs.

### 5.3.1 Detection Limits

The reporting limits specified in Table C-1 will be observed for all laboratory analyses performed during this project, except where matrix interferences and high concentrations of target and non-target compounds increase the reporting detection limits.

### 5.3.2 Precision

Precision will be determined for field duplicate samples by examining sample results for degree of variance and determining if sampling error has occurred. One field duplicate will be collected for each media analyzed: groundwater, soil, and vapor.

Precision is a measure of agreement among individual measurements of the same parameter, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. The relative percent difference (RPD) parameter will be calculated to define the precision between duplicate analyses.

The RPD for each component is calculated using the following equation:

$$\%\,\mathrm{RPD} = \frac{(X_2 - X_1)}{[(X_1 + X_2)/2]} \times 100$$

where:

$X_1$ = first duplicate sample value
$X_2$ = second duplicate sample value

The laboratory objective for precision is to generate RPD values that fall within the established control limits for the method employed. If the criteria are not met, the data reviewer will examine other quality-control criteria to determine the need for some qualification of the data.

### 5.3.3 Accuracy

Accuracy is defined as the degree of agreement between a measurement and an accepted reference of true concentration. Accuracy is determined by spiking laboratory-generated QC samples with a known concentration of standard compounds and comparing the analytical results with the known value. Matrix spikes are not performed for air samples. Data accuracy will be assessed by determining the percent recovery of a spiked compound. Percent recovery (%R) is determined by the equation:

$$\%\,\mathrm{R} = \frac{(C_1 - C_0)}{C_S} \times 100$$

where:

$C_1$ = measured concentration in the spiked sample
$C_o$ = measured concentration in the unspiked sample
$C_s$ = concentration at which the sample was spiked

The concentration at which the sample was spiked ($C_s$) is calculated, using the following equation:

$$C_S = \frac{\left(C_{spike} \times V_{spike}\right)}{V_{sample} + V_{spike}}$$

where:

$C_s$ = concentration at which the sample was spiked
$C_{spike}$ = spike concentration
$V_{spike}$ = volume of spike
$V_{sample}$ = volume of sample

The laboratory objective for accuracy is to generate %Rs that fall within established control limits for the method employed.

Surrogate and spiking compounds and QC sample selection are determined by the analytical methods used. Percent recoveries indicate the actual performance of the analytical method on real world samples. Tests for laboratory accuracy will be conducted using standard laboratory methods and will be included in the laboratory report.

### 5.3.4 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic population, a process control, or an environmental condition. Appropriate sampling procedures (i.e., those sampling procedures presented in this SAP) will be implemented so that the samples are representative of the environmental matrices from which they were obtained.

### 5.3.5 Comparability and Completeness

Comparability is achieved through the use of the same analytical methods that were used previously, through use of trained personnel and through following procedures in the SOPs. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. The completeness goal will be at least 90 percent.

### 5.3.6 Data Validation

Data quality and utility depends on many factors, including sampling methods, sample preparation, analytical methods, quality control, and documentation. Physical and chemical data have been divided into five categories, as follows:

**Level V B Nonstandard Methods***.* Analyses by nonstandard protocols, such as ultra-low detection limits or analysis of an unusual chemical compound. These analyses often require method modification and/or development. CLP (Contract Laboratory Program) Special Analytical Services (SAS) projects are considered Level V.

**Level IV B CLP Routine Analytical Services (RAS)**. This level is characterized by rigorous QA/QC protocols and documentation, and it provides qualitative and quantitative analytical data. Some EPA regions have obtained similar support via their own regional laboratories, university laboratories, or other commercial laboratories.

**Level III B Laboratory Analysis Using Methods Other than the CLP RAS**. This level is used primarily in support of engineering studies, using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS, without the CLP document requirements.

**Level II B Field Analysis**. This level is characterized by the use of portable analytical instruments which can be used on-site or in mobile laboratories stationed near a site (close-support labs).

Depending upon the types of impacts, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.

**Level I B Field Screening**. This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. The types of data included are those generated on site through the use of PID, pH, conductivity, or other real-time monitoring equipment. Data can be generated regarding the presence or absence of certain materials (especially volatiles) at sampling locations.

The data generated in this project was prepared and reviewed for Level III validation, using method criteria as well as national guidance. One hundred percent of the data set that was supplied in the Level III data package was reviewed and validated by a third party (ENSR staff in Fort Collins office).

# 6.0 References

ENSR 2008. *Site Investigation Work Plan – Lora Lake Apartments*, ENSR, March 24, 2008.

Letter report from GeoScience Management Inc. to the Port of Seattle re/ Report of Focused Subsurface Investigation at Lora Lake Apartment in vicinity of Previous Environmental Cleanup in 1987 Golder Associates, Tax Lot Number 2023049105, Port of Seattle Parcel Number 029R, 15001 Des Moines Memorial Way South, Burien WA. February 26, 2008.

*Phase 1 Groundwater Study Report.* Aspect Consulting, Inc., February 15, 2005.

Ecology 2007. Dirt Alert – Soil Sampling Guidance for Owners, Managers, and Administrators of Large Properties Where Children Play. Washington State Department of Ecology – Toxics Cleanup Program, January 2007.

# Appendix A

# ENSR Standard Operating Procedures

# Decontamination of Field Equipment

## SOP Number 7600

Revision Number: 0.0

January 2008

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# Decontamination of Field Equipment

## CONTENTS

## LIST OF ACRONYMS

| | |
|---|---|
| SAP | Sampling Analysis Plan |
| HASP | Health and Safety Plan |
| IDW | Investigation Derived Waste |
| OSHA | Occupational Safety and Health Administration |
| QC | Quality Control |
| SOP | Standard Operating Procedure |
| QAPP | Quality Assurance Project Plan |

## 1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. Field equipment for decontamination may include a variety of items used in the field for monitoring or for collection of soil, sediment, and/or water samples, such as water level meters, water quality monitoring meters (turbidity meter, multi-parameter meter), split-spoon samplers, trowels, scoops, spoons, and pumps. Heavy equipment such as drill rigs also requires decontamination, usually in a specially constructed temporary decontamination area.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination between samples or sample locations through use of contaminated equipment. Decontamination also protects field personnel from potential exposure to hazardous materials on equipment.

This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Dedicated or disposable equipment will not need to be decontaminated.

## 2.0 SUMMARY OF METHOD

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, and/or solvents.

Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation derived waste (IDW) for later management and/or disposal (refer to procedures outlined in the Sampling Analysis Plan (SAP)). All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the materials used or produced throughout the investigation program.

## 3.0 HEALTH AND SAFETY WARNINGS

Decontamination procedures may involve chemical exposure hazards associated with exposure to soil, water, or sediment and may involve physical hazards associated with decontamination materials. When decontamination is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

## 4.0 INTERFERENCES

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities, but close enough to the sampling area to maintain an efficient working environment.

## 5.0 PERSONNEL QUALIFICATIONS

Decontamination of field equipment is a relatively simple procedure requiring minimal training. It is recommended that the initial decontamination of field equipment be supervised by more experienced personnel. Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of field personnel to be familiar with the decontamination procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within Sampling Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HASP). Field personnel are responsible for decontamination of field equipment and for proper documentation in the field logbook.

## 6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Decontamination agents
  - Simple Green, or other non-phosphate and non-borate biodegradable detergent/degreaser
  - Distilled/deionized water
- Health and safety supplies (as required by the HASP)
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon buckets with covers, plastic bags
- Cleaning containers: plastic buckets or tubs
- Cleaning brushes
- Pressure sprayers (if applicable)

- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Zipper-lock bags
- Approved plans (e.g., HASP, QAPP, SAP)
- Field project logbook/pen

## 7.0 METHODS

### 7.1 General Preparation

**7.1.1** New materials, such as well materials, are generally assumed to be clean and decontamination is not anticipated. However, they should be inspected and if they appear to be dirty, should be decontaminated.

Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in zipper-lock plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears dirty.

**7.1.2** Heavy equipment (drill rigs, Geoprobes®, excavators) should be decontaminated upon arrival at the Area of Investigation, prior to beginning any work.

**7.1.2** A decontamination station will be established within an area that is convenient to each sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station or a portable decontamination station may be established.

**7.1.3** One or more IDW containment stations should be established at this time also. In general, decontamination solutions are discarded as IDW between sampling locations.

**7.2** Decontamination for Inorganic (Metals) Analyses

**7.2.1** This procedure applies to equipment used in the collection of environmental samples submitted for inorganic constituent analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, and other small items. Submersible pump decontamination procedures are outlined in Section 7.2.

**7.2.2** Decontamination is to be performed before sampling events and between sampling points, unless otherwise noted in the SAP.

**7.2.3** After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water. This initial step may be completed using a 5-gallon bucket filled with tap water. A water pressure sprayer may also be used to remove solids and/or other contamination.

**7.2.4** Wash the equipment with a non-phosphate and non-borate detergent and tap water solution. This solution should be kept in a 5-gallon bucket with its own brush.

**7.2.5** Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

**7.2.6** Rinse with 10% nitric acid.

**7.2.7** Rinse with distilled/deionized water to remove any residual acid.

**7.2.8** Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in aluminum foil with the shiny side out and/or seal it in a zipper-lock plastic bag if it will not be reused immediately.

**7.2.9** Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

**7.3** Decontamination of Submersible Pumps

**7.3.1** This procedure will be used to decontaminate submersible pumps before and between groundwater sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure also applies to discharge tubing if it will be reused between sampling points.

**7.3.2** Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

**7.3.3** Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

**7.3.4** As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

**7.3.5** Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (phosphate-free, borate-free detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

**7.3.6** Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

**7.3.7** Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump, discharge line, and power cord thoroughly, shake all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used immediately, the pump itself should be wrapped with aluminum foil before placing it into the bag.

**7.4** Decontamination of Large Equipment

**7.4.1** A temporary decontamination pad may be established for decontamination of heavy equipment. This pad may include a membrane-lined and bermed area large enough to drive heavy equipment (e.g., drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump is necessary to collect and contain rinsate (a pump is used to remove these wastes from the sump). A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

**7.4.2** Upon arrival at the Area of Investigation, all heavy equipment (such as drill rigs) should be thoroughly cleaned. This can be accomplished by steam cleaning or high pressure water wash and manual scrubbing.

Between each sample location (i.e., between boreholes), heavy equipment that has been in the ground must be cleaned by steam cleaning or high pressure water wash and manual scrubbing. This may be performed at the decontamination pad or in the vicinity of the drilling location.

## 8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding decontamination procedures should be documented in the project-specific field logbook. Documentation within the logbook should thoroughly describe the construction of any decontamination facility and the decontamination steps implemented in order to show compliance with the SAP. Decontamination events should be logged when they occur with the following information documented:

- Date, time, and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents and/or acids used

- Notable circumstances
- Identification of equipment rinsate blanks
- Management of decontamination fluids
- Method, date, and time of equipment blank collection
- Disposition of IDW

Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

## 9.0 QUALITY CONTROL AND QUALITY ASSURANCE

General guidelines for quality control check of field equipment decontamination usually require the collection of quality control (QC) samples such as equipment rinsate blanks. These requirements should be outlined in the QAPP and SAP.

Equipment rinsate blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Equipment rinsate blanks should then be labeled as a sample (as per the QAPP and SAP) and submitted to the laboratory to be analyzed for the same parameters as the associated sample, or an appropriate subset thereof. Equipment rinsate blank sample numbers, as well as collection method, time and location should be recorded in the field logbook.

## 10.0 REFERENCES

Not applicable.

# Groundwater Sample Collection from Monitoring Wells – Low Flow

## SOP Number 7130

Revision Number:  0.0

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# Groundwater Sample Collection From Monitoring Wells

## CONTENTS

## LIST OF ACRONYMS

| | |
|---|---|
| DO | Dissolved Oxygen |
| SAP | Sampling Analysis Plan |
| HASP | Health and Safety Plan |
| IDEM | Indiana Department of Environmental Management |
| L/min | Liter per minute |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| NTU | Nephelometric Turbidity Units |
| OLQ | Office of Land Quality |
| ORP | Oxygen Reduction Potential |
| OSHA | Occupational Safety and Health Administration |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| SOP | Standard Operating Procedure |
| TOC | Top of Casing |
| USEPA | United States Environmental Protection Agency |

## 1.0 SCOPE AND APPLICABILITY

This Standard Operation Procedure (SOP) describes the method for collecting valid and representative samples of groundwater from monitoring wells. This SOP is written such that consideration of different sampling equipment may be used in different instances for collecting representative groundwater samples.

## 2.0 SUMMARY OF METHOD

Groundwater sample collection generally involves purging the stagnant water from a well while monitoring field parameters. After field parameters have stabilized, groundwater samples are then collected into the appropriate bottleware.

## 3.0 HEALTH AND SAFETY WARNINGS

Groundwater sampling may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with groundwater sampling equipment. When groundwater sampling is performed, adequate health and safety measures must be taken to protect field personnel. These measures will be addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

## 4.0 INTERFERENCES

Potential interferences could result from cross-contamination between samples and sample locations. Minimization of the cross-contamination will occur through the use of clean sampling tools at each location, which will require decontamination of sampling equipment as per ENSR SOP No. 7600 – Decontamination of Field Equipment.

## 5.0 PERSONNEL QUALIFICATIONS

Groundwater sample collection is a relatively involved procedure requiring formal training and a variety of equipment. It is recommended that initial sampling of groundwater wells be supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of the field sampling personnel to be familiar with the sampling procedures outlined within this SOP, and with specific sampling, quality assurance, and health and safety requirements outlined in the Sampling Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for collecting groundwater samples, decontamination of equipment, as well as proper documentation of sampling activities in the field logbook or field forms (as appropriate).

## 6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Purging and Sampling Pumps
    - Grundfos Redi-flo2$^{TM}$ submersible pumps
    - Bladder pumps
- Field Instruments
    - Individual or multi-parameter meter(s) to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
    - Water level meter
- Sample Collection Records (Figure 1)
- Sample kit (i.e., bottles, labels, preservatives, custody records and tape, cooler, ice)
- Sample Chain-of-Custody forms (as required by ENSR SOP No. 7007 – Chain-of-Custody Procedures)
- Sample packaging and shipping supplies (as required by ENSR SOP No. 7510– Packaging and Shipment of Environmental Samples)
- Waterproof marker or paint
- Distilled/deionized water supply
- Deionized water dispenser bottler
- Flow measurement cup or bucket
- Buckets
- Instrument calibration solutions
- Power source

- Paper towels
- Plastic sheeting
- Trash bags
- Zipper-lock bags
- Equipment decontamination supplies (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)
- Approved plans (e.g., HASP, SAP, QAPP)
- Field project logbook/pen

## 7.0 METHODS

### 7.1 Instrument Calibration

Field instruments will be calibrated daily according to the requirements of the QAPP and manufacturer's specifications for each piece of equipment (e.g., ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). Equipment will also be checked daily with the calibration solutions at the end of use of the equipment. Calibration records shall be recorded in the field logbook or appropriate field form.

### 7.2 Well Security and Condition

At each monitoring well location, observe the conditions of the well and surrounding area. The following information may be noted on the Groundwater Sample Collection Record (Figure 1) or in the field logbook:

- Condition of the well's identification marker
- Condition of the well lock and associated locking cap
- Integrity of the well - protective outer casing, obstructions or kinks in the well casing presence of water in the annular space, and the top of the interior casing
- Condition of the general area surrounding the well

**7.3** Measuring Point Determination

Before collecting a water level measurement, check for an existing measuring point (notch, or other visible mark) established either at the time of well installation or by the latest survey. Generally, the measuring point is referenced from the top of the well casing (TOC), not the protective casing. If no measuring point exists, a measuring point should be established, clearly marked, and identified on the Groundwater Sample Collection Record (Figure 1) or the field logbook. The same measuring point should be used for subsequent sampling events.

**7.4** Water Level Measurement

Water level measurements should be collected in accordance with ENSR SOP No. 7101 – Water Level Measurements. The water level measurement should be entered on the Groundwater Sample Collection Record (Figure 1) or in the field logbook.

**7.5** Purge Volume Calculation

Wells designated for sampling require purging to remove stagnant water in the well. A single casing volume of groundwater will be calculated after measuring the length of the water column and checking the well casing diameter. The Groundwater Sample Collection Record (Figure 1) provides information used to compute the casing volume, which includes a diagram, a numerical conversion table, and the standard calculation. The volume of standing water in the well (i.e., one purge volume) should be entered on the Groundwater Sample Collection Record (Figure 1).

**7.6** Well Purging Methods and Procedures

**7.6.1** Objectives

Prior to sample collection, purging must be performed for all groundwater monitoring wells to remove stagnant water from within the casing and gravel pack and to ensure that a representative groundwater sample is obtained.

All groundwater samples will be collected using low stress (low-flow) purging and sampling procedures according to the United States Environmental Protection Agency (USEPA) Region 1 SOP titled “Low Stress Purging and Sampling

Procedure for the Collection of Groundwater Samples from Monitoring Wells", Revision 2, July 1996 (USEPA, 1996) and Indiana Department of Environmental Management (IDEM) Office of Land Quality (OLQ) Geological Services Technical Memorandum titled "Micro-Purge Sampling for Monitoring Wells" dated January 8, 2003 (IDEM, 2003). The low-flow method emphasizes the need to minimize water level drawdown and low groundwater pumping rates to collect samples with minimal alterations to groundwater chemistry.

During well purging, the water level will be measured with a water level meter in accordance with ENSR SOP No. 7101 – Water Level Measurement. Water level drawdown and flow rate will be recorded on the Groundwater Collection Record (Figure 1). A final purging rate will be selected that does not exceed 0.5 liters per minute (L/min) (typically between 0.1 L/min and 0.3 L/min), and results in a stable drawdown, ideally less than 0.3 feet.

The general types of non-dedicated equipment used for well purging include surface pumps and down-well pumps. The purge method and equipment selected is specified in the SAP. For this project, peristaltic pumps will be used where depths to water are sufficiently shallow, and submersible pumps used where depths to water are too great for peristaltic pumps.

Purge water will be pumped through a flow-through cell and the following parameters will be measured: pH, specific conductivity, temperature, DO, and ORP. These parameters will be measured with a water quality meter, calibrated according to the manufacturer's specifications (see ENSR SOP No. 7105 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). Turbidity will be measured separately with a nephelometer, also calibrated to the manufacturer's specifications (see ENSR SOP No. 7125 – Field Measurement of Turbidity). A round of parameter measurements will be recorded after the flow-through cell is full, approximately 10 minutes after the flow-through cell is full, and then approximately every 5 minutes thereafter, until parameter values have stabilized.

Purging is considered complete and sampling may begin when all parameter values have stabilized and turbidity is below 5 Nephelometric Turbidity Units (NTU). Stabilization is considered to be achieved when three consecutive readings, taken at 3- to 5-minute intervals, are within the following limits:

- Turbidity : less than 5 NTU or ± 10%
- DO : ± 10%
- Specific Conductance : ± 3%
- Temperature : ± 3%
- pH : ± 0.1 standard units
- ORP : ± 10 millivolts

Every effort will be made to lower the turbidity to less than 5 NTU before sampling. If the turbidity cannot be reduced to below 5 NTU, the pumping rate should be reduced. If turbidity still cannot be reduced below 5 NTU, samples may be collected if all other parameters are stable and the turbidity is stable, that is, not improving. The condition will be noted on the field form or in the logbook.

If low-flow purging cannot be achieved for a particular well (typically due to insufficient yield to establish a stable drawdown), the well may be purged dry, then sampled when sufficient water has recharged. The condition will be noted on the field form or in the logbook.

### **7.6.2** Surface Pumps

General

Well purging using pumps located at the ground surface can be performed with a peristaltic pump if the water level in the well is within approximately 20 feet of the top of the well.

Peristaltic pumps provide a low rate of flow typically in the range of 0.02-0.2 gallons/minute (gal/min) (0.075-0.750 L/min). Peristaltic pumps are suitable for purging situations where disturbance of the water column must be kept minimal for particularly sensitive analyses and where volatile organic compounds are not being analyzed.

### **7.6.3** Down-Well Pumps

General

Groundwater withdrawal using non-dedicated down-well pumps may be performed with a submersible pump or a bladder pump.

Electric submersible pumps provide an effective means for well purging and in some cases sample collection. Submersible pumps are particularly useful for situations where the depth to water table is greater than 20 feet and where the depth or diameter of the well requires that a large purge volume be removed before sample collection.

A commonly available submersible pump, the Grundfos Redi-Flo2$^{TM}$ pump, is suited for operation in 2-inch or larger internal diameter wells. Pumping rates are adjusted to low-flow levels by adjusting the current to the pump motor rather than using a flow valve.

As an alternative method to using the submersible pump, bladder pumps may also be used. Bladder Pumps usually consist of a stainless steel pump housing with an internal Teflon® or polyethylene bladder. Discharge and air line tubing is connected to the bladder pump to the air compressor and control unit. The pump is operated by lowering it into the water column within the well screen, then pulsing air into the bladder from the air compressor and pump controller unit. Pumps and controllers are often not interchangeable between manufacturers; therefore, it is usually necessary to have both items provided by the same manufacturer. Pump bladders are generally field-serviceable and replaceable.

A check of well condition may be required prior to inserting any down-well pump if the well has not been sampled for some time or if groundwater quality conditions are not known. The well condition check should include a check of casing plumbness as a bent well casing could cause a pump to get stuck. Casing plumbness can be checked by lowering a clean cylindrical tube with the approximate pump dimensions into the well. If the well casing is not plumb then an alternative purging method should be used.

Submersible pumps (i.e., Grundfos Redi-Flo2$^{TM}$) will generally be used in wells where water levels are too deep to allow use of a peristaltic pump.

Electric Submersible Pump Procedure

Slowly lower the submersible pump with attached discharge line into the monitoring well taking notice of any roughness or restriction within the well riser pipe. The pump should be placed in the uppermost section of the static water column of the monitoring well. The power cord should be attached to the discharge line with an inert material (i.e., zip-ties) to prevent the power cord from getting stuck between the pump, discharge line, and the well casing. Secure the discharge line and power cord to the well casing, using tape or a clamp, taking care not to crimp or cut either the discharge line or power cord.

Connect the power cord to the power source (i.e., rechargeable battery pack, auto battery, or generator) and turn the pump on. Voltage and amperage meter readings on the pump controller (if provided) should be monitored closely during purging. The operations manual for the specific pump used should be reviewed regarding changes in voltage/amperage and the potential impacts on pump integrity. The pumping rate will be adjusted so that drawdown is stabilized, ideally at a level less than 0.3 feet. Pumping should be discontinued if warning conditions occur and/or if the well is pumped to where drawdown falls below the pump's intake level.

Bladder Pump Procedure

As an alternative method to the submersible pump, bladder pumps may be used. To operate the bladder pump system, the pump and discharge line should be lowered into the well close to the bottom of the well screen, then secured to the well casing with a clamp. The air compressor should then be turned on to activate pumping. The pump controller is used to vary the discharge rate to the required flow. The pumping rate will be adjusted so that drawdown is stabilized, ideally at a level less than 0.3 feet.

## **7.7** Sample Collection Methods and Procedures

### **7.7.1** Objectives

Groundwater samples can be collected using similar methods employed for purging. In most cases during sampling, groundwater will be transferred to the appropriate containers directly from the discharge source. It is important that the tubing from the pump to the flow-through cell be disconnected prior to sample collection. During transfer, discharge tubing and other equipment shall not contact the inside of the sample containers.

### **7.7.2** Down-Well Pumps

Using the pump methods described in Section 7.6.3, groundwater samples can be collected from either the electric submersible or bladder pump directly from the discharge line (after tubing has been disconnected from the flow-through cell). Sample bottles will be filled directly from the discharge line of the pump.

## **7.8** Sample Handling and Preservation

- Once each sample container is filled, clean the rim and threads of the sample container by wiping with a paper towel.
- Cap and label the container with (at a minimum) the sample identifier and sampling date and time. Additional information such as preservation information and analytical tests may also be added to the sample label as appropriate.
- Place the sample containers into a cooler and maintain on ice.
- Complete sample chain-of-custody and other documentation per ENSR SOP No. 7007 – Chain-of-Custody Procedures.
- Package the samples for shipment to the laboratory per ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

## **7.9** Equipment Decontamination

All equipment that comes into contact with groundwater (e.g., submersible pumps) should be decontaminated in accordance with ENSR SOP No. 7600 – Decontamination of Equipment protocol before moving to the next location. Dedicated or disposable equipment does not need to be decontaminated.

## 8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding sample collection should be documented in several areas: the sample chain-of-custody record, sample collection record, field logbook, and sample labels or tags. Additional information regarding each form of documentation is presented in the following paragraphs:

### **8.1** Sample Chain-of-Custody Record

This standard form requires input of specific information regarding each collected sample for laboratory analytical purposes, as specified in ENSR SOP No. 7007 – Chain-of-Custody Procedures and ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

### **8.2** Sample Collection Record

This form (Figure 1) requires input of specific information regarding the collection of each individual sample including sample identification, water quality parameters, collection method, and containers/preservation requirements.

### **8.3** Field Logbook

This logbook should be dedicated to the project and should be used by field personnel to maintain a general log of activities throughout the sampling program. This logbook should be used in support of, and in combination with, the sample collection record. Documentation within the logbook should be thorough and sufficiently detailed to present a concise, descriptive history of the sample collection process.

### **8.4** Sample Labels

Sample labels shall be completed at the time each sample is collected and attached to each sample container. Sample labeling will be conducted per the SAP and QAPP. Labels may include the information listed below.

- Project number (not project name)
- Sample number
- Sample designation

- Analysis type
- Preservative
- Sample collection date
- Sample collection time
- Sampler's name

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

## 9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the QAPP and/or SAP.

Quality assurance requirements typically suggest the collection of a sufficient quantity of quality control (QC) samples such as field duplicate, equipment and/or field blanks and matrix spike/matrix spike duplicate (MS/MSD) samples. These requirements are outlined in the SAP and QAPP. Additional information regarding quality assurance sample collection relevant to groundwater sampling is described below.

### **9.1** Field Blank/Equipment Blank Sample Collection

Field blank samples serve as a quality assurance check of equipment and field conditions at the time of sampling. Field blank samples are usually prepared by transferring analyte-free water into a clean set of sample containers, then analyzing it as a sample. Sometimes, the analyte-free water is transferred over or through the sampling device before it is placed into the sample containers. This type of field blank sample is known as an equipment blank. The SAP and QAPP contains specific information regarding the type and number of field blanks or equipment blanks required for collection.

### **9.2** Field Duplicate Sample Collection

Field duplicate samples are collected for the purpose of providing two sets of results for comparison. To the extent possible based on available information, field duplicates will be selected at locations with the likelihood of detectable concentrations of constituents.

These samples are used to assess precision. Duplicate samples are usually prepared by splitting the sample into two sets of sample containers, then analyzing each set as a separate sample. The QAPP contains specific information regarding the type and number of duplicate samples for collection.

### **9.3** Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample Collection

MS/MSDs provide information about the effect of the sample matrix on digestion and measurement methodology. For samples submitted for MS/MSD analysis, triple sample volume is generally required. The QAPP contains specific information regarding the frequency of MS/MSD samples.

## 10.0 REFERENCES

Code of Federal Regulations, Chapter 40 (Section 261.4(d)).

ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor.

ENSR SOP No. 7101– Water Level Measurements.

ENSR SOP No. 7125 – Field Measurement of Turbidity.

ENSR SOP No. 7007 – Chain-of-Custody Procedures.

ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

ENSR SOP No. 7600 – Decontamination of Field Equipment.

IDEM. 2003. OLQ Geologic Services Technical Memorandum – Micro-Purge Sampling for Monitoring Wells. Indiana Department of Environmental Management Office of Land Quality. January 8, 2003.

USEPA. 1996. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells, Revision 2. U.S. Environmental Protection Agency, Region 1. July 30, 1996.

## FIGURE 1 – EXAMPLE GROUNDWATER SAMPLE COLLECTION RECORD

Well ID:

### Low Flow Ground Water Sample Collection Record

Client: ____________________ Date: ____________ Time: Start ________ am/pm
Project No: ____________________ Finish ________ am/pm
Site Location: ____________________
Weather Conds: ____________________ Collector(s): ____________________

**1. WATER LEVEL DATA: (measured from Top of Casing)**

a. Total Well Length ________ c. Length of Water Column ________ (a-b)

b. Water Table Depth ________ d. Calculated System Volume (see back) ________

Casing Diameter/Material ____________________

**2. WELL PURGE DATA**

a. Purge Method: ____________________

b. Acceptance Criteria defined (see workplan)

| | | | |
|---|---|---|---|
| - Temperature | 3% | -D.O. | 10% |
| - pH | ± 1.0 unit | - ORP | ± 10mV |
| - Sp. Cond. | 3% | - Drawdown | < 0.3' |

c. Field Testing Equipment used: Make Model Serial Number

| Time (24hr) | Volume Removed (Liters) | Temp. (°C) | pH | Spec. Cond. (µS/cm) | DO (mg/L) | ORP (mV) | Turbidity (NTU) | Flow Rate (ml/min) | Drawdown (feet) | Color/Odor |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| d. Acceptance criteria pass/fail | Yes | No | N/A |
|---|---|---|---|
| Has required volume been removed | ☐ | ☐ | ☐ |
| Has required turbidity been reached | ☐ | ☐ | ☐ |
| Have parameters stabilized | ☐ | ☐ | ☐ |

(continued on back)

If no or N/A - Explain below.

____________________

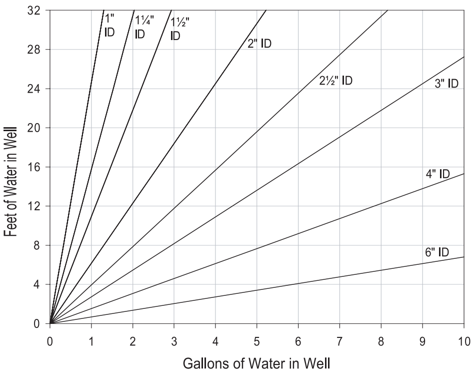
**3. SAMPLE COLLECTION:** Method: ____________________

| Sample ID | Container Type | No. of Containers | Preservation | Analysis Req. | Time |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Comments ____________________

Signature ____________________ Date ____________

Purge Volume Calculation



| Volume / Linear Ft. of Pipe | | |
|---|---|---|
| ID (in) | Gallon | Liter |
| 0.25 | 0.0025 | 0.0097 |
| 0.375 | 0.0057 | 0.0217 |
| 0.5 | 0.0102 | 0.0386 |
| 0.75 | 0.0229 | 0.0869 |
| 1 | 0.0408 | 0.1544 |
| 1.25 | 0.0637 | 0.2413 |
| 1.5 | 0.0918 | 0.3475 |
| 2 | 0.1632 | 0.6178 |
| 2.5 | 0.2550 | 0.9653 |
| 3 | 0.3672 | 1.3900 |
| 4 | 0.6528 | 2.4711 |
| 6 | 1.4688 | 5.5600 |

(continued from front)

| Time (24 hr) | Volume Removed (Liters) | Temp (°C) | pH | Spec. Cond. (µS/cm) | DO (mg/L) | ORP (mV) | Turbidity (NTU) | Flow Rate (ml/min) | Drawdown (ft) | Color/Odor |
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ENSR | AECOM

# Monitoring Well Development

## SOP Number 7221

Revision Number:  0.0

January 2008

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January 23, 2008

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January 23, 2008

**SOP NUMBER: 7221**

# Monitoring Well Development

**Date:** January 2008
**Revision Number:** 0.0
**Page:** 1 of 14

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## APPENDICES

## LIST OF ACRONYMS

| | |
|---|---|
| SAP | Sampling Analysis Plan |
| HASP | Health and Safety Plan |
| IDW | Investigation Derived Waste |
| OSHA | Occupational Safety and Health Administration |
| QAPP | Quality Assurance Project Plan |
| SOP | Standard Operating Procedure |

## 1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods used for developing newly installed monitoring wells and/or existing wells that may require redevelopment/rehabilitation. This SOP is applicable to any wells that require development in accordance with the Sampling Analysis Plan (SAP).

Monitoring well development and/or redevelopment is necessary for several reasons:

- To improve/restore hydraulic conductivity of the surrounding formations as they have likely been disturbed during the drilling process, or may have become partially plugged with silt;
- To remove drilling fluids (water, mud), when used, from the borehole and surrounding formations; and
- To remove residual fines from well filter materials and reduce turbidity of groundwater, therefore, reducing the chance of chemical alteration of groundwater samples caused by suspended sediments and provide representative groundwater samples.

## 2.0 SUMMARY OF METHOD

Well development generally involves withdrawal of an un-specified volume of water from a well using a pump, surge block or other suitable method such that, when completed effectively, the well is in good or restored hydraulic connection with the surrounding water bearing unit and is suitable for obtaining representative groundwater samples or for other testing purposes.

## 3.0 HEALTH AND SAFETY WARNINGS

Monitoring well development may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with use of well development equipment. When well development is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

## 4.0 INTERFERENCES

Potential interferences could result from cross-contamination between sample locations. Minimization of the cross-contamination will occur through the use of clean tools at each location, which will require decontamination of sampling equipment as per ENSR SOP No. 7600 – Decontamination of Field Equipment.

The process of installing a well necessarily disturbs the geologic formation. Wells will be developed appropriately as described in this SOP. The wells will be allowed to stabilize a minimum of two weeks after development before a well is sampled. In no cases will methods using air (e.g., air jetting) be used for well development on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

## 5.0 PERSONNEL QUALIFICATIONS

Well development procedures vary in complexity. It is recommended that initial development attempts be supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within the SAP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for proper well development, decontamination of equipment, as well as proper documentation in the field logbook or field forms (if appropriate).

## 6.0 EQUIPMENT AND SUPPLIES

Well development can be performed using a variety of methods and equipment. The specific method chosen for development of any given well is governed by the purpose of the well, well diameter and materials, depth, accessibility, geologic conditions, static water level in the well, and type of constituents present, if any.

The following list of equipment, each with their own particular application, may be used to develop and/or purge monitoring wells. In no cases will methods using air (e.g., air jetting) be used on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

### **6.1** Bailer Purging

A bailer is used to purge silt-laden water from wells after using other devices such as a surge block. In some situations, the bailer can be used to develop a well by bailing and surging, often accompanied with pumping. A bailer can be used for purging in situations where the depth to static water is greater than 25 feet and/or where insufficient hydraulic head is available for use of other development methods.

### **6.2** Surge Block Development

Surge blocks are commercially available for use with Waterra™-type pumping systems or may be manufactured using a "plunger" attached to a rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks if requested. A recommended design is shown in Figure 1.

### **6.3** Pump Development

A pump is often necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone can be used to develop the well and remove the fines by overpumping. Because the purpose of well development is to remove suspended solids from a well and the surrounding filter pack, the pump must be capable of moving some solids without damage. The preferred pump is a submersible pump, which can be used in both shallow and deep ground water situations. A centrifugal pump may be used in shallow wells, but will work only where the depth to static ground water is less than approximately 25 feet. Pumping may not be successful in low-yielding aquifer materials or in wells with insufficient hydraulic head.

### **6.4** Other Required Materials:

- Well Development Records (Figure 2)
- Boring and well construction logs (if available)
- Utility knife
- Plastic sheeting
- Buckets

- Paper towels
- Trash bags
- Power source (generator or 12-volt marine battery)
- Water level meter and/or well depth measurement device
- Water quality instrumentation to measure turbidity (i.e., nephelometer)
- Instrument calibration solutions
- Equipment decontamination supplies (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)
- Appropriate containers and materials to manage investigation-derived waste (IDW) (as specified in the SAP)
- Approved plans (e.g., HASP, QAPP, SAP)
- Field project logbook/pen

## 7.0 METHODS

### 7.1 General Preparation

Well completion diagrams should be reviewed to determine well construction characteristics. Formation characteristics should also be determined from review of available boring logs.

Well development, similar to groundwater sampling, should be conducted in as clean an environment as possible. This usually requires, at a minimum, placing sheet plastic on the ground to provide a clean working area for development equipment.

Provisions should be in place for collection and management of IDW, specifically well development water and miscellaneous expendable materials generated during the development process. The collection of IDW in drums or tanks may be required depending on project-specific requirements.

The water level and well depth should be measured in accordance with ENSR SOP No. 7101 – Water Level Measurements and written on the Well Development Record (Figure 2). This information is used to calculate the volume of standing water (i.e., the well volume) within the well.

Drilling fluids such as mud or water, if used during the drilling and well installation process, should be removed during the well development procedure. It is recommended that a minimum of 3 times the volume of added fluid be removed from the well during development. If the quantity of added fluid is not known or cannot be reasonably estimated, removal of a minimum of 20 well volumes of water is recommended during the development procedure.

## 7.2 Development Procedure

### 7.2.1 Development Method Selection

The construction details of each well shall be used to define the most suitable method of well development. Some consideration should be given to the potential concentrations of constituents in each well as this will impact IDW containment requirements.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and potential concentrations of constituents, and characteristics of the geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

### 7.2.2 General Water Quality Measurements (optional)

Measurements for water quality parameters such as specific conductance may be monitored periodically during development using the available water quality instruments (e.g., ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). These measurements may be used to determine whether or not well development is proceeding efficiently, determine whether or not the development process is effective with any given well and, potentially, may identify well construction irregularities (i.e., grout in well, poor well screen slot-size selection). Water quality parameters will be recorded on the Well Development Record (Figure 2).

### **7.2.3** Turbidity

Turbidity will be monitored during well development to monitor the progress of development. Visual observations on turbidity, such as silty or cloudy water, should be noted in the Well Development Record (Figure 2). Turbidity should also be measured quantitatively using a nephelometer. Turbidity should be measured a minimum of three times during development, including at the completion of development. All turbidity readings will be recorded in the Well Development Record (Figure 2).

### **7.2.4** Bailer Procedure

As stated previously, bailers shall preferably not be used for well development but may be used in combination with a surge block to remove silt-laden water from the well.

- When using a bailer to purge well water; select the appropriate bailer, then tie a length of bailer cord onto the end of it.

- Lower the bailer into the screened interval of the monitoring well. Silt, if present, will generally accumulate within the lower portions of the well screen.

- The bailer may be raised and lowered repeatedly in the screened interval to further simulate the action of a surge block and pull silt through the well screen.

- Remove the bailer from the well and empty it into the appropriate storage container.

- Continue surging/bailing the well until sediment-free water is obtained. If moderate to heavy siltation is still present, the surge block procedure should be repeated and followed again with bailing. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters, periodically.

### 7.2.5 Surge Block Procedure

A surge block effectively develops most monitoring wells. This device first forces water within the well through the well screen and out into the formation, and then pulls water back through the screen into the well along with fine soil particles. Surge blocks may be manufactured to meet the design criteria shown in the example (Figure 1) or may be purchased as an adaptor to fit commercially available well purging systems such as the Waterra$^{TM}$ system.

- Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of approximately 3 feet, will allow material that is blocking the screen to separate and become suspended.

- After 5 to 10 plunger strokes, silt-laden water will be removed from the well using a pump integrated with the surge block, or removing the surge block to purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. Discharge the purged water into the appropriate storage container.

- Repeat the process. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time. Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters periodically.

### 7.2.6 Pump Procedure

Well development using only a pump is most effective in monitoring wells that will yield water continuously. Theoretically, pumping will increase the hydraulic gradient and velocity of groundwater near the well by drawing the water level down. The increased velocity will move residual fine soil particles into the well and clear the well screen of this material. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

- When using a submersible pump or surface pump, set the intake of the pump or intake line in the center of the screened interval of the monitoring well.
- Pump a minimum of three well volumes of water from the well and raise and lower the pump line through the screened interval to remove any silt/laden water.
- Continue pumping water from the well until sediment-free water is obtained. This method may be combined with the manual surge block method if well yield is not rapid enough to extract silt from the surrounding formations. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.
- Check turbidity and any other water quality parameters periodically.

### **7.3** Equipment Decontamination

All equipment that comes into contact with groundwater (e.g., surge block) will be decontaminated in accordance with ENSR SOP No. 7600 – Decontamination of Field Equipment before moving to the next location. The bailer should be properly discarded and disposed of in accordance with procedures for managing IDW.

## 8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the development process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

## 9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or SAP.

A well will have been successfully developed when one or more of the following criteria are met:

- The sediment load in the well has been eliminated or greatly reduced. Use of a nephelometer is required during the well development procedure to measure water turbidity if meeting a specific turbidity value is required by the SAP. Attaining low turbidity values in fine-grained formations may be difficult to achieve.

- If it is not possible to reduce turbidity to acceptable levels, the well will be developed for a maximum of four hours.

## 10.0 REFERENCES

ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor.

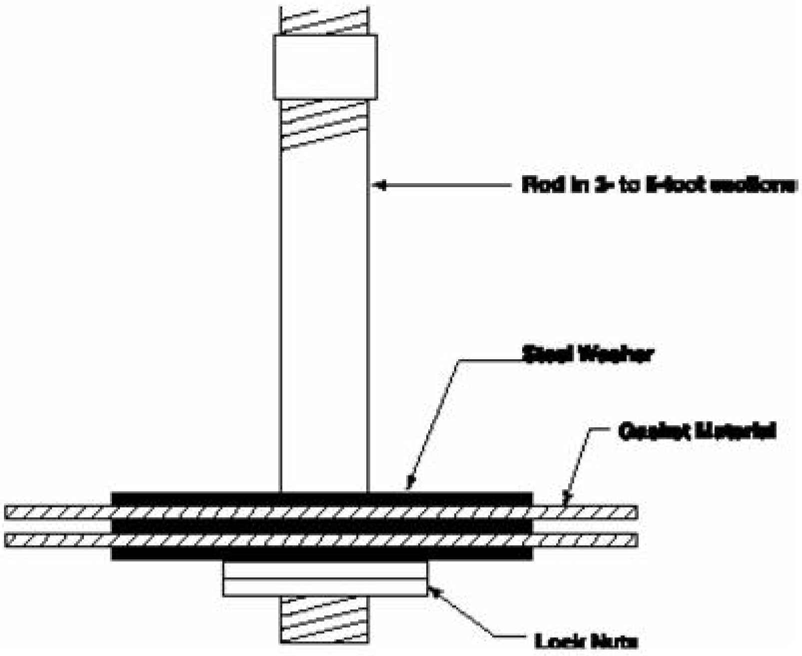
ENSR SOP No. 7101 – Water Level Measurements.

ENSR SOP No. 7600 – Decontamination of Field Equipment. Revision 0.0.

## FIGURE 1 – RECOMMENDED SURGE BLOCK DESIGN

**SURGE BLOCK DESIGN**
**(Not to Scale)**

**Steel washers should be 1/2" to 3/4" smaller in diameter than the well ID. Gasket can be rubber or leather and should be the same diameter or 1/8" smaller than the well ID to compensate for swelling of the leather/ Rod can be steel, fiberglass, or plastic but must be strong and lightweight.**



## FIGURE 2 – EXAMPLE WELL DEVELOPMENT RECORD

ENSR

Well/Piez. ID:

### Well/Piezometer Development Record

Client: ____________

Project No: ____________ Date: ________ Developer: ____________

Site Location: ____________

**Well/Piezometer Data**

Well ☐ Piezometer ☐ Diameter ________ Material ________

Measuring Point Description ________ Geology at Screen Interval (if known) ________

Depth to Top of Screen (ft.) ________

Depth to Bottom of Screen (ft.) ________ Time of Water Level Measurement ________

Total Well Depth (ft.) ________ Calculate Purge Volume (gal.) ________

Depth to Static Water Level (ft.) ________ Disposal Method ________

Headspace ________

Original Well Development ☐ Redevelopment ☐ Date of Original Development ________

**DEVELOPMENT METHOD** ____________

**PURGE METHOD** ____________

| Time | Total Volume Purged (gal.) | Flow Rate (gpm) | Turbidity (NTU) | Color | pH | Temp | Other |
|---|---|---|---|---|---|---|---|
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**ACCEPTANCE CRITERIA (from workplan)**
Minimum Purge Volume Required _____ gallons
Maximum Turbidity Allowed _____ NTUs
Stabilization of parameters _____%

| | Yes | No | N/A |
|---|---|---|---|
| Has required volume been removed | ☐ | ☐ | ☐ |
| Has required turbidity been reached | ☐ | ☐ | ☐ |
| Has parameters stabilized | ☐ | ☐ | ☐ |

If no or N/A explain below:

____________

Signature ____________ Date: ________

## APPENDIX A – GLOSSARY

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: a characteristic property of aquifer materials which describes the permeability of the material with respect to flow of water.

Hydraulic Connection: A properly installed and developed monitoring well should have good hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer into the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Static Water Level: The water level in a well that represents an equilibrium or stabilized condition, usually with respect to atmospheric conditions in the case of monitoring wells.

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing standing water from a well to allow surrounding formation water to enter the well.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. The perforated, or slotted, portion of a well is also known as the screened interval.

# Tables

# Table C-1 Analytical Methods and Laboratory Reporting Limits

| Sampling Event | Parameter | Analysis Method | CAS Reporting Limit |
|---|---|---|---|
| **March 2008** | *Shallow Soil* | | |
| | Total Solids | EPA 160.3M | 0.01% |
| | Volatile Organics | SW-846 6260B | 0.005 - 0.2 mg/kg |
| | Semivolatile Organics | SW-846 8270C | 0.010 - 0.2 mg/kg |
| | Dioxins / Furans | SW-846 8290 | 1 - 5 ng/Kg |
| | PCBs | 3545/8082 | 0.01 mg/kg |
| | TPH | NWTPH-Dx | 25 mg/kg |
| | | NWTPH-Gx | 5 mg/kg |
| | Metals (except Mercury) | SW-846 6020 | 1 - 400 mg/kg |
| | Mercury | 7470A/7471A | 0.02 mg/kg |
| | *Soil Vapor* | | |
| | Oxygen, CO$_2$, Methane | Modified 3C | |
| | Helium | Modified ASTM D-1946 | |
| | Volatile Organics | TO-15 | 1.5 - 7 µg/m$^3$ (approximate) |
| | *Groundwater* | | |
| | Volatile Organics | SW-846 6260B | 0.5 - 20 µg/L |
| | Semivolatile Organics | SW-846 8270C | 0.2 - 2 µg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | PCBs | 3545/8082 | 0.2 µg/L |
| | TPH | NWTPH-Dx | 100 µg/L |
| | | NWTPH-Gx | 250 µg/L |
| | Metals (except Mercury) | SW-846 6020 | 5 - 2000 µg/L |
| | Mercury | 7470A/7471A | 0.2 µg/L |
| | Turbidity | EPA 180.1 | |
| | *Groundwater* | | |
| | PAHs | SW-846 8270 SIM | 0.02 µg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | Pentachlorophenol | SW-846 8151 | 0.5 µg/L |
| | TPH | NWTPH-Dx | 100 µg/L |
| | Priority Metals | SW-846 6020 | 5 - 2000 µg/L |
| | Mercury | SW-846 7470A | 0.2 µg/L |
| | Hardness | 130.2 | 2 mg/L |
| | pH | 150.1 | |
| **December 2008** | *Soil* | | |
| | Total Organic Carbon | ASTM 4129-82M | 0.05 mg/kg |
| | *Groundwater* | | |
| | TSS | 160.2 | 5 mg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | Pentachlorophenol | SW-846 8151 | 0.5 µg/L |
| | TPH | NWTPH-Dx | 100 µg/L |
| | Priority Metals | SW-846 6020 | 5 - 2000 µg/L |
| | Mercury | SW-846 7470A | 0.2 µg/L |
| | TOC | EPA 415.1 | |
| | pH | 150.1 | |

## Table C-2 Sample Location and Purpose

| Location ID | Approximate Location | Rationale |
|---|---|---|
| *Groundwater* | | |
| MW-1 | Approximate center of property in location of known historic impacts | Validate previously collected groundwater data |
| MW-2 | Northwest corner of the property by building Q | Characterize groundwater entering property |
| MW-3 | South side of the property by buildings E and F | Characterize groundwater leaving property |
| MW-4 | Eastern property boundary by former buildings C and D | |
| MW-5 | Eastern property boundary by former buildings A and C | |
| MW-6 | Eastern property boundary by former buildings W and X | Characterize groundwater in NE corner of property |
| MW-7 | Beyond eastern property boundary, east of Des Moines Memorial Drive, across from former buildings X and W | Characterize groundwater outside property boundaries |
| MW-8 | Beyond eastern property boundary, east of Des Moines Memorial Drive, across from former buildings W and A | |
| MW-9 | Beyond eastern property boundary, east of Des Moines Memorial Drive, across from former buildings A and C | |
| MW-10 | Beyond eastern property boundary, east of Des Moines Memorial Drive, across from former building C and building D | |
| MW-11 | Beyond eastern property boundary, east of Des Moines Memorial Drive, across from buildings D and F | |
| *Soil* | | |
| LL-01 | East side of the Rec. building | Potential high-use area;<br>Previous MTCA exceedances at depth |
| MW-2 | Northwest corner of the property by building Q | Likely point of influx of groundwater to site;<br>Achieve site-wide coverage |
| MW-3 | South side of the property by buildings E and F | Achieve site-wide coverage |
| MW-4 | East side of property by buildings C and D | Achieve site-wide coverage |
| MW-5 | East side of the property by former building A | Achieve site-wide coverage |
| MW-6 | Northeast corner of the property by former buildings X and W | Achieve site-wide coverage |
| LL-07 | West side of the property by building N | Achieve site-wide coverage |
| LL-08 | Boneyard / Play area | Potential high-use area; adjacent to former off-site transformer location |
| LL-09 | Northeast corner of the property by former buildings U and V | Achieve site-wide coverage |
| LL-10 | North side of the Rec. building | Potential high-use area;<br>Adjacent to previous MTCA exceedances |
| LL-11 | South side of the Rec. building | |
| LL-12 | Near the basketball court / pool | Potential high-use area |

# Table C3 Sample Holding Times and Jar Requirements

| Analytical Parameter | Holding Time ($4^oC$) | Holding Time ($-18^oC$) | Sample Bottle Size / Type |
|---|---|---|---|
| *Soil* | | | |
| Volatile Organics | 14 days | 14 days | Terra Core Kit |
| Total Solids | NA | NA | 2 * 8-oz glass |
| Semivolatile Organics | 14 days | 1 year | |
| Dioxins / Furans | 30 days | 1 year | |
| PCBs | 14 days | 1 year | |
| Metals (except Mercury) | 6 months | 1 year | |
| Mercury | 28 days | 1 year | 8-oz glass/$HNO_3$ |
| TPH | 14 days | 1 year | 8-oz glass and Terra Core |
| *Groundwater* | | | |
| Volatile Organics | 14 days | NA | 3 * 40 mL voa vials |
| Semivolatile Organics | 7 days | NA | 2 * 1 L amber glass |
| Dioxins / Furans | 30 days | NA | 2 * 1 L amber glass |
| PCBs | 7 days | NA | 2 * 1 L amber glass |
| TPH | 7 days | NA | 500 mL amber/HCl,<br>2 * 40mL voa vials |
| Metals (except Mercury) | 6 months | NA | 1 L plastic/$HNO_3$ |
| Mercury | 28 days | NA | 1 L plastic/$HNO_3$ |

# Figures

File: L:\Lora Lake\SITE MAP.dwg Layout: ANSI_B1-CP User: MarshallE Plotted: Mar 24, 2009 - 8:30am Xref's:

AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

DATE: 03/24/09
DRWN: E.M./SEA

**SITE MAP**

**FIGURE C-1**

# BORING & WELL CONSTRUCTION LOG

# WELL MW-1 (BORING LLP-4 LOCATION)

GEOSCIENCE MANAGEMENT, INC.
ENVIRONMENTAL CONSULTING SERVICES
809 156TH STREET NE
ARLINGTON, WA 98223

**PROJECT**
Lora Lake Apartments

**CLIENT**
Port of Seattle

**DRILLING COMPANY**
Hollow-stem Auger

**GEOLOGIST**
H. W. Small, L.HG.

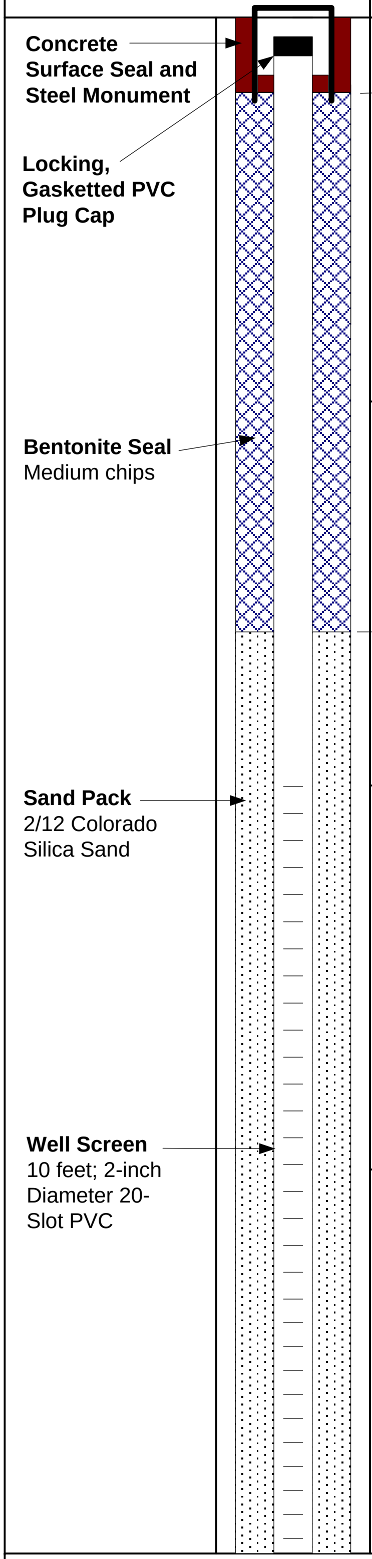
**START DATE** 10/25/2007
**END DATE** 10/25/2007

**DRILLING METHOD**
Hollow-stem Auger (4.25 ID x 9 OD)

**SAMPLING METHOD**
3-in. O.D. Split-Spoon Sampler

**SURFACE COMPLETION**
Flush-mount steel monument

**Elevation Ground:** Not Measured
**Elevation TOC:** Not Measured
**Total Boring Depth:** 20 Feet
**Depth to Water ATD:** 14 Feet



| DEPTH (FEET) | SAMPLE ID | BLOW COUNT (PER 6 INCHES) | SAMPLE INTERVAL AND RECOVERY | PID READINGS (PPM) | USCS | |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 1.0 Feet | | | | | FILL | Planter soil over:<br>Gray, brown and black, damp, slightly silty, gravelly, medium to fine SAND (Fill). Occasional fragments of wood, debris, roots and organic matter to approximately 6 feet bgs. |
| 5 | | | | | | |
| 5.5 to 6.0 | MW-1-5.5' | 50/6” | | 10 | | Drove sample at 5.5 feet, but did not encounter target zone of substantial organics, as observed in boring LLP-4. |
| 6.0 to 6.5 | MW-1-6' | 50/6" | | 10 | | Drove sample at 6.0 feet, but did not encounter target zone of substantial organics. Gravel in shoe. |
| 7.0 to 8.0 | MW-1-7' | 10<br>20<br>22 | | 5 | SP | Drilled to 7 feet and drove sample again, but did not encounter target zone of substantial organics.<br>Brown, damp, trace to slightly silty, gravelly, medium to fine SAND (Native soil). |
| 8 Feet | | | | | | |
| 10 | | | | | | |
| | | | | ATD | | Water level approximately 14.0 feet below ground surface at time of drilling. |
| 14.0 to 15.0 | MW-1-14' | 40<br>36<br>50 | | 80 | GP | Gray, wet, sandy gravel zone approximately 3-inch thick. Strong hydrocarbon-like odor, sheen on gravel. |
| 15 | | | | | | |
| | | | | | SP | Gray, wet, trace to slightly silty, gravelly, medium to fine SAND. |
| 20 | | | | | | Total depth = 20 feet. |

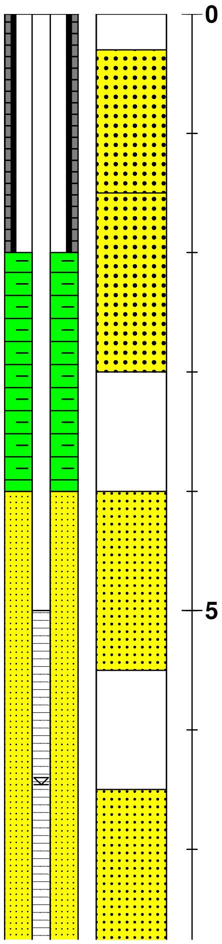
Construction Notes: Installed 2-inch diameter PVC well screen from 20 to 10 feet (see as-built diagram this page). Completed at the ground surface in concrete pad with steel, traffic-rated well monument. No water added during drilling except to hydrate bentonite seal.

AECOM

# Boring/Well Log

**Well #: MW-2**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174871.1516** Easting: **1271948.3761** | Ground Elevation: **299.891 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **15.5'** |
| Start Date & Time: **3/18/08 0800** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 0850** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 5-15 ft-bgs** |



| Sample<br>Type & Number | Sample<br>Depth Range | Sample<br>% Rec | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|
| SS-1 | 0.0-1.5 | 66 | (0.0-0.3) MULCH<br>(0.3-1.5) SP: POORLY GRADED SAND, dark yellowish brown, fine, medium dense, moist. Trace rootlets, and fine, rounded, gravel. No odor or visible contamination. | | Flush Mount Monument<br>2-inch Sch. 40 PVC riser from 0-5 ft-bgs |
| SS-2 | 1.5-3.0 | 72 | (1.5-3.0) SP: POORLY GRADED SAND, light yellowish gray, fine, medium dense, moist. One large, long root, 1/8" in diameter. Trace coarse sand, and rounded, fine gravel, up to 0.5" in diameter. No odor or visible contamination. | | 0.0-0.5' Sampled for analytical<br>1.5-2.0' Sampled for analytical |
| | | | (3.0-4.0) Not Sampled. | | Bentonite seal from 2 to 4 ft-bgs |
| SS-3 | 4.0-5.5 | 66 | (4.0-5.5) SW: WELL GRADED SAND, yellowish gray grading to dark yellowish gray, fine to medium, dense, moist to wet. Trace fine gravel, up to 3/4" in diameter. No odor or visible contamination. | 295 | |
| | | | (5.5-6.5) Not Sampled. | | |
| SS-4 | 6.5-8.0 | 75 | (6.5-8.0) SW: WELL GRADED SAND, yellowish brown, fine to coarse, very dense, wet. Trace rounded, fine gravel, up to 3/4" in diameter. No odor or visible contamination. | | 6.5-8.0' Sampled for analytical |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**Amb. - ambient air**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

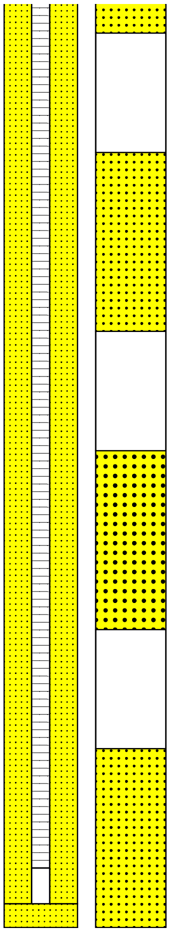
| Groundwater | | |
|---|---|---|
| Date | Time | Depth (ft.) |
| **03/18/08** | **0944** | **6.46'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-2**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174871.1516** Easting: **1271948.3761** | Ground Elevation: **299.891 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **15.5'** |
| Start Date & Time: **3/18/08 0800** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 0850** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 5-15 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | | (8.0-9.0) Not Sampled. | | |
| **SS-5** | **9.0-10.5** | **66** | **10** | (9.0-10.5) SW: WELL GRADED SAND, grayish brown, fine to medium, very dense, wet. 10% coarse sand to fine gravel, up to 3/4" in diameter. 10% silt. No odor or visible contamination. | 290 | 2-inch diameter 0.010 inch slot, Sch. 40 PVC screen from 5 to15 ft-bgs |
| | | | | (10.5-11.5) Not Sampled. | | |
| **SS-6** | **11.5-13.0** | **83** | | (11.5-13.0) SP: POORLY GRADED SAND, brown to grayish brown, very fine, dense, wet. At 11.5-11.7', sub angular, fine to coarse sand, and coarse gravel, up to 2" long. At 12.25', 4" thick lense of fine sand. No odor or visible contamination. | | 10/20 silica sand pack from 4 to 15.5 ft-bgs |
| | | | | (13.0-14.0) Not Sampled. | | 14-15.5' Sampled for analytical |
| **SS-7** | **14.0-15.5** | **-** | **15** | (14.0-15.5) SW: WELL GRADED SAND, brownish gray, fine to medium, very dense, wet.. Sharp contact at 15.3' with sub angular to sub rounded, medium sand. No odor or visible contamination. | 285 | Slight heaving sand |

| | | | | | |
|---|---|---|---|---|---|
| **Remarks and Datum Used:** | | **Sample Type** | **Groundwater** | | |
| | | N = SPT | Date | Time | Depth (ft.) |
| **AECOM - Environment**<br>**710 2nd Ave. Suite 1000**<br>**Seattle, WA 98104**<br>**Phone: (206) 624-9349**<br>**Fax: (206) 623-3793** | **HSA - Hollow Stem Auger** | DP = Direct Push | **03/18/08** | **0944** | **6.46'** |
| | **Sch. - Schedule** | SS = Split Spoon | | | |
| | **Amb. - ambient air** | C = Core | | | |

AECOM

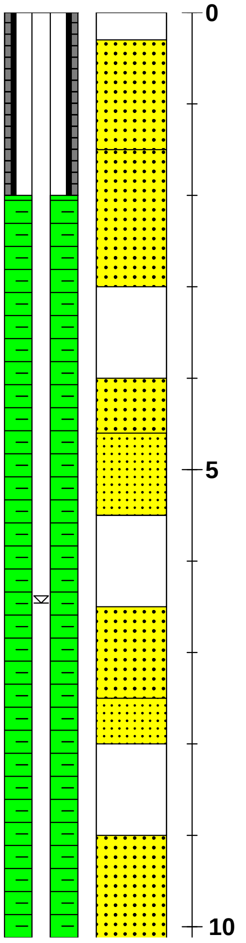
# Boring/Well Log

**Well #: MW-3**
**Sheet 1 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174355.3983** Easting: **1272271.6255** | Ground Elevation: **300.36 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **25.5'** |
| Start Date & Time: **3/18/08 1015** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1115** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-23 ft-bgs** |

| Sample | | |
|---|---|---|
| **Type & Number** | **Depth Range** | **% Rec** |
| **SS-1** | **0.0-1.5** | **66** |
| **SS-2** | **1.5-3.0** | **72** |
| **SS-3** | **4.0-5.5** | **66** |
| **SS-4** | **6.5-8.0** | **75** |
| **SS-5** | **9.0-10.5** | **66** |

**Well Completion Log** | **Graphic** | **Depth (ft.)**



## Soil and Rock Description

Classification Scheme: **USCS/ASTM**

(0.0-0.3) MULCH

(0.3-1.5) SP: POORLY GRADED SAND, dark yellowish brown to yellowish brown, fine, dense, moist. 10% medium to coarse sand and rounded, fine to coarse gravel, up to 1.5" long. Trace rootlets. No odor or visible contamination.

(1.5-3.0) SP: POORLY GRADED SAND, brown to slightly dark brown, fine, dense, moist. 10% medium to coarse sand. Trace, elongated, fine to coarse gravel, up to 1.5" long. No odor or visible contamination.

(3.0-4.0) Not Sampled.

(4.0-4.6) SP: POORLY GRADED SAND, brown to dark brown, fine, dense, moist. 10% rounded to sub rounded, elongate, coarse sand and fine gravel, up to 0.5" long. No odor or visible contamination.

(4.6-5.5) SW: WELL GRADED SAND, yellowish brown, fine to medium, dense, moist. Trace rounded, coarse sand and fine gravel, up to 0.5" in diameter. No odor or visible contamination.

(5.5-6.5) Not Sampled.

(6.5-7.5) SP: POORLY GRADED SAND, brown to dark brown, fine, very dense, moist. 20% medium to coarse sand. 10% rounded, fine gravel, up to 1/4" in diameter. No odor or visible contamination.

(7.5-8.0) SW: WELL GRADED SAND, yellowish brown, fine to medium. Trace rounded coarse sand and fine gravel, up to 1/2" long. No odor or visible contamination.

(8.0-9.0) Not Sampled.

**Elevation (ft.)**

300
295

## Comments & Samples

Flush Mount Monument 2-inch diameter, Sch. 40 PVC riser from 0-13 ft-bgs

0.0-0.5' Sampled for analytical; mulch not included in sample

1.5-2.0' Sampled for analytical

Bentonite seal from 2 to 11 ft-bgs

6.5-8.0' Sampled for analytical

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**Amb. - ambient air**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

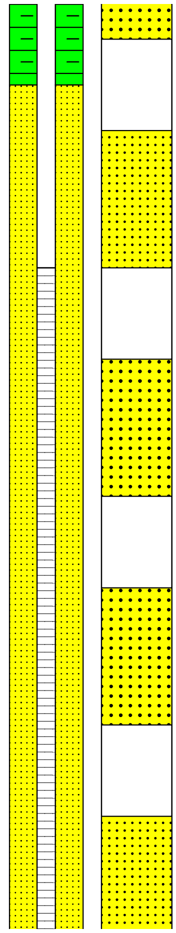
| Groundwater | | |
|---|---|---|
| Date | Time | Depth (ft.) |
| **03/18/08** | **1220** | **17.46'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-3**
**Sheet 2 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174355.3983** Easting: **1272271.6255** | Ground Elevation: **300.36 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **25.5'** |
| Start Date & Time: **3/18/08 1015** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1115** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-23 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | **10** | | 290 | |
| | | | | (9.0-10.5) SP: POORLY GRADED SAND, light yellowish gray, fine, very dense. 20% medium to coarse sand. Trace rounded, fine gravel, up to 3/4" long. No odor or visible contamination. | | 2-inch diameter, 0.010-inch slot, Sch. 40 PVC screen from 13 to 23 ft-bgs |
| | | | | (10.5-11.5) Not Sampled. | | |
| **SS-6** | **11.5-13.0** | **83** | | (11.5-13.0) SW: WELL GRADED SAND, light grayish brown to brown, fine to medium, very dense. 15% coarse sand. 10-15% sub rounded to rounded, fine to coarse gravel, up to 1" in diameter. Trace silt and iron staining. No odor or visible contamination. | | |
| | | | | (13.0-14.0) Not Sampled. | | |
| **SS-7** | **14.0-15.5** | **-** | **15** | (14.0-15.5) SP: POORLY GRADED SAND, yellowish brown, fine, very dense, moist to wet. Trace medium sand and silt. No odor or visible contamination. | 285 | 14-15.5' Sampled for analytical<br>10/20 silica sand pack from 11 to 23.5 ft-bgs |
| | | | | (15.5-16.5) Not Sampled. | | |
| **SS-8** | **16.5-18** | **94** | | (16.5-18.0) SP: POORLY GRADED SAND, brownish gray, medium, very dense, moist to wet. 10-15% fine sand. Trace silt. No odor or visible contamination. | | |
| | | | | (18.0-19.0) Not Sampled. | | |
| **SS-9** | **19.0-20.5** | **77** | **20** | (19.0-20.5) SW: WELL GRADED SAND, grayish brown to brown, fine to medium, very dense, wet. Trace silt and mica flakes. 10% winnowing. No odor or visible contamination. | 280 | |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**Amb. - ambient air**

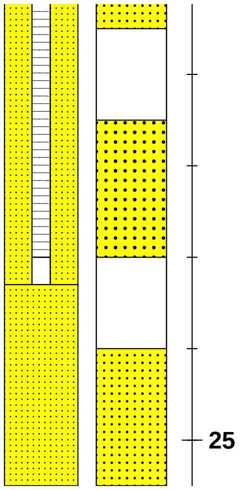
**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

| Groundwater | | |
|---|---|---|
| Date | Time | Depth (ft.) |
| **03/18/08** | **1220** | **17.46'** |
| | | |
| | | |

# Boring/Well Log

**Well #: MW-3**
**Sheet 3 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174355.3983** Easting: **1272271.6255** | Ground Elevation: **300.36 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **25.5'** |
| Start Date & Time: **3/18/08 1015** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1115** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-23 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Soil and Rock Description (Classification Scheme: **USCS/ASTM**) | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|
| | | | | 280 | |
| | | | (20.5-21.5) Not Sampled. | | |
| **SS-10** | **21.5-23.0** | **92** | (21.5-23.0) SP: POORLY GRADED SAND, gray to bluish gray, fine, very dense, wet. Abundant wood pieces. Trace large, mica flakes. 2mm thick lamination in soil layer. Very slight H2S-like odor. No visible contamination. | | |
| | | | (23.0-24.0) Not Sampled. | | |
| **SS-11** | **24.0-25.5** | **100** | (24.0-25.5) SW: WELL GRADED SAND, slightly yellowish brown ro gray, medium to fine, very dense, wet. Iron stained beds, up to 1/4" thick at top of interval. No odor or visible contamination. | 275 | heaving sand, filled top foot of SS-11 with slough |

| **Remarks and Datum Used:** | | **Sample Type** | **Groundwater** | | |
|---|---|---|---|---|---|
| | | N = SPT | Date | Time | Depth (ft.) |
| **AECOM - Environment**<br>**710 2nd Ave. Suite 1000**<br>**Seattle, WA 98104**<br>**Phone: (206) 624-9349**<br>**Fax: (206) 623-3793** | **HSA - Hollow Stem Auger** | DP = Direct Push | **03/18/08** | **1220** | **17.46'** |
| | **Sch. - Schedule** | SS = Split Spoon | | | |
| | **Amb. - ambient air** | C = Core | | | |

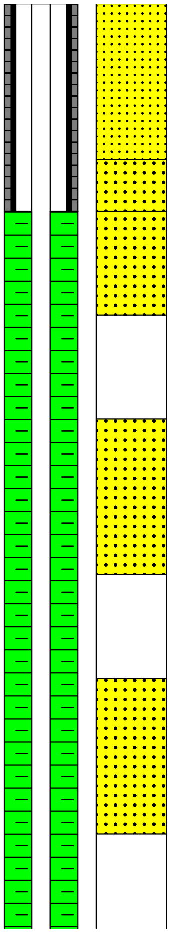
AECOM

# Boring/Well Log

**Well #: MW-4**
**Sheet 1 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174435.4039** Easting: **1272496.5424** | Ground Elevation: **294.562 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **26'** |
| Start Date & Time: **3/17/08 1400** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1515** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 11-25.75 ft-bgs** |

Classification Scheme: **USCS/ASTM**



| Sample<br>Type & Number | Sample<br>Depth Range | Sample<br>% Rec | Depth (ft.) | Soil and Rock Description | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| **SS-1** | **0.0-1.5** | **66** | **0** | (0.0-1.5) SW: SAND, brown, fine to medium, medium dense, moist. 20% rounded, coarse sand to fine gravel. Trace silt and rounded, coarse gravel, up to 1" long. Abundant grass and rootlets from 0.0-0.2'. Moderate organic-like odor, no visible contamination. | | Flush Mount Monument 2-inch diameter, Sch. 40 PVC riser from 0 to 11 ft-bgs |
| **SS-2** | **1.5-3.0** | **72** | | (1.5-2.0) SP: POORLY GRADED SAND, brown, fine, medium dense, moist. 15% silt. Trace rounded, fine, gravel. Organic-like odor, no visible contamination. | | |
| | | | | (2.0-3.0) SP: POORLY GRADED SAND, yellowish brown with pockets of gray from 2.5-3', fine, medium dense, moist. 20% medium sand from 2-2.5'. Trace rounded, fine gravel. No odor or visible contamination. | | 0.0-0.5' Sampled for analytical |
| | | | | (3.0-4.0) Not Sampled. | 290 | 1.5-2.0' Sampled for analytical |
| **SS-3** | **4.0-5.5** | **66** | **5** | (4.0-5.5) SP: POORLY GRADED SAND, yellowish brown grading to light yellowish brown at 5.0', fine, medium dense, moist. 20% medium sand from 4-5'. Trace rounded, fine gravel, content decreases downhole. Trace rootlets at 4.5'. No odor or visible contamination. | | Bentonite seal from 2 to 9 ft-bgs |
| | | | | (5.5-6.5) Not Sampled. | | |
| **SS-4** | **6.5-8.0** | **75** | | (6.5-8.0) SP: POORLY GRADED SAND, yellowish brown, medium, very dense, moist. 20% rounded, fine to coarse gravel. Trace rootlets. No odor or visible contamination. | | |
| | | | | (8.0-9.0) Not Sampled. | | |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**-**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

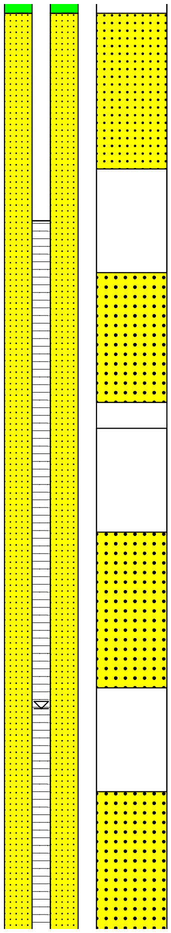
| Date | Time | Depth (ft.) |
|---|---|---|
| **03/17/08** | **1644** | **15.70'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-4**
**Sheet 2 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174435.4039** Easting: **1272496.5424** | Ground Elevation: **294.562 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **26'** |
| Start Date & Time: **3/17/08 1400** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1515** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 11-25.75 ft-bgs** |



Well Completion Log / Graphic

| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| **SS-5** | **9.0-10.5** | **66** | **10** | (9.0-10.5) SW: WELL GRADED SAND WITH GRAVEL, brown to yellowish brown, fine to coarse, very dense, moist. 30% rounded to sub rounded, flat, elongate, fine to coarse gravel, up to 1" long. Slight sweet odor, no visible contamination. | 285 | 9.5-10.5' Sampled for analytical |
| | | | | (10.5-11.5) Not Sampled. | | 2-inch diameter, 0.010-inch slot, Sch. 40 PVC screen from 11 to 25.75 ft-bgs |
| **SS-6** | **11.5-13.0** | **83** | | (11.5-13.0) SP: POORLY GRADED SAND, slightly yellowish brown grading to yellowish gray, fine, dense, moist. Few 0.5" thick lenses of very fine sand. Trace coarse sand. No odor or visible contamination. | | |
| | | | | (13.0-14.0) Not Sampled. | | |
| **SS-7** | **14.0-15.5** | **-** | **15** | (14.0-15.5) SP: POORLY GRADED SAND, brownish gray, fine, very dense, moist. 10-15% silt. Trace mica. No odor or visible contamination. | 280 | 14-15.5' Sampled for analytical<br>10/20 silica sand pack from 9 to 26 ft-bgs |
| | | | | (15.5-16.5) Not Sampled. | | |
| **SS-8** | **16.5-18** | **94** | | (16.5-18.0) SP: POORLY GRADED SAND, gray to grayish brown, fine, very dense, moist. 20% medium sand at 16.75-17'. Little iron staining at 17.5-18'. At 17.9', 4mm thick black and iron stained bed. No odor or visible contamination. | | |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**-**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

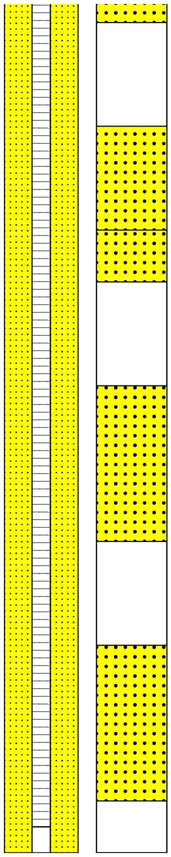
**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **03/17/08** | **1644** | **15.70'** |
| | | |
| | | |

# Boring/Well Log

**Well #: MW-4**
**Sheet 3 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174435.4039** Easting: **1272496.5424** | Ground Elevation: **294.562 ft.** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **26'** |
| Start Date & Time: **3/17/08 1400** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1515** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 11-25.75 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | | (18.0-19.0) Not Sampled. | | |
| **SS-9** | **19.0-20.5** | **77** | | (19.0-20.0) SP: POORLY GRADED SAND, gray, fine, very dense, wet. 2.5" long, gray, friable, clay pocket with one white rock at 19.75'. No odor or visible contamination. | 275 | |
| | | | **20** | (20.0-20.5) SP: POORLY GRADED SAND, brown, fine, very dense, wet. Trace rounded, coarse sand. No odor or visible contamination. | | |
| | | | | (20.5-21.5) Not Sampled. | | |
| **SS-10** | **21.5-23.0** | **92** | | (21.5-23.0) SP: POORLY GRADED SAND, brown to slightly yellowish brown, fine, very dense, wet. Wood pieces and gray sand at top of interval. No odor or visible contamination. | | |
| | | | | (23.0-24.0) Not Sampled. | | Slight heaving sand at bottom of borehole |
| **SS-11** | **24.0-25.5** | **100** | **25** | (24.0-25.5) SP: POORLY GRADED SAND, yellowish brown to brown, medium, very dense, wet. 25% winnowing. No odor or visible contamination. | 270 | |
| | | | | (25.5-26.0) Not Sampled. | | |

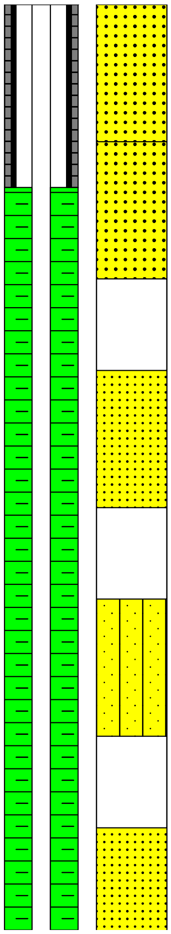
| | | | | | |
|---|---|---|---|---|---|
| **Remarks and Datum Used:** | | **Sample Type** | **Groundwater** | | |
| | | N = SPT | Date | Time | Depth (ft.) |
| **AECOM - Environment**<br>**710 2nd Ave. Suite 1000**<br>**Seattle, WA 98104**<br>**Phone: (206) 624-9349**<br>**Fax: (206) 623-3793** | **HSA - Hollow Stem Auger** | DP = Direct Push | **03/17/08** | **1644** | **15.70'** |
| | **Sch. - Schedule** | SS = Split Spoon | | | |
| | **-** | C = Core | | | |

AECOM

# Boring/Well Log

**Well #: MW-5**
**Sheet 1 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174563.4071** Easting: **1272562.8511** | Ground Elevation: **295.151'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **28'** |
| Start Date & Time: **3/17/08 1025** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1210** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-28 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| **SS-1** | **0.0-1.5** | **66** | **0** | (0.0-1.5) SP: POORLY GRADED SAND, brown to dark brown, fine, loose, moist. 15% rounded, fine gravel, 0.25-0.5" long. One rounded gravel, 3" in diameter. Trace straw. No odor or visible contamination. | 295 | Flush Mount Monument<br>2-inch diameter Sch. 40 PVC riser from 0 to 13 ft-bgs |
| **SS-2** | **1.5-3.0** | **100** | | (1.5-3.0) SP: POORLY GRADED SAND, yellowish brown, fine, dense, moist. Trace coarse sand to fine gravel, rounded, up to 0.5" long. No odor or visible contamination. | | 0.0-0.5' Sampled for analytical |
| | | | | (3.0-4.0) Not Sampled. | | 1.5-2.0' Sampled for analytical |
| **SS-3** | **4.0-5.5** | **91** | **5** | (4.0-5.5) SW: WELL GRADED SAND, yellowish brown, fine to medium, very dense, moist. 20% sub rounded, gravel, up to 1/2" in diameter. Gravel content increases to 30% with depth. No odor or visible contamination. | 290 | Bentonite seal from 2 to 11 ft-bgs |
| | | | | (5.5-6.5) Not Sampled. | | |
| **SS-4** | **6.5-8.0** | **100** | | (6.5-8.0) SM: SILTY SAND, gray to slightly brownish gray, fine, very dense, moist. 20% silt. 10% rounded, sand and fine gravel. One gravel up to 2" long. No odor or visible contamination. | | 6.5-8.0' Sampled for analytical |
| | | | | (8.0-9.0) Not Sampled. | | |
| **SS-5** | **9.0-10.5** | **75** | **10** | (9.0-10.5) SW: WELL GRADED SAND, gray to brownish gray, fine to medium, very dense, moist to wet. Trace coarse sand, fine gravel, and 1" thick pockets of silt and very fine sand. Trace hydrocarbon-like odor in 0.5" thick silt lense at 10.5'. No visible contamination. | 285 | |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**-**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

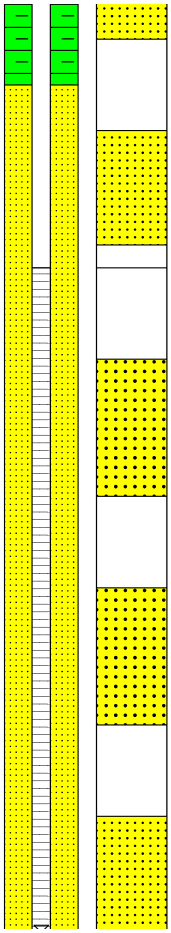
| Groundwater: Date | Groundwater: Time | Groundwater: Depth (ft.) |
|---|---|---|
| **03/17/08** | **1332** | **20.27'** |
| | | |
| | | |

# Boring/Well Log

**Well #: MW-5**
**Sheet 2 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174563.4071** Easting: **1272562.8511** | Ground Elevation: **295.151'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **28'** |
| Start Date & Time: **3/17/08 1025** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1210** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-28 ft-bgs** |

Well Completion Log / Graphic



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | 10 | | 285 | |
| | | | | (10.5-11.5) Not Sampled. | | |
| **SS-6** | **11.5-13.0** | **88** | | (11.5-12.75) SW: WELL GRADED SAND, fine to medium, very dense, moist. 15% rounded, fine to coarse gravel, up to 1.5" long. 2" thick, light gray silt lense at 12' with a slight hydrocarbon-like odor. Trace wood peices at 12.5', no odor. No visible contamination. | | 11.5-13.0' Sampled for analytical |
| | | | | (12.75 - 13.0) ML-SM: SILT WITH SAND TO SILTY SAND, dark gray, fine, very dense. At 13', 20% rounded, fine gravel, from 1/4- 3/8" in diameter. Slight to moderate hydrocarbon-like odor, no visible contamination. | | 2-inch diameter, 0.010-inch slot, Sch. 40, PVC screen from 13 to 28 ft-bgs |
| | | | | (13.0-14.0) Not Sampled. | | |
| **SS-7** | **14.0-15.5** | **77** | 15 | (14.0-15.5) SP: POORLY GRADED SAND, dark gray, fine, medium dense, moist. 15% rounded, medium to coarse sand. Trace silt. No odor or visible contamination. | 280 | |
| | | | | (15.5-16.5) Not Sampled. | | |
| **SS-8** | **16.5-18** | **72** | | (16.5-18.0) SP: POORLY GRADED SAND, gray to light gray, fine from 16.5-17', medium from 17-18', very dense, wet. Trace rounded, fine, gravel with medium sand. Trace silt with fine sand. No odor or visible contamination. | | 10/20 silica sand pack from 11 to 28 ft-bgs |
| | | | | (18.0-19.0) Not Sampled. | | |
| **SS-9** | **19.0-20.5** | **77** | 20 | (19.0-20.5) SW: WELL GRADED SAND, gray, medium to coarse, medium dense, wet . 10-15% sub rounded, fine gravel. At 20.25', silt lense, 0.5" thick, no plasticity. No odor or visible contamination. | 275 | |

**Remarks and Datum Used:**

**AECOM - Environment**
**710 2nd Ave. Suite 1000**
**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**-**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

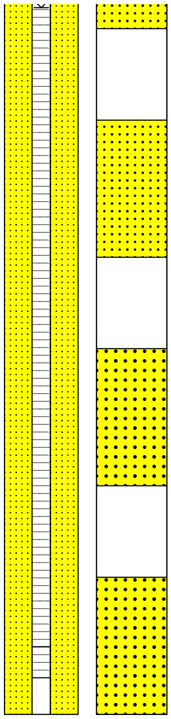
| Date | Time | Depth (ft.) |
|---|---|---|
| **03/17/08** | **1332** | **20.27'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-5**
**Sheet 3 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174563.4071** Easting: **1272562.8511** | Ground Elevation: **295.151'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **28'** |
| Start Date & Time: **3/17/08 1025** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/17/08 1210** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 13-28 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | | | 275 | |
| | | | | (20.5-21.5) Not Sampled. | | |
| **SS-10** | **21.5-23.0** | **66** | | (21.5-23.0) SW: WELL GRADED SAND, grayish brown grading to yellowish brown, sub angular to sub rounded, very dense, wet. 20% sub angular to rounded, elongated, fine to coarse, gravel. No odor or visible contamination. | | |
| | | | | (23.0-24.0) Not Sampled. | | |
| **SS-11** | **24.0-25.5** | **100** | **25** | (24.0-25.5) SP: POORLY GRADED SAND, grayish brown, fine, very dense, wet. Trace medium sand and rounded, fine gravel. No odor or visible contamination. | 270 | |
| | | | | (25.5-26.5) Not Sampled. | | |
| **SS-12** | **26.5-28** | **100** | | (26.5-28.0) SP: POORLY GRADED SAND, gray from 26.5-27.0', sharp contact to yellowish brown at 27.0', fine, very dense, wet. 15% gray, medium to coarse sand. Trace, soft, silt. 50% winnowing. No odor or visible contamination. | | Slight heaving sand at bottom of borehole |

| **Remarks and Datum Used:** | | **Sample Type** |
|---|---|---|
| **AECOM - Environment**<br>**710 2nd Ave. Suite 1000**<br>**Seattle, WA 98104**<br>**Phone: (206) 624-9349**<br>**Fax: (206) 623-3793** | **HSA - Hollow Stem Auger**<br>**Sch. - Schedule**<br>**-** | N = SPT<br>DP = Direct Push<br>SS = Split Spoon<br>C = Core |

**Groundwater**

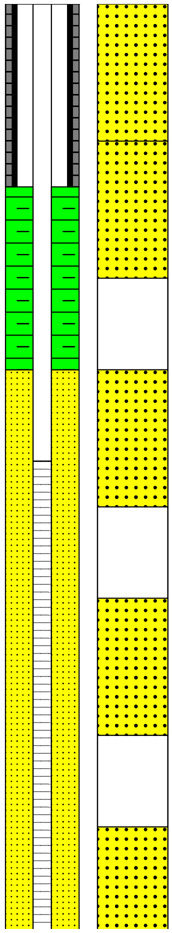
| Date | Time | Depth (ft.) |
|---|---|---|
| **03/17/08** | **1332** | **20.27'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-6**
**Sheet 1 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174850.9922** Easting: **1272784.1135** | Ground Elevation: **291.083'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **3/18/08 1344** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1445** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 5-15 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| **SS-1** | **0.0-1.5** | **83** | **0** | (0.0-1.5) SP: POORLY GRADED SAND, brown, fine, medium dense, moist. 20-25% silt. 10% medium to coarse sand. Trace fine gravel, up to 1/4" in diameter. Abundant rootlets throughout, grass on top. Moderate organic odor, no visible contamination. | 290 | Flush Mount Monument 2-inch diameter Sch. 40 PVC riser from 0 to 5 ft-bgs |
| **SS-2** | **1.5-3.0** | **66** | | (1.5-3.0) SP: POORLY GRADED SAND, brown to slightly dark brown, fine, very dense, moist. 20% silt. Trace rounded, coarse sand to fine gravel. Little rootlets. Friable. Moderate organic odor, no visible contamination. | | 0.0-0.5' Sampled for analytical |
| | | | | (3.0-4.0) Not Sampled. | | |
| **SS-3** | **4.0-5.5** | **66** | **5** | (4.0-5.5) SP: POORLY GRADED SAND, slightly reddish brown, fine, loose, moist. 10-15% medium to coarse sand. Trace rounded, fine gravel, up to 3/4" in diameter. Trace rootlets in catcher. No odor or visible contamination. | | 1.5-2.0' Sampled for analytical |
| | | | | (5.5-6.5) Not Sampled. | 285 | 6.5-8.0' Sampled for analytical |
| **SS-4** | **6.5-8.0** | **72** | | (6.5-8.0) SP: POORLY GRADED SAND, reddish brown grading to light reddish brown, fine, medium dense, moist. Trace fine gravel, up to 1/2" in diameter. No odor or visible contamination. | | |
| | | | | (8.0-9.0) Not Sampled. | | |
| **SS-5** | **9.0-10.5** | **94** | **10** | (9.0-10.5) SP: POORLY GRADED SAND, gray with iron staining, fine, dense, moist. Trace organic matter and silt. No odor or visible contamination. | | Bentonite seal |

**Remarks and Datum Used:**

**AECOM - Environment**
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**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**Amb. - ambient air**

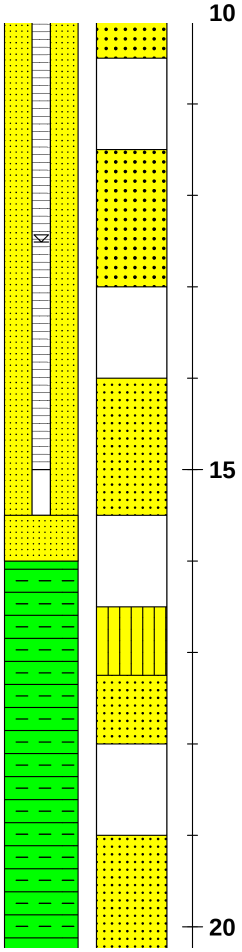
**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

| Groundwater: Date | Time | Depth (ft.) |
|---|---|---|
| **03/18/08** | **1553** | **12.51'** |
| | | |
| | | |

# Boring/Well Log

**Well #: MW-6**
**Sheet 2 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174850.9922** Easting: **1272784.1135** | Ground Elevation: **291.083'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **3/18/08 1344** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1445** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 5-15 ft-bgs** |



| Sample: Type & Number | Sample: Depth Range | Sample: % Rec | Depth (ft.) | Soil and Rock Description (Classification Scheme: USCS/ASTM) | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|
| | | | 10 | | | from 2 to 4 ft-bgs |
| | | | | (10.5-11.5) Not Sampled. | 280 | |
| **SS-6** | **11.5-13.0** | **92** | | (11.5-13.0) SP: POORLY GRADED SAND, gray, fine, very dense, wet. 25% sub angular, fine to coarse gravel. 10% coarse sand. Slight to moderate soapy-like to hydrocarbon-like odor, no visible contamination. | | 11.5-13.0' Sampled for analytical |
| | | | | (13.0-14.0) Not Sampled. | | 2-inch diameter, 0.010-inch slot, Sch. 40 PVC screen from 5 to 15 ft-bgs |
| **SS-7** | **14.0-15.5** | **100** | 15 | (14.0-15.5) SW: WELL SORTED SAND, gray to brownish gray, fine to coarse, very dense, wet. 10-15% rounded, fine to coarse gravel, up to 2" in diameter. Trace to little iron mottles. Slight soapy-like to hydrocarbon-like odor, no visible contamination. | | |
| | | | | (15.5-16.5) Not Sampled. | 275 | 10/20 silica sand pack from 4 to 16 ft-bgs |
| **SS-8** | **16.5-18** | **61** | | (16.5-17.25) ML: SILT, gray to brownish gray, high plasticity, hard, wet. 15% clay. Slight soap-like odor, no visible contamination. | | |
| | | | | (17.25-18.0) SW: WELL GRADED SAND, gray, fine to coarse, very dense, wet. 25% rounded, fine gravel, up to 1/2" in diameter. Slight soap-like odor, no visible contamination. | | Bentonite from 16 to 20.5 ft-bgs |
| | | | | (18.0-19.0) Not Sampled. | | |
| **SS-9** | **19.0-20.5** | **55** | 20 | (19.0-20.3) SW: WELL GRADED SAND, gray, fine to medium, very dense, wet. 10% silt and rounded, fine gravel, up to 1/4" in diameter. No odor or visible contamination. | | 19.0-20.5' Sampled for analytical |

**Remarks and Datum Used:**

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**Seattle, WA 98104**
**Phone: (206) 624-9349**
**Fax: (206) 623-3793**

**HSA - Hollow Stem Auger**
**Sch. - Schedule**
**Amb. - ambient air**

**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **03/18/08** | **1553** | **12.51'** |
| | | |
| | | |

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# Boring/Well Log

**Well #: MW-7**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174801.0531** Easting: **1272865.8926'** | Ground Elevation: **288.525'** |
| Location: **NE of Des Moines Memorial Dr.** | Drill Rig Type: **HSA** | MP Elevation: **287.907'** |
| Client: **Port of Seattle** | Method: **Split Spoon** | Total Depth: **25.5'** |
| Start Date & Time: **10/22/08 1110** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **10/22/08 1210** | Boring ID: **8.25"** | Seal: **Bentionie Chips** |
| Contractor: **Cascade Drilling** | Bit Type: **HSA Coring Bit** | Grout: **-** |
| Operator: **Dave** | Logged By: **R. Knecht** | Screen: **Sch. 40 PVC from 15-24.6 ft-bgs** |

| Sample: Type & | Sample: Depth Range | Sample: % Rec | Sample: Blows per 6" | Sample: PID (ppm) | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | (0.0-5.0) Asphalt from 0-1'. Not sampled. | 285 | Flush mount monument.<br>Bentonite chip plug from 1.5-13 ft-bgs. 2-inch, Sch. 40 PVC riser from 0.7-15 ft-bgs. |
| **SS-1** | **5-6.5** | **66** | **12<br>18<br>20** | **-** | | | 5 | (5.0-6.5) SP: POORLY GRADED SAND, dark brown to yellowish brown at 5.5', fine, dense, dry. 15% sub angular to rounded, fine gravel from 5-5.5'. 10% reddish brown silt with 1" thick mottles from 5.5-6.5'. No odor or visible contamination. | | |
| | | | | | | | | (6.5-10.0) Not sampled. | 280 | |
| **SS-2** | **10-11.5** | **100** | **50/6"** | **-** | | | 10 | (10.0-11.5) SW: WELL GRADED SAND, light yellowish brown, fine to medium, sub rounded to sub angular, equant, very dense, dry to moist. 20% rounded, elongate to equant, coarse gravel up to 2.5" long. Flat piece of concrete, 0.5" long. Trace coarse sand and silt. No odor or visible contamination. | | |
| | | | | | | | | (11.5-12.5) Not sampled. | | |
| **SS-3** | **12.5-14** | **33** | **50/6"** | **-** | | | | (12.5-14.0) SP: POORLY GRADED SAND, brown, fine, equant, very dense, moist. 20% rounded, fine gravel and coarse sand. 20% silt. No odor or visible contamination. | 275 | 10/20 silica sand pack from 13-26.5 ft-bgs. |
| | | | | | | | 15 | (14.0-15.0) Not sampled. | | |

**Remarks and Datum Used:**

**HSA = Hollow Stem Auger**
**Sch. = Schedule**
**ft-bgs = feel below ground surface**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **10/22/08** | **1300** | **16.65'** |
| **10/22/08** | **1215** | **19'** |

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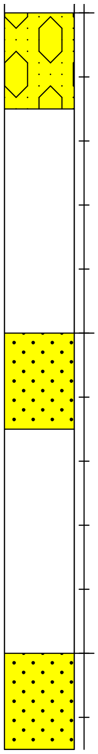
# Boring/Well Log

**Well #: MW-7**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174801.0531** Easting: **1272865.8926'** | Ground Elevation: **288.525'** |
| Location: **NE of Des Moines Memorial Dr.** | Drill Rig Type: **HSA** | MP Elevation: **287.907'** |
| Client: **Port of Seattle** | Method: **Split Spoon** | Total Depth: **25.5'** |
| Start Date & Time: **10/22/08 1110** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **10/22/08 1210** | Boring ID: **8.25"** | Seal: **Bentionie Chips** |
| Contractor: **Cascade Drilling** | Bit Type: **HSA Coring Bit** | Grout: **-** |
| Operator: **Dave** | Logged By: **R. Knecht** | Screen: **Sch. 40 PVC from 15-24.6 ft-bgs** |



| Sample: Type & | Sample: Depth Range | Sample: % Rec | Sample: Blows per 6" | Sample: PID (ppm) | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| **SS-4** | **15-16.5** | **100** | **50/6"** | **-** | | | **15** | (15.0-16.5) SW: WELL GRADED SAND, yellowish brown to dark brown, fine to medium, sub rounded to sub angular, equant, very dense, wet at 15.5'. 20-25% rounded to sub angular, fine gravel from 16.3-16.5'. Large, rounded, gravel up to 2" wide and long at 15.25'. No odor or visible contamination. | | 2-inch, 0.010-slot, sch. 40 PVC screen from 15-24.6 ft-bgs. |
| | | | | | | | | (16.5-20.0) Not sampled. | 270 | 15-16.5', sample collected for analytical. |
| **SS-5** | **20-21.5** | **100** | **50/6"** | **-** | | | **20** | (20.0-21.5) SP: POORLY GRADED SAND, brown to yellowish brown, fine, rounded, equant, very dense, wet. 20% medium sand. 15-20% sile. 10% rounded, fine gravel up to 1" long from 21.2-21.5'. Silty sand lense at 20.3'. No odor or visible contamination. | | |
| | | | | | | | | (21.5-25.0) Not Sampled. | 265 | 2-inch PVC end cap from 24.6-25 ft-bgs. |
| **SS-6** | **25-26.5** | **83** | **50/6"** | **-** | | | **25** | (25.0-26.5) SP: POORLY GRADED SAND, dark gray, fine, very dense, wet. Trace medium to coarse sand and silt. Slight rotten egg-like odor, no visible contamination. | | 25-25.5', sample collected for analytical. |

**Remarks and Datum Used:**

**HSA = Hollow Stem Auger**
**Sch. = Schedule**
**ft-bgs = feel below ground surface**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **10/22/08** | **1300** | **16.65'** |
| **10/22/08** | **1215** | **19'** |
| | | |

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# Boring/Well Log

**Well #: MW-8**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174627.2741** Easting: **1272775.8574'** | Ground Elevation: **282.534'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **287.907'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1357** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1429** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| | | | | | | | 0 | (0.0-5.0) Not sampled. | 280 | Flush mount monument.<br>Bentonite chip plug from 1.5-8 ft-bgs. |
| **SS -1** | **5-6.5** | **80** | **7<br>8<br>17** | **0.4<br>aa=<br>0.4** | | | 5 | (5.0-6.5) SW: WELL GRADED SAND, brown, fine to coarse, sub angular to sub rounded, medium dense, dry. Trace rootlets. No odor or visible contamination. | | 2-inch schedule 40 riser pipe from 0-10 ft-bgs. |
| | | | | | | | | (6.5-10.0) Not sampled. | 275 | 10/20 silica sand pack from 8-20.5 ft-bgs. |
| | | | | | | | | (10.0-10.4) SM: SILTY SAND, gray and brown, fine to medium, very dense, moist. 40% silt. Trace, angular, coarse sand. Trace rootlets. No odor or visible contamination. | | |
| **SS -2** | **10-11.5** | **46** | **50/6"** | **0.3<br>aa=<br>0.3** | | | 10 | (10.4-11.5) SP: POORLY GRADED SAND, brown, fine, very dense, moist. Trace coarse sand. One rounded peice of large gravel. No odor or visible contamination. | | 0.010-inch slot, 2-inch schedule 40 PVC screen from 10-20 ft-bgs. |
| | | | | | | | | (11.5-12.5) Not sampled. | 270 | |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **1415** | **12'** |
| | | |
| | | |

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# Boring/Well Log

**Well #: MW-8**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174627.2741** Easting: **1272775.8574'** | Ground Elevation: **282.534'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **287.907'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1357** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1429** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

Classification Scheme: **USCS/ASTM**

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| **SS -3** | **12.5-14** | **80** | **50/6"** | **0.3 aa= 0.3** | | | | (12.5-14.0) SP: POORLY GRADED SAND, white, black, orange, and yellow grains, medium, sub rounded, very dense, wet. Trace coarse sand to large gravel. Trace, orange, iron oxide staining. One cobble, 3" in diameter. No odor or visible contamination. | 270 | 12.5-14': Sampled for analytical. |
| | | | | | | | **15** | (14.0-19.0) Not sampled. | 265 | |
| **SS -4** | **19-20.5** | **26** | **50/4"** | **0.3 aa= 0.3** | | | **20** | (19.0-20.5) SW: WELL GRADED SAND, brown with white, black, and yellow grains, fine to medium, very dense, wet. Trace coarse sand. 10% winnowing. No odor or visible contamination. | | Threaded end cap from 20-20.35 ft-bgs. |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**

N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **1415** | **12'** |
| | | |
| | | |

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# Boring/Well Log

**Well #: MW-9**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174474.2134** Easting: **1272627.3356'** | Ground Elevation: **283.698'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **283.335'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1217** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1240** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

Classification Scheme: **USCS/ASTM**

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| | | | | | | | 0 | (0.0-5.0) Not sampled. | 280 | Flush mount monument.<br>Bentonite chip plug from 1.5-8 ft-bgs. |
| SS -1 | 5-6.5 | 53 | 24<br>50/6" | 0.4<br>aa=<br>0.4 | | | 5 | (5.0-6.5) SM: SILTY SAND, brown, fine to medium, very dense, moist. At 5-5.3', trace coarse sand and rootlets, large 3", rounded, cobble. At 5.3-5.6', color grades to gray. No odor or visible contamination. | | 2-inch schedule 40 riser pipe from 0-10 ft-bgs. |
| | | | | | | | | (6.5-10.0) Not sampled. | 275 | 10/20 silica sand pack from 8-20.5 ft-bgs. |
| SS -2 | 10-11.5 | - | 21<br>25<br>30 | 0.3<br>aa=<br>0.3 | | | 10 | (10.0-10.7) SW: WELL GRADED SAND, brown, fine to coarse, sub rounded, very dense, moist. Angular, crushed, dark gray boulder at 10.5'. No odor or visible contamination. | | |
| | | | | | | | | (10.7-11.5) SP: POORLY GRADED SAND, brown, fine, very dense, moist. Few 1/4" thick gray lenses at 11.1' and 11.3'. No odor or visible contamination. | | 0.010-inch slot, 2-inch schedule 40 PVC screen from 10-20 ft-bgs. |
| | | | | | | | | (11.5-15.0) Not sampled. | | |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**

N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **1230** | **14'** |
| | | |
| | | |

ENSR | AECOM

# Boring/Well Log

**Well #: MW-9**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174474.2134** Easting: **1272627.3356'** | Ground Elevation: **283.698'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **283.335'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1217** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1240** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| | | | | | | | | | 270 | |
| **SS -3** | **15-16.5** | **66** | **50/6"** | **0.3 aa= 0.3** | | ▨ | **15** | (15.0-16.5) SP: POORLY GRADED SAND, brown with white, black and yellow grains, fine, very dense, wet. Trace silt. 15% winnowing. No odor or visible contamination. | | 15-16.5 ft-bgs: Sampled for analytical. |
| | | | | | | | | (16.5-19) Not sampled. | | |
| | | | | | | | | | 265 | Threaded end cap from 20-20.35 ft-bgs. |
| **SS -4** | **19-20.5** | **-** | **50/6"** | **0.3 aa= 0.3** | | ▨ | **20** | (19.0-20.5) SP: POORLY GRADED SAND, brown with white, black and yellow grains, fine, very dense, wet. Trace silt. 15% winnowing. No odor or visible contamination. | | |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

| **Groundwater** | | |
|---|---|---|
| Date | Time | Depth (ft.) |
| **8/12/08** | **1230** | **14'** |
| | | |
| | | |

ENSR | AECOM

# Boring/Well Log

**Well #: MW-10**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174386.6154** Easting: **1272561.6472'** | Ground Elevation: **284.397'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **284.149'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1041** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1115** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| | | | | | | | 0 | (0.0-5.0) Not sampled. | 280 | Flush mount monument.<br>Bentonite chip plug from 1.5-8 ft-bgs. |
| **SS -1** | **5-6.5** | **46** | **24<br>50/6"** | **0.3<br>aa=<br>0.3** | | | 5 | (5.0-6.5) SP: POORLY GRADED SAND, orangish brown, medium, very dense, dry. Trace, angular, coarse sand to small gravel. Some fine sand and silt. No odor or visible contamination. | | 2-inch schedule 40 riser pipe from 0-10 ft-bgs. |
| | | | | | | | | (6.5-10.0) Not sampled. | 275 | 10/20 silica sand pack from 8-20.5 ft-bgs. |
| **SS -2** | **10-11.5** | **44** | **21<br>25<br>30** | **0.3<br>aa=<br>0.3** | | | 10 | (10.0-11.5) SW: WELL GRADED SAND, brown, fine to medium, very dense, moist. Some silt and coarse sand. No odor or visible contamination. | | 0.010-inch slot, 2-inch schedule 40 PVC screen from 10-20 ft-bgs. |
| | | | | | | | | (11.5-12.5) Not sampled. | | |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**

N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **1115** | **13'** |
| | | |
| | | |

ENSR | AECOM

# Boring/Well Log

**Well #: MW-10**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174386.6154** Easting: **1272561.6472'** | Ground Elevation: **284.397'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **284.149'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 1041** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1115** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| **SS -3** | **12.5-14** | **60** | **50/6"** | **0.3 aa= 0.3** | | ▨ | | (12.5-14.0) SP: POORLY GRADED SAND, brown, medium, sub rounded, very dense, moist to wet at 13'. Trace, fine sand and silt. No odor or visible contamination. | | |
| | | | | | | | **15** | (14.0-18.5) Not sampled. | 270 | 12.5-14 ft-bgs: Sampled for analytical. |
| **SS -4** | **19-20.5** | **80** | **50/6"** | **0.3 aa= 0.3** | | ▨ | **20** | (19.0-20.5) SP: POORLY GRADED SAND, brown with black, white, yellow, and orange grains, medium, sub rounded, very dense, wet. Trace silt. No odor or visible contamination. | 265 | Threaded end cap from 20-20.35 ft-bgs. |

**Remarks and Datum Used:**

**aa = ambient air**
**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **1115** | **13'** |
| | | |
| | | |

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# Boring/Well Log

**Well #: MW-11**
**Sheet 1 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174287.7124** Easting: **1272485.4391'** | Ground Elevation: **284.948'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **284.36'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 0930** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1005** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| | | | | | | | 0 | (0.0-5.0) Not sampled. | | Flush mount monument.<br>Bentonite chip plug from 1.5-8 ft-bgs. |
| **SS -1** | **5-6.5** | **100** | **50/2"** | **0.0** | | | 5 | (5.0-6.5) SW: WELL GRADED SAND, dark brown, fine to medium, very dense, moist. Trace coarse sand. Few, angular gravel up to 1" in diameter. Few grass and rootlets. No odor or visible contamination. | 280 | 2-inch schedule 40 riser pipe from 0-10 ft-bgs. |
| | | | | | | | | (6.5-7.5) Not sampled. | | |
| **SS -2** | **7.5-9** | **100** | **50/6"** | **0.0** | | | | (7.5-9.0) SW: WELL GRADED SAND, dark brown, fine to medium, very dense, moist. Trace, angular, coarse sand and small gravel. Some rootlets. No odor or visible contamination. | | 10/20 silica sand pack from 8-20.5 ft-bgs. |
| | | | | | | | | (9.0-10.0) Not sampled. | | |
| **SS -3** | **10-11.5** | **100** | **50/6"** | **0.0** | | | 10 | (10.0-10.3) SW: WELL GRADED SAND, brown, fine to medium, very dense, moist. Trace coarse sand. No odor or visible contamination. | 275 | 0.010-inch slot, 2-inch schedule 40 PVC screen from 10-20 ft-bgs. |
| | | | | | | | | (10.3-11.5) SP: POORLY GRADED SAND, brown, medium, very dense, moist. No odor or visible contamination. | | |
| | | | | | | | | (11.5-12.5) Not sampled. | | |

**Remarks and Datum Used:**

**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **0950** | **12.8'** |
| | | |
| | | |

ENSR | AECOM

# Boring/Well Log

**Well #: MW-11**
**Sheet 2 of 2**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-3000** | Northing: **174287.7124** Easting: **1272485.4391'** | Ground Elevation: **284.948'** |
| Location: **Seattle, WA** | Drill Rig Type: **Limited Access Track Rig** | MP Elevation: **284.36'** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **08/12/08 0930** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **08/12/08 1005** | Boring ID: **4.25"** | Seal: **Bentonite Chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **C. Smith** | Screen: **0.010-inch slot, Sch. 40 PVC** |

| Sample | | | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Type & | Depth Range | % Rec | Blows per 6" | PID (ppm) | | | | | | |
| **SS -4** | **12.5-14** | **100** | **60/5"** | **0.0** | | ▨ | | (12.5-14.0) SP: POORLY GRADED SAND, brown, medium, moist to wet at 12.8'. Trace coarse sand. No odor or visible contamination. | | |
| | | | | | | | | (14.0-15.0) Not sampled. | | |
| **SS -5** | **15-16.5** | **100** | **50/5"** | **0.0** | | ▨ | **15** | (15.0-16.5) SP: POORLY GRADED SAND, brown, medium, very dense, wet. Trace silt at 16'. No odor or visible contamination. | 270 | 12.5-13 ft-bgs: Sampled for analytical. |
| | | | | | | | | (16.5-19.0) Not sampled. | | |
| **SS -6** | **19-20.5** | **100** | **50/6"** | **0.0** | | ▨ | **20** | (19.0-20.5) SP: POORLY GRADED SAND, brown with white, black, orange and yellow grains, medium, sub angular, very dense, wet. Trace silt. 10% winnowing. No odor or visible contamination. | 265 | Threaded end cap from 20-20.35 ft-bgs. |

**Remarks and Datum Used:**

**ft-bgs = feet below ground suface**
**Sch. = schedule**
**HSA = Hollow Stem Auger**

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**Sample Type**
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

**Groundwater**

| Date | Time | Depth (ft.) |
|---|---|---|
| **8/12/08** | **0950** | **12.8'** |
| | | |
| | | |

AECOM

# Boring/Well Log

**Well #: MW-6**
**Sheet 3 of 3**

| | | |
|---|---|---|
| Project: **Lora Lake Apartments** | Monument: **Flush Mount** | Stick Up: **-** |
| Project #: **05482-025-210** | Northing: **174850.9922** Easting: **1272784.1135** | Ground Elevation: **291.083'** |
| Location: **Burien, WA** | Drill Rig Type: **HSA Limited Access** | MP Elevation: **-** |
| Client: **Port of Seattle** | Method: **HSA** | Total Depth: **20.5'** |
| Start Date & Time: **3/18/08 1344** | Casing ID: **2"** | Filter Pack: **10/20 Silica Sand** |
| Finish Date & Time: **3/18/08 1445** | Boring ID: **8.25"** | Seal: **Bentonite chips** |
| Contractor: **Cascade Drilling Inc.** | Bit Type: **4.25" HSA** | Grout: **-** |
| Operator: **Curtis Askew** | Logged By: **R. Knecht/ C. Smith** | Screen: **0.010" slot Sch. 40 PVC 5-15 ft-bgs** |

| Sample | | | Well Completion Log | Graphic | Depth (ft.) | Soil and Rock Description<br>Classification Scheme: **USCS/ASTM** | Elevation (ft.) | Comments & Samples |
|---|---|---|---|---|---|---|---|---|
| Type & Number | Depth Range | % Rec | | | | | | |
| | | | 🟩 | 🟨 | | (20.3-20.5) SP: POORLY GRADED SAND, black, fine, wet. No odor or visible contamination. | | |

| **Remarks and Datum Used:** | | **Sample Type** | **Groundwater** | | |
|---|---|---|---|---|---|
| | | N = SPT | Date | Time | Depth (ft.) |
| **AECOM - Environment**<br>**710 2nd Ave. Suite 1000**<br>**Seattle, WA 98104**<br>**Phone: (206) 624-9349**<br>**Fax: (206) 623-3793** | **HSA - Hollow Stem Auger** | DP = Direct Push | **03/18/08** | **1553** | **12.51'** |
| | **Sch. - Schedule** | SS = Split Spoon | | | |
| | **Amb. - ambient air** | C = Core | | | |

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# Field Activity Log

Page: 1 of 2

Project Name: LORA LAKES
Project Number:
Field Activity: G.W. SAMPLING
Completed By: Fred Merrill
Date: 3/27/08
Weather: SNOW - RAINY ~ 40°F
Personnel on site: F. MERRILL

---

0840 Arrive on site - Review H&S plan
0907 Gauge MW-6 12.50 - Do not have key for lock
- PVC not cut level - measure from E. side (lowest part of PVC
0918 Gauge MW-5 @ lowest part of TOC 20.31
0926 Gauge MW 3 @ " " " " 17.38
0934 Gauge MW-2 " " " " 6.51 (N. Side)
0952 Gauge MW-4 & call Renee " " " 15.81 (W. side
Gauge MW-1 16.28-DTP 16.29 DTW
on E. side
1015-1043 Decant product from MW-1 (Heavy diesely product).
- calibrate equipment
1043 set up on well MW-5 place tubing @ 24ft
~~1102 Begin purging~~ FM
1110 Begin purging after troubleshooting pump
1220 Begin sampling - Take Duplicate Dup-1-0308
1240 Battery begins to die - call for back up battery
1320 Chip & Stacy & Danny arrive w/ back up battery
- break down equipment
- Empty purged H2O
1400 Chip & company leave site
- Troubleshoot pump - pump not functioning
1441 - begin purging MW-4
1515 - begin Sampling MW-4
1550 Move equipment to MW-3 - Trouble w/ pump starting on MW-3"
1607 - Begin purging MW-3
1640 - Begin SAMPLING

RETEC

# Field Activity Log

**Page:** 2 of 2

Project Name:

Project Number:

Field Activity:

Completed By: Fred Merrill

Date: 3/27/08

Weather: SNOWY-RAINY ~ 40°F

Personnel on site: F MERRILL

1710 Pack up equipment - empty purged $H_2O$ into drum labled purged $H_2O$

1720 LEAVE LORA LAKE APTS.

3-27-08

Refer to GW logs for more details

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes
**PROJECT NO.**
**DATE** 3/27/08

**WELL NO.** MW-3
**SAMPLED BY** F.M
**WEATHER**

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | | (TOC-ft) |
| | 17.42 | (wl.prot.-ft) |
| DEPTH OF WELL | | (ft) |
| WELL DIAMETER | | (inches) |
| FEET OF WATER | | |
| PRODUCT THICK | | (ft) |
| WELL CONDITION | | |
| WEATHER | | |

**PURGE DATA**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1607 | | | | | | | | | |
| TIME | 1620 | 1623 | 1626 | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| DTW (Ft-TOC) | 17.44 | 17.44 | 17.44 | | | | | | | |
| FLOW RATE (L/min) | 210 | 210 | 210 | | | | | | | |
| TDS (g/L) | | | | | | | | | | |
| pH (units) (units) | 6.37 | 6.37 | 6.38 | | | | | | | |
| CONDUCTIVITY (umhos/cm) | 0.158 | 0.158 | 0.158 | | | | | | | |
| TEMPERATURE (deg C) | 11.83 | 11.81 | 11.78 | | | | | | | |
| ORP (mv) | 107.9 | 109.6 | 110.5 | | | | | | | |
| D. O. (mg/L) | 2.95 | 2.77 | 2.81 | | | | | | | |
| TURBIDITY (NTU) | NM | NM | NM | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW- 3 -0308 | 1640 | | | | |
| MW- 3 - 0308 | 1640 | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:**

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes

**PROJECT NO.**

**DATE** 3/27/08

**WELL NO.** MW-4

**SAMPLED BY** F.M

**WEATHER** patches of Sun ~42°F

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | |
| 15.81 | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | |
| WELL DIAMETER | (inches) | |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | |
| WELL CONDITION | | |
| WEATHER | | |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1441 | | | | | | | | | |
| TIME | 1454 | 1457 | 1500 | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| DTW (Ft-TOC) | 15.95 | 15.93 | 15.90 | | | | | | | |
| FLOW RATE (L/min) | 210 | 210 | 210 | | | | | | | |
| TDS (g/L) | — | — | — | — | — | — | — | — | — | — |
| pH (units) (units) | 6.25 | 6.24 | 6.23 | | | | | | | |
| CONDUCTIVITY (umhos/cm) | 0.182 | 0.175 | 0.173 | | | | | | | |
| TEMPERATURE (deg C) | 12.10 | 12.00 | 11.97 | | | | | | | |
| ORP (mv) | 86.8 | 87.8 | 91.7 | | | | | | | |
| D. O. (mg/L) | 0.99 | 0.93 | 0.90 | | | | | | | |
| TURBIDITY (NTU) | NM | NM | NM | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

FM

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW- 4 -0308 | 1515 | | | | |
| MW- 4 - 0308 | 1515 | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:** - Turbidity mete not functioning properly

7
.182
.017
166

Continued from pg 1

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes

**PROJECT NO.**

**DATE** 3/27/08

**WELL NO.** MW-5

**SAMPLED BY** F.M

**WEATHER** Cloudy - windy - 60 °F

| WELL INFORMATION | |
|---|---|
| DEPTH TO WATER | (TOC-ft) |
| | (wl.prot.-ft) |
| DEPTH OF WELL | (ft) |
| WELL DIAMETER | (inches) |
| FEET OF WATER | |
| PRODUCT THICK | (ft) |
| WELL CONDITION | |
| WEATHER | |

**PURGE DATA**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | | | | | | | | | | |
| TIME | 1153 | 1156 | 1159 | 1202 | 1205 | 1208 | | | | |
| VOLUME PURGED (L) | 20.41 | | | | | | | | | |
| DTW (Ft-TOC) | ~~20.44~~ | FM 20.41 | 20.41 | 20.41 | 20.41 | 20.41 | | | | |
| FLOW RATE (L/min) | 250 | | | | | | | | | |
| TDS (g/L) | | | | | | | | | | FM |
| pH (units) (units) | 6.42 | 6.41 | 6.42 | 6.42 | 6.43 | | | | | |
| CONDUCTIVITY (umhos/cm) | 0.372 | 0.374 | 0.375 | 0.375 | 0.376 | 0.375 | | | | |
| TEMPERATURE (deg C) | 12.44 | 12.44 | 12.50 | 12.71 | 12.75 | 12.75 | | | | |
| ORP (mv) | 77.3 | 77.0 | 76.6 | 75.9 | 76.2 | 75.5 | | | | |
| D. O. (mg/L) | 0.63 | 0.56 | 0.53 | 0.47 | 0.45 | 0.44 | | | | |
| TURBIDITY (NTU) | NM | NM | NM | NM | NM | NM | | | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-5-0308 | 1220 | | | | |
| MW-5-0308 | 1220 | | | | |
| ~~DP~~ FM DUP-1-0308 | 1120 | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:**

RETEC

# Field Activity Log

Page: 1 of 1

Project Name: Lora Lake Apts

Completed By: Fred Merrill

Project Number:

Date: 3/28/08

Field Activity: G.W. SAMPLING

Weather: RAINY-SNOWY

Personnel on site: F. MERRILL

0820 Arrive on site - Review H&S Hazards

0840 Set up on ~~MW-3~~ FM MW-2 -> have troubles starting peristaltic pump

0900 Begin purging MW-2

0940 Begin SAMPLING MW-2

1010 PACK up equipment - move to MW-6

1015 Begin setting up on MW-6 - troubles getting peristaltic pump to start

1059 Begin purging MW-6

1135 Begin SAMPLING MW-6

1200 Move equipment to MW-1

1215 Set up on MW-1 -> contact PM (Chip B.) to determine SAMPLING Approach - Will sample for product after sampling $H_2O$ - Difficulties getting pump to start

1259 Begin purging MW-1

1345 Begin SAMPLING MW-1, Attempt to sample for free product - Only obtained heavy sheen w/ few blebs

1415 - Empty purged $H_2O$ into drum after packing up equipment

1509 LEAVE LORA LAKE APARTMENTS.

3/28/08

Refer to GW sampling logs for more information

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes

**PROJECT NO.** ~~3/26/08~~ FM

**DATE** ~~3/26/08~~ FM 3/28/08

**WELL NO.** MW-2

**SAMPLED BY** F.M

**WEATHER** Overcast- Rainy - 42°F

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | 6.41 | (TOC-ft) |
| | | (wl.prot.-ft) |
| DEPTH OF WELL | | (ft) |
| WELL DIAMETER | | (inches) |
| FEET OF WATER | | |
| PRODUCT THICK | | (ft) |
| WELL CONDITION | | |
| WEATHER | | |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 0900 | | | | | | | | | |
| TIME | 0915 | 0918 | 0921 | 0924 | 0927 | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| DTW (Ft-TOC) | 6.46 | 6.47 | 6.47 | 6.49 | 6.50 | | | | | |
| FLOW RATE (L/min) | 2.85 | 285 | 285 | 285 | 285 | | | | | |
| TDS (g/L) | | | | | | | | | | |
| pH (units) (units) | 6.38 | 6.30 | ~~6.31~~ | 6.30 | 6.28 | | | | | |
| CONDUCTIVITY (umhos/cm) | 0.085 | 0.086 | 0.087 | 0.089 | [illegible] | | | | | |
| TEMPERATURE (deg C) | 7.64 | 7.77 | 8.61 | 8.62 | 8.70 | | | | | |
| ORP (mv) | 114.5 | 115.9 | 116.1 | 116.8 | 117.1 | | | | | |
| D. O. (mg/L) | 9.27 | 9.23 | 9.44 | [illegible] | 9.45 | | | | | |
| TURBIDITY (NTU) | | | | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW- 2 -0308 | 0940 | | | | |
| MW- 2 - 0308 | 940 | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:**

[illegible]

0.32

75

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes

**PROJECT NO.**

**DATE** 3/28/08

**WELL NO.** MW-6

**SAMPLED BY** F.M

**WEATHER** RAINY ~ SNOW ~ 40°F

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | | (TOC-ft) |
| | ~~12.31~~ FM 12.35 | (wl.prot.-ft) |
| DEPTH OF WELL | | (ft) |
| WELL DIAMETER | | (inches) |
| FEET OF WATER | | |
| PRODUCT THICK | | (ft) |
| WELL CONDITION | | |
| WEATHER | | |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1059 | | | | | | | | | |
| TIME | 1113 | 1117 | 1120 | | | | | | | |
| VOLUME PURGED (L) | — | — | — | FM | | | | | | |
| DTW (Ft-TOC) | 12.62 | 12.62 | 12.62 | | | | | | | |
| FLOW RATE (L/min) | 200 | 200 | 200 | | | | | | | |
| TDS (g/L) | — | — | — | FM | | | | | | |
| pH (units) (units) | 6.11 | 6.10 | 6.10 | | | | | | | |
| CONDUCTIVITY (umhos/cm) | 0.376 | 0.374 | 0.373 | | | | | | | |
| TEMPERATURE (deg C) | 9.36 | 9.37 | 9.35 | | | | | | | |
| ORP (mv) | 154.6 | 154.6 | 1.542 | | | | | | | |
| D. O. (mg/L) | 1.71 | 1.58 | 1.56 | | | | | | | |
| TURBIDITY (NTU) | NM | NM | NM | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW- 6 -0308 | 1135 | | | | |
| MW- 6 - 0308 | 1135 | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:**

000006

[illegible]
.15
56

## GROUNDWATER SAMPLING LOG

| | | | |
|---|---|---|---|
| **PROJECT NAME** | Lora Lakes | **WELL NO.** | MW-1 |
| **PROJECT NO.** | | **SAMPLED BY** | F.M |
| **DATE** | 3/28/08 | **WEATHER** | Snowy-Rainy ~ 39° F |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | |
| WELL DIAMETER | (inches) | |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | |
| WELL CONDITION | | |
| ~~WEATHER~~ Pump Tube inlet ~ 18 ft | | |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1256 | | | | | | | | | |
| TIME | 1306 ~~1308~~ | 1309 | 1312 | 1315 | 1318 | 1321 | 1324 | 1327 | | |
| VOLUME PURGED (L) | — | — | — | — | — | — | — | — | — | — |
| DTW (Ft-TOC) | 16.43 | 16.48 | 16.55 | NM | 16.65 | 16.75 | 16.79 | 16.85 | | |
| FLOW RATE (L/min) | | | | | | | | | | |
| TDS (g/L) | — | — | — | — | — | — | — | — | — | — |
| pH (units) (units) | 6.73 | 6.72 | 6.73 | 6.73 | 6.74 | 6.74 | 6.74 | 6.74 | | |
| CONDUCTIVITY (umhos/cm) | 0.865 | 0.879 | 0.894 | 0.905 | 0.909 | 0.909 | 0.913 | 0.916 | | |
| TEMPERATURE (deg C) | 10.09 | 10.05 | 10.59 | 10.43 | 10.34 | 10.21 | 10.22 | 10.31 | | |
| ORP (mv) | -27.4 | -38.5 | -46.6 | -51.7 | -56.2 | -58.4 | -60.8 | -62.9 | | |
| D. O. (mg/L) | 1.95 | 1.58 | 1.10 | 0.86 | 0.74 | 0.65 | 0.65 | 0.60 | | |
| TURBIDITY (NTU) | NM | NM | NM | NM | NM | NM | NM | NM | | |
| PURGE AND SAMPLE EQUIPT: | | | | | | | | | | |

FM

FM

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW- 1 -0308 | 1345 | | | | |
| MW- 1 - 0308 | 1345 | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

**comments:**

0.7,
.06
68
.65
.06
59

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An Employee - Owned Company

# CHAIN OF CUSTODY

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SR#: ________ ________

PAGE 1 OF 1 COC #________

PROJECT NAME Lora Lake Apartments
PROJECT NUMBER
PROJECT MANAGER [illegible] / [illegible]
COMPANY/ADDRESS [illegible] SW Klickitat Way
CITY/STATE/ZIP Seattle, WA 98134
E-MAIL ADDRESS
PHONE # 206)624-9349 FAX#
SAMPLER'S SIGNATURE

| SAMPLE I.D. | DATE | TIME | LAB I.D. | MATRIX | NUMBER OF CONTAINERS | | Semivolatile Organics by GC/MS 625☐ 8270☐ 8270LL☒ | Volatile Organics 624☐ 8260☒ | Hydrocarbons (*see below) Gas☒ Diesel☒ Oil☐ 8021☐ BTEX☐ | ☐ Fuel Fingerprint (FIQ) ☐ NW-HCID Screen | Oil & Grease/TRPH 1664 HEM☐ 1664 SGT☐ | PCB's Aroclors☒ Congeners☒ | Pesticides/Herbicides 608☐ 8081A☐ 8141A☐ 8151A☐ | Chlorophenolics - 8151M Tri☐ Tetra☐ PCP☐ | PAHS 8310☐ SIM☐ | Metals, Total or Dissolved (See list below) | Cyanide☐ Hex-Chrom☐ | pH, Cond., Cl, SO4, PO4, F, NO2, NO3, BOD, TSS, TDS (circle) | NH3-N, COD, Total-P, TKN, TOC, DOC (circle) NO2+NO3 | TOX 9020 ☐ AOX 1650☐ 506☐ | [illegible] | Turbidity | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-1-0308 | 3/28/08 | 1345 | | GW | 12 | | X | X | X | | | X | | | | X | | | | | X | X | | | Assumed 8270LL IS |
| MW-2-0308 | 3/28/08 | 0940 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | 8270LVI |
| MW-3-0308 | 3/27/08 | 1640 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | |
| MW-4-0308 | 3/27/08 | 1515 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | |
| MW-5-0308 | 3/27/08 | 1220 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | |
| MW-6-0308 | 3/28/08 | 1135 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | |
| Dup-1-0308 | 3/27/08 | 1120 | | GW | 13 | | X | X | X | | | X | | | | X | | | | | X | X | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |

**REPORT REQUIREMENTS**

___ I. Routine Report: Method Blank, Surrogate, as required
___ II. Report Dup., MS, MSD as required
___ III. Data Validation Report (includes all raw data)
___ IV. CLP Deliverable Report
___ V. EDD

**INVOICE INFORMATION**

P.O. # ________
Bill To: ________

**TURNAROUND REQUIREMENTS**

___ 24 hr. ___ 48 hr.
___ 5 Day
___ Standard (10-15 working days)
___ Provide FAX Results
________
Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al [✓ As] Sb Ba [✓ Be] B Ca [✓ Cd] Co [✓ Cr] [✓ Cu] Fe [✓ Pb] Mg Mn Mo [✓ Ni] K [✓ Ag] Na [✓ Se] Sr [✓ Tl] Sn V [✓ Zn] [✓ Hg]

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI [✓ NORTHWEST] OTHER:______ (CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:
Please hold all PCBs

2 WEEK TURNAROUND REQUESTED

| RELINQUISHED BY: | | RECEIVED BY: | | RELINQUISHED BY: | | RECEIVED BY: | |
|---|---|---|---|---|---|---|---|
| | 3/28/08 1600 | | | | | | |
| Signature | Date/Time | Signature | Date/Time | Signature | Date/Time | Signature | Date/Time |
| FRED D MERRILL | ENSR | | | | | | |
| Printed Name | Firm | Printed Name | Firm | Printed Name | Firm | Printed Name | Firm |

# FIELD ACTIVITY LOG

**ENSR**

PROJECT NAME: POS - Lora Lake
PROJECT NO: 05482-025
DAY & DATE: Tues, Aug 19, 2008
COMPLETED BY: D. Kinney
APPROVED BY:
SHEET 1 OF 1

FIELD ACTIVITY SUBJECT: Groundwater Sampling
DESCRIPTION OF DAILY ACTIVITIES & EVENTS:

| TIME | |
|---|---|
| 0745 | Arrived onsite & went to locate wells |
| 0820 | Located all the wells & drums; wells MW-4 & MW-5 are under plastic sheeting |
| 0830 | Setup to sample |
| 0835 | Stacy Patterson onsite; discussed wells MW-4, -5 & 6 (cut plastic at MW-4 & -5) & purge water drums |
| 0900 | SP off-site |
| 0920 | Went to start on MW-3; need to get over curb w/van; found 2"x4"s & stacked against curb |
| 0930 | Calibrated YSI (model 556) & Oakton (Model T-100) meters |
| 0942 | Started purging MW-3 |
| 1010 | Sampled MW-3 (see GW sampling form) |
| 1059 | Dumped purge water into drum from MW-3 |
| 1110 | Went to MW-6; measured WL - only 0.19' of water we will not be sampling MW-6 |
| 1135 | Started purging MW-11 |
| 1210 | Sampled MW-11 |
| 1246 | Started purging MW-10 |
| 1325 | Sampled MW-10 |
| 1350 | Dumped purge water |
| 1414 | Started purging MW-9 |
| 1440 | Sampled MW-9; took duplicate - labeled: MW-90-081908 |
| 1532 | Started purging MW-8 |
| 1610 | Sampled MW-8 |
| 1725 | Dumped purge water |
| 1730 | Gauged wells MW-4 & MW-5 & MW-1 & MW-2 |
| 1745 | Left site for Lowe's |

| Well No | TOC-ft DTW | TD (ft) |
|---|---|---|
| MW-4 | 16.81 | 24.9 |
| MW-5 | 21.21 | 27.8 |
| MW-1 | 17.21 | — |
| MW-2 | 7.74 | — |

VISITORS ONSITE:
None

CHANGES FROM PLANS OR IMPORTANT DECISIONS:
Not enough water in MW-6 (0.19') → no sample collected

WEATHER CONDITIONS:
Cloudy to Raining, 60-70°F

IMPORTANT TELEPHONE CALLS:
None

PERSONNEL ONSITE: Dean Kinney, Stacy Patterson

## FIELD ACTIVITY LOG

**ENSR**

PROJECT NAME: POS - Cora Lake
PROJECT NO: 05482-025-3000
DAY & DATE: Wed Aug 20th 2008
COMPLETED BY: D. Kinney
APPROVED BY:
SHEET 1 OF 1

FIELD ACTIVITY SUBJECT: Groundwater Sampling
DESCRIPTION OF DAILY ACTIVITIES & EVENTS:

| TIME | |
|---|---|
| 0815 | Arrived onsite & setup to sample |
| 0825 | Calibrated meters - YSI model 556 & Oakton model T-100 |
| 0853 | started purging MW-4 |
| 0925 | Sampled MW-4 (See gw sampling form) |
| 1015 | started purging MW-5 |
| 1040 | sampled MW-5 |
| 1135 | Packing equipment & left site |

VISITORS ONSITE: None

CHANGES FROM PLANS OR IMPORTANT DECISIONS: None

WEATHER CONDITIONS: Cloudy, 60-65 °F

IMPORTANT TELEPHONE CALLS: None

PERSONNEL ONSITE: Dean Kinney

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW-3 |
| **SAMPLED BY** | DWK |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft)<br>(wl.prot.-ft) | 18.63 |
| DEPTH OF WELL | (ft) | 23.1 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | Cloudy, 60°F |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 0942 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 0952 | 0955 | 0958 | 1001 | 1004 | 1007 | 1010 | 1013 | 1016 | 1019 |
| DTW (Ft-TOC) | 18,85 | 18,87 | 18,85 | 18,85 | 18,86 | 18,85 | 18,85 | 18,85 | 18,85 | 18,85 |
| FLOW RATE (L/min) | 0,20 | 0,175 | → | | | | | | | |
| pH (units) (units) | 4,63 | 5,28 | 5,71 | 6,08 | 6,20 | 6,24 | 6,28 | 6,31 | 6,28 | 6,28 |
| CONDUCTIVITY mS (~~umhos~~/cm) | 0,157 | 0,156 | 0,158 | 0,157 | 0,157 | 0,157 | 0,157 | 0,158 | 0,157 | 0,157 |
| TEMPERATURE (deg C) | 14,2 | 14,2 | 14,2 | 14,2 | 14,2 | 14,2 | 14,2 | 14,1 | 14,2 | 14,2 |
| ORP (mv) | 256 | 223 | 199 | 180 | 173 | 170 | 169 | 168 | 169 | 169 |
| D. O. (mg/L) | 4,88 | 4,87 | 4,48 | 4,58 | 4,63 | 4,68 | 4,68 | 4,81 | 4,90 | 4,71 |
| TURBIDITY (NTU) | 20,1 | 18,4 | 15,9 | 11,6 | 6,94 | 5,90 | 5,10 | 2,97 | 2,71 | 2,75 |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-3-081908 | 1020 | 8151mod/PCP | 40mL Vial | 1 | None |
| | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500mL Poly | 1 | $HNO_3$ |
| | | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing
wl.prot.=top of well protector

Tubing inlet @ ~21'

# GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes
**PROJECT NO.** 05482-025-3000
**DATE** 8/20/08
**WELL NO.** MW-4
**SAMPLED BY** DWK

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 16.81 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 24.9 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | Cloudy, 60°F |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 0853 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 0903 | 0906 | 0909 | 0912 | 0915 | 0918 | 0921 | | | |
| DTW (Ft-TOC) | 16.93 | 16.93 | 16.93 | 16.93 | 16.93 | 16.93 | 16.93 | | | |
| FLOW RATE (L/min) | 0.30 → | | | | | | | | | |
| pH (units) (units) | 5.94 | 5.61 | 5.39 | 5.42 | 5.49 | 5.47 | 5.44 | | | |
| CONDUCTIVITY (mS ~~umhos~~/cm) | 0.213 | 0.207 | 0.206 | 0.207 | 0.206 | 0.207 | 0.206 | | | |
| TEMPERATURE (deg C) | 17.9 | 17.8 | 17.7 | 17.6 | 17.6 | 17.5 | 17.5 | | | |
| ORP (mv) | 157 | 181 | 185 | 186 | 181 | 186 | 187 | | | |
| D. O. (mg/L) | 1.90 | 2.16 | 2.13 | 2.02 | 2.01 | 1.98 | 1.94 | | | |
| TURBIDITY (NTU) | 11.33 | 10.32 | 5.84 | 5.20 | 3.72 | 3.45 | 3.39 | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-4-082008 | 0925 | 8151A / PCP | 40mL | 1 | None |
| | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500mL Poly | 1 | HNO3 |
| | ↓ | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**
TOC=Top of well casing
wl.prot.=top of well protector

Tubing Inlet @ ~21'
Purge rate decreased to 0.20 L/min to sample

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/20 /08 |

| | |
|---|---|
| **WELL NO.** | MW-5 |
| **SAMPLED BY** | DWR |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 21.19 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 27.8 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | – |
| WELL CONDITION | | ok |
| WEATHER | | Cloudy, 60 °F |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1015 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1025 | 1028 | 1031 | 1034 | 1037 | | | | | |
| DTW (Ft-TOC) | 21,25 | 21,25 | 21,25 | 21,25 | 21,25 | | | | | |
| FLOW RATE (L/min) | 0,30 | → | | | | | | | | |
| pH (units) (units) | 5,19 | 5,26 | 5,33 | 5,36 | 5,43 | | | | | |
| CONDUCTIVITY mS (umhos/cm) | 0,372 | 0,375 | 0,375 | 0,375 | 0,37 | | | | | |
| TEMPERATURE (deg C) | 15,0 | 15,0 | 14,9 | 14,9 | 14,9 | | | | | |
| ORP (mv) | 102 | 94,6 | 89,0 | 84,2 | 80,0 | | | | | |
| D. O. (mg/L) | 1,03 | 0,91 | 0,80 | 0,73 | 0,71 | | | | | |
| TURBIDITY (NTU) | 3,54 | 2,27 | 1,32 | 1,61 | 1,27 | | | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-5-082008 | 1040 | 8151A/PCP | 40mL Vial | 1 | None |
| | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500mL Poly | 1 | HNO3 |
| | | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

Tubing inlet @ ~ 25'

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW-6 |
| **SAMPLED BY** | DWL |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 14.61 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 14.80 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | 0.19 |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | Cloudy, 65°F |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | | | Insufficient | | | | | | | |
| DTW (Ft-TOC) | | | water | | | | | | | |
| FLOW RATE (L/min) | | | | | | | | | | |
| pH (units) (units) | | | to | | | | | | | |
| CONDUCTIVITY (umhos/cm) | | | | | | | | | | |
| TEMPERATURE (deg C) | | | Sample | | | | | | | |
| ORP (mv) | | | | | | | | | | |
| D. O. (mg/L) | | | | | | | | | | |
| TURBIDITY (NTU) | | | | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-6-081908 | No Sample | 8015mod/PCP | 40ml Vial | 1 | None |
| | | NWTPH-DX | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | metals | 500mL Poly | 1 | $HNO_3$ |
| | | Hardness, pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

ADDITIONAL INFORMATION:

TOC=Top of well casing

wl.prot.=top of well protector

## GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW-8 |
| **SAMPLED BY** | DWK |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 10,99 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 19,9 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | P. Cloudy, 65 °F |

**PURGE DATA**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1532 | | | | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | | | | |
| TIME | 1542 | 1545 | 1548 | 1551 | 1554 | 1557 | 1600 | 1603 | 1606 | 1609 | 1612 | 1615 | 1618 |
| DTW (Ft-TOC) | 11,49 | 11,50 | 11,51 | 11,52 | 11,53 | 11,54 | 11,55 | 11,56 | 11,57 | 11,59 | 11,60 | 11,61 | 11,62 |
| FLOW RATE (L/min) | 0,10 | → | | | | | | | | | | | |
| pH (units) (units) | 5,43 | 5,91 | 6,30 | 6,39 | 6,38 | 6,40 | 6,44 | 6,45 | 6,50 | 6,53 | 6,55 | 6,56 | 6,58 |
| CONDUCTIVITY mS ~~(umhos/cm)~~ | 0,332 | 0,328 | 0,327 | 0,327 | 0,326 | 0,327 | 0,329 | 0,330 | 0,330 | 0,332 | 0,332 | 0,332 | 0,333 |
| TEMPERATURE (deg C) | 15,3 | 15,3 | 15,3 | 15,3 | 15,3 | 15,3 | 15,3 | 15,3 | 15,4 | 15,5 | 15,5 | 15,5 | 15,5 |
| ORP (mv) | 221 | 193 | 160 | 155 | 161 | 158 | 155 | 153 | 148 | 145 | 143 | 140 | 137 |
| D. O. (mg/L) | 2,06 | 2,13 | 2,20 | 2,24 | 2,26 | 2,19 | 2,17 | 2,15 | 2,10 | 2,06 | 2,04 | 2,05 | 2,06 |
| TURBIDITY (NTU) | 34,2 | 38,5 | 38,8 | 39,4 | 36,8 | 33,2 | 29,5 | 26,3 | 24,3 | 25,4 | 23,9 | 24,6 | 23,8 |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-8-081908 | 1620 ↓ | 8151A/ALP | 40mL Vial | 1 | None |
| | | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500mL Poly | 1 | HNO3 |
| | | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

Tubing inlet @ ~17,0'

Pump speed at minimum (~100 mL/min)

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW9 |
| **SAMPLED BY** | DWK |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 13,05 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 19,9 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | Cloudy, 65 °F |

PURGE DATA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | [illegible] 1414 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1424 | 1427 | 1430 | 1433 | 1436 | 1439 | | | | |
| DTW (Ft-TOC) | 13,11 | 13,11 | 13,11 | 13,11 | 13,11 | 13,11 | | | | |
| FLOW RATE (L/min) | 0,30 | → | | | | | | | | |
| pH (units) (units) | 6,15 | 6,09 | 6,10 | 6,12 | 6,13 | 6,10 | | | | |
| CONDUCTIVITY (~~umhos~~ mS/cm) | 0,311 | 0,313 | 0,310 | 0,310 | 0,310 | 0,310 | | | | |
| TEMPERATURE (deg C) | 17,3 | 17,3 | 17,3 | 17,3 | 17,3 | 17,2 | | | | |
| ORP (mv) | 169 | 172 | 168 | 169 | 167 | 165 | | | | |
| D. O. (mg/L) | 1,80 | 1,75 | 1,76 | 1,75 | 1,77 | 1,74 | | | | |
| TURBIDITY (NTU) | 9,23 | 6,01 | 4,65 | 4,44 | 3,76 | 4,06 | | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-9-081908 | 1440 | 8151A/PCP | 40mL Vial | 1 | None |
| MW-90-081908 | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| (Duplicate) | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500mL Poly | 1 | HNO3 |
| | | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

ADDITIONAL INFORMATION:

TOC=Top of well casing
wl.prot.=top of well protector

Tubing Inlet @ ~ 17,5'
Turned purge rate down to 0,20 L/min to sample

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW-10 |
| **SAMPLED BY** | DWK |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 13.74 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 19.6 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | ~~0~~ |
| WELL CONDITION | | OK |
| WEATHER | | Cloudy, 65°F |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1240 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1256 | 1259 | 1302 | 1305 | 1308 | 1311 | 1314 | 1317 | 1320 | |
| DTW (Ft-TOC) | 13,80 | 13,80 | 13,80 | 13,80 | 13,80 | 13,80 | 13,80 | 13,80 | 13,80 | |
| FLOW RATE (L/min) | 0,30 | → | | | | | | | | |
| pH (units) (units) | 6,26 | 6,45 | 6,48 | 6,38 | 6,54 | 6,55 | 6,57 | 6,58 | 6,59 | |
| CONDUCTIVITY mS (~~umhos~~/cm) | 0,235 | 0,236 | 0,236 | 0,235 | 0,234 | 0,233 | 0.233 | 0,232 | 0,232 | |
| TEMPERATURE (deg C) | 15,9 | 15,7 | 15,6 | 15,7 | 15,7 | 15,8 | 15.9 | 15,9 | 15,9 | |
| ORP (mv) | 147 | 155 | 156 | 157 | 144 | 146 | 143 | 142 | 142 | |
| D. O. (mg/L) | 2,24 | 2,25 | 2,23 | 2,10 | 2,08 | 2,09 | 2,07 | 2,05 | 2,04 | |
| TURBIDITY (NTU) | 27,1 | 15,9 | 11.1 | 8.21 | 5,44 | 4,53 | 2,51 | 2,43 | 2,29 | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-10-081908 | 1325 | 8151A / PCP | 40mL Vial | 1 | None |
| | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | Metals | 500ml Poly | 1 | HNO3 |
| | | Hardness/pH | 500ml Poly | 1 | None |
| | | | | | |
| | | | | | |

ADDITIONAL INFORMATION:

TOC=Top of well casing

wl.prot.=top of well protector

Tubing inlet @ ~17.5'

Turned purge rate down to 0,20 L/min to sample

# GROUNDWATER SAMPLING LOG

| | |
|---|---|
| **PROJECT NAME** | Lora Lakes |
| **PROJECT NO.** | 05482-025-3000 |
| **DATE** | 8/19/08 |

| | |
|---|---|
| **WELL NO.** | MW-11 |
| **SAMPLED BY** | DWK |

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | (TOC-ft) | 11,53 |
| | (wl.prot.-ft) | |
| DEPTH OF WELL | (ft) | 19,25 |
| WELL DIAMETER | (inches) | 2 |
| FEET OF WATER | | |
| PRODUCT THICK | (ft) | — |
| WELL CONDITION | | ok |
| WEATHER | | P.Cloudy, 65 0F |

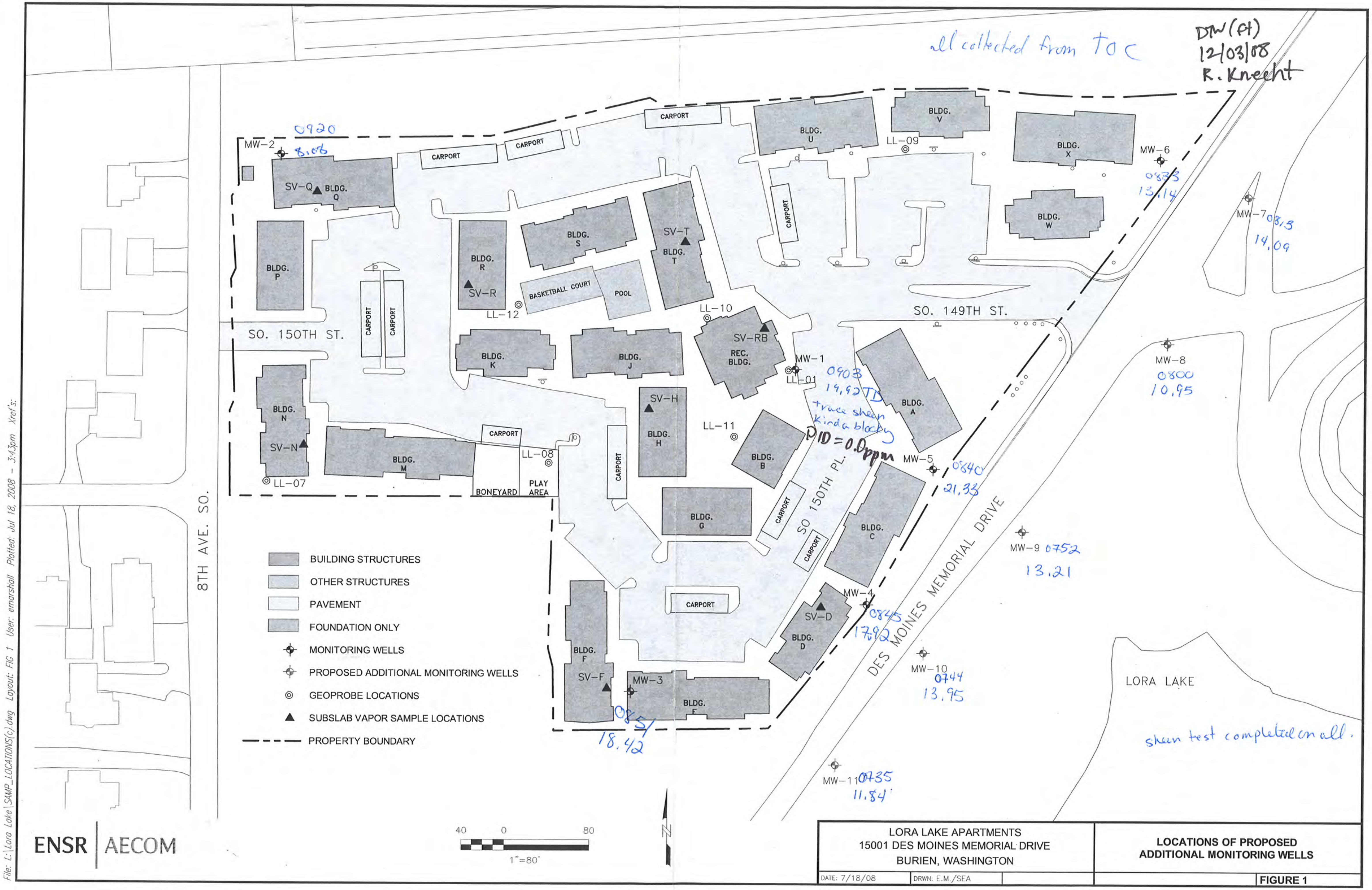
| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: | 1135 | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1145 | 1148 | 1151 | 1154 | 1157 | 1200 | 1203 | 1206 | | |
| DTW (Ft-TOC) | 0.30 | 11,65 | 11,65 | 11,65 | 11,65 | 11,65 | 11,65 | 11,65 | | |
| FLOW RATE (L/min) | 11.64 | 0,30 | → | | | | | | | |
| pH (units) (units) | 6.12 | 6,15 | 6,16 | 6,21 | 6,27 | 6,28 | 6,28 | 6,27 | | |
| CONDUCTIVITY (~~umhos~~ mS/cm) | 0,169 | 0,169 | 0,167 | 0,167 | 0,167 | 0,167 | 0,169 | 0,170 | | |
| TEMPERATURE (deg C) | 16.2 | 16,3 | 16,3 | 16,3 | 16,3 | 16,3 | 16,3 | 16,2 | | |
| ORP (mv) | 174 | 175 | 174 | 172 | 171 | 168 | 167 | 166 | | |
| D. O. (mg/L) | 1,19 | 1,14 | 1,18 | 1,10 | 1,05 | 1,02 | 0,97 | 0,96 | | |
| TURBIDITY (NTU) | 8.99 | 9,45 | 6,55 | 3,85 | 2,94 | 2,54 | 2,63 | 2,49 | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| MW-11-081908 | 1210 | 8151 mod/PCP | 40mL Vial | 1 | None |
| | ↓ | NWTPH-Dx | 500mL Amber | 1 | HCl |
| | | 8270/8290 | 1L Amber | 4 | None |
| | | metals | 500mL Poly | 1 | $HNO_3$ |
| | | Hardness/pH | 500mL Poly | 1 | None |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing
wl.prot.=top of well protector

Tubing Inlet @ ~17'
Turned purge rate down to 0,20 L/min to sample



all collected from TOC

DTW (ft)
12/03/08
R. Knecht

MW-2: 0920
8.08

MW-6: 0833
13.14

MW-7: 0818
14.09

MW-8: 0800
10.95

MW-1: 0903
19.92 TD
trace sheen
kinda blocky

PID = 0.0 ppm

MW-5: 0840
21.33

MW-9: 0752
13.21

MW-4: 0845
17.92

MW-10: 0744
13.95

MW-3: 0851
18.42

MW-11: 0735
11.84'

sheen test completed on all.

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

LOCATIONS OF PROPOSED ADDITIONAL MONITORING WELLS

DATE: 7/18/08 DRWN: E.M./SEA

FIGURE 1

File: L:\Lora Lake\SAMP_LOCATIONS(c).dwg Layout: FIG 1 User: emarshall Plotted: Jul 18, 2008 - 3:43pm Xref's:

**FIELD ACTIVITY LOG** **ENSR**

**PROJECT NAME:** Lora Lakes
**PROJECT NO:** 05482-025-~~220~~3000
**DAY & DATE:** Wed. 12/03/08
**COMPLETED BY:** H. Hirsch
**APPROVED BY:**
**SHEET** 1 **OF** 1

**FIELD ACTIVITY SUBJECT:**

**DESCRIPTION OF DAILY ACTIVITIES & EVENTS:**

| TIME | |
|---|---|
| 715 | H. Hirsch arrives on-site. |
| | ~~Clear~~ HH Overcast, no rain, ~50°F |
| 730 | R. Knecht on-site - gauging wells - recorded on map |
| 730 | HH Calibrate Hydrolab Quanta |
| | SpCond 1.409 ms/cm Cal. soltn, reads 1.408, 10.48°C |
| | D.O. reading 10.82 mg/L @ 10.47°C |
| | pH Cal. 7.00 Buffer - reads ~~7.80~~ HH 7.39 |
| | Cal. 10.0 Buffer - reads "FAIL", 9.97 |
| | H.H. Recal. pH 4.0 Buffer - FAIL reads 4.14 |
| | End Cal. |
| | Put new #2004 lock on MW-8 |
| | #0356 lock on MW-7 |
| 1100 | C. Smith on-site - delivered extra portable battery |
| 1200 | R. Knecht off-site. |
| | |
| 800 | Don Robbins arrives to unlock gate |
| 945 | Seattle PD check in w/ us + walk the site |
| | Meters used: |
| | Heron Dipper T Water level probe |
| | PID - Mini Rae 2000 PID - used @ MW-1 only |
| | Hydrolab Quanta multiparameter meter (includes turbidity) |
| | |
| | Field Dup = LL-MW-70-120308 collected @ MW-7 |
| 1530 | Disposed of purge water in on-site drum labeled "Development $H_2O$" |
| 1535 | Off-site - locked gate. |

**VISITORS ONSITE:**
R. Knecht
C. Smith
Don Robbins
Seattle PD

**CHANGES FROM PLANS OR IMPORTANT DECISIONS:**
Quanta pH would not calibrate; DO suspect @ MW-2; sampled MW-6 before stabilization due to low flow + drawdown

**WEATHER CONDITIONS:**
overcast to partly cloudy, Fair

**IMPORTANT TELEPHONE CALLS:**

**PERSONNEL ONSITE:**
R. Knecht, H. Hirsch

## GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes
**PROJECT NO.** 05482-025-~~220~~ 3000
**DATE** 12/3/2008

**WELL NO.** MW-2
**SAMPLED BY** H. Hirsch

| **WELL INFORMATION** | | |
|---|---|---|
| DEPTH TO WATER | 8.04 | (TOC-ft) |
| | | (wl.prot.-ft) |
| DEPTH OF WELL | 15.3 | (ft) |
| WELL DIAMETER | 2" | (inches) |
| FEET OF WATER | 7 | |
| PRODUCT THICK | N/A | (ft) |
| WELL CONDITION | Good | |
| WEATHER | Fair | |

| **PURGE DATA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: 949 | | | | | | | | | | |
| Purge Rate ~~VOLUME PURGED~~ (~~L~~) mL | 200 mL/min | | | | | | | | | |
| TIME | 954 | 959 | 1002 | 1006 | | | | | | |
| DTW (Ft-TOC) | 8.18 | 8.18 | 8.18 | 8.18 | | | | | | |
| FLOW RATE (mL/min) | 200 | 240 | 225 | 225 | | | | | | |
| pH (units) (units) | 6.95 | 6.97 | 6.98 | 6.99 | | | | | | |
| 3l. CONDUCTIVITY mS ~~(umhos/cm)~~ | 0.195 | 0.92 | 0.191 | 0.190 | | | | | | |
| TEMPERATURE (deg C) | 11.50 | 11.53 | 11.54 | 11.59 | | | | | | |
| ORP (mv) | 214 | 210 | 209 | 208 | | | | | | |
| D. O. (mg/L) | 6.22 | 6.20 | 6.33 | 6.32 | | | | | | |
| TURBIDITY (NTU) | 3.1 | 2.1 | 2.2 | 1.8 | | | | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| LL-MW2 120308 | 1612 | 8151 | 40mL V | 1 | N/A |
| ↓ | ↓ | 8290 | 1L A | 2 | N/A |
| | | TSS, pH | 1L Pl | 1 | N/A |
| | | TOC | 500 mL Pl | 1 | H2SO4 |
| | | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**
TOC=Top of well casing
wl.prot.=top of well protector

# GROUNDWATER SAMPLING LOG

| | | | | |
|---|---|---|---|---|
| **PROJECT NAME** | Lora Lakes | | **WELL NO.** | MW-6 |
| **PROJECT NO.** | 05482-025-~~220~~ 3000 | | **SAMPLED BY** | H. Hirsch |
| **DATE** | 12/3/2008 | | | |

| **WELL INFORMATION** | | |
|---|---|---|
| DEPTH TO WATER | 13.14 | (TOC-ft) |
| | | (wl.prot.-ft) |
| DEPTH OF WELL | 15.5 | (ft) |
| WELL DIAMETER | 2" | (inches) |
| FEET OF WATER | 2.4 | |
| PRODUCT THICK | N/A | (ft) |
| WELL CONDITION | Good | |
| WEATHER | Fair | |

| **PURGE DATA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: 1058 | | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1102 | 1105 | 1136 | | | | | | | |
| DTW (Ft-TOC) | 13.34 | 13.42 | 14.68 | | | | | | | |
| FLOW RATE (mL/min) | 175 | 125 | | | | | | | | |
| pH (units) (units) | 6.58 | 6.54 | | | | | | | | |
| CONDUCTIVITY (~~umhos~~ mS/cm) | 0.305 | 0.316 | | | | | | | | |
| TEMPERATURE (deg C) | 12.22 | 12.78 | | | | | | | | |
| ORP (mv) | 213 | 213 | | | | | | | | |
| D. O. (mg/L) | 1.28 | 1.28 | | | | | | | | |
| TURBIDITY (NTU) | 13.7 | 14.5 | | | | | | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| LL-MW6-120308 | 1109 | 8151 | 40mL | 1 | — |
| ↓ | ↓ | 8290 | 1L A | | — |
| | | TOC | 500mL P | 1 | H2SO4 |
| | | TPH-Dx | 500mL A | 1 | HCl |
| | | Metals | 500mL P | 1 | HNO3 |
| ↓ | ↓ | TSS, pH | 1L P | 1 | — |
| | | | | | |

**ADDITIONAL INFORMATION:**

TOC=Top of well casing

wl.prot.=top of well protector

## GROUNDWATER SAMPLING LOG

**PROJECT NAME** Lora Lakes
**PROJECT NO.** 05482-025-~~220~~ 300
**DATE** 12/3/2008
**WELL NO.** MW-7
**SAMPLED BY** H. Hirsch

| WELL INFORMATION | | |
|---|---|---|
| DEPTH TO WATER | 14.09 | (TOC-ft)<br>(wl.prot.-ft) |
| DEPTH OF WELL | 25.5 | (ft) |
| WELL DIAMETER | 2" | (inches) |
| FEET OF WATER | 11.5 | |
| PRODUCT THICK | N/A | (ft) |
| WELL CONDITION | Good | |
| WEATHER | Fair | |

| PURGE DATA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: 1208 | | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1212 | 1215 | 1218 | 1221 | 1224 | 1227 | 1230 | | | |
| DTW (Ft-TOC) | 14.15 | 14.18 | 14.18 | 14.16 | 14.16 | — | — | | | |
| FLOW RATE (mL/min) | 100 | 125 | 100 | 100 | 100 | — | — | | | |
| pH (units) (units) | 7.29 | 7.45 | 7.56 | 7.62 | 7.67 | 7.70 | 7.72 | | | |
| CONDUCTIVITY (~~umhos~~ mS/cm) | 0.306 | 0.313 | 0.317 | 0.313 | 0.309 | 0.308 | 0.307 | | | |
| TEMPERATURE (deg C) | 13.87 | 13.96 | 13.89 | 14.00 | 14.05 | 14.04 | 14.05 | | | |
| ORP (mv) | 68 | 55 | 49 | 42 | 39 | 37 | 31 | | | |
| D. O. (mg/L) | 2.01 | 1.54 | 1.75 | 1.10 | 0.97 | 0.87 | 0.89 | | | |
| TURBIDITY (NTU) | 4.4 | 4.8 | 3.5 | 2.0 | 1.9 | 2.3 | 3.6 | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| LL-MW7-120308 | 1230 | 8151 | 40 mL V | 2 | — |
| | | 8290 | 1 L A | 4 | — |
| | | TOC | 500 mL P | 2 | H2SO4 |
| | | TPH-Dx | 500 mL A | 2 | HCl |
| | | Metals | 500 mL P | 2 | HNO3 |
| ↓ | ↓ | TSS, pH | 1 L P | 2 | — |
| | | | | | |

**ADDITIONAL INFORMATION:**
TOC=Top of well casing
wl.prot.=top of well protector

Field Duplicate collected
LL-MW70-120308

# GROUNDWATER SAMPLING LOG

| | | | |
|---|---|---|---|
| **PROJECT NAME** | Lora Lakes | **WELL NO.** | Mw-10 |
| **PROJECT NO.** | 05482-025-~~220~~ 3000 | **SAMPLED BY** | H. Hirsch |
| **DATE** | 12/3/2008 | | |

| **WELL INFORMATION** | | |
|---|---|---|
| DEPTH TO WATER | 13.95 | (TOC-ft) |
| | | (wl.prot.-ft) |
| DEPTH OF WELL | 20.5 | (ft) |
| WELL DIAMETER | 2" | (inches) |
| FEET OF WATER | 6.4 | |
| PRODUCT THICK | N/A | (ft) |
| WELL CONDITION | Good | |
| WEATHER | Fair | |

Tubing at ~17.2

| **PURGE DATA** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| START PURGE TIME: 1422 | | | | | | | | | | |
| VOLUME PURGED (L) | | | | | | | | | | |
| TIME | 1425 | 1428 | 1431 | 1434 | 1437 | 1440 | 1443 | | | |
| DTW (Ft-TOC) | 13.96 | 13.96 | 13.96 | 13.96 | — | — | — | | | |
| FLOW RATE (mL/min) | 175 | 175 | 175 | 190 | — | — | — | | | |
| pH (units) (units) | 7.83 | 7.80 | 7.77 | 7.74 | 7.73 | 7.71 | 7.70 | | | |
| CONDUCTIVITY (~~umhos~~ mS/cm) | 0.261 | 0.260 | 0.258 | 0.257 | 0.253 | 0.255 | 0.253 | | | |
| TEMPERATURE (deg C) | 12.63 | 12.80 | 12.84 | 12.92 | 12.96 | 12.99 | 12.93 | | | |
| ORP (mv) | 113 | 112 | 112 | 113 | 114 | 116 | 117 | | | |
| D. O. (mg/L) | 3.49 | 2.77 | 2.49 | 2.39 | 2.62 | 2.63 | 2.80 | | | |
| TURBIDITY (NTU) | 0.5 | 0.7 | 0.9 | 1.5 | 1.9 | 1.3 | 1.3 | | | |
| PURGE AND SAMPLE EQUIPT: | Peristaltic pump & polyethylene tubing | | | | | | | | | |

| SAMPLE NUMBER | SAMPLE TIME | ANALYSIS | CONTAINER | # BOTTLES | PRESERVATIVE |
|---|---|---|---|---|---|
| LL-MW10-120308 | 1440 | 8290 | 1L A | 2 | — |
| ↓ | ↓ | TOC | 500mL P | 1 | H2SO4 |
| | | TSS, pH | 1L P | 1 | — |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**ADDITIONAL INFORMATION:**
TOC=Top of well casing
wl.prot.=top of well protector

**Columbia Analytical Services**

# CHAIN OF CUSTODY

1 amber

SR#:

1317 South 13th Ave. • Kelso, WA 98626 • (360) 577-7222 • (800) 695-7222x07 • FAX (360) 636-1068

PAGE 1 OF 1 COC #

PROJECT NAME Lora Lakes Apartments
PROJECT NUMBER 05482-025-3000
PROJECT MANAGER Stacy Patterson
COMPANY/ADDRESS AECOM, 1011 SW Klickitat Way, Seattle, WA Ste 201
CITY/STATE/ZIP 98134
E-MAIL ADDRESS stacy.patterson@aecom.com
PHONE # 206-403-4261 FAX #
SAMPLER'S SIGNATURE

| SAMPLE I.D. | DATE | TIME | LAB I.D. | MATRIX | NUMBER OF CONTAINERS | | Semivolatile Organics by GC/MS 625☐ 8270☐ 8270LL☐ | Volatile Organics 624☐ 8260☐ | Hydrocarbons (*see below) Gas☐ 8021☐ BTEX☐ | ☐ Fuel Fingerprint (FIQ) Diesel☐ Oil☐ ☐ NW-HCID Screen | Oil & Grease/TRPH 1664 HEM☐ 1664 SGT☐ | PCB's Aroclors☐ Congeners☐ | Pesticides/Herbicides 608☐ 8081A☐ 8141A☐ 8151A☐ | Chlorophenolics - 8151M Tri☐ Tetra☐ PCP☐ | PAHS 8310☐ SIM☐ | Metals, [✓ Total] or Dissolved (See list below) | Cyanide☐ | Hex-Chrom☐ [✓ pH], Cond., Cl, SO4, PO4, F, NO2, NO3, BOD, [✓ TSS], TDS (circle) | $NH_3$-N, COD, Total-P, TKN, [✓ TOC] DOC (circle) $NO_2$+$NO_3$ | TOX 9020☐ AOX 1650☐ 506☐ | Pentachlorophenol 8151 | Dioxins/Furans 8290 | TPH-Dx | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL-MW2-120308 | 12/3/08 | 1012 | | W | | | | | | | | | | | | | | X | X | | X | X | | | |
| LL-MW6-120308 | ↓ | 1109 | | ↓ | | | | | | | | | | | | X | | X | X | | X | X | X | | |
| LL-MW7-120308 | | 1230 | | | | | | | | | | | | | | X | | X | X | | X | X | X | | |
| LL-MW10-120308 | | 1440 | | | | | | | | | | | | | | | | X | X | | | X | | | |
| LL-MW70-120308 | | 1230 | | | | | | | | | | | | | | X | | X | X | | X | X | X | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |

**REPORT REQUIREMENTS**

___ I. Routine Report: Method Blank, Surrogate, as required

___ II. Report Dup., MS, MSD as required

___ III. Data Validation Report (includes all raw data)

___ IV. CLP Deliverable Report

___ V. EDD

**INVOICE INFORMATION**

P.O. # ____________

Bill To: ____________

**TURNAROUND REQUIREMENTS**

____ 24 hr. ____ 48 hr.

____ 5 Day

____ Standard (10-15 working days)

____ Provide FAX Results

____________ Requested Report Date

Circle which metals are to be analyzed: Priority metals + Hg

Total Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn [✓ Hg]

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI NORTHWEST OTHER:________ (CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:

| RELINQUISHED BY: | RECEIVED BY: | RELINQUISHED BY: | RECEIVED BY: |
|---|---|---|---|
| Signature / Date/Time 12/3/08 1400 | Signature / Date/Time | Signature / Date/Time | Signature / Date/Time |
| Printed Name Heather Hirsch / Firm Aecom | Printed Name / Firm | Printed Name / Firm | Printed Name / Firm |

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SR#:

PAGE 1 OF 1 COC #

PROJECT NAME POS - Lora Lake Apts.
PROJECT NUMBER 05482-025
PROJECT MANAGER Stacy Patterson
COMPANY/ADDRESS ENSR
1011 SW Klickitat Way, Ste 207
CITY/STATE/ZIP Seattle, WA 98134
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PHONE# (206) 624-9349 FAX# (206) 624-2839
SAMPLER'S SIGNATURE

| SAMPLE I.D. | DATE | TIME | LAB I.D. | MATRIX | NUMBER OF CONTAINERS | | Semivolatile Organics by GC/MS 625 ☐ 8270 ☐ 8270LL ☒ (PAH SIM) | Volatile Organics 624 ☐ 8260 ☐ 8021 ☐ BTEX ☐ | Hydrocarbons (*see below) Gas ☐ Diesel ☐ Oil ☐ | Fuel Fingerprint (FIQ) ☐ NW-HCID Screen ☐ | Oil & Grease/TRPH 1664 HEM ☐ 1664 SGT ☐ | PCB's Aroclors ☐ Congeners ☐ | Pesticides/Herbicides 608 ☐ 8081A ☐ 8141A ☐ 8151A ☑ PCP | Chlorophenolics - 8151M Tri ☐ Tetra ☐ PCP ☐ | PAHS 8310 ☐ SIM ☐ | Metals, Total or Dissolved (See list below) | Cyanide ☐ | Hex-Chrom ☐ pH, Cond., Cl, SO4, PO4, F, NO2, NO3, BOD, TSS, TDS (circle) | NH3-N, COD, Total-P, TKN, TOC, DOC (circle) NO2+NO3 | TOX 9020 ☐ AOX 1650 ☐ 506 ☐ | Dioxins/Furans (method 8290) | Hardness (method SM 2340B) | pH (method SM 4500 H+B) | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-3-081908 | 8/19/08 | 1020 | | W | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -11- | | 1210 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -10- | | 1325 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -9- | | 1440 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -90- | | 1440 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -8- ↓ | ↓ | 1620 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| -4-082008 | 8/20/08 | 0925 | | | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| ↓ -5- ↓ | ↓ | 1040 | | ↓ | 8 | | X | | | | | | X | | | X | | | | | X | X | X | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |

**REPORT REQUIREMENTS**

___ I. Routine Report: Method Blank, Surrogate, as required
___ II. Report Dup., MS, MSD as required
_X_ III. Data Validation Report (includes all raw data)
___ IV. CLP Deliverable Report
___ V. EDD

**INVOICE INFORMATION**
**P.O. #** Port of Seattle
**Bill To:** A-LB11047

**TURNAROUND REQUIREMENTS**
___ 24 hr. ___ 48 hr.
_X_ 5 Day
_X_ Standard (10-15 working days)
___ Provide FAX Results

Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al As [✓ Sb] Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI [✓ NORTHWEST] OTHER:_____ (CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:

| RELINQUISHED BY: | | RECEIVED BY: | | RELINQUISHED BY: | | RECEIVED BY: | |
|---|---|---|---|---|---|---|---|
| Signature | Date/Time 8/20/08 / 1400 | Signature | Date/Time | Signature | Date/Time | Signature | Date/Time |
| Printed Name Dean W. Kinney | Firm ENSR | Printed Name | Firm | Printed Name | Firm | Printed Name | Firm |

Prepared for:
**Port of Seattle**
**Seattle, Washington**

# Soil and Groundwater Analytical Results

## Lora Lakes Apartments

AECOM, Inc.
February 12, 2009
**Document No.: 05482025**

Prepared for:
**Port of Seattle**
**Seattle, Washington**

# Soil and Groundwater Analytical Results

## Lora Lakes Apartments

Prepared by Stacy Patterson, Project Manager

Reviewed by Merv Coover, Senior Project Manager

AECOM
February 12, 2009
**Document No.: 05482-025**

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## List of Figures

## List of Attachments

# 1.0 Introduction

As described in the main body of this report, the *Site Investigation Work Plan – Lora Lake Apartments* (ENSR, 2008) and the Modified Work Plan in Appendix C describe in detail the soil and groundwater sampling and analyses for site investigation conducted by ENSR/AECOM in 2008. There were three investigation events: March-April, August, and December. The analytical results are presented in this appendix. Each investigation event is discussed separately; in this manner the reader can understand the need and rationale for the follow-up investigations. All of the corresponding table and figures for each sampling and analysis event are provided herein.

# 2.0 Sample Location, Analyses, and Screening Levels

The March-April event included the collection and analysis of 44 shallow and deep soil samples from twelve locations across the site. It also included collection and analysis of groundwater from six site wells (MW-1 through MW-6) and, a sub-slab vapor investigation. The sub-slab vapor investigation in not presented in this appendix. It is presented as a stand-alone document in Appendix B. The August event included collection and analysis of groundwater from seven wells (MW-3, MW-4, MW-5, MW-8, MW-9, MW-10, and MW-11) and the December event included collection and analysis of groundwater from four wells (MW-2, MW-6, MW-7, and MW-10). During the December event three archived soil samples from the ground water interface of monitoring wells (MW-7, MW-8, and MW-11) were also analyzed. The rational for all sample locations is listed in Table F-2-1.

Soil samples collected in the March-April event were analyzed for total metals, VOCs, sVOCs, PCBs, total petroleum hydrocarbons (TPH) and dioxins and furans. Groundwater samples collected during each of the three events were analyzed for a combination of dissolved metals, VOCs, sVOCs, TPH, and dioxins and furans, and general chemistry parameters such as pH, total suspended solids (TSS), total organic carbon (TOC) and dissolved metals. Table F-2-2 lists the analytical methods used during each event.

In order evaluate the concentrations of detected analytes in samples screening concentrations were developed. Site zoning, adjacent property information, and characteristics of the affected media were considered in the selection of applicable screening concentrations. The screening concentrations are not site cleanup levels. Screening concentrations are conservative levels used to assess whether site impacts pose a risk to human health or the environment. The site clean-up levels and/or remediation levels will be determined during the RI/FS. The screening concentrations used for this investigation were obtained from the Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 WAC. Both Method A and Method B Cleanup Levels (CULs) were used as preliminary screening concentrations for soil and groundwater. Method A CULs were obtained from Table 720-1 Method A Cleanup Level for Ground Water and Table 740-1 Method A Cleanup Levels for Unrestricted Land Uses and consider both direct contact and leaching to groundwater pathways. For chemicals not included on the Method A tables (and with the exception of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins and furans), Method B CULS for soil (direct contact) and groundwater were obtained from the Cleanup Levels and Risk Calculations (CLARC) on-line database developed and maintained by the Washington Department of Ecology (Ecology). All screening values are included in the analytical data tables for easy reference and comparison.

The Method B screening levels for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins and furans in soils were obtained following WAC173-340-740 (3)(B)(II) for carcinogenic effects of soil ingestion. In order to compare the cPAH analytical results to the screening level, the analytical results are multiplied by their individual toxic equivalency factors (TEF) to obtain the toxic equivalent (TEQ) of benzo(a)pyrene (BAP). The total cPAH TEQ concentration for each sample was compared to the BAP screening concentration of 137 µg/kg. For dioxin/furan in soil, the analytical results for each congener are multiplied by their individual TEF values to obtain the TEQ of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The total TEQ concentration for each sample was then compared to the TCDD screening concentration of 11 ng/kg.

The Method B screening level for cPAHs in groundwater was obtained following WAC173-340-720 (4)(B) for carcinogens in potable water. Again, the analytical results are multiplied by their individual TEF to obtain the TEQ of BAP. Then the total cPAH TEQ concentration for each sample was compared to the BAP screening concentration of 0.012 µg/L. The Modified Method B screening level for dioxin/furan compounds in groundwater was obtained following WAC 173-340-720 (4)(c)(iv). The analytical results from each sample are multiplied by their individual TEF to obtain the TEQ of TCDD. Then the total TCDD TEQ concentration for each sample was compared to the TCDD screening concentration of 5.83 pg/L.

## 2.1 March—April 2008 Investigation

Soil sample analytical results are compiled in the following tables:

| | |
|---|---|
| Table F-3-1 | Geoprobe Soils Analytical Results: Metals, PCBs, SVOCs, VOCs, and TPH |
| Table F-3-2 | Geoprobe Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) |
| Table F-3-3 | Geoprobe Soils Analytical Results: cPAH Total Toxic Equivalency Quotient (TEQ) |
| Table F-3-4 | Monitoring Well Soils Analytical Results: Metals, SVOCs, VOCs, and TPH |
| Table F-3-5 | Monitoring Well Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) |
| Table F-3-6 | Monitoring Well Soils Analytical Results: cPAH Total Toxic Equivalency Quotient (TEQ). |

The data provided in these tables are for compounds detected above the method reporting limit (or estimated at a value below the method reporting limit) at least once. Analytes not detected in any soil samples are not represented in the summary tables.

Analytes in concentrations exceeding regulated levels (i.e., MTCA Method A or B) are displayed on Figure F-3-1. Laboratory reports and data validation reports are provided in electronic format in Attachment F-1.

### 2.1.1 Metals

Only two metals (arsenic and lead) were detected in LLA soil at concentrations that exceed CULs.

Arsenic concentrations exceeded the MTCA Method B (carcinogenic) CUL of 0.67 mg/kg in all soil samples collected from the site, but are below the MTCA Method A residential arsenic standard of 20 mg/kg. The highest arsenic concentrations observed (~10 – 11 mg/kg) were detected in near-surface soil at locations LL-10, MW-4 and MW-5. Information provided by the Department of Ecology suggests that the typical concentration of arsenic present in the area is approximately 7 mg/kg (Ecology, 2002), except in areas—including the LLA Site—impacted by ASARCO Ruston smelter airborne plume. Arsenic concentrations present in soil at the LLA Site are comparable to the regional value, and well within expected ASARCO plume levels, and are therefore consistent with background.

Lead was detected at concentrations slightly above the MTCA Method A CUL of 250 mg/kg in the following three samples:

- LL01 (1.5-2’): 265 mg/kg
- MW-4 (0-0.5’): 370 mg/kg
- MW-5 (0-0.5’): 294 mg/kg.

There is no published Method B soil CUL for lead. All other soil samples contained lead at concentrations below 250 mg/kg.

### 2.1.2 Volatile organic compounds

No VOCs were detected in soil at concentrations that exceed MTCA Method B CULs.

### 2.1.3 Semi-volatile organic compounds

Pentachlorophenol was detected in soil sample MW-4-0-0.5 at a concentration of 15,000 µg/kg. This is the only sample that exceeded the MTCA Method B (carcinogenic) CUL of 8,300 µg/kg.

Carcinogenic polycyclic aromatic hydrocarbon (cPAH) concentrations were evaluated in the context of toxicity equivalencies (WAC 173-340-708(8)(e)). The TEQs were determined assuming one half of the method reporting limit for non-detected compounds. The cPAH TEQs slightly exceeded the MTCA Method B (carcinogen) CUL of 137 µg/kg in the following samples:

- LL08 (2’ - 4’ DUP): 156 µg/kg
- MW-4 (0’ - 0.5’): 149 µg/kg
- MW-5 (0’ - 0.5’): 243 µg/kg
- MW-5 (11.5’ - 13’): 144 µg/kg.

### 2.1.4 Total petroleum hydrocarbons

Neither gasoline-range nor diesel and residual oil-range TPH were detected in soil at concentrations that exceed the MTCA Method A cleanup levels (CUL).

### 2.1.5 Polychlorinated biphenyls

PCBs were analyzed in three soil samples collected from location LL-08 which is positioned near an electrical transformer located near the bone yard. Concentrations of total PCBs (sum of specific Aroclor concentrations) were below the MTCA Method B (carcinogen) CUL of 500 µg/kg.

### 2.1.6 Dioxins and furans

Dioxin and furan analytical results were evaluated in the context of total toxic equivalent concentrations of 2,3,7,8-TCDD as required under the MTCA Cleanup Regulations WAC 173-340-708(8)(d). The total toxic equivalency quotient (TEQ) for each sample was calculated using one half of the method reporting limit for non-detected congeners. Dioxin and furan TEQs exceeded the MTCA Method B (carcinogenic) CUL of 11 ng/kg in several samples distributed across the site (Figure F-3-1). The highest TEQs were associated with samples located near-surface at the eastern edge of the site (MW-4 and MW-5) and near the recreation building (LL-01 and LL-10) where contaminated materials were removed in 1987.

### 2.1.7 March-April summary

Based on the available data, the highest chemical concentrations in near-surface soil (0-2 feet) are near the Recreation Building and in the vicinity of Buildings A, C and D on the east side of the property. The chemicals detected above MTCA residential CULs in near-surface soil were lead, arsenic, PAH, pentachlorophenol, dioxins and furans. Neither VOCs nor TPH were detected in near-surface soil above protective levels. Arsenic was present at concentrations consistent with area background values for the central Puget Sound region (~5 – 10 mg/kg). Lead was detected slightly in excess of the MTCA Method A CUL of 250 mg/kg (there is no published value for a MTCA Method B level) on the eastern side of the site near Buildings A, C and D. Pentachlorophenol and cPAH were detected in the same area at a concentration above the MTCA Method B CUL. Dioxins and furans exist above MTCA Method B CULs more broadly across the site than the aforementioned chemicals. However, the highest concentrations of dioxins and furans are, again, located near Buildings A, C, and D.

Data for deeper soil contamination (i.e., > 2 feet bgs) are generally consistent with the near-surface soil data in that the highest concentrations are located near Buildings A, C, and D. The only chemicals that exceeded

Method B CULs in this area were cPAH, dioxins, and furans. Dioxins and furans were also detected in excess of the Method B CUL in the play area (near Building M). No deep soil samples were collected near the Recreation Building during this investigation. That area was previously characterized (Geosciences Management, 2008) and shown to contain the same array of constituents. The area near the Recreation Building is understood to be approximately collocated with the source of contamination originally investigated and subjected to a clean-up action before the apartment complex was constructed.

# 3.0 Groundwater Analytical Results

## 3.1 March-April 2008 Investigation

Analytical results for all detected compounds in the ground water samples are presented in the following tables:

| | |
|---|---|
| Table F-4-1 | Groundwater Analytical Results: Metals, SVOCs, VOCs, and TPH |
| Table F-4-2 | Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) |
| Table F-4-3 | Groundwater Analytical Results: cPAH Total Toxic Equivalency Quotient (TEQ). |

Analytes detected above MTCA CULs are displayed in Figure F-4-1. The laboratory reports and data validation work for all groundwater analyses are included in Attachment F-1.

### 3.1.1 Metals

The only metal detected in groundwater at concentrations above a CUL was arsenic. Arsenic exceeded the Method B (non-carcinogenic) CUL of 4.8 µg/L in MW-1. Concentrations of arsenic in monitoring wells MW-5 and MW-6 were below the Method B non-carcinogenic CUL but above the carcinogenic CUL of 0.058 µg/L. All results were below the Method A CUL of 5 µg/L. Method A is the appropriate CUL to use for evaluating arsenic levels in groundwater because Washington State has naturally elevated background levels of arsenic and this is factored into the Method A CUL. Arsenic was not detected in MW-2, MW-3 and MW-4.

### 3.1.2 Volatile organic compounds

Tetrachloroethene and trichloroethene were the only VOCs detected in groundwater at concentrations above Method B CULs but below the Method A CULs. The sample collected from MW-1 contained tetrachloroethene at 0.23 µg/L and trichloroethene at 0.17 µg/L. These concentrations slightly exceed the carcinogenic CULs for the two compounds of 0.08 and 0.11 µg/L, respectively; but were below applicable Method A CULs and therefore below applicable designated screening levels.

Low levels of other VOCs were present in groundwater from MW-2 suggesting that there are other upgradient (and off-site) sources of contamination impacting groundwater quality at the LLA Site.

### 3.1.3 Semi-volatile organic compounds

Pentachlorophenol was detected at concentrations exceeding the MTCA Method B (carcinogenic) CUL of 0.73 µg/L in groundwater samples collected from MW-1 and MW-5 (Table F-4-1). In all other samples PCP was not detected at the method reporting limit (MRL), however, the MRL was slightly above the Method B CUL and reported as < 0.95 - <0.99 µg/L. Benzo(a)pyrene was the only other compound detected in groundwater at concentrations above the Method B CUL. In the latter case, the reported concentrations were estimates (i.e., J-flagged).

As with VOCs, low levels of SVOCs were detected in the sample from MW-2 which is located in the northwest (and upgradient) corner of the site.

The cPAH TEQ concentrations in groundwater slightly exceeded the MTCA Method B (carcinogen) CUL of 0.012 µg/L in all wells except MW-6 (Table F-4-3). MW-1 had the highest concentration, an unsurprising result given this well's location near the area where contaminated materials were removed in 1987.

### 3.1.4 Total petroleum hydrocarbons

Gasoline-range TPH was not detected above MTCA Method A CULs in any of the groundwater samples collected from the site. Diesel and residual oil-range TPH were detected at concentrations exceeding the MTCA Method A CUL of 500 µg/L in wells MW-1 and MW-6. Well MW-1 is located near the area where the previous contaminated material removal action occurred in 1987. The groundwater flow direction and cross-gradient location of MW-6 relative to MW-1 suggested that the source of contamination impacting groundwater quality at MW-1 was not the same as the source of contamination impacting groundwater quality at MW-6. Further, the NWTPH-Dx chromatograms for these two samples showed very different petroleum hydrocarbon signatures, again suggesting different sources (Figure F-4-2).

### 3.1.5 Dioxins and furans

Dioxin and furan TEQs exceeded the MTCA Method B (carcinogen) CUL of 5.8 pg/L in one groundwater sample (MW-1) when one-half the detection limit was assumed as the concentration for non-detected congeners (Table F-4-1). These results suggested that groundwater impacts from dioxins and furans were limited to the area where contamination was previously characterized and removed in the late 1980s. Further, the data are consistent with the understanding that these very hydrophobic compounds attenuate strongly through sorption to soil organic matter and are therefore expected to rapidly diminish in aqueous phase concentration with distance from a source of contamination.

### 3.1.6 March-April summary

All six groundwater monitoring wells were sampled during this event (MW-1, MW-2, MW-3, MW-4, MW-5, and MW-6). MW-1 was installed by GeoScience Management in 2007 and wells MW-2 through MW-6 were installed as part of this investigation event.

The groundwater data show that shallow groundwater on the site has been impacted by historical activities. Arsenic, TPH-Dx, pentachlorophenol, cPAH and dioxins and furans were detected in site groundwater. Further, impacted groundwater exceeding Method B CULs may potentially extend off-site to the east based on findings for down gradient wells MW-4, MW-5, and MW-6. The highest chemical concentrations were observed in MW-1, which is located within or very close to the source area previously investigated and subjected to clean-up.

Arsenic was the only metal detected above applicable Method A or B cleanup levels. This metal was detected in all site wells but was only in excess of Method A in MW-1. The Method A cleanup level is the applicable screening level for this site and is based on concentrations protective of groundwater.

Petroleum hydrocarbons in the diesel and oil range were present in monitoring well MW-1 in the center of the site and in monitoring well MW-6 in the northeast corner of the site above the MTCA Method A CUL. The chromatographs from the two samples depict different signatures (Figure F-4-2) suggesting the possibility of independent hydrocarbon sources.

Pentachlorophenol (PCP) was detected in monitoring wells MW-1 and MW-5 above the Method B CUL of 0.73 µg/L. It was not detected in the other wells above the method reporting limit however the reporting limit in three of the well was above the Method B CUL so presences or absence of the PCP above the CUL could not be definitively concluded in those wells.

CPAHs were detected in all wells, with the exception of MW-6. The groundwater sample from MW-1 showed the highest TEQ concentration above the MTCA Method B CUL. Dioxin and Furans were detected in all site wells but only the sample collected from MW-1 near the Recreation Building exceeded the Method B CUL.

VOCs (tetrachloroethene and trichloroethene) were detected in MW-1 above slightly Method B but below Method A. Theses analytes were not present in other wells. Other low level VOCs were present in groundwater from MW-2 suggesting that there are other up gradient (and off-site) sources of contamination impacting groundwater quality at the LLA Site.

## 3.2 August 2008 Investigation

Analytical results for all detected compounds in the ground water samples are presented in the following tables:

- Table F-4-4 Groundwater Analytical Results: Metals, PCP, PAHs, TPH-Dx, Hardness and pH
- Table F-4-5 Groundwater Analytical Results: Total Metals Results Compared to Surface Water Toxic Substance Criteria (WAC 173-201A-240)
- Table F-4-6 Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ).

The data provided in these tables are for compounds detected above the method reporting limit (or estimated at a value below the method reporting limit) at least once. Analytes not detected in any samples are not represented in the summary tables.

Analytes detected above regulated levels (i.e., MTCA Method A or B) are displayed in Figure F-4-3. The laboratory reports and data validation work for all groundwater analyses are included in electronic format in Attachment F-1.

### 3.2.1 Metals

The only metal detected in groundwater at concentrations above the CUL was arsenic. The reported concentrations of arsenic were below the Method A and Method B non-carcinogenic CULs but above the Method B carcinogenic CUL of 0.058 µg/L in all groundwater samples collected (Table F-4-4). These data are consistent with the March 2008 analytical results where arsenic was detected above the Method B carcinogenic CULs in all site wells. Method A is the appropriate CUL to use for arsenic because Washington State has naturally elevated background levels of arsenic and this is factored into the Method A CUL.

All detected metals concentrations were also compared to Washington States Surface Water Toxic Substance Criteria in order to determine if concentrations present in the groundwater could impact surface water of Lora Lake which is down gradient of the wells MW-8 through MW-11. None of the detected analytes exceeded surface water criteria (Table F-4-5).

### 3.2.2 Semi-volatile organic compounds

Pentachlorophenol (PCP) was detected at 1.5 µg/L, exceeding the MTCA Method B carcinogenic CUL of 0.73 µg/L, in the groundwater sample collected from MW-5 (Table F-4-4). This is consistent with the data collected during the initial investigation in which PCP was reported in MW-5 at 1.0 µg/L. PCP concentrations were not detected above the method reporting limit of 0.5 µg/L in any of the other samples.

The individual carcinogenic polycyclic aromatic hydrocarbons (cPAH) were not detected above method detection limits in any of the samples and were therefore not evaluated in the context of toxicity equivalencies (WAC 173-340-708(8)(e)). Previous results indicated exceedances of the MTCA Method B carcinogenic CUL 0.012 µg/L in all monitoring wells with the exception of MW-6. However, all results were J flagged (estimated) due to the higher detection limit of the SW-846 method 8270C. Use of the SW-846 method 8270 SIM during this sampling event provided data that was not J flagged and therefore more reliable indicator of actual concentrations.

### 3.2.3 Total petroleum hydrocarbons

Diesel- and oil-range TPH were not detected at concentrations exceeding the MTCA Method A CUL of 500 µg/L in any of the seven wells (Table F-4-4).

### 3.2.4 Dioxins and furans

Dioxin and furan concentrations were evaluated in the context of total toxicity equivalencies (WAC 173-340-708(8)(e)). The toxic equivalent quotient (TEQ) of the sample from MW-10 was the only one that exceeded the Method B CUL using half of the estimated reporting limit as the concentration of non-detect congeners (Table F-4-6). It is important to note that many of the congeners detected in the sample were U flagged (undetected) during data validation due the fact there was contamination in the method blank. Additional information explaining the flagging is provided in the validation report in Attachment F-1. No other samples exceeded the 5.8 pg/L CUL.

### 3.2.5 August summary

A select number of ground water monitoring wells were sampled during this event (MW-4, MW-5 and newly installed wells MW-8, MW-9, MW-10 and MW-11). These wells were sampled to determine if impacted groundwater originating on the Lora Lake Site was migrating off site toward the east.

Analytical results indicated that all detected priority pollutant metals were below applicable MTCA Method A and B CULs. Due to the close proximity of Lora Lake all detected metals concentrations were also compared to protective surface water standards. The results of the comparison indicate that surface water would not be impacted by metals concentrations in the groundwater flowing from the LLA Site.

Diesel- and oil-range TPH and cPAHs concentrations were also below MTCA Method A CULs. PCP was detected in MW-5 and MW-9. The concentration of 1.5 µg/L in MW-5 exceeded MTCA Method B carcinogenic CUL of 0.73 µg/L, but the concentration of 0.58 µg/L found in off-site well MW-9 does not.

Dioxins and furans were detected in all wells but only the TEQ concentration in off-site well MW-10 exceeded the Method B CUL of 5.8 pg/L. However, many of the detected congeners were flagged U (undetected) during data validation based on method blank contamination thus final TEQ calculations, though conservative, are suspect. The presence of dioxins in the groundwater may be related to the presence of total suspended solids. The samples were not analyzed for TSS during the March and August sampling events; thus, it is not possible to directly link the presence of dioxins to the concentration of TSS in each sample. However, published research states that dioxins are highly immobile due to their very low water solubility and very strong sorption capacity. In other words, dioxins are hydrophobic and have a strong tendency to adhere to sediments and suspended solids; they are not likely to leach to groundwater.

## 3.3 December 2008 Investigation

Analytical results for all detected compounds in the ground water samples are presented in the following tables:

- Table F-4-7 Groundwater Analytical Results: Metals, PCP, and TPH
- Table F-4-8 Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ).

The data provided in these tables are for compounds detected above the method reporting limit (or estimated at a value below the method reporting limit) at least once. Analytes not detected in any samples are not represented in the summary tables.

All analytes detected are displayed in Figure F-4-4. The laboratory reports and data validation work for all groundwater analyses are included in electronic format in Attachment F-1.

### 3.3.1 Metals

No metals were detected above the applicable MTCA Method A or B CUL.

### 3.3.2 Pentachlorophenol

Pentachlorophenol (PCP) was detected above the method reporting limit of 0.5 µg/L in groundwater samples from wells MW-2 and MW-6; although, these results were J flagged (estimated). The detected concentrations do not exceed the MTCA Method B carcinogenic CUL of 0.73 µg/L (Table F-4-7). PCP concentrations were not detected above the method reporting limit in any of the other samples. This is consistent with the data collected during the August 2008 investigation when EPA Method 8151 was used instead of EPA Method 8270 to detect PCP at lower concentrations.

### 3.3.3 Total petroleum hydrocarbons

Diesel- and residual-range TPH were detected at concentrations exceeding the MTCA Method A CUL of 500 µg/L in the groundwater sample from well MW-6 (Table F-4-7). Diesel- and residual-range TPH were also detected in the groundwater sample and duplicate sample collected from well MW-7. The laboratory detected diesel range organics at 19 µg/L in the original sample and 13 µg/L in the duplicate sample. The laboratory detected residual-range organics at 48 µg/L in the original sample and 37 µg/L in the duplicate sample, however, due to method blank contamination the values for residual-range organics were qualified with a U flag (undetected) and reported as <520 µg/L after data validation.

These results are consistent with the findings of the March 2008 investigation, which reported diesel- and residual-range TPH above the CUL in groundwater well MW-6; this well was not sampled in August 2008.

The groundwater sample from MW-6 was re-analyzed (outside of acceptable holding time) for TPH using a silica gel clean-up. The reported TPH concentrations were reduced to 350 µg/L DRO and 34 µg/L RRO. This reduction indicates the presence of naturally occurring hydrocarbons.

### 3.3.4 Dioxins and furans

Dioxin and furan concentrations were evaluated in the context of total toxicity equivalencies (WAC 173-340-708(8)(e)). The toxic equivalent quotients (TEQs) were calculated using non-detect congeners that are included in the TEQ calculation by using ½ the estimated detection limit (EDL). None of the samples for the December investigation exceeded the MTCA Method B (carcinogen) CUL of 5.8 pg/L (Table F-4-8).

It is important to note that many of the congeners detected in the samples were U flagged (undetected) during data validation due the fact there was contamination in the method blank. Additional information explaining the flagging is provided in the validation report in Attachment F-1.

### 3.3.5 December summary

A select number of four groundwater monitoring wells (MW-2, MW-6, MW-7 and MW-10) was sampled during this sampling event to determine if impacted groundwater was migrating off-site on the northeast portion of the property and to re-evaluate the suspect dioxin and furan data in MW-10 collected in August.

Analytical results indicate that all detected priority pollutant metals, PCP, and dioxin and furans were below applicable MTCA Method A and B CULs in all wells sampled. Dioxin and furans were detected in MW-10 but at levels similar to the other wells and below MTCA Method B CULs.

Diesel- and residual-range TPH concentrations exceeded MTCA Method A CULs in MW-6 which is consistent with the March investigation. Diesel- and residual-range TPH concentrations were detected in the down gradient well MW-7, but well due to blank contamination could only be reported as not detected at the MRL. TPH was not detected in the other two wells.

General chemistry analyses (pH, total suspended solids, and total organic carbon) were conducted on these samples for the purpose of acquiring general site chemistry.

# 4.0 References

Ecology, 2002. *Tacoma Smelter Plume Site, King County Mainland Soil Study*. Washington State Department of Ecology – Toxics Cleanup Program, March 2002

ENSR 2008. *Site Investigation Work Plan – Lora Lake Apartments*, ENSR March 24, 2008

ENSR 2008. *Soil, Groundwater, and Sub-slab Air Investigation – Lora Lake Apartments*, ENSR June, 2008

# Attachment F-1

# March, August and December Laboratory Certificates and Validation Reports

***(Provided on CD-ROM behind Appendix E tab)***

# Tables

# Table F-2-1 Sample Location and Purpose

| Location ID | Approximate Location | Rationale |
|---|---|---|
| *Groundwater* | | |
| MW-1 | Approximate center of property in location of known historic impacts | Validate previously collected groundwater data |
| MW-2 | Northwest corner of the property by building Q | Characterize groundwater entering property |
| MW-3 | South side of the property by buildings E and F | Characterize groundwater leaving property |
| MW-4 | Eastern property boundary by former buildings C and D | |
| MW-5 | Eastern property boundary by former buildings A and C | |
| MW-6 | Eastern property boundary by former buildings W and X | Characterize groundwater in NE corner of property |
| MW-7 | East of Des Moines Memorial Drive down-gradient of MW-6 | Charaterize groundwater beyond property line |
| MW-8 | East of Des Moines Memorial Drive down-gradient of MW-1 | |
| MW-9 | East of Des Moines Memorial Drive down-gradient of MW-5 | |
| MW-10 | East of Des Moines Memorial Drive down-gradient of MW-4 | |
| MW-11 | East of Des Moines Memorial Drive down-gradient of MW-3 | |
| *Soil* | | |
| LL-01 | East side of the Rec. building | Potential high-use area;<br>Previous MTCA exceedances at depth |
| MW-2 | Northwest corner of the property by building Q | Likely point of influx of groundwater to site;<br>Achieve site-wide coverage |
| MW-3 | South side of the property by buildings E and F | Achieve site-wide coverage |
| MW-4 | East side of property by buildings C and D | Achieve site-wide coverage |
| MW-5 | East side of the property by former building A | Achieve site-wide coverage |
| MW-6 | Northeast corner of the property by former buildings X and W | Achieve site-wide coverage |
| LL-07 | West side of the property by building N | Achieve site-wide coverage |
| LL-08 | Boneyard / Play area | Potential high-use area;<br>adjacent to former off-site transformer location |
| LL-09 | Northeast corner of the property by former buildings U and V | Achieve site-wide coverage |
| LL-10 | North side of the Rec. building | Potential high-use area;<br>Adjacent to previous MTCA exceedances |
| LL-11 | South side of the Rec. building | |
| LL-12 | Near the basketball court / pool | Potential high-use area |
| *Soil Vapor* | | |
| LL-SV-RB | Recreation building | Achieve site-wide coverage |
| LL-SV-D | Building D | Achieve site-wide coverage |
| LL-SV-F | Building F | Achieve site-wide coverage |
| LL-SV-H | Building H | Achieve site-wide coverage |
| LL-SV-N | Building N | Achieve site-wide coverage |
| LL-SV-Q | Building Q | Achieve site-wide coverage |
| LL-SV-R | Building R | Achieve site-wide coverage |
| LL-SV-T | Building T | Achieve site-wide coverage |
| LL-SV-AA (Background) | Carport on west side of property | Determine background air values |

# Table F-2-2  Analytical Methods and Laboratory Reporting Limits

| Sampling Event | Parameter | Analysis Method | CAS Reporting Limit |
|---|---|---|---|
| March 2008 | *Shallow Soil* | | |
| | Total Solids | EPA 160.3M | 0.01% |
| | Volatile Organics | SW-846 6260B | 0.005 - 0.2 mg/kg |
| | Semivolatile Organics | SW-846 8270C | 0.010 - 0.2 mg/kg |
| | Dioxins / Furans | SW-846 8290 | 1 - 5 ng/Kg |
| | PCBs | 3545/8082 | 0.01 mg/kg |
| | TPH | NWTPH-Dx | 25 mg/kg |
| | | NWTPH-Gx | 5 mg/kg |
| | Metals (except Mercury) | SW-846 6020 | 1 - 400 mg/kg |
| | Mercury | 7470A/7471A | 0.02 mg/kg |
| | *Soil Vapor* | | |
| | Oxygen, $CO_2$, Methane | Modified 3C | |
| | Helium | Modified ASTM D-1946 | |
| | Volatile Organics | TO-15 | 1.5 - 7 μg/m$^3$ (approximate) |
| | *Groundwater* | | |
| | Volatile Organics | SW-846 6260B | 0.5 - 20 μg/L |
| | Semivolatile Organics | SW-846 8270C | 0.2 - 2 μg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | PCBs | 3545/8082 | 0.2 μg/L |
| | TPH | NWTPH-Dx | 100 μg/L |
| | | NWTPH-Gx | 250 μg/L |
| | Metals (except Mercury) | SW-846 6020 | 5 - 2000 μg/L |
| | Mercury | 7470A/7471A | 0.2 μg/L |
| | Turbidity | EPA 180.1 | |
| August 2008 | *Groundwater* | | |
| | PAHs | SW-846 8270 SIM | 0.02 μg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | Pentachlorophenol | SW-846 8151 | 0.5 μg/L |
| | TPH | NWTPH-Dx | 100 μg/L |
| | Priority Metals | SW-846 6020 | 5 - 2000 μg/L |
| | Mercury | SW-846 7470A | 0.2 μg/L |
| | Hardness | 130.2 | 2 mg/L |
| | pH | 150.1 | |
| December 2008 | *Soil* | | |
| | Total Organic Carbon | ASTM 4129-82M | 0.05 mg/kg |
| | *Groundwater* | | |
| | TSS | 160.2 | 5 mg/L |
| | Dioxins / Furans | SW-846 8290 | 10 - 25 pg/L |
| | Pentachlorophenol | SW-846 8151 | 0.5 μg/L |
| | TPH | NWTPH-Dx | 100 μg/L |
| | Priority Metals | SW-846 6020 | 5 - 2000 μg/L |
| | Mercury | SW-846 7470A | 0.2 μg/L |
| | TOC | EPA 415.1 | |
| | pH | 150.1 | |

# Table F-3-1 Geoprobe Soils Analytical Results: Metals, PCBs, SVOCs, VOCs, and TPH

| | | | Location ID | LL01 | LL01 | LL01 | LL07 | LL07 | LL08 | LL08 | LL08 | LL08 | LL08 | LL09 | LL09 | LL09 | LL09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID | LL01-0.0.5 | LL01-1.5-2 | DUP02-040308 | LL07-0-0.5 | LL07-1.5-2 | LL08-0-0.5 | LL08-1.5-2 | LL08-2-4 | DUP01-040308 | LL08-13-15 | LL09-0-0.5 | LL09-1.5-2 | LL09-6-8 | LL09-13-15 |
| | | | Sample Date | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 | 04/03/08 |
| **Chemical Name** | **Method A** | **MTCA B - Carcinogen** | **MTCA B - Non-Carcinogen** | | | | | | | | | | | | | | |
| **Metals EPA 6020 / 7471A (mg/kg)** | | | | | | | | | | | | | | | | | |
| Antimony | | | 32 | 0.29 J | 0.23 J | 0.2 J | 0.39 J | 0.27 J | 0.27 J | 0.16 J | 0.6 J | 3.51 J | 0.05 J | 0.13 J | 0.1 J | 0.07 J | 0.06 J |
| Arsenic | 20 | 0.67 | 24 | 4.39 J | 3.17 J | 2.83 J | 3.17 | 7.11 | 6.02 | 2.93 | 5.47 J | 5.32 J | 1.2 | 2.67 | 2.2 | 1.96 | 1.47 |
| Beryllium | | | 160 | 0.216 J | 0.252 J | 0.189 J | 0.203 | 0.169 | 0.204 | 0.277 | 0.322 J | 0.206 | 0.187 | 0.231 | 0.187 | 0.222 | 0.18 |
| Cadmium | 2 | | 80 | 0.437 J | 0.282 J | 0.268 J | 0.315 | 0.236 | 0.307 | 0.38 | 1.32 J | 1.26 J | 0.031 | 0.102 | 0.081 | 0.054 | 0.054 |
| Chromium | 19/2000 | | | 48.6 | 34.7 J | 23.3 | 20.9 | 21 | 18.9 | 21.5 | 22.2 | 19 J | 32.2 | 24.3 | 22.1 | 26.6 | 24.5 |
| Copper | | | 3.0E+03 | 20.1 J | 16.2 J | 14 J | 16.5 J | 16.2 J | 23.2 J | 17.1 J | 33 J | 28.8 J | 6.13 J | 15.5 J | 12.7 J | 12.5 J | 14.8 J |
| Lead | 250 | | | 41.6 | 265 J | 91.6 | 33.6 J | 30 J | 42.3 J | 18.4 J | 106 J | 108 J | 2.06 J | 6.29 J | 4.65 J | 2.34 J | 2.05 J |
| Nickel | | | 1.6E+03 | 26.2 | 28.2 | 23.7 J | 29.8 | 25.2 | 23.7 | 27.8 | 40.5 J | 29.2 | 21.7 | 31.5 | 31.2 | 34 | 37.5 |
| Selenium | | | 400 | 0.5 J | 0.3 J | < 1.1 | 0.4 J | < 1.2 | < 1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.2 |
| Silver | | | 400 | 0.065 | 0.048 J | 0.044 J | 0.065 | 0.057 | 0.068 | 0.052 | 0.094 J | 0.088 J | 0.015 J | 0.07 | 0.04 | 0.039 | 0.027 |
| Thallium | | | 5.6 | 0.081 | 0.054 | 0.048 | 0.044 J | 0.05 J | 0.051 J | 0.056 J | 0.056 J | 0.047 J | 0.031 J | 0.08 J | 0.051 J | 0.093 J | 0.047 J |
| Zinc | | | 2.4E+04 | 62.6 J | 75.7 J | 66.2 J | 47.3 J | 33.2 J | 60.7 J | 47.9 J | 119 J | 119 J | 22.3 J | 29.4 J | 25.9 J | 21.8 J | 25.9 J |
| Mercury | 2 | | 24 | 0.053 | 0.04 J | 0.034 J | 0.041 | 0.068 | 0.065 | 0.032 | 0.065 J | 0.088 J | < 0.02 | 0.024 | 0.02 | 0.02 | 0.019 J |
| **PCBs EPA 8082 (µg/kg)** | | | | | | | | | | | | | | | | | |
| Aroclor 1242 | | | | NA | NA | NA | NA | NA | < 7.1 | < 5.5 | 14 | NA | < 5.5 | NA | NA | NA | NA |
| Aroclor 1254 | | | 1.6E+03 | NA | NA | NA | NA | NA | < 80 | < 5.5 | 39 J | NA | < 5.5 | NA | NA | NA | NA |
| Aroclor 1260 | | | | NA | NA | NA | NA | NA | < 7.1 | 8.9 | 51 | NA | < 5.5 | NA | NA | NA | NA |
| Total PCBs | 1.00E+04 | 500 | | NA | NA | NA | NA | NA | 47 | 14.4 | 104 | NA | 8.25 | NA | NA | NA | NA |
| **Volatile Organic Compounds EPA 8260 (µg/kg)** | | | | | | | | | | | | | | | | | |
| 1,1,1-Trichloroethane | | | 7.2E+07 | < 6.4 | < 5.2 | < 5.6 | < 5.4 | < 6 | < 4.8 | < 4.8 | < 4.7 | < 5.1 | < 5 | < 4.6 | < 4.9 | < 5 | < 5.1 |
| 1,2,4-Trimethylbenzene | | | 4.0E+06 | < 26 | < 21 | < 23 | 0.097 J | < 24 | < 19 | < 19 | < 19 | < 21 | < 20 | < 19 | < 20 | < 20 | < 21 |
| 2-Butanone | | | 4.8E+07 | 16 J | < 21 | < 23 | < 22 | < 24 | 2.8 J | < 19 | 8.1 J | 4.9 J | < 20 | < 19 | < 20 | < 20 | < 21 |
| Acetone | | | 8.0E+06 | 230 | 42 | 67 | 41 | 33 | 22 | 24 | 67 | 46 | 16 J | 12 J | 11 J | 3.3 J | 3 J |
| Carbon Disulfide | | | 8.0E+06 | 0.43 J | < 5.2 | < 5.6 | < 5.4 | < 6 | < 4.8 | 0.095 J | 0.21 J | < 5.1 | < 5 | < 4.6 | < 4.9 | < 5 | < 5.1 |
| Dichlorodifluoromethane | | | 1.6E+07 | < 6.4 | < 5.2 | 0.29 J | < 5.4 | < 6 | < 4.8 | < 4.8 | < 4.7 | < 5.1 | < 5 | < 4.6 | < 4.9 | < 5 | 0.4 J |
| Ethylbenzene | 6 | | 8.0E+06 | < 6.4 | < 5.2 | < 5.6 | < 5.4 | 0.34 J | 0.23 J | < 4.8 | < 4.7 | 0.31 J | < 5 | < 4.6 | < 4.9 | < 5 | < 5.1 |
| m,p-Xylene | 9 | | | 0.54 J | 0.19 J | 0.23 J | 0.43 J | 1.1 J | 0.72 J | < 4.8 | < 4.7 | 0.88 J | 0.51 J | < 4.6 | < 4.9 | < 5 | < 5.1 |
| o-Xylene | 9 | | 1.6E+08 | < 6.4 | < 5.2 | < 5.6 | < 5.4 | 0.26 J | 0.17 J | < 4.8 | < 4.7 | 0.17 J | < 5 | < 4.6 | < 4.9 | < 5 | < 5.1 |
| Toluene | 7 | | 6.4E+06 | 1.8 J | 0.46 J | 0.65 J | 0.87 J | 2.6 J | 1.8 J | < 4.8 | 0.38 J | 2.3 J | 1.6 J | 0.24 J | 0.53 J | 0.26 J | 0.38 J |
| **Semi-volatile Organic Compounds EPA 8270 (µg/kg)** | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | | | 3.2E+05 | < 5.8 | < 5.5 UJ | < 5.5 UJ | < 7.3 | < 5.8 | < 7.1 | < 5.5 | 90 J | 190 J | < 5.5 | 2.4 J | < 5.6 | < 5.6 | < 6.1 |
| 4-Methylphenol | | | 4.0E+05 | < 5.8 | 5.9 J | < 5.5 | < 7.3 | < 5.8 | < 7.1 | < 5.5 | 24 J | 39 J | < 5.5 | 1.6 J | < 5.6 | < 5.6 | < 6.1 |
| Acenaphthene | | | 4.8E+06 | < 5.8 | < 5.5 UJ | < 5.5 UJ | < 7.3 | < 5.8 | 2.2 J | < 5.5 | 110 J | 220 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Acenaphthylene | | | | 1.6 J | < 5.5 | 1.6 J | < 7.3 | < 5.8 | < 7.1 | < 5.5 | 14 J | 16 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Anthracene | | | 2.4E+07 | 3.1 J | < 5.5 UJ | 1.9 J | 1.6 J | < 5.8 | 5.7 J | < 5.5 | 59 J | 87 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Benzo(a)anthracene | | | | 7.8 | 2.9 J | 3.9 J | 2.3 J | 2 J | 17 | 15 | 78 J | 120 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Benzo(a)pyrene | | 140 | | 9.2 | < 5.5 UJ | < 5.5 UJ | < 7.3 | < 5.8 | 18 | 24 | 77 J | 97 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Benzo(b)fluoranthene | | | | 15 | 4.6 J | 5.1 J | 5 J | 4.5 J | 23 | 29 | 180 J | 250 J | < 5.5 | 3.5 J | < 5.6 | < 5.6 | < 6.1 |
| Benzo(g,h,i)perylene | | | | 9.3 | 3.2 J | 4.3 J | < 7.3 | 3.6 J | 12 | 16 | 56 J | 68 J | < 5.5 | 2.3 J | < 5.6 | < 5.6 | < 6.1 |
| Benzo(k)fluoranthene | | | | 4.2 J | < 5.5 UJ | 1.9 J | < 7.3 | 1.5 J | 8.1 | 11 | 62 J | 80 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Benzoic Acid | | | 3.2E+08 | 270 | < 110 | < 110 UJ | < 150 UJ | < 120 | < 150 UJ | < 110 UJ | < 580 UJ | < 580 UJ | < 110 UJ | < 110 UJ | < 120 UJ | < 120 UJ | < 130 UJ |
| Benzyl Alcohol | | | 2.4E+07 | 8.9 J | < 11 | < 11 | 51 | < 12 | 2.7 J | < 11 | < 58 | < 58 | < 11 | < 11 | < 12 | < 12 | < 13 |
| bis(2-Ethylhexyl)phthalate | | 7.1E+04 | 1.6E+06 | 60 | 19 J | 8.4 J | 24 J | < 58 | 130 | < 55 | 69 J | 84 J | < 55 | 35 J | < 56 | < 56 | 7.1 J |
| Butylbenzylphthalate | | | 1.6E+07 | 17 | < 5.5 | < 5.5 UJ | 7 J | < 5.8 | < 7.1 | < 5.5 | 49 J | < 29 | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Chrysene | | | | 13 | 4.3 J | 5.5 J | 4.5 J | 4 J | 20 | 18 | 210 J | 460 J | < 5.5 | 4.3 J | < 5.6 | < 5.6 | < 6.1 |
| Dibenz(a,h)anthracene | | | | < 5.8 | < 5.5 | < 5.5 | < 7.3 | < 5.8 | 2.7 J | 3.6 J | 12 J | 15 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Dibenzofuran | | | 1.6E+05 | < 5.8 | < 5.5 | < 5.5 UJ | < 7.3 | < 5.8 | < 7.1 | < 5.5 | 85 J | 170 | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Diethylphthalate | | | 6.4E+07 | < 5.8 | < 5.5 | < 5.5 | 1.4 | < 5.8 | < 7.1 | < 5.5 | < 29 | < 29 | 1.4 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Di-n-Butylphthalate | | | 8.0E+06 | 19 | < 11 | < 11 | 8.2 J | < 12 | 11 J | < 11 | < 58 | < 58 | < 11 | < 11 | < 12 | < 12 | < 13 |
| Fluoranthene | | | 3.2E+06 | 20 | < 6.8 U | 8.7 J | 7.8 | < 4.2 U | 34 | 20 | 510 J | 740 J | < 5.5 | 6.1 | < 5.6 | < 5.6 | < 6.1 |
| Fluorene | | | 3.2E+06 | < 5.8 | < 5.5 UJ | 1.5 J | 1.3 J | < 5.8 | 1.7 J | < 5.5 | 100 J | 210 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Hexachlorobenzene | | 630 | 6.4E+04 | < 5.8 | < 5.5 | 1.7 J | < 7.3 | < 5.8 | < 7.1 | < 5.5 | < 29 | < 29 | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Indeno(1,2,3-cd)pyrene | | | | 8.9 | 2.8 J | 3.6 J | < 7.3 | 2.7 J | 12 | 18 | 67 J | 74 J | < 5.5 | < 5.5 | < 5.6 | < 5.6 | < 6.1 |
| Naphthalene | 5 | | 1.6E+06 | < 5.8 | < 5.5 UJ | < 5.5 UJ | < 7.3 | < 5.8 | < 7.1 | < 5.5 | 250 J | 540 J | < 5.5 | 2.3 J | < 5.6 | < 5.6 | < 6.1 |
| Pentachlorophenol | | 8.3E+03 | 2.4E+06 | 110 | 370 | 720 J | 38 J | < 58 | 39 J | 53 J | 340 J | 250 J | < 55 | < 55 | < 56 | < 56 | < 61 |
| Phenanthrene | | | | < 16 U | < 5.9 U | 10 J | 9.2 | < 4.2 U | 26 | 4.7 | 430 J | 670 J | < 5.5 | 4 | < 5.6 | < 5.6 | < 6.1 |
| Pyrene | | | 2.4E+06 | 20 | 8.1 J | 10 J | 6.5 J | 4.1 J | 36 | 20 | 400 J | 590 J | < 5.5 | 5 J | < 5.6 | < 5.6 | < 6.1 |
| **NWTPH-Dx (mg/kg)** | | | | | | | | | | | | | | | | | |
| Diesel Range Hydrocarbons | 2.0E+03 | | | 22 J | 22 J | 13 J | 9.4 J | 16 J | 13 J | NA | 160 NJ | 100 NJ | 1.4 J | 5 J | 2.6 J | < 28 | < 31 |
| Residual Range Organics (RRO) | 2.0E+03 | | | 170 NJ | 97 J | 69 J | 75 J | 120 J | 52 J | NA | 610 J | 400 J | < 6.9 U | 27 J | < 5 U | < 120 | < 130 |
| **NWTPH-Gx (mg/kg)** | | | | | | | | | | | | | | | | | |
| Gasoline Range Organics-NWTPH | 100/30 | | | 2.4 J | < 5.7 | < 5.7 | < 5.5 | < 6.1 | < 5.3 | < 5.6 | 5.4 J | 2.6 J | < 5.6 | < 5.8 | < 5.8 | < 5.8 | < 6.5 |

**Shaded and Bold - Value exceed Method B CUL**
**(or Method A if no Method B value available)**
Qualifiers:
J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
+ = biased high

# Table F-3-1 Geoprobe Soils Analytical Results: Metals, PCBs, SVOCs, VOCs, and TPH

| | | | Location ID<br>Sample ID<br>Sample Date | LL10<br>LL10-0-0.5<br>04/03/08 | LL10<br>LL10-1.5-2<br>04/03/08 | LL11<br>LL11-0-0.5<br>04/03/08 | LL11<br>LL11-1.5-2<br>04/03/08 | LL12<br>LL12-0-0.5<br>04/03/08 | LL12<br>LL12-1.5-2<br>04/03/08 | LL12<br>LL12-6-8<br>04/03/08 | LL12<br>LL12-13-15<br>04/03/08 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **Method A** | **MTCA B - Carcinogen** | **MTCA B - Non-Carcinogen** | | | | | | | | |
| **Metals EPA 6020 / 7471A (mg/kg)** | | | | | | | | | | | |
| Antimony | | | 32 | **0.69 J** | **0.22 J** | **0.19 J** | **0.05 J** | **0.49 J** | **0.13 J** | **0.06 J** | **0.07 J** |
| Arsenic | 20 | 0.67 | 24 | **11.1** | **3.28 J** | **3.76 J** | **1.62 J** | **6.3** | **2.62** | **1.97** | **0.89** |
| Beryllium | | | 160 | **0.242** | **0.201 J** | **0.207 J** | **0.174 J** | **0.255** | **0.214** | **0.14** | **0.244** |
| Cadmium | 2 | | 80 | **0.377** | **0.487 J** | **0.319 J** | **0.056 J** | **0.727** | **0.442** | **0.059** | **0.066** |
| Chromium | 19/2000 | | | **24.4** | **26.1** | **29.6** | **21.4** | **27.3** | **22.8** | **23.9** | **37** |
| Copper | | | 3.0E+03 | **17.6 J** | **17.2 J** | **24.3 J** | **11 J** | **50.8 J** | **13.4 J** | **11 J** | **19.8 J** |
| Lead | 250 | | | **67.6 J** | **57** | **21.3** | < 2.14 U | **74.9 J** | **6.7 J** | **2.18 J** | **2.76 J** |
| Nickel | | | 1.6E+03 | **26.6** | **26.3** | **23.7** | **28.7** | **27.8** | **33** | **30.2** | **40.6** |
| Selenium | | | 400 | < 1.2 | < 1.1 | < 1.1 | < 1.1 | **0.5 J** | < 1.1 | < 1 | < 1.3 |
| Silver | | | 400 | **0.092** | **0.082** | **0.064** | **0.034** | **0.084** | **0.037** | **0.037** | **0.037** |
| Thallium | | | 5.6 | **0.074 J** | **0.057** | **0.069** | **0.044** | **0.056 J** | **0.049 J** | **0.031 J** | **0.058 J** |
| Zinc | | | 2.4E+04 | **52.8 J** | **95.8 J** | **47 J** | **21.6 J** | **140 J** | **38.4 J** | **24.1 J** | **32.2 J** |
| Mercury | 2 | | 24 | **0.072** | **0.05** | **0.04** | **0.017 J** | **0.063** | **0.032** | **0.013 J** | **0.018 J** |
| **PCBs EPA 8082 (µg/kg)** | | | | | | | | | | | |
| Aroclor 1242 | | | | NA | NA | NA | NA | NA | NA | NA | NA |
| Aroclor 1254 | | | 1.6E+03 | NA | NA | NA | NA | NA | NA | NA | NA |
| Aroclor 1260 | | | | NA | NA | NA | NA | NA | NA | NA | NA |
| Total PCBs | 1.00E+04 | 500 | | NA | NA | NA | NA | NA | NA | NA | NA |
| **Volatile Organic Compounds EPA 8260 (µg/kg)** | | | | | | | | | | | |
| 1,1,1-Trichloroethane | | | 7.2E+07 | < 6.6 | < 6 | < 6.9 | < 5.5 | **0.28 J** | < 6.1 | < 4.8 | < 5 |
| 1,2,4-Trimethylbenzene | | | 4.0E+06 | < 27 | < 24 | < 28 | < 22 | < 24 | < 25 | < 19 | < 20 |
| 2-Butanone | | | 4.8E+07 | < 27 | < 24 | **4.7 J** | < 22 | **5.9 J** | **4.8 J** | < 19 | < 20 |
| Acetone | | | 8.0E+06 | **62** | **41** | **70** | **18 J** | **95** | **79** | **9.1 J** | < 20 |
| Carbon Disulfide | | | 8.0E+06 | < 6.6 | < 6 | < 6.9 | **0.099 J** | **0.12 J** | < 6.1 | **0.18 J** | < 5 |
| Dichlorodifluoromethane | | | 1.6E+07 | < 6.6 | < 6 | < 6.9 | **0.42 J** | **0.72 J** | < 6.1 | < 4.8 | < 5 |
| Ethylbenzene | 6 | | 8.0E+06 | < 6.6 | < 6 | < 6.9 | < 5.5 | **0.46 J** | **0.28 J** | < 4.8 | < 5 |
| m,p-Xylene | 9 | | | **0.35 J** | **0.51 J** | < 6.9 | **0.35 J** | **1.6 J** | **0.63 J** | **0.48 J** | **0.18 J** |
| o-Xylene | 9 | | 1.6E+08 | < 6.6 | < 6 | < 6.9 | < 5.5 | **0.54 J** | < 6.1 | < 4.8 | < 5 |
| Toluene | 7 | | 6.4E+06 | **0.98 J** | **1.1 J** | **0.86 J** | **0.73 J** | **3.1 J** | **1.5 J** | **1.3 J** | **0.93 J** |
| **Semi-volatile Organic Compounds EPA 8270 (µg/kg)** | | | | | | | | | | | |
| 2-Methylnaphthalene | | | 3.2E+05 | **2.4 J** | < 55 | < 5.8 | < 5.5 | **6.4** | < 5.5 | < 5.3 | < 6.4 |
| 4-Methylphenol | | | 4.0E+05 | < 5.9 | < 55 | < 5.8 | < 5.5 | < 5.9 | < 5.5 | < 5.3 | < 6.4 |
| Acenaphthene | | | 4.8E+06 | **2.2 J** | < 55 | < 5.8 | < 5.5 | < 5.9 | < 5.5 | < 5.3 | < 6.4 |
| Acenaphthylene | | | | **1.7 J** | **17 J** | < 5.8 | < 5.5 | **2.5 J** | < 5.5 | < 5.3 | < 6.4 |
| Anthracene | | | 2.4E+07 | **10** | < 55 | < 5.8 | < 5.5 | **3.1 J** | < 5.5 | < 5.3 | < 6.4 |
| Benzo(a)anthracene | | | | **55** | < 55 | **2.2 J** | < 5.5 | **9** | < 5.5 | < 5.3 | < 6.4 |
| Benzo(a)pyrene | | 140 | | **59** | < 55 | < 5.8 | < 5.5 | **13** | < 5.5 | < 5.3 | < 6.4 |
| Benzo(b)fluoranthene | | | | **60** | < 55 | **3.5 J** | < 5.5 | **20** | **2.5 J** | < 5.3 | < 6.4 |
| Benzo(g,h,i)perylene | | | | **38** | < 55 | **2.6 J** | < 5.5 | **11** | < 5.5 | < 5.3 | < 6.4 |
| Benzo(k)fluoranthene | | | | **20** | < 55 | < 5.8 | < 5.5 | **6.2** | < 5.5 | < 5.3 | < 6.4 |
| Benzoic Acid | | | 3.2E+08 | **240 J** | < 1,100 UJ | < 120 UJ | < 110 UJ | < 120 UJ | < 110 UJ | < 110 UJ | < 130 UJ |
| Benzyl Alcohol | | | 2.4E+07 | < 12 | < 110 | < 12 | < 11 | < 12 | < 11 | < 11 | < 13 |
| bis(2-Ethylhexyl)phthalate | | 7.1E+04 | 1.6E+06 | **25 J** | < 550 | **14 J** | < 55 | **110** | **15 J** | < 53 | < 64 |
| Butylbenzylphthalate | | | 1.6E+07 | < 5.9 | < 55 | < 5.8 | < 5.5 | < 5.9 | **15** | < 5.3 | < 6.4 |
| Chrysene | | | | **62** | < 55 | **2.8 J** | < 5.5 | **16** | **1.8 J** | < 5.3 | < 6.4 |
| Dibenz(a,h)anthracene | | | | **5.1 J** | < 55 | < 5.8 | < 5.5 | **1.8 J** | < 5.5 | < 5.3 | < 6.4 |
| Dibenzofuran | | | 1.6E+05 | **1.5 J** | < 55 | < 5.8 | < 5.5 | **1.7 J** | < 5.5 | < 5.3 | < 6.4 |
| Diethylphthalate | | | 6.4E+07 | < 5.9 | < 55 | < 5.8 | **1.5** | < 5.9 | **1.8** | < 5.3 | < 6.4 |
| Di-n-Butylphthalate | | | 8.0E+06 | < 12 | < 110 | < 12 | < 11 | **11 J** | < 11 | < 11 | < 13 |
| Fluoranthene | | | 3.2E+06 | **97** | < 55 | **5.1** | < 5.5 | **22** | **2.9** | < 5.3 | **2.3** |
| Fluorene | | | 3.2E+06 | **2.6 J** | < 55 | < 5.8 | < 5.5 | < 5.9 | < 5.5 | < 5.3 | < 6.4 |
| Hexachlorobenzene | | 630 | 6.4E+04 | < 5.9 | < 55 | < 5.8 | < 5.5 | < 5.9 | < 5.5 | < 5.3 | < 6.4 |
| Indeno(1,2,3-cd)pyrene | | | | **37** | < 55 | **1.6 J** | < 5.5 | **11** | < 5.5 | < 5.3 | < 6.4 |
| Naphthalene | 5 | | 1.6E+06 | **3.2 J** | < 55 | < 5.8 | < 5.5 | **6** | < 5.5 | < 5.3 | < 6.4 |
| Pentachlorophenol | | 8.3E+03 | 2.4E+06 | **42 J** | **1,900** | **310** | **29 J** | **150** | < 55 | < 53 | < 64 |
| Phenanthrene | | | | **51** | < 55 | **4.6** | **1.8** | **12** | **1.6** | < 5.3 | **4.2** |
| Pyrene | | | 2.4E+06 | **120** | **27 J** | **5.1 J** | < 5.5 | **24** | **2.4 J** | < 5.3 | **1.5 J** |
| **NWTPH-Dx (mg/kg)** | | | | | | | | | | | |
| Diesel Range Hydrocarbons | 2.0E+03 | | | **12 J** | **37 NJ** | **4.3 J** | **1.6 J** | **23 J** | **43 J** | **1.6 J** | **1.7 J** |
| Residual Range Organics (RRO) | 2.0E+03 | | | **94 J** | **230 J** | **53 J** | < 11 U | **110 J** | **43 J** | < 9.7 U | < 9.9 U |
| **NWTPH-Gx (mg/kg)** | | | | | | | | | | | |
| Gasoline Range Organics-NWTPH | 100/30 | | | < 6.3 | **17 NJ** | < 6.1 | < 5.7 | < 6.2 | < 5.7 | < 5.4 | < 7.1 |

**Shaded and Bold - Value exceed Method B CUL**
**(or Method A if no Method B value available)**
Qualifiers:
J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
+ = biased high

## Table F-3-2 Geoprobe Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ)

| | | Location ID | LL01 | | | LL01 | | | LL01 | | | LL07 | | | LL07 | | | LL08 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample ID | LL01-0-0.5 | | | LL01-1.5-2 | | | DUP02-040308 | | | LL07-0-0.5 | | | LL07-1.5-2 | | | LL08-0-0.5 | | |
| | | Sample Date | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 322,000 | **96.6** | J | 1,440,000 | **432.0** | J | 1,280,000 | **384.0000** | J | 719 | **0.216** | | 12,200 | **3.66** | J | 3,450 | **1.04** | J |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | 44,100 | **13.23** | | 236,000 | **70.80** | J | 228,000 | **68.4** | J | 87.2 | **0.0262** | | 1,050 | **0.315** | | 446 | **0.134** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | 21,500 | **215** | | 67,000 | **670** | | 83,200 | **832.000** | | 91.9 | **0.919** | | 1,130 | **11.3** | J | 337 | **3.37** | J |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | 4,270 | **42.7** | | 14,600 | **146.0** | | 20,000 | **200.0000** | | 21 | **0.210** | | 319 | **3.19** | | 83.2 | **0.832** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | 143 | **1.43** | | 416 | **4.16** | | 454 | **4.54** | J | 2.17 | **0.0217** | NJ+ | 14.4 | **0.144** | | 3.3 | **0.0330** | |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | 92 | **9.2** | | 117 | **11.7** | | 135 | **13.5000** | | 1.08 | **0.108** | J | 6.53 | **0.653** | | 2.61 | **0.261** | |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | 59.3 | **5.93** | | 253 | **25.30** | | 307 | **30.7000** | | 1.01 | **0.101** | J | 12.9 | **1.29** | | 2.26 | **0.226** | J |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | 333 | **33.3** | | 846 | **84.6** | | 1,070 | **107.0000** | | 3.27 | **0.327** | | 27.4 | **2.74** | | 10 | **1.00** | |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | 28.2 | **2.82** | | 109 | **10.90** | | 134 | **13.4000** | | 0.881 | **0.0881** | J | 11.1 | **1.11** | | 1.49 | **0.149** | J |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | 209 | **20.9** | | 352 | **35.2** | | 382 | **38.2000** | | 2.98 | **0.298** | | 21.8 | **2.18** | | 8.73 | **0.873** | |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | 0.75 | **0.075** | J | 1.56 | **0.156** | J | 2.25 | **0.225** | J | < 0.232 | 0.012 | | 0.34 | **0.0340** | J | < 0.0826 | 0.004 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | 39.5 | **39.5** | | 68.4 | **68.4** | | 80.7 | **80.700** | | 0.725 | **0.725** | J | 3.42 | **3.42** | | 1.37 | **1.37** | NJ+ |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | 2.66 | **0.080** | J | 5.67 | **0.170** | | 6.86 | **0.2058** | | 0.11 | **0.0033** | NJ+ | 0.89 | **0.0267** | J | < 0.434 | 0.0065 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | 29.1 | **2.91** | | 96.4 | **9.64** | | 122 | **12.2000** | | 1.01 | **0.101** | J | 15 | **1.50** | | 1.8 | **0.180** | J |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | 8.5 | **2.55** | | 35.7 | **10.71** | | 43.6 | **13.080** | | 0.341 | **0.102** | J | 5.39 | **1.62** | | 0.833 | **0.250** | J |
| 2,3,7,8-TCDD | 1 | ng/kg | 6.53 | **6.5** | | 7.59 | **7.6** | | 9.05 | **9.050** | | < 0.0919 | 0.046 | | 0.517 | **0.517** | NJ+ | 0.425 | **0.425** | NJ+ |
| 2,3,7,8-TCDF | 0.1 | ng/kg | 1.41 | **0.141** | | 1.95 | **0.195** | | 2.04 | **0.2040** | | < 0.123 | 0.0062 | | 1.06 | **0.106** | | 0.524 | **0.0524** | NJ+ |
| **Total TCDD TEQ (1)** | | | | 493 | | | 1588 | | | 1807 | | | **3.31** | | | **33.8** | | | **10.2** | |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:

J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
+ = biased high

Method B CUL - 11 ng/kg

▨ - Shaded value exceeds Method B screening level

## Table F-3-2 Geoprobe Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ)

| Location ID | | | LL08 | | | LL08 | | | LL08 | | | LL08 | | | LL09 | | | LL09 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | | | LL08-1.5-2 | | | LL08-2-4 | | | DUP01-040308 | | | LL08-13-15 | | | LL09-0-0.5 | | | LL09-1.5-2 | | |
| Sample Date | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 13,800 | **4.14** | **J** | 351,000 | **105.3** | **J** | 156,000 | **46.8** | **J** | 116 | **0.0348** | **J** | 149 | **0.0447** | **J** | 177 | **0.0531** | **J** |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | 1,960 | **0.588** | **J** | 36,700 | **11.0** | | 17,300 | **5.19** | | 13.7 | **0.00411** | | 16.8 | **0.00504** | | 20 | **0.006** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | 1,320 | **13.2** | **J** | 26,800 | **268** | **J** | 17,200 | **172** | **J** | 16.4 | **0.164** | **J** | 15.1 | **0.151** | **J** | 18.3 | **0.183** | **J** |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | 397 | **3.97** | | 4,280 | **42.8** | | 2,300 | **23.0** | | 2.78 | **0.0278** | | 4.05 | **0.0405** | | 5.23 | **0.0523** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | 14.4 | **0.144** | | 155 | **1.55** | | 109 | **1.09** | | 0.253 | **0.00253** | **J** | 0.226 | **0.00226** | **NJ+** | 0.185 | **0.00185** | **NJ+** |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | 7.38 | **0.738** | | 105 | **10.5** | | 127 | **12.7** | | 0.243 | **0.0243** | **NJ+** | 0.17 | **0.0170** | **J** | 0.15 | **0.0150** | **J** |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | 9 | **0.900** | | 73.3 | **7.33** | | 65.2 | **6.52** | | 0.14 | **0.0140** | **J** | 0.329 | **0.0329** | **J** | 0.398 | **0.0398** | **J** |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | 34.7 | **3.47** | | 438 | **43.8** | | 461 | **46.1** | | 0.606 | **0.0606** | **J** | 0.462 | **0.0462** | **NJ+** | 0.609 | **0.0609** | **J** |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | 5.31 | **0.531** | | 48.6 | **4.86** | | 41.8 | **4.18** | | 0.119 | **0.0119** | **J** | 0.231 | **0.0231** | **J** | 0.206 | **0.0206** | **J** |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | 31.5 | **3.15** | | 468 | **46.8** | | 592 | **59.2** | | 0.977 | **0.0977** | **J** | 0.533 | **0.0533** | **J** | 0.464 | **0.0464** | **J** |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | < 0.293 | 0.015 | | 1.91 | **0.191** | **J** | 2.03 | **0.203** | **J** | < 0.0426 | 0.002 | | < 0.0391 | 0.002 | | < 0.0227 | 0.001 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | 9.28 | **9.28** | | 82.8 | **82.8** | | 102 | **102** | | 0.303 | **0.303** | **J** | 0.108 | **0.108** | **NJ+** | 0.131 | **0.131** | **NJ+** |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | < 0.811 | 0.0122 | | 5.93 | **0.178** | | 6.31 | **0.189** | | < 0.0234 | 0.0004 | | < 0.092 | 0.00138 | | < 0.133 | 0.001995 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | 4.71 | **0.471** | | 40.3 | **4.03** | | 37.1 | **3.71** | | 0.109 | **0.0109** | **J** | 0.156 | **0.0156** | **NJ+** | 0.167 | **0.0167** | **NJ+** |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | 1.74 | **0.522** | **J** | 12.3 | **3.69** | | 12 | **3.60** | | < 0.0225 | 0.003 | | 0.144 | **0.0432** | **J** | 0.127 | **0.0381** | **NJ+** |
| 2,3,7,8-TCDD | 1 | ng/kg | 2.57 | **2.57** | | 16.5 | **16.5** | | 17.1 | **17.1** | | < 0.0313 | 0.016 | | < 0.0274 | 0.014 | | < 0.0384 | 0.019 | |
| 2,3,7,8-TCDF | 0.1 | ng/kg | 0.361 | **0.0361** | **J** | 2.62 | **0.262** | | 1.68 | **0.168** | | < 0.0216 | 0.0011 | | < 0.106 | 0.0053 | | < 0.0928 | 0.0046 | |
| **Total TCDD TEQ (1)** | | | | 43.7 | | | 650 | | | 504 | | | **0.8** | | | **0.61** | | | **0.69** | |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:
J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
+ = biased high

Method B CUL - 11 ng/kg

▨ - Shaded value exceeds Method B screening level

## Table F-3-2 Geoprobe Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ)

| | | Location ID | LL09 | | | LL09 | | | LL10 | | | LL10 | | | LL11 | | | LL11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample ID | LL09-6-8 | | | LL09-13-15 | | | LL10-0-0.5 | | | LL10-1.5-2 | | | LL11-0-0.5 | | | LL11-1.5-2 | | |
| | | Sample Date | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | | 04/03/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 13.9 | **0.00417** | **J** | < 4.58 | 0.00069 | | 76,800 | **23.0** | **J** | 2,350,000 | **705** | **J** | 24,100 | **7.2** | **J** | **622** | **0.2** | |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | < 0.394 | 5.9E-05 | | < 0.186 | 2.8E-05 | | 11,000 | **3.30** | | 371,000 | **111.3** | **J** | 6,300 | **1.89** | | **214** | **0.06** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | < 1.05 | 0.0053 | | < 0.546 | 0.00273 | | 6,480 | **64.8** | | 113,000 | **1130** | **J** | 2,590 | **25.9** | | **107** | **1.1** | |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | < 0.0888 | 0.00044 | | < 0.0321 | 0.00016 | | 1,640 | **16.4** | | 22,800 | **228** | | 965 | **9.7** | | **57.3** | **0.6** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | < 0.0233 | 0.0001 | | < 0.023 | 0.0001 | | 70.9 | **0.709** | | 586 | **5.86** | | 26.6 | **0.266** | | **1.87** | **0.019** | **J** |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | < 0.0146 | 0.001 | | < 0.0149 | 0.001 | | 17.4 | **1.74** | | 137 | **13.7** | | 1.92 | **0.19** | **J** | **0.353** | **0.04** | **J** |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | < 0.0105 | 0.001 | | < 0.00876 | 0.000 | | 40.5 | **4.05** | | 441 | **44.1** | | 13 | **1.30** | | **0.602** | **0.06** | **J** |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | < 0.0142 | 0.001 | | < 0.0145 | 0.001 | | 149 | **14.9** | | 1,490 | **149** | | 54.8 | **5.5** | | **3.95** | **0.4** | |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | < 0.0107 | 0.001 | | < 0.00899 | 0.000 | | 16.4 | **1.64** | | 156 | **15.6** | | 3.98 | **0.40** | | < 0.218 | 0.01 | |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | < 0.0154 | 0.001 | | < 0.0156 | 0.001 | | 68.8 | **6.88** | | 583 | **58.3** | | 11.7 | **1.2** | | **1.4** | **0.1** | **J** |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | < 0.0142 | 0.001 | | < 0.0119 | 0.001 | | < 0.772 | 0.039 | | 4.94 | **0.494** | | < 0.655 | 0.0328 | | < 0.278 | 0.0139 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | < 0.0184 | 0.01 | | < 0.0161 | 0.01 | | 11.3 | **11.3** | | 93.2 | **93.2** | | 1.89 | **1.9** | **J** | **0.415** | **0.4** | **J** |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | < 0.013 | 0.0002 | | < 0.0148 | 0.0002 | | 1.42 | **0.0426** | **J** | 8.69 | **0.261** | | 0.274 | **0.0082** | **J** | < 0.0496 | 0.0007 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | < 0.0118 | 0.001 | | < 0.00993 | 0.000 | | 16 | **1.60** | | 137 | **13.7** | | 4.25 | **0.43** | | **1.2** | **0.12** | **J** |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | < 0.0125 | 0.002 | | < 0.0142 | 0.002 | | 6.34 | **1.90** | | 65.1 | **19.5** | | 1.95 | **0.59** | **J** | < 0.0488 | 0.01 | |
| 2,3,7,8-TCDD | 1 | ng/kg | < 0.0259 | 0.01295 | | < 0.0295 | 0.015 | | 2.63 | **2.63** | | 14.5 | **14.5** | | 0.544 | **0.54** | **J** | < 0.075 | 0.04 | |
| 2,3,7,8-TCDF | 0.1 | ng/kg | < 0.0266 | 0.0013 | | < 0.0183 | 0.0009 | | 0.941 | **0.0941** | **J** | 2.37 | **0.237** | | < 0.153 | 0.008 | | < 0.0455 | 0.002 | |
| **Total TCDD TEQ (1)** | | | | **0.04** | | | **0.034** | | | ▨ **155** | | | ▨ **2603** | | | **57.0** | | **3.2** | **3.2** | |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:

J = estimated concentration (value less than calculated reporting limit)

N = analyte is tentatively identified (validator qualifier)

+ = biased high

Method B CUL - 11 ng/kg

▨ - Shaded value exceeds Method B screening level

## Table F-3-2 Geoprobe Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ)

| | | Location ID | | LL12 | | | | LL12 | | | | LL12 | | | | LL12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample ID | | LL12-0-0.5 | | | | LL12-1.5-2 | | | | LL12-6-8 | | | | LL12-13-15 | | |
| | | Sample Date | | 04/03/08 | | | | 04/03/08 | | | | 04/03/08 | | | | 04/03/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | | 90,500 | **27.2** | J | | 1,970 | **0.591** | J | | 84.9 | **0.0255** | | | 439 | **0.132** | |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | | 10,000 | **3.00** | | | 279 | **0.0837** | | | 22.6 | **0.00678** | | | 42.9 | **0.0129** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | | 7,910 | **79.1** | J | | 203 | **2.03** | | | 19.4 | **0.194** | | | 56.7 | **0.567** | |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | | 1,320 | **13.2** | | | 72.9 | **0.729** | | | 5.1 | **0.0510** | | | 5.3 | **0.0530** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | | 73.5 | **0.735** | | | 2.63 | **0.0263** | J | | 0.499 | **0.00499** | NJ+ | | 1.6 | **0.0160** | J |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | | 52.4 | **5.24** | | | 0.916 | **0.0916** | J | | 0.26 | **0.0260** | NJ+ | | 0.959 | **0.0959** | J |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | | 39.7 | **3.97** | | | 1.38 | **0.138** | J | < | 0.313 | 0.016 | | < | 0.396 | 0.020 | |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | | 235 | **23.5** | | | 4.7 | **0.470** | | | 0.986 | **0.0986** | J | | 1.61 | **0.161** | J |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | | 25.1 | **2.51** | | | 0.66 | **0.0660** | J | < | 0.31 | 0.016 | | < | 0.404 | 0.020 | |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | | 228 | **22.8** | | | 2.8 | **0.280** | | | 0.915 | **0.0915** | NJ+ | | 3.11 | **0.311** | |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | | 0.78 | **0.0780** | NJ+ | < | 0.516 | 0.026 | | < | 0.396 | 0.020 | | < | 0.536 | 0.027 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | | 39.9 | **39.9** | | | 0.67 | **0.670** | J | | 0.331 | **0.331** | J | < | 0.0977 | 0.05 | |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | | 2.92 | **0.0876** | | < | 0.0725 | 0.0011 | | < | 0.05 | 0.0008 | | < | 0.108 | 0.0016 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | | 23.9 | **2.39** | | < | 0.431 | 0.022 | | < | 0.336 | 0.017 | | < | 0.448 | 0.022 | |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | | 6.85 | **2.06** | | < | 0.0699 | 0.010 | | < | 0.0492 | 0.007 | | < | 0.104 | 0.016 | |
| 2,3,7,8-TCDD | 1 | ng/kg | | 7.91 | **7.91** | | < | 0.0814 | 0.041 | | < | 0.0619 | 0.031 | | < | 0.088 | 0.044 | |
| 2,3,7,8-TCDF | 0.1 | ng/kg | | 1.15 | **0.115** | | < | 0.06 | 0.0030 | | < | 0.0534 | 0.0027 | | < | 0.112 | 0.0056 | |
| **Total TCDD TEQ (1)** | | | | | **234** | | | | **5.3** | | | | **0.9** | | | | **1.55** | |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:

J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
+ = biased high

Method B CUL - 11 ng/kg

▨ - Shaded value exceeds Method B screening level

# Table F-3-3    Geoprobes Soils Analytical Results: cPAH Total Toxic Equivalency Quotient (TEQ)

| Location ID | | | LL01 | | LL01 | | LL01 | | LL07 | | LL07 | | LL08 | | LL08 | | LL08 | | LL08 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | | | LL01-0-0.5 | | LL01-1.5-2 | | DUP02-040308 | | LL07-0-0.5 | | LL07-1.5-2 | | LL08-0-0.5 | | LL08-1.5-2 | | LL08-2-4 | | DUP01-040308 | |
| Sample Date | | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | |
| Chemical Name (µg/kg) | TEFs | Unit | | | | | | | | | | | | | | | | | | |
| Carcinogenic PAH | | | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ |
| Benzo(a)anthracene | 0.1 | µg/kg | 7.8 | **0.8** | 2.9 | **0.3** J | 3.9 | **0.39** J | 2.3 | **0.2** J | 2 | **0.2** J | 17 | **1.7** | 15 | **1.5** | 78 | **7.8** J | 120 | **12** J |
| Benzo(a)pyrene | 1 | µg/kg | 9.2 | **9.2** | < 5.5 | 2.8 UJ | < 5.5 | 2.75 UJ | < 7.3 | 3.7 | < 5.8 | 2.9 | 18 | **18** | 24 | **24** | 77 | **77** J | 97 | **97** J |
| Benzo(b)fluoranthene | 0.1 | µg/kg | 15 | **1.5** | 4.6 | **0.5** J | 5.1 | **0.51** J | 5 | **0.5** J | 4.5 | **0.5** J | 23 | **2.3** | 29 | **2.9** | 180 | **18** J | 250 | **25** J |
| Benzo(k)fluoranthene | 0.1 | µg/kg | 4.2 | **0.4** J | < 5.5 | 0.3 UJ | 1.9 | **0.19** J | < 7.3 | 0.4 | 1.5 | **0.2** J | 8.1 | **0.81** | 11 | **1.1** | 62 | **6.2** J | 80 | **8** J |
| Chrysene | 0 | µg/kg | 13 | **0.1** | 4.3 | **0** J | 5.5 | **0.06** J | 4.5 | **0** J | 4 | **0** J | 20 | **0.2** | 18 | **0.18** | 210 | **2.1** J | 460 | **4.6** J |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | < 5.8 | 0.3 | < 5.5 | 0.3 | < 5.5 | 0.28 | < 7.3 | 0.4 | < 5.8 | 0.3 | 2.7 | **0.27** J | 3.6 | **0.36** J | 12 | **1.2** J | 15 | **1.5** J |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | 8.9 | **0.9** | 2.8 | **0.3** J | 3.6 | **0.36** J | < 7.3 | 0.4 | 2.7 | **0.3** J | 12 | **1.2** | 18 | **1.8** | 67 | **6.7** J | 74 | **7.4** J |
| **Total cPAH TEQ (1)** | | | | **13.2** | | **4.4** | | **4.53** | | **5.5** | | **4.3** | | **24.5** | | **31.8** | | **119** | | ▨ **156** |

| Location ID | | | LL08 | | LL09 | | LL09 | | LL09 | | LL09 | | LL10 | | LL10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | | | LL08-13-15 | | LL09-0-0.5 | | LL09-1.5-2 | | LL09-6-8 | | LL09-13-15 | | LL10-0-0.5 | | LL10-1.5-2 | |
| Sample Date | | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | |
| Chemical Name | TEFs | Unit | | | | | | | | | | | | | | |
| Carcinogenic PAH | | | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ |
| Benzo(a)anthracene | 0.1 | µg/kg | < 5.5 | 0.3 | < 5.5 | 0.3 | < 5.6 | 0.28 | **< 5.6** | 0.3 | < 6.1 | 0.3 | 55 | **5.5** | < 55 | 2.75 |
| Benzo(a)pyrene | 1 | µg/kg | < 5.5 | 2.8 | < 5.5 | 2.8 | < 5.6 | 2.8 | **< 5.6** | 2.8 | < 6.1 | 3.1 | 59 | **59** | < 55 | 27.5 |
| Benzo(b)fluoranthene | 0.1 | µg/kg | < 5.5 | 0.3 | 3.5 | **0.4** J | < 5.6 | 0.28 | **< 5.6** | 0.3 | < 6.1 | 0.3 | 60 | **6** | < 55 | 2.75 |
| Benzo(k)fluoranthene | 0.1 | µg/kg | < 5.5 | 0.3 | < 5.5 | 0.3 | < 5.6 | 0.28 | **< 5.6** | 0.3 | < 6.1 | 0.3 | 20 | **2** | < 55 | 2.75 |
| Chrysene | 0 | µg/kg | < 5.5 | 0 | 4.3 | **0** J | < 5.6 | 0.03 | **< 5.6** | 0 | < 6.1 | 0 | 62 | **0.62** | < 55 | 0.28 |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | < 5.5 | 0.3 | < 5.5 | 0.3 | < 5.6 | 0.28 | **< 5.6** | 0.3 | < 6.1 | 0.3 | 5.1 | **0.51** J | < 55 | 2.75 |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | < 5.5 | 0.3 | < 5.5 | 0.3 | < 5.6 | 0.28 | **< 5.6** | 0.3 | < 6.1 | 0.3 | 37 | **3.7** | < 55 | 2.75 |
| **Total cPAH TEQ (1)** | | | | NC | | **4.2** | | NC | | **4.2** | | NC | | **77.3** | | NC |

| Location ID | | | LL11 | | LL11 | | LL12 | | LL12 | | LL12 | | LL12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | | | LL11-0-0.5 | | LL11-1.5-2 | | LL12-0-0.5 | | LL12-1.5-2 | | LL12-6-8 | | LL12-13-15 | |
| Sample Date | | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | | 04/03/08 | |
| Chemical Name | TEFs | Unit | | | | | | | | | | | | |
| Carcinogenic PAH | | | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ | Reported Value | TEQ |
| Benzo(a)anthracene | 0.1 | µg/kg | 2.2 | **0.2** J | < 5.5 | 0.3 | 9 | **0.9** | < 5.5 | 0.3 | < 5.3 | 0.3 | < 6.4 | 0.32 |
| Benzo(a)pyrene | 1 | µg/kg | < 5.8 | 2.9 | < 5.5 | 2.8 | 13 | **13** | < 5.5 | 2.8 | < 5.3 | 2.7 | < 6.4 | 3.2 |
| Benzo(b)fluoranthene | 0.1 | µg/kg | 3.5 | **0.4** J | < 5.5 | 0.3 | 20 | **2** | 2.5 | **0.3** J | < 5.3 | 0.3 | < 6.4 | 0.32 |
| Benzo(k)fluoranthene | 0.1 | µg/kg | < 5.8 | 0.3 | < 5.5 | 0.3 | 6.2 | **0.62** | < 5.5 | 0.3 | < 5.3 | 0.3 | < 6.4 | 0.32 |
| Chrysene | 0 | µg/kg | 2.8 | **0** J | < 5.5 | 0 | 16 | **0.16** | 1.8 | **0** J | < 5.3 | 0 | < 6.4 | 0.03 |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | < 5.8 | 0.3 | < 5.5 | 0.3 | 1.8 | **0.18** J | < 5.5 | 0.3 | < 5.3 | 0.3 | < 6.4 | 0.32 |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | 1.6 | **0.2** J | < 5.5 | 0.3 | 11 | **1.1** | < 5.5 | 0.3 | < 5.3 | 0.3 | < 6.4 | 0.32 |
| **Total cPAH TEQ (1)** | | | | **4.2** | | NC | | **18** | | **4.1** | | NC | | NC |

**MTCA Method B CUL - 0.137 mg/kg (137 µg/kg)**

**Notes**

(1) Total cPAH TEQ calculated using Toxicity Equivalency Factors from MTCA Regulations Revised November 2007. One-half the detection limit used for non-detect results.

Qualifiers

U = non-detect

J = estimated concentration (value less than calculated reporting limit)

D = compounds at secondary dilution factor

▨ highlight indicates exceedance of the MTCA Method B cleanup level of 137 µg/kg

NC= Not Calculated where all contituents are not detected

**Bold** = Deleted values

# Table F-3-4 Monitoring Well Soils Analytical Results: Metals, VOCs, SVOCs, TPH

| | | | Location ID | MW-2 | MW-2 | MW-2 | MW-2 | MW-3 | MW-3 | MW-3 | MW-3 | MW-4 | MW-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID | MW-2-0-0.5 | MW-2-1.5-2 | MW-2-6.5-8 | MW-2-14-15.5 | MW-3-0-0.5 | MW-3-1.5-2 | MW-3-6.5-8 | MW-3-14-15.5 | MW-4-0-0.5 | MW-4-1.5-2 |
| | | | Sample Date | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/18/2008 | 3/17/2008 | 3/17/2008 |
| **Chemical Name** | **MTCA A** | **MTCA B - Carcinogen** | **MTCA B Non-Carcinogen** | | | | | | | | | | |
| **Metals EPA Method 6020 / 7471A (mg/kg)** | | | | | | | | | | | | | |
| Antimony | | | 32 | **0.83** J | **0.27** J | **0.06** J | **0.07** J | **0.17** J | **0.19** J | **0.24** J | **0.09** J | **2.27** J | **0.28** J |
| Arsenic | 20 | 0.67 | 24 | **11.2** | **1.5** | **1.8** | **1.8** | **3.2** | **3.7** | **4.6** | **2.1** | **10.1** | **2.6** |
| Beryllium | | | 160 | **0.269** J | **0.275** J | **0.164** J | **0.177** J | **0.259** J | **0.262** J | **0.323** J | **0.214** J | **0.257** J | **0.212** J |
| Cadmium | | | 80 | **0.437** | **0.072** | **0.043** | **0.057** | **0.226** | **0.21** | **0.352** | **0.064** | **3.56** | **0.176** |
| Chromium | 19/2000 | | | **25.8** | **20.7** J | **27.3** J | **30.2** J | **20.9** | **24.7** J | **27.2** J | **26.4** J | **41** J | **24.8** J |
| Copper | | | 3000 | **30** | **6.44** J | **8.18** J | **12.1** J | **16.5** | **12.9** J | **18.4** J | **13** J | **64.8** J | **13.7** J |
| Lead | 250 | | | **53.7** | **2.46** | **1.82** | **1.91** | **10.4** | **13.2** | **15.1** | **2.07** | **370** | **12.3** |
| Mercury | 2 | | 24 | **0.072** J | **0.027** | **0.01** J | **0.02** | **0.039** J | **0.032** | **0.042** | **0.016** J | **0.131** | **0.027** |
| Nickel | | | 1600 | **37.5** | **25** J | **26.9** J | **35.6** J | **33.5** | **29.8** J | **37.5** J | **34.3** J | **32.2** J | **29.6** J |
| Selenium | | | 400 | **0.3** J | **0.4** J | < 1.2 | < 1.1 | J | < 1.1 | **0.4** J | < 1.1 | **0.5** J | **0.4** J |
| Silver | | | 400 | **0.086** | **0.107** | **0.033** | **0.038** | **0.045** | **0.072** | **0.087** | **0.034** | **0.188** | **0.111** |
| Thallium | | | 6 | **0.066** | **0.067** | **0.03** | **0.035** | **0.053** | **0.05** | **0.067** | **0.042** | **0.059** | **0.043** |
| Zinc | | | 24000 | **76.9** | **18.8** J | **22.3** J | **26.9** J | **38.9** | **33.4** J | **44.2** J | **27.2** J | **598** J | **34.4** J |
| **Volatile Organic Compounds EPA Method 8260 (µg/kg)** | | | | | | | | | | | | | |
| 1,2,4-Trichlorobenzene | | | | < 27 | < 24 | < 22 | < 21 | < 21 | < 22 | < 28 | < 31 | < 24 | < 20 |
| 1,2,4-Trimethylbenzene | | | 4.0E+06 | < 27 | < 24 | < 22 | < 21 | < 21 | < 22 | < 28 | < 31 | < 24 | < 20 |
| 1,3,5-Trimethylbenzene | | | | < 27 | < 24 | < 22 | < 21 | < 21 | < 22 | < 28 | < 31 | < 24 | < 20 |
| 1,4-Dichlorobenzene | | | | **0.3** J | **0.15** J | < 5.5 | < 5.2 | < 5.3 | < 5.5 | < 6.9 | < 7.7 | **0.14** J | < 4.9 |
| 2-Butanone | | | 4.8E+07 | **16** J | **6.1** J | < 22 | < 21 | **3.8** J | **6.5** J | **6.5** J | < 31 | **7.9** J | **3.9** J |
| 4-Isopropyltoluene | | | | **1.9** J | **0.67** J | < 22 | < 21 | < 21 | < 22 | **0.11** J | < 31 | < 24 | < 20 |
| 4-Methyl-2-Pentanone (MIBK) | | | | < 27 | < 24 | < 22 | < 21 | < 21 | < 22 | < 28 | < 31 | < 24 | < 20 |
| Acetone | | | 8.0E+06 | **320** | **95** | **3.5** J | **3.6** J | **98** | **190** | **99** | **13** J | **150** | **71** |
| Benzene | 0.03 | 180 | 3.2E+05 | ***< 6.6*** | ***< 5.9*** | ***< 5.5*** | ***< 5.2*** | ***< 5.3*** | ***< 5.5*** | ***< 6.9*** | ***< 7.7*** | ***< 5.9*** | ***< 4.9*** |
| Carbon Disulfide | | | 8.0E+06 | < 6.6 | **2.2** J | < 5.5 | < 5.2 | < 5.3 | **0.097** J | **0.63** J | < 7.7 | **0.13** J | **0.059** J |
| Dichlorodifluoromethane | | | 1.6E+07 | **0.29** J | < 5.9 | **0.29** J | **0.31** J | **0.19** J | < 5.5 | **2.8** J | **3.8** J | **0.26** J | **0.14** J |
| m,p-Xylene | 9.0E+03 | | | **0.25** J | < 5.9 | < 5.5 | < 5.2 | < 5.3 | **0.53** J | < 6.9 | < 7.7 | < 5.9 | < 4.9 |
| Methylene Chloride | 20 | 1.3E+05 | 4.8E+06 | **0.59** J | **0.5** J | **0.52** J | **0.61** J | **0.35** J | **0.67** J | **0.49** J | **0.57** J | **0.34** J | **0.36** J |
| Naphthalene | 5.0E+03 | | 1.6E+06 | **0.76** J | **0.22** J | **0.21** J | < 21 | **0.17** J | **0.28** J | < 28 | < 31 | **0.46** J | **0.32** J |
| o-Xylene | 9.0E+03 | | 1.6E+08 | < 6.6 | < 5.9 | < 5.5 | < 5.2 | < 5.3 | **0.25** J | < 6.9 | < 7.7 | < 5.9 | < 4.9 |
| Styrene | | | | < 6.6 | < 5.9 | < 5.5 | < 5.2 | < 5.3 | < 5.5 | < 6.9 | < 7.7 | < 5.9 | < 4.9 |
| Toluene | 7.0E+03 | | 6.4E+06 | **0.6** J | **1** J | < 5.5 | **0.26** J | **0.35** J | **0.89** J | **0.51** J | **0.22** J | **0.34** J | **0.33** J |
| Trichlorofluoromethane | | | | < 6.6 | **0.21** J | < 5.5 | < 5.2 | **1.1** J | < 5.5 | < 6.9 | **2.7** J | < 5.9 | < 4.9 |

**Shaded and Bold - Value exceed Method B CUL (or Method A if no Method B value available)**

***Italics and Bold*** **- Detection limit exceeds CUL**

## Table F-3-4 Monitoring Well Soils Analytical Results: Metals, VOCs, SVOCs, TPH

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Location ID** | **MW-2** | **MW-2** | **MW-2** | **MW-2** | **MW-3** | **MW-3** | **MW-3** | **MW-3** | **MW-4** | **MW-4** |
| | | | **Sample ID** | **MW-2-0-0.5** | **MW-2-1.5-2** | **MW-2-6.5-8** | **MW-2-14-15.5** | **MW-3-0-0.5** | **MW-3-1.5-2** | **MW-3-6.5-8** | **MW-3-14-15.5** | **MW-4-0-0.5** | **MW-4-1.5-2** |
| | | | **Sample Date** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/18/2008** | **3/17/2008** | **3/17/2008** |
| **Chemical Name** | **MTCA A** | **MTCA B - Carcinogen** | **MTCA B Non-Carcinogen** | | | | | | | | | | |
| **Semi-volatile Organic Compounds EPA Method 8270 (µg/kg)** | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | | | | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | < 99 | < 9.9 |
| 2-Methylnaphthalene | | | 3.2E+05 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | **36 J** | < 9.9 |
| Acenaphthene | | | 4.8E+06 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | < 99 | < 9.9 |
| Acenaphthylene | | | | **4 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | **67 J** | < 9.9 |
| Anthracene | | | 2.4E+07 | **3 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | **1.7 J** | **1.9 J** | < 7.3 | **44 J** | < 9.9 |
| Benzo(a)anthracene | | | | **7.9 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | **4.6 J** | **3.4 J** | < 7.3 | **91 J** | < 9.9 |
| Benzo(a)pyrene | | 140 | | **13** | < 9.9 | < 9.2 | < 8.2 | < 9 | **5.9 J** | < 9.7 | < 7.3 | **99** | **1.9 J** |
| Benzo(b)fluoranthene | | | | **19** | < 9.9 | < 9.2 | < 8.2 | < 9 | **6.7 J** | **5.2 J** | < 7.3 | **190** | **2 J** |
| Benzo(g,h,i)perylene | | | | **14** | < 9.9 | < 9.2 | < 8.2 | < 9 | **4.3 J** | **3.3 J** | < 7.3 | **110** | **2.3 J** |
| Benzo(k)fluoranthene | | | | **5.9 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | **2.6 J** | **2.3 J** | < 7.3 | **64 J** | < 9.9 |
| Benzoic Acid | | | 3.2E+08 | **110 J** | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Benzyl Alcohol | | | 2.4E+07 | < 20 | < 20 | < 19 | < 17 | < 18 | < 20 | < 20 | < 15 | < 200 | < 20 |
| bis(2-Ethylhexyl)phthalate | | 7.1E+04 | 1.6E+06 | **36 J** | < 99 | **10 J** | **7.9 J** | **19 J** | **16 J** | **99** | **19 J** | < 990 | **12 J** |
| Butylbenzylphthalate | | | 1.6E+07 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | < 99 | < 9.9 |
| Chrysene | | | | **16** | < 9.9 | < 9.2 | < 8.2 | **2.2 J** | **5.8 J** | **6 J** | < 7.3 | **200** | **2.5 J** |
| Dibenz(a,h)anthracene | | | | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | **25 J** | < 9.9 |
| Dibenzofuran | | | 1.6E+05 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | **16 J** | < 9.9 |
| Di-n-Butylphthalate | | | 8.0E+06 | < 20 | < 20 | < 19 | < 17 | < 18 | < 20 | < 20 | < 15 | < 200 | < 20 |
| Fluoranthene | | | 3.2E+06 | **24** | < 9.9 | < 9.2 | < 8.2 | **2.6 J** | **8.4 J** | **12** | < 7.3 | **290** | **3.5 J** |
| Fluorene | | | 3.2E+06 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | **2.1 J** | < 7.3 | < 99 | < 9.9 |
| Indeno(1,2,3-cd)pyrene | | | | **14** | < 9.9 | < 9.2 | < 8.2 | < 9 | **4.6 J** | **2.8 J** | < 7.3 | **110** | **1.8 J** |
| Naphthalene | 5.0E+03 | | 1.6E+06 | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 | < 99 | < 9.9 |
| Pentachlorophenol | | 8.3E+03 | 2.4E+06 | **57 J** | < 99 | < 92 | < 82 | < 90 | < 99 | < 97 | < 73 | **15,000** | **57 J** |
| Phenanthrene | | | | **19** | < 9.9 | < 9.2 | < 8.2 | **1.7 J** | **6.8 J** | **15** | < 7.3 | **220** | **1.9 J** |
| Pyrene | | | 2.4E+06 | **25** | < 9.9 | < 9.2 | < 8.2 | **2.2 J** | **10** | **9.9** | < 7.3 | **320** | **3.4 J** |
| **NWTPH (mg/kg)** | | | | | | | | | | | | | |
| Diesel Range Hydrocarbons | 2.0E+03 | | | < 21 U | < 14 U | < 3.3 U | < 1.8 U | < 8.9 U | < 5.3 U | < 15 U | < 1.4 U | **96 NJ** | **2.1 J** |
| Residual Range Organics (RRO | 2.0E+03 | | | **190 NJ** | < 50 U | < 26 U | < 14 U | < 67 U | < 36 U | < 86 U | < 11 U | **480 J** | < 15 U |
| Gasoline Range Hydrocarbons | 30 | | | < 1.3 U | < 5.8 | < 6.4 | < 7 | **0.65 J** | < 5.8 | < 8.7 | < 5.7 | < 4.6 U | < 1 U |

**Shaded and Bold - Value exceed Method B CUL (or Method A if no Method B value available)**

***Italics and Bold*** **- Detection limit exceeds CUL**

## Table F-3-4 Monitoring Well Soils Analytical Results: Metals, VOCs, SVOCs, TPH

| | | | **Location ID**<br>**Sample ID**<br>**Sample Date** | **MW-4**<br>**MW-4-9-10.5**<br>**3/17/2008** | **MW-4**<br>**MW-4-14-15.5**<br>**3/17/2008** | **MW-5**<br>**MW-5-0-0.5**<br>**3/17/2008** | **MW-5**<br>**MW-5-1.5-2**<br>**3/17/2008** | **MW-5**<br>**MW-5-6.5-8**<br>**3/17/2008** | **MW-5**<br>**MW-5-11.5-13**<br>**3/17/2008** | **MW-6**<br>**MW-6-0-0.5**<br>**3/18/2008** | **MW-6**<br>**MW-6-1.5-2**<br>**3/18/2008** | **MW-6**<br>**MW-6-11.5-13**<br>**3/18/2008** | **MW-6**<br>**MW-6-19-21.5**<br>**3/18/2008** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **MTCA A** | **MTCA B - Carcinogen** | **MTCA B Non-Carcinogen** | | | | | | | | | | |
| **Metals EPA Method 6020 / 7471A (mg/kg)** | | | | | | | | | | | | | |
| Antimony | | | 32 | **0.19 J** | **0.14 J** | **2.32 J** | **0.26 J** | **1.6 J** | **0.61 J** | **0.56 J** | **0.35 J** | **0.11 J** | **0.08 J** |
| Arsenic | 20 | 0.67 | 24 | **2.6** | **2.2** | **10.2** | **3.6** | **3.1** | **8.7** | **9.2** | **5.3** | **2.2** | **2.2** |
| Beryllium | | | 160 | **0.185 J** | **0.28 J** | **0.293 J** | **0.279 J** | **0.214 J** | **0.229 J** | **0.28 J** | **0.24 J** | **0.259 J** | **0.167 J** |
| Cadmium | | | 80 | **0.149** | **0.081** | **4.49** | **0.163** | **0.573** | **0.377** | **0.402** | **0.277** | **0.074** | **0.086** |
| Chromium | 19/2000 | | | **27.8** | **31.3 J** | **38.2 J** | **29** | **21.1 J** | **25 J** | **52.9 J** | **44.9 J** | **47.8 J** | **36 J** |
| Copper | | | 3000 | **16** | **24.5 J** | **72.6 J** | **17.8** | **17.9 J** | **17.3 J** | **18 J** | **13.6 J** | **13.4 J** | **12.2 J** |
| Lead | 250 | | | **10.3** | **2.98** | **294** | **18.2** | **78.8** | **121** | **51.1** | **26.6** | **4.17** | **2.13** |
| Mercury | 2 | | 24 | **0.023 J** | **0.029** | **0.128** | **0.053 J** | **0.053** | **0.047** | **0.215** | **0.107** | **0.019 J** | **0.02** |
| Nickel | | | 1600 | **39.5** | **44.6 J** | **38.3 J** | **37.1** | **28.3 J** | **29.5 J** | **28.7 J** | **26.7 J** | **36.4 J** | **32.7 J** |
| Selenium | | | 400 | J | < 1.2 | **0.5 J** | **0.3 J** | **0.4 J** | < 1.2 | **0.4 J** | < 1.1 | **0.4 J** | < 1.2 |
| Silver | | | 400 | **0.021 J+** | **0.05** | **0.179** | **0.062** | **0.107** | **0.113** | **0.124** | **0.085** | **0.064** | **0.037** |
| Thallium | | | 6 | **0.052** | **0.068** | **0.096** | **0.06** | **0.056** | **0.054** | **0.062** | **0.054** | **0.066** | **0.044** |
| Zinc | | | 24000 | **37.1** | **34.9 J** | **641 J** | **42.4** | **143 J** | **68.1 J** | **64.6 J** | **50.1 J** | **27.6 J** | **26.9 J** |
| **Volatile Organic Compounds EPA Method 8260 (µg/kg)** | | | | | | | | | | | | | |
| 1,2,4-Trichlorobenzene | | | | < 11 | < 25 | **0.35 J** | < 23 | < 23 | < 21 | < 39 | < 24 | < 15 | < 18 |
| 1,2,4-Trimethylbenzene | | | 4.0E+06 | < 11 | < 25 | **0.29 J** | < 23 | **0.19 J** | **0.16 J** | **0.25 J** | < 24 | < 15 | < 18 |
| 1,3,5-Trimethylbenzene | | | | < 11 | < 25 | **0.13 J** | < 23 | < 23 | < 21 | < 39 | < 24 | < 15 | < 18 |
| 1,4-Dichlorobenzene | | | | < 2.8 | **0.22 J** | **0.55 J** | **0.15 J** | < 5.6 | < 5.2 | **0.39 J** | < 6 | < 3.6 | < 4.4 |
| 2-Butanone | | | 4.8E+07 | **1.5 J** | < 25 | **21 J** | **6.5 J** | **6.3 J** | **8.3 J** | **26 J** | **9.4 J** | < 15 | < 18 |
| 4-Isopropyltoluene | | | | < 11 | < 25 | < 27 | **0.34 J** | < 23 | **0.34 J** | < 39 | < 24 | < 15 | < 18 |
| 4-Methyl-2-Pentanone (MIBK) | | | | < 11 | < 25 | **0.95 J** | < 23 | < 23 | < 21 | < 39 | < 24 | < 15 | < 18 |
| Acetone | | | 8.0E+06 | **18** | **5.3 J** | **410** | **210** | **110** | **81** | **380** | **180** | **8.7 J** | **4.6 J** |
| Benzene | 0.03 | 180 | 3.2E+05 | **<** ***2.8*** | **<** ***6.2*** | **1.7 J** | **<** ***5.6*** | **<** ***5.6*** | **0.96 J** | **<** ***9.8*** | **<** ***6*** | **<** ***3.6*** | **<** ***4.4*** |
| Carbon Disulfide | | | 8.0E+06 | **0.06 J** | < 6.2 | **0.35 J** | **0.18 J** | **0.3 J** | **1.9 J** | **0.14 J** | < 6 | **0.093 J** | < 4.4 |
| Dichlorodifluoromethane | | | 1.6E+07 | **2.4 J** | **0.27 J** | **1.1 J** | **0.19 J** | **0.19 J** | **0.17 J** | **12** | < 6 | **0.61 J** | **1.9 J** |
| m,p-Xylene | 9.0E+03 | | | < 2.8 | < 6.2 | **0.73 J** | **0.23 J** | **0.44 J** | **0.27 J** | < 9.8 | < 6 | < 3.6 | < 4.4 |
| Methylene Chloride | 20 | 1.3E+05 | 4.8E+06 | **2.4 J** | **0.42 J** | **0.75 J** | **0.41 J** | **0.46 J** | **0.35 J** | **6.4 J** | **0.37 J** | **0.93 J** | **0.63 J** |
| Naphthalene | 5.0E+03 | | 1.6E+06 | < 11 | **0.5 J** | **1 J** | **0.61 J** | **0.59 J** | **0.7 J** | **1.7 J** | < 24 | **0.41 J** | **0.21 J** |
| o-Xylene | 9.0E+03 | | 1.6E+08 | < 2.8 | < 6.2 | **0.43 J** | < 5.6 | **0.22 J** | < 5.2 | < 9.8 | < 6 | < 3.6 | < 4.4 |
| Styrene | | | | < 2.8 | < 6.2 | **0.12 J** | < 5.6 | < 5.6 | < 5.2 | < 9.8 | < 6 | < 3.6 | < 4.4 |
| Toluene | 7.0E+03 | | 6.4E+06 | < 2.8 | < 6.2 | **1.5 J** | **0.52 J** | **0.64 J** | **0.99 J** | **0.66 J** | **0.59 J** | **0.22 J** | **0.22 J** |
| Trichlorofluoromethane | | | | < 2.8 | < 6.2 | < 6.7 | < 5.6 | < 5.6 | < 5.2 | **2.4 J** | < 6 | < 3.6 | < 4.4 |

**Shaded and Bold - Value exceed Method B CUL (or Method A if no Method B value available)**

***Italics and Bold*** **- Detection limit exceeds CUL**

## Table F-3-4 Monitoring Well Soils Analytical Results: Metals, VOCs, SVOCs, TPH

| | | | **Location ID**<br>**Sample ID**<br>**Sample Date** | **MW-4**<br>**MW-4-9-10.5**<br>**3/17/2008** | **MW-4**<br>**MW-4-14-15.5**<br>**3/17/2008** | **MW-5**<br>**MW-5-0-0.5**<br>**3/17/2008** | **MW-5**<br>**MW-5-1.5-2**<br>**3/17/2008** | **MW-5**<br>**MW-5-6.5-8**<br>**3/17/2008** | **MW-5**<br>**MW-5-11.5-13**<br>**3/17/2008** | **MW-6**<br>**MW-6-0-0.5**<br>**3/18/2008** | **MW-6**<br>**MW-6-1.5-2**<br>**3/18/2008** | **MW-6**<br>**MW-6-11.5-13**<br>**3/18/2008** | **MW-6**<br>**MW-6-19-21.5**<br>**3/18/2008** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **MTCA A** | **MTCA B - Carcinogen** | **MTCA B Non-Carcinogen** | | | | | | | | | | |
| **Semi-volatile Organic Compounds EPA Method 8270 (µg/kg)** | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | | | | < 9.9 | < 9.8 | **20 J** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| 2-Methylnaphthalene | | | 3.2E+05 | < 9.9 | < 9.8 | **22 J** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Acenaphthene | | | 4.8E+06 | < 9.9 | < 9.8 | **8.1 J** | < 9.9 | < 9.9 | **51 J** | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Acenaphthylene | | | | **1.2 J** | < 9.8 | **50** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Anthracene | | | 2.4E+07 | < 9.9 | < 9.8 | **43 J** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Benzo(a)anthracene | | | | **2.7 J** | < 9.8 | **100** | < 9.9 | **3 J** | **35 J** | **6.2 J** | **2.2 J** | **2 J** | < 9.9 |
| Benzo(a)pyrene | | 140 | | **4 J** | < 9.8 | **180** | < 9.9 | **4.2 J** | **<** ***200*** | **7.8 J** | < 9.6 | < 9.9 | < 9.9 |
| Benzo(b)fluoranthene | | | | **4.3 J** | < 9.8 | **220** | < 9.9 | **6.7 J** | < 200 | **12** | **3.4 J** | < 9.9 | < 9.9 |
| Benzo(g,h,i)perylene | | | | **3 J** | < 9.8 | **210** | < 9.9 | **5.1 J** | **39 J** | **8 J** | **2.2 J** | < 9.9 | < 9.9 |
| Benzo(k)fluoranthene | | | | **1.5 J** | < 9.8 | **79** | < 9.9 | **2.8 J** | < 200 | **4 J** | < 9.6 | < 9.9 | < 9.9 |
| Benzoic Acid | | | 3.2E+08 | NA | NA | NA | NA | NA | NA | **130 J** | **140 J** | NA | NA |
| Benzyl Alcohol | | | 2.4E+07 | < 20 | < 20 | < 99 | < 20 | < 20 | < 400 | < 20 | < 20 | **2.9 J** | < 20 |
| bis(2-Ethylhexyl)phthalate | | 7.1E+04 | 1.6E+06 | **170** | **18 J** | **67 J** | **24 J** | **470** | **180 J** | **31 J** | **35 J** | **130** | **10 J** |
| Butylbenzylphthalate | | | 1.6E+07 | < 9.9 | < 9.8 | < 50 | < 9.9 | **8.3 J** | < 200 | < 10 | < 9.6 | < 9.9 | **4.4 J** |
| Chrysene | | | | **4.2 J** | < 9.8 | **160** | **3.3 J** | **5.3 J** | **58 J** | **10** | **2.9 J** | **1.7 J** | < 9.9 |
| Dibenz(a,h)anthracene | | | | < 9.9 | < 9.8 | **27 J** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Dibenzofuran | | | 1.6E+05 | < 9.9 | < 9.8 | **6.2 J** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Di-n-Butylphthalate | | | 8.0E+06 | < 20 | < 20 | **330** | < 20 | < 20 | < 400 | < 20 | < 20 | < 20 | < 20 |
| Fluoranthene | | | 3.2E+06 | **5.9 J** | < 9.8 | **280** | **3.4 J** | **7 J** | **56 J** | **13** | **5.9 J** | **5 J** | **4.5 J** |
| Fluorene | | | 3.2E+06 | < 9.9 | < 9.8 | **14 J** | < 9.9 | < 9.9 | < 200 | < 10 | **1.1 J** | < 9.9 | **1.3 J** |
| Indeno(1,2,3-cd)pyrene | | | | **3 J** | < 9.8 | **190** | < 9.9 | **5 J** | < 200 | **7 J** | **2.1 J** | < 9.9 | < 9.9 |
| Naphthalene | 5.0E+03 | | 1.6E+06 | < 9.9 | < 9.8 | **50** | < 9.9 | < 9.9 | < 200 | < 10 | < 9.6 | < 9.9 | **4 J** |
| Pentachlorophenol | | 8.3E+03 | 2.4E+06 | **130** | < 98 | **2,700** | **53 J** | **120** | < 2,000 | **65 J** | < 96 | < 99 | < 99 |
| Phenanthrene | | | | **5.6 J** | < 9.8 | **190** | **2.3 J** | **4 J** | **210** | **8.3 J** | **8.1 J** | **8.2 J** | **7.7 J** |
| Pyrene | | | 2.4E+06 | **6.6 J** | < 9.8 | **290** | **3.1 J** | **6.8 J** | **150 J** | **12** | **4.5 J** | **3.8 J** | **2.8 J** |
| **NWTPH (mg/kg)** | | | | | | | | | | | | | |
| Diesel Range Hydrocarbons | 2.0E+03 | | | **1.5 J** | < 31 | **90 NJ** | **2.7 J** | **19 J** | **1,100 J** | < 15 U | < 11 U | **56 J** | < 2.3 U |
| Residual Range Organics (RR | 2.0E+03 | | | < 9.5 U | < 9.3 U | **480 J** | < 21 U | < 88 U | **810 J** | **180 NJ** | < 99 U | < 32 U | < 19 U |
| Gasoline Range Hydrocarbons | 30 | | | < 0.83 U | < 2 U | < 2.9 U | < 5.8 | < 0.73 U | **14 NJ** | < 6.9 | < 6.1 | < 5.9 | < 6 |

**Shaded and Bold - Value exceed Method B CUL (or Method A if no Method B value available)**

***Italics and Bold*** **- Detection limit exceeds CUL**

## Table F-3-5 Monitoring Well Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotients (TEQ)

| | | Location ID | MW-2 | | | MW-2 | | | MW-2 | | | MW-2 | | | MW-3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample ID | MW-2-0-0.5 | | | MW-2-1.5-2 | | | MW-2-6.5-8 | | | MW-2-14-15.5 | | | MW-3-0-0.5 | | |
| | | Sample Date | 03/18/08 | | | 03/18/08 | | | 03/18/08 | | | 03/18/08 | | | 03/18/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 12,300 | **3.69** | J | 12.9 | **0.00387** | J | 21.0 | **0.0063** | J | 910 | **0.273** | J | 608 | **0.182** | |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | 1,520 | **0.456** | J | < 1.88 | 0.000282 | | < 2.89 | 0.0004335 | | 98.3 | **0.02949** | | 77.6 | **0.0233** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | 998 | **9.98** | J | < 2.42 | 0.0121 | | 2.35 | **0.0235** | | 75.9 | **0.759** | | 67 | **0.670** | |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | 258 | **2.58** | | < 0.668 | 0.00334 | | < 0.625 | 0.003125 | | 17.7 | **0.177** | | 18.3 | **0.183** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | 12.3 | **0.123** | | < 0.063 | 0.0003 | | < 0.0572 | 0.000286 | | 0.706 | **0.00706** | J | 0.577 | **0.00577** | J |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | 4.27 | **0.427** | | < 0.0331 | 0.001655 | | < 0.0243 | 0.001215 | | 0.224 | **0.0224** | NJ+ | 0.381 | **0.0381** | J |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | 8.94 | **0.894** | | 0.0614 | **0.00614** | NJ+ | < 0.0235 | 0.001 | | 0.276 | **0.0276** | J | 0.946 | **0.0946** | J |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | 23.2 | **2.32** | | < 0.0321 | 0.002 | | 0.0989 | **0.00989** | J | 1.81 | **0.181** | J | 1.73 | **0.173** | J |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | 3.33 | **0.333** | | < 0.0239 | 0.001 | | < 0.0241 | 0.001 | | 0.171 | **0.0171** | J | 0.575 | **0.0575** | J |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | 12.3 | **1.23** | | 0.164 | **0.0164** | J | 0.0976 | **0.00976** | J | 1.43 | **0.143** | J | 1.44 | **0.144** | J |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | < 0.198 | 0.010 | | < 0.0317 | 0.002 | | < 0.0319 | 0.002 | | < 0.0349 | 0.002 | | < 0.0458 | 0.002 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | 2.87 | **2.87** | | < 0.0362 | 0.02 | | < 0.0172 | 0.01 | | 0.296 | **0.296** | NJ+ | 0.301 | **0.301** | NJ+ |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | 0.802 | **0.0241** | J | < 0.0191 | 0.0003 | | < 0.0139 | 0.0002 | | < 0.021 | 0.0003 | | 0.0999 | **0.002997** | NJ+ |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | 2.99 | **0.299** | NJ+ | < 0.0265 | 0.001 | | < 0.0266 | 0.001 | | 0.144 | **0.0144** | NJ+ | 0.238 | **0.0238** | J |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | 1.75 | **0.525** | J | < 0.0185 | 0.003 | | < 0.0134 | 0.002 | | 0.0429 | **0.0129** | NJ+ | 0.276 | **0.0828** | J |
| 2,3,7,8-TCDD | 1 | ng/kg | 4.38 | **4.38** | | < 0.0538 | 0.027 | | < 0.0208 | 0.010 | | 0.114 | **0.114** | NJ+ | < 0.0345 | 0.017 | |
| 2,3,7,8-TCDF | 0.1 | ng/kg | 0.917 | **0.0917** | J | < 0.0641 | 0.0032 | | < 0.0287 | 0.0014 | | < 0.0214 | 0.0011 | | < 0.138 | 0.0069 | |
| **Total TCDD TEQ (1)** | | | | **30.2** | | | **0.10** | | | **0.082** | | | **2.08** | | | **2.01** | |

| | | Location ID | MW-3 | | | MW-3 | | | MW-3 | | | MW-4 | | | MW-4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample ID | MW-3-1.5-2 | | | MW-3-6.5-8 | | | MW-3-14-15.5 | | | MW-4-0-0.5 | | | MW-4-1.5-2 | | |
| | | Sample Date | 03/18/08 | | | 03/18/08 | | | 03/18/08 | | | 03/17/08 | | | 03/17/08 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 880 | **0.264** | | 890 | **0.267** | | 16.1 | **0.00483** | | 295,000 | **88.5** | | 9,340 | **2.80** | J |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | 71.6 | **0.0215** | | 101 | **0.0303** | | < 1.16 | 0.000174 | | 75,400 | **22.6** | | 1,260 | **0.378** | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | 87 | **0.870** | | 98.7 | **0.987** | | < 1.76 | 0.0088 | | 81,300 | **813** | | 909 | **9.09** | |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | 20.6 | **0.206** | | 24.2 | **0.242** | | < 0.266 | 0.00133 | | 19,200 | **192** | | 251 | **2.51** | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | 1.17 | **0.0117** | J | 0.937 | **0.00937** | J | < 0.0395 | 0.0002 | | 897 | **8.97** | | 9.86 | **0.0986** | |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | 0.641 | **0.0641** | J | 0.737 | **0.0737** | J | < 0.0265 | 0.001 | | 506 | **50.6** | J | 6.33 | **0.633** | |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | 1.74 | **0.174** | J | 0.97 | **0.0970** | J | < 0.0231 | 0.001 | | 619 | **61.9** | J | 5.1 | **0.510** | |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | 3.26 | **0.326** | | 2.82 | **0.282** | J | 0.0966 | **0.00966** | J | 3,560 | **356** | | 32.7 | **3.27** | |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | 1.01 | **0.101** | J | 0.885 | **0.0885** | J | < 0.0235 | 0.001 | | 354 | **35.4** | | 3.1 | **0.310** | |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | 1.78 | **0.178** | J | 2.45 | **0.245** | J | 0.0946 | **0.00946** | J | 2,550 | **255** | | 28.3 | **2.83** | |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | < 0.0594 | 0.003 | | < 0.19 | 0.010 | | < 0.0313 | 0.002 | | 15.2 | **1.52** | NJ+ | < 0.757 | 0.038 | |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | 0.453 | **0.453** | J | 0.47 | **0.470** | NJ+ | < 0.0162 | 0.01 | | 511 | **511** | J | 6.48 | **6.48** | |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | 0.284 | **0.00852** | J | < 0.0606 | 0.0009 | | < 0.0118 | 0.0002 | | 35.1 | **1.05** | NJ+ | 0.449 | **0.0135** | J |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | 0.691 | **0.0691** | J | 0.595 | **0.0595** | J | < 0.026 | 0.001 | | 273 | **27.3** | | 3.04 | **0.304** | |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | 0.376 | **0.113** | J | 0.491 | **0.147** | J | < 0.0114 | 0.002 | | 89.1 | **26.7** | | 1.01 | **0.303** | J |
| 2,3,7,8-TCDD | 1 | ng/kg | < 0.0197 | 0.010 | | 0.098 | **0.0980** | NJ+ | < 0.02 | 0.010 | | 121 | **121** | | 1.59 | **1.59** | |
| 2,3,7,8-TCDF | 0.1 | ng/kg | < 0.136 | 0.0068 | | < 0.14 | 0.0070 | | < 0.0142 | 0.0007 | | 20.9 | **2.09** | | < 0.0895 | 0.0045 | |
| **Total TCDD TEQ (1)** | | | | **2.88** | | | **3.11** | | | **0.062** | | | **2575** | | | **31.2** | |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:

J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
\+ = biased high

Method B CUL - 11 ng/kg
▨ Value Exceeds Method B CUL

## Table F-3-5 Monitoring Well Soils Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotients (TEQ)

| | | Location ID<br>Sample ID<br>Sample Date | MW-4<br>MW-4-9-10.5<br>03/17/08 | | MW-4<br>MW-4-14-15.5<br>03/17/08 | | MW-5<br>MW-5-0-0.5<br>03/17/08 | | MW-5<br>MW-5-1.5-2<br>03/17/08 | | MW-5<br>MW-5-6.5-8<br>03/17/08 | | MW-5<br>MW-5-11.5-13<br>03/17/08 | | MW-6<br>MW-6-0-0.5<br>03/18/08 | | MW-6<br>MW-6-1.5-2<br>03/18/08 | | MW-6<br>MW-6-11.5-13<br>03/18/08 | | MW-6<br>MW-6-19-21.5<br>03/18/08 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** | **Reported Value** | **TEQ** |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | ng/kg | 35,800 | **10.7 J** | 1,390 | **0.417 J** | 657,000 | **197 J** | 6,450 | **1.94 J** | 164,000 | **49.2 J** | 27,700 | **8.31 J** | 2,950 | **0.885 J** | 1,170 | **0.351 J** | 37.6 | **0.0113** | 14.1 | **0.00423** |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | ng/kg | 4,530 | **1.36** | 187 | **0.0561** | 110,000 | **33.0** | 771 | **0.231** | 20,800 | **6.24** | 3,490 | **1.05** | 401 | **0.120** | 121 | **0.0363** | < 4.66 | 0.000699 | < 0.645 | 0.00009675 |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ng/kg | 5,700 | **57.0 J** | 155 | **1.55** | 109,000 | **1090** | 767 | **7.67 J** | 20,200 | **202** | 2,490 | **24.9** | 342 | **3.42** | 141 | **1.41** | 4.16 | **0.0416** | < 1.79 | 0.0090 |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | ng/kg | 1,080 | **10.8** | 34.6 | **0.346** | 23,600 | **236** | 150 | **1.50** | 4,160 | **41.6** | 458 | **4.58** | 70.1 | **0.701** | 22.5 | **0.225** | < 0.887 | 0.004435 | < 0.183 | 0.000915 |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | ng/kg | 38.6 | **0.386** | 1.81 | **0.0181 J** | 722 | **7.22 NJ+** | 6.35 | **0.0635** | 236 | **2.36** | 33.5 | **0.335** | 3.01 | **0.0301 J** | 1.51 | **0.0151 J** | < 0.0541 | 0.0003 | < 0.0513 | 0.0003 |
| 1,2,3,4,7,8-HxCDD | 0.1 | ng/kg | 19.3 | **1.93** | 2.18 | **0.218 J** | 539 | **53.9** | 3.67 | **0.367** | 110 | **11.0** | 9.12 | **0.912** | 1.62 | **0.162 J** | 0.735 | **0.0735 J** | < 0.0308 | 0.002 | < 0.0275 | 0.001 |
| 1,2,3,4,7,8-HxCDF | 0.1 | ng/kg | 17.1 | **1.71** | 0.932 | **0.0932 J** | 462 | **46.2 NJ+** | 4.27 | **0.427** | 99.6 | **9.96** | 11.3 | **1.13** | 3.33 | **0.333** | 1.33 | **0.133 J** | < 0.026 | 0.001 | < 0.0333 | 0.002 |
| 1,2,3,6,7,8-HxCDD | 0.1 | ng/kg | 95.8 | **9.58** | 5.03 | **0.503** | 3,750 | **375** | 21.8 | **2.18** | 570 | **57.0** | 71.7 | **7.17** | 8.61 | **0.861** | 3.44 | **0.344** | 0.145 | **0.0145 NJ+** | < 0.0266 | 0.001 |
| 1,2,3,6,7,8-HxCDF | 0.1 | ng/kg | 9.95 | **0.995** | 0.684 | **0.0684 J** | 290 | **29.0** | 2.59 | **0.259 J** | 59.7 | **5.97** | 5.86 | **0.586** | 1.42 | **0.142 J** | 0.567 | **0.0567 J** | < 0.0265 | 0.001 | < 0.0341 | 0.002 |
| 1,2,3,7,8,9-HxCDD | 0.1 | ng/kg | 81.3 | **8.13** | 6.86 | **0.686** | 3,350 | **335** | 16.9 | **1.69** | 464 | **46.4** | 30.4 | **3.04** | 5.32 | **0.532** | 2.26 | **0.226 J** | < 0.0322 | 0.002 | < 0.0287 | 0.001 |
| 1,2,3,7,8,9-HxCDF | 0.1 | ng/kg | < 0.463 | 0.023 | < 0.283 | 0.014 | 12.9 | **1.29** | < 0.229 | 0.011 | 1.94 | **0.194 NJ+** | < 0.398 | 0.020 | < 0.106 | 0.005 | < 0.0698 | 0.003 | < 0.0351 | 0.002 | < 0.0451 | 0.002 |
| 1,2,3,7,8-PeCDD | 1 | ng/kg | 18.1 | **18.1** | 1.88 | **1.88 J** | 547 | **547** | 5.41 | **5.41** | 107 | **107** | 5.34 | **5.34** | 1.04 | **1.04 J** | 0.368 | **0.368 NJ+** | < 0.0341 | 0.02 | < 0.0304 | 0.0152 |
| 1,2,3,7,8-PeCDF | 0.03 | ng/kg | 1.23 | **0.0369 NJ+** | < 0.0639 | 0.0010 | 38 | **1.14 NJ+** | 0.473 | **0.0142 J** | 8.76 | **0.263** | 0.717 | **0.0215 J** | 0.394 | **0.0118 NJ+** | 0.232 | **0.00696 J** | < 0.0158 | 0.0002 | < 0.0225 | 0.0003 |
| 2,3,4,6,7,8-HxCDF | 0.1 | ng/kg | 7.81 | **0.781** | 0.498 | **0.0498 J** | 209 | **20.9** | 1.93 | **0.193 J** | 46.8 | **4.68** | 5.59 | **0.559** | 0.823 | **0.0823 J** | 0.595 | **0.0595 J** | < 0.0294 | 0.001 | < 0.0377 | 0.002 |
| 2,3,4,7,8-PeCDF | 0.3 | ng/kg | 2.59 | **0.777** | < 0.0617 | 0.009 | 73.9 | **22.2** | 1.28 | **0.384 J** | 16.8 | **5.04** | 1.25 | **0.375 J** | 0.791 | **0.237 J** | 0.428 | **0.128 J** | < 0.0152 | 0.002 | < 0.0217 | 0.003 |
| 2,3,7,8-TCDD | 1 | ng/kg | 4.11 | **4.11** | 0.521 | **0.521 NJ+** | 102 | **102** | 1.55 | **1.55** | 22.6 | **22.6** | 1.3 | **1.30** | 1.29 | **1.29** | 0.656 | **0.656 J** | < 0.0405 | 0.020 | < 0.0516 | 0.026 |
| 2,3,7,8-TCDF | 0.1 | ng/kg | 0.333 | **0.0333 J** | < 0.0482 | 0.0024 | 9.76 | **0.976** | 1 | **0.100 NJ+** | 4.14 | **0.414** | < 0.51 | 0.0255 | 0.685 | **0.0685 J** | 0.396 | **0.0396 J** | < 0.0494 | 0.0025 | < 0.0444 | 0.0022 |
| **Total TCDD TEQ (1)** | | | | **126** | | **6.43** | | **3098** | | **24.0** | | **572** | | **59.7** | | **9.92** | | **4.13** | | **0.12** | | **0.073** |

**Notes**

Total TCDD TEQ calculated using Toxicity Equivalency Factors in MTCA Regulations revised November 2007.

(1) One-half the detection limit used in TEQ calculation for non-detect results

Qualifiers:

- J = estimated concentration (value less than calculated reporting limit)
- N = analyte is tentatively identified (validator qualifier)
- \+ = biased high

Method B CUL - 11 ng/kg

▨ Value Exceeds Method B CUL

# Table F-3-6 Monitoring Well Soils Analytcial Results: cPAH Total Toxic Equivalency Quotient (TEQ)

| | | Location ID | MW-2 | MW-2 | MW-2 | MW-2 | MW-3 | MW-3 | MW-3 | MW-3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sample ID** | **MW-2-0-0.5** | **MW-2-1.5-2** | **MW-2-6.5-8** | **MW-2-14-15.5** | **MW-3-0-0.5** | **MW-3-1.5-2** | **MW-3-6.5-8** | **MW-3-14-15.5** |
| | | **Sample Date** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** |
| **Chemical Name (µg/kg)** | **TEFs** | **Unit** | | | | | | | | |
| **Carcinogenic PAH** | | | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** |
| Benzo(a)anthracene | 0.1 | µg/kg | **7.9 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | **4.6 J** | **3.4 J** | < 7.3 |
| Benzo(a)pyrene | 1 | µg/kg | **13** | < 9.9 | < 9.2 | < 8.2 | < 9 | **5.9 J** | < 9.7 | < 7.3 |
| Benzo(b)fluoranthene | 0.1 | µg/kg | **19** | < 9.9 | < 9.2 | < 8.2 | < 9 | **6.7 J** | **5.2 J** | < 7.3 |
| Benzo(k)fluoranthene | 0.1 | µg/kg | **5.9 J** | < 9.9 | < 9.2 | < 8.2 | < 9 | **2.6 J** | **2.3 J** | < 7.3 |
| Chrysene | 0.01 | µg/kg | **16** | < 9.9 | < 9.2 | < 8.2 | **2.2 J** | **5.8 J** | **6 J** | < 7.3 |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | < 10 | < 9.9 | < 9.2 | < 8.2 | < 9 | < 9.9 | < 9.7 | < 7.3 |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | **14** | < 9.9 | < 9.2 | < 8.2 | < 9 | **4.6 J** | **2.8 J** | < 7.3 |
| **Total cPAH TEQ (1)** | | | **18.3** | **NC** | NC | NC | **6.8** | **8.3** | **6.8** | NC |

| | | Location ID | MW-4 | MW-4 | MW-4 | MW-4 | MW-5 | MW-5 | MW-5 | MW-5 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sample ID** | **MW-4-0-0.5** | **MW-4-1.5-2** | **MW-4-9-10.5** | **MW-4-14-15.5** | **MW-5-0-0.5** | **MW-5-1.5-2** | **MW-5-6.5-8** | **MW-5-11.5-13** |
| | | **Sample Date** | **03/17/08** | **03/17/08** | **03/17/08** | **03/17/08** | **03/17/08** | **03/17/08** | **03/17/08** | **03/17/08** |
| **Chemical Name (µg/kg)** | **TEFs** | **Unit** | | | | | | | | |
| **Carcinogenic PAH** | | | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** | **TEQ** |
| Benzo(a)anthracene | 0.1 | µg/kg | **91 J** | < 9.9 | **2.7 J** | < 9.8 | **100** | < 9.9 | **3 J** | **35 J** |
| Benzo(a)pyrene | 1 | µg/kg | **99** | **1.9 J** | **4 J** | < 9.8 | **180** | < 9.9 | **4.2 J** | < 200* |
| Benzo(b)fluoranthene | 0.1 | µg/kg | **190** | **2 J** | **4.3 J** | < 9.8 | **220** | < 9.9 | **6.7 J** | < 200* |
| Benzo(k)fluoranthene | 0.1 | µg/kg | **64 J** | < 9.9 | **1.5 J** | < 9.8 | **79** | < 9.9 | **2.8 J** | < 200* |
| Chrysene | 0.01 | µg/kg | **200** | **2.5 J** | **4.2 J** | < 9.8 | **160** | **3.3 J** | **5.3 J** | **58 J** |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | **25 J** | < 9.9 | < 9.9 | < 9.8 | **27 J** | < 9.9 | < 9.9 | < 200* |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | **110** | **1.8 J** | **3 J** | < 9.8 | **190** | < 9.9 | **5 J** | < 200* |
| **Total cPAH TEQ (1)** | | | **149** | **3.8** | **5.7** | NC | **243** | **7.5** | **6.5** | **144** |

| | | Location ID | MW-6 | MW-6 | MW-6 | MW-6 |
|---|---|---|---|---|---|---|
| | | **Sample ID** | **MW-6-0-0.5** | **MW-6-1.5-2** | **MW-6-11.5-13** | **MW-6-19-21.5** |
| | | **Sample Date** | **03/18/08** | **03/18/08** | **03/18/08** | **03/18/08** |
| **Chemical Name (µg/kg)** | **TEFs** | **Unit** | | | | |
| **Carcinogenic PAH** | | | **TEQ** | **TEQ** | **TEQ** | **TEQ** |
| Benzo(a)anthracene | 0.1 | µg/kg | **6.2 J** | **2.2 J** | **2 J** | < 9.9 |
| Benzo(a)pyrene | 1 | µg/kg | **7.8 J** | < 9.6 | < 9.9 | < 9.9 |
| Benzo(b)fluoranthene | 0.1 | µg/kg | **12** | **3.4 J** | < 9.9 | < 9.9 |
| Benzo(k)fluoranthene | 0.1 | µg/kg | **4 J** | < 9.6 | < 9.9 | < 9.9 |
| Chrysene | 0.01 | µg/kg | **10** | **2.9 J** | **1.7 J** | < 9.9 |
| Dibenz(a,h)anthracene | 0.1 | µg/kg | < 10 | < 9.6 | < 9.9 | < 9.9 |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/kg | **7 J** | **2.1 J** | < 9.9 | < 9.9 |
| **Total cPAH TEQ (1)** | | | **11.3** | **6.6** | **7.2** | NC |

**MTCA Method B CUL - 0.137 mg/kg (137 µg/kg)**

**Notes**

Concentrations reported in µg/kg
(1) Total cPAH TEQs calculated using Toxicity Equivalency Factors from MTCA Regulations Revised November 2007. One-half the detection limit used for non-detect results.
Qualifiers:
U = non-detect
J = estimated concentration (value less than calculated reporting limit)
D = compounds at secondary dilution factor
▨ highlight indicates exceedance of the MTCA Method B cleanup level of 137 µg/kg
NC= Not Calculated where all constituents are not detected
* = Elevated detection levels due to sample dilution.

## Table F-4-1 Groundwater Analytical Results: Metals, VOCs, SVOCs, and TPH (March 2008)

| | | | Location ID<br>Sample ID<br>Sample Date | MW-1<br>MW-1-0308<br>3/28/2008 | MW-2<br>MW-2-0308<br>3/28/2008 | MW-3<br>MW-3-0308<br>3/27/2008 | MW-4<br>MW-4-0308<br>3/27/2008 | MW-5<br>MW-5-0308<br>3/27/2008 | MW-5<br>DUP-1-0308<br>3/27/2008 | MW-6<br>MW-6-0308<br>3/28/2008 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **Method A** | **MCTA B Carcinogen** | **MCTA B Non-carcinogen** | | | | | | | |
| **Metals EPA Method 6020/7470A (µg/L)** | | | | | | | | | | |
| Antimony | | | 6.4 | **0.237** | **0.056** | **0.258** | **0.341** | **0.063 J** | **0.071 J** | **0.188** |
| Arsenic | 5 | 0.058 | 4.8 | **10.5** | ***< 0.33 U*** | ***< 1.39 U*** | ***< 1.38 U*** | **3.44** | **3.58** | **1.66** |
| Beryllium | | | 32 | < 0.02 | < 0.02 | < 0.02 | **0.008 J** | < 0.04 | < 0.04 | **0.035 J** |
| Cadmium | 5 | | 8 | **0.01 J** | **0.026** | **0.018 J** | **0.024** | **0.035 J** | **0.051** | **0.117** |
| Chromium | 50 | | | **2.73 J** | < 0.91 U | < 0.35 U | < 0.85 U | < 0.61 U | < 0.69 U | **3.16 J** |
| Copper | | | 590 | **1.03** | **0.61** | < 0.28 U | **0.65** | **0.49** | **0.43** | **12.6** |
| Lead | 15 | | | **0.322** | **0.207** | **0.017 J** | **0.134** | **0.082 J** | **0.087 J** | **0.324** |
| Zinc | | | 4800 | **1.5** | **4.8** | **0.7** | **3.2** | **9.6 J** | **2.3 J** | **4** |
| Mercury | 2 | | 4.8 | **0.01 J** | J | **0.01 J** | J | J | **0.01 J** | **0.02 J** |
| **Volatile Organic Compounds EPA Method 8260 (µg/L)** | | | | | | | | | | |
| 1,2,4-Trimethylbenzene | | | 400 | **3.1** | **0.72 J** | < 2 | < 2 | < 2 | < 2 | **0.17 J** |
| 1,3,5-Trimethylbenzene | | | 400 | < 2 | **0.21 J** | < 2 | < 2 | < 2 | < 2 | < 2 |
| 4-Isopropyltoluene | | | | **0.58 J** | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| Ethylbenzene | 700 | | 800 | **0.33 J** | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | **3.5** |
| Isopropylbenzene | | | 800 | **0.31 J** | < 2 | < 2 | < 2 | < 2 | < 2 | **1.8 J** |
| m,p-Xylene | 1000 | | | **0.37 J** | **0.55** | < 0.5 | < 0.5 | < 0.5 | < 0.5 | **0.33 J** |
| Naphthalene | 160 | | 160 | **1.9 J** | **0.36 J** | < 2 | < 2 | < 2 | < 2 | **4** |
| n-Butylbenzene | | | | **0.25 J** | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| n-Propylbenzene | | | | **0.42 J** | < 2 | < 2 | < 2 | < 2 | < 2 | **1.2 J** |
| o-Xylene | | | 16000 | **0.54** | **0.28 J** | < 0.5 | < 0.5 | < 0.5 | < 0.5 | **0.18 J** |
| sec-Butylbenzene | | | | **0.47 J** | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| Tetrachloroethene | 5 | 0.08 | 80 | **0.23 J** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** |
| Toluene | 1000 | | 640 | < 0.5 | **0.19 J** | < 0.5 | < 0.5 | < 0.5 | < 0.5 | **0.17 J** |
| Trichloroethene | 5 | 0.11 | 2.4 | **0.17 J** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** | ***< 0.5*** |
| **Semivolatile Organic Compounds EPA Method 8270 (µg/L)** | | | | | | | | | | |
| 2,4,5-Trichlorophenol | | | 800 | **0.4 J** | < 0.48 | < 0.5 | < 0.49 | **0.033 J** | < 0.49 | **0.23 J** |
| 2,4,6-Trichlorophenol | | 4 | | **1.5 J** | < 0.48 | < 0.5 | < 0.49 | < 0.5 | < 0.49 | < 2.5 |
| 2-Methylnaphthalene | | | 32 | < 0.97 | **0.16 J** | < 0.2 | < 0.2 | **0.038 J** | **0.028 J** | < 1 |
| 2-Methylphenol | | | 400 | < 2.5 | < 0.48 | < 0.5 | < 0.49 | **0.14 J** | **0.15 J** | < 2.5 |
| 4-Methylphenol | | | 40 | < 2.5 | < 0.48 | < 0.5 | < 0.49 | **0.12 J** | **0.13 J** | < 2.5 |
| Anthracene | | | 4800 | < 0.97 | < 0.19 | < 0.2 | **0.025 J** | < 0.2 | **0.025 J** | < 1 |
| Benzo(a)anthracene | | | | **0.6 J** | **0.049 J** | **0.044 J** | **0.065 J** | **0.051 J** | **0.066 J** | < 1 |
| Benzo(a)pyrene | | 0.01 | | **0.72 J** | **0.038 J** | ***< 0.2*** | **0.047 J** | **0.037 J** | **0.039 J** | ***< 1*** |
| Benzo(b)fluoranthene | | | | **0.83 J** | **0.05 J** | **0.036 J** | **0.059 J** | **0.061 J** | **0.064 J** | < 1 |
| Benzo(g,h,i)perylene | | | | **0.37 J** | **0.034 J** | **0.022 J** | **0.035 J** | **0.035 J** | **0.044 J** | < 1 |
| Benzo(k)fluoranthene | | | | **0.37 J** | **0.04 J** | **0.027 J** | **0.047 J** | **0.053 J** | **0.053 J** | < 1 |
| Benzoic Acid | | | 64000 | **6.9 J** | < 4.8 | **1.2 J** | **1.2 J** | **1.2 J** | **1.2 J** | **6.3 J** |
| Benzyl Alcohol | | | 2400 | < 25 | **0.21 J** | < 5 | < 4.9 | **0.22 J** | **0.21 J** | < 25 |
| bis(2-Ethylhexyl)phthalate | | 6.3 | 320 | **1.2 J** | **0.5 J** | < 0.99 | **0.48 J** | **0.13 J** | **0.27 J** | **0.74 J** |
| Chrysene | | | | **0.75 J** | **0.065 J** | **0.046 J** | **0.079 J** | **0.071 J** | **0.077 J** | < 1 |
| Dibenz(a,h)anthracene | | | | < 0.97 | **0.027 J** | **0.024 J** | **0.041 J** | **0.045 J** | **0.041 J** | < 1 |
| Di-n-Octyl phthalate | | | 320 | < 0.97 | **0.045 J** | **0.024 J** | **0.059 J** | **0.048 J** | **0.055 J** | < 1 |
| Fluoranthene | | | 640 | **0.85 J** | **0.079 J** | **0.052 J** | **0.094 J** | **0.081 J** | **0.081 J** | < 1 |
| Indeno(1,2,3-cd)pyrene | | | | **0.4 J** | **0.036 J** | **0.027 J** | **0.042 J** | **0.034 J** | **0.037 J** | < 1 |
| Naphthalene | | | 160 | **0.39 J** | **0.15 J** | **0.029 J** | **0.045 J** | **0.042 J** | **0.038 J** | < 1 |
| Pentachlorophenol | | 0.73 | 480 | **16** | ***< 0.95*** | ***< 0.99*** | ***< 0.97*** | **0.97 J** | **1.1** | ***< 5*** |
| Phenanthrene | | | | < 0.97 | **0.041 J** | **0.022 J** | **0.04 J** | **0.03 J** | **0.037 J** | < 1 |
| Pyrene | | | 480 | **2.6** | **0.072 J** | **0.047 J** | **0.089 J** | **0.077 J** | **0.083 J** | < 1 |
| **NWTPH (µg/L)** | | | | | | | | | | |
| Diesel Range Hydrocarbons | 500 | | | **6,300 J** | < 39 U | < 18 U | < 19 U | < 57 U | < 130 U | **7,300 J** |
| Residual Range Organics (RRO) | 500 | | | **8,300 J** | < 73 U | < 34 U | < 43 U | < 46 U | < 100 U | **890 NJ** |
| Gasoline Range Organics-NWTPH | 800 | | | **390 NJ** | **34 J** | < 250 | < 250 | < 250 | **17 J** | **150 J** |

**Shaded and Bold - Value exceed Method B CUL (or Method A if no Method B value available)**

***Italics and Bold - Detection limit exceeds CUL***

## Table F-4-2 Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) (March 2008)

| | | **Location ID** | **MW-1** | | | **MW-2** | | | **MW-3** | | | **MW-4** | | | **MW-5** | | | **MW-5** | | | **MW-6** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sample ID** | **MW-1-0308** | | | **MW-2-0308** | | | **MW-3-0308** | | | **MW-4-0308** | | | **MW-5-0308** | | | **DUP-1-0308** | | | **MW-6-0308** | | |
| | | **Sample Date** | **03/28/08** | | | **03/28/08** | | | **03/27/08** | | | **03/27/08** | | | **03/27/08** | | | **03/27/08** | | | **03/28/08** | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | pg/l | 109,000 | **32.7** | **J** | 73 | **0.0219** | **J** | < 21.2 | 0.00318 | | 101 | **0.0303** | **J** | < 46.5 | 0.00698 | | < 28.2 | 0.00423 | | 54.7 | **0.01641** | **J** |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | pg/l | 3,590 | **1.08** | | 3.45 | **0.00104** | **J** | 1.73 | **0.00052** | **NJ+** | 9.32 | **0.00280** | **J** | 4.1 | **0.00123** | **J** | 2.52 | **0.00076** | **J** | 1.64 | **0.00049** | **NJ+** |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | pg/l | 6,380 | **63.8** | **J** | < 7.06 | 0.0353 | | < 2.25 | 0.01125 | | < 9.72 | 0.0486 | | < 5.9 | 0.0295 | | < 4.55 | 0.02275 | | < 3.68 | 0.0184 | |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | pg/l | 758 | **7.58** | | < 0.563 | 0.00282 | | < 0.365 | 0.002 | | < 3.6 | 0.018 | | < 0.937 | 0.00469 | | < 0.61 | 0.00305 | | < 0.274 | 0.00137 | |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | pg/l | 35.3 | **0.353** | | < 0.494 | 0.002 | | < 0.479 | 0.002 | | < 0.303 | 0.002 | | < 0.657 | 0.00329 | | < 0.474 | 0.00237 | | < 0.359 | 0.0018 | |
| 1,2,3,4,7,8-HxCDD | 0.1 | pg/l | 10.2 | **1.02** | **J** | < 0.421 | 0.02 | | < 0.413 | 0.02 | | < 0.383 | 0.02 | | < 0.405 | 0.02 | | < 0.264 | 0.01 | | < 0.269 | 0.01 | |
| 1,2,3,4,7,8-HxCDF | 0.1 | pg/l | 27.9 | **2.79** | | < 0.266 | 0.01 | | < 0.254 | 0.01 | | < 0.155 | 0.01 | | < 0.229 | 0.01 | | < 0.185 | 0.01 | | < 0.227 | 0.01 | |
| 1,2,3,6,7,8-HxCDD | 0.1 | pg/l | 213 | **21.3** | | < 0.418 | 0.02 | | < 0.409 | 0.02 | | < 0.379 | 0.02 | | < 0.401 | 0.02 | | < 0.262 | 0.01 | | < 0.266 | 0.01 | |
| 1,2,3,6,7,8-HxCDF | 0.1 | pg/l | 20.7 | **2.07** | **J** | < 0.277 | 0.01 | | < 0.264 | 0.01 | | < 0.162 | 0.01 | | < 0.238 | 0.01 | | < 0.194 | 0.01 | | < 0.237 | 0.01 | |
| 1,2,3,7,8,9-HxCDD | 0.1 | pg/l | 147 | **14.7** | | < 0.423 | 0.02 | | < 0.414 | 0.02 | | < 0.384 | 0.02 | | < 0.406 | 0.02 | | < 0.265 | 0.01 | | < 0.269 | 0.01 | |
| 1,2,3,7,8,9-HxCDF | 0.1 | pg/l | 1.63 | **0.163** | **NJ+** | < 0.342 | 0.02 | | < 0.327 | 0.02 | | < 0.199 | 0.01 | | < 0.294 | 0.01 | | < 0.239 | 0.01 | | < 0.292 | 0.01 | |
| 1,2,3,7,8-PeCDD | 1 | pg/l | 60.6 | **60.6** | **J** | < 0.407 | 0.2 | | < 0.363 | 0.2 | | < 0.224 | 0.1 | | < 0.41 | 0.2 | | < 0.24 | 0.1 | | < 0.317 | 0.2 | |
| 1,2,3,7,8-PeCDF | 0.03 | pg/l | 14.6 | **0.438** | **J** | < 0.211 | 0.003 | | < 0.166 | 0.002 | | < 0.14 | 0.002 | | < 0.216 | 0.00324 | | < 0.103 | 0.00155 | | < 0.232 | 0.00348 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | pg/l | 8.78 | **0.878** | **J** | < 0.293 | 0.01 | | < 0.28 | 0.01 | | < 0.17 | 0.01 | | < 0.252 | 0.01 | | < 0.205 | 0.01 | | < 0.25 | 0.01 | |
| 2,3,4,7,8-PeCDF | 0.3 | pg/l | 12.1 | **3.63** | **J** | < 0.207 | 0.03 | | < 0.163 | 0.02 | | < 0.138 | 0.02 | | < 0.212 | 0.03 | | < 0.101 | 0.02 | | < 0.228 | 0.03 | |
| 2,3,7,8-TCDD | 1 | pg/l | 19.5 | **19.5** | **J** | < 0.858 | 0.43 | | < 0.702 | 0.35 | | < 0.751 | 0.38 | | < 0.474 | 0.24 | | < 0.673 | 0.34 | | < 0.707 | 0.35 | |
| 2,3,7,8-TCDF | 0.1 | pg/l | 9.7 | **0.970** | **J** | < 0.395 | 0.020 | | < 0.427 | 0.021 | | < 0.282 | 0.014 | | < 0.384 | 0.0192 | | < 0.34 | 0.017 | | < 0.363 | 0.01815 | |
| **Total TCDD TEQ (1)** | | | | 234 | | | **0.87** | | | **0.72** | | | **0.72** | | | **0.65** | | | **0.60** | | | **0.70** | |
| **Total TCDD TEQ (2)** | | | | 234 | | | **0.023** | | | **0.00052** | | | **0.033** | | | **0.0012** | | | **0.00076** | | | **0.017** | |

**Notes**

Total TCDD and TCDF equivalents calculated using WHO 2005 Toxicity Equivalency Factors (MTCA, 2007).
(1) One-half the detection limit used for non-detect results
(2) Non-detect results excluded from TEQ calculation
Qualifiers
J = estimated concentration (value less than calculated reporting limit)
N = analyte is tentatively identified (validator qualifier)
J+ = estimated concentration, biased high
Method B CUL - 5.8 pg/L
▨ Value Exceeds Method B CUL

# Table F-4-3 Groundwater Analytical Results: cPAH Total Toxic Equivalency Quotient (TEQ) (March 2008)

| Location ID<br>Sample ID<br>Sample Date | | | MW-1<br>MW-1-0308<br>03/28/08 | MW-2<br>MW-2-0308<br>03/28/08 | MW-3<br>MW-3-0308<br>03/27/08 | MW-4<br>MW-4-0308<br>03/27/08 | MW-5<br>MW-5-0308<br>03/27/08 | MW-5<br>DUP-1-0308<br>03/27/08 | MW-6<br>MW-6-0308<br>03/28/08 |
|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | |
| | | µg/L | | | | | | | |
| Benzo(a)anthracene | 0.1 | µg/L | **0.6 J** | **0.05 J** | **0.04 J** | **0.07 J** | **0.05 J** | **0.07 J** | < 1 |
| Benzo(a)pyrene | 1 | µg/L | **0.72 J** | **0.04 J** | < 0.2 | **0.05 J** | **0.04 J** | **0.04 J** | < 1 |
| Benzo(b)fluoranthene | 0.1 | µg/L | **0.83 J** | **0.05 J** | **0.04 J** | **0.06 J** | **0.06 J** | **0.06 J** | < 1 |
| Benzo(k)fluoranthene | 0.1 | µg/L | **0.37 J** | **0.04 J** | **0.03 J** | **0.05 J** | **0.05 J** | **0.05 J** | < 1 |
| Chrysene | 0.01 | µg/L | **0.75 J** | **0.07 J** | **0.05 J** | **0.08 J** | **0.07 J** | **0.08 J** | < 1 |
| Dibenz(a,h)anthracene | 0.1 | µg/L | < 0.97 | **0.03 J** | **0.02 J** | **0.04 J** | **0.05 J** | **0.04 J** | < 1 |
| Indeno(1,2,3-cd)pyrene | 0.1 | µg/L | **0.4 J** | **0.04 J** | **0.03 J** | **0.04 J** | **0.03 J** | **0.04 J** | < 1 |
| **Total cPAH TEQ (1)** | | | **1.00** | **0.06** | **0.17** | **0.07** | **0.06** | **0.07** | NC |

**MTCA Method B - 0.012 µg/L**

**Notes**

(1) Total cPAH equivalents calculated using Toxicity Equivalency Factors from MTCA Regulations Revised Novermber 2007.

Qualifiers

U = non-detect

J = estimated concentration (value less than calculated reporting limit)

D = compounds at secondary dilution factor

NC= Not calculated where all constituents are not detected

▨ Exceeds Method B

# Table F-4-4 Groundwater Analytical Results: Metals, PCP, PAHs, TPH-Dx, Hardness and pH (August 2008)

| | | | Location ID | MW-3 | MW-4 | MW-5 | MW-8 | MW-9 | MW-9 (DUP) | MW-10 | MW-11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample ID | MW-3-081908 | MW-4-082008 | MW-5-082008 | MW-8-081908 | MW-9-081908 | MW-90-081908 | MW-10-081908 | MW-11-081908 |
| | | | Sample Date | 8/19/2008 | 8/20/2008 | 8/20/2008 | 8/19/2008 | 8/19/2008 | 8/19/2008 | 8/19/2008 | 8/19/2008 |
| **Chemical Name** | **Method A** | **MCTA B Carcinogen** | **MCTA B Non-carcinogen** | | | | | | | | |
| **Metals EPA Method 6020/7470A (µg/L)** | | | | | | | | | | | |
| Antimony | | | 6.4 | **0.11** | **0.16** | **0.03 J** | **0.2** | **0.04 J** | **0.03 J** | **0.05** | **0.03 J** |
| Arsenic | 5 | 0.058 | 4.8 | **0.77** | **0.66** | **2.76** | **0.92** | **0.32 J** | **0.22 J** | **0.59** | **0.33 J** |
| Beryllium | | | 32 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 |
| Cadmium | 5 | | 8 | < 0.024 J- | < 0.027 J- | < 0.039 J- | < 0.01 J- | < 0.02 J | < 0.02 J | < 0.01 J- | **0.066** |
| Chromium | 50 | | | < 0.42 | < 0.45 | < 0.27 | < 0.7 | < 0.46 | < 0.41 | < 0.57 | < 0.35 |
| Copper | | | 590 | < 0.34 | < 0.3 | < 0.3 | < 0.57 | < 0.47 | < 0.44 | < 0.23 | < 0.26 |
| Lead | 15 | | | < 0.026 | < 0.025 | < 0.023 | < 0.054 | < 0.007 | < 0.02 | < 0.019 | < 0.026 |
| Nickel | | | | **4.61** | **11.6** | **2.08** | **2.74** | **4.74** | **4.63** | **2.5** | **3.3** |
| Selenium | | | | < 0.2 | < 0.3 | < 2 | < 1 | < 1 | < 1 | < 0.4 | < 1 |
| Silver | | | | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.019 |
| Thallium | | | | < 0.004 | < 0.004 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.02 | < 0.007 |
| Zinc | | | 4800 | < 2.32 | < 2.5 | < 2.06 | < 1.55 | < 1.39 | < 1.04 | < 2.06 | < 2.04 |
| Mercury | 2 | | 4.8 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| **Semi-volatile Organic Compound EPA Method 8151M (µg/L)** | | | | | | | | | | | |
| Pentachlorophenol | | 0.73 | 480 | < 0.5 | < 0.5 | **1.5** | < 0.5 | **0.58 J** | **0.56 J** | < 0.5 | < 0.5 |
| **Polynuclear Aromatic Hydrocarbons EPA Method 8270C SIM (µg/L)** | | | | | | | | | | | |
| 2-Methylnaphthalene | | | 32 | < 0.016 | < 0.016 | < 0.016 | **0.0067 J** | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Acenaphthene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Acenaphthylene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Anthracene | | | 4800 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Benzo(a)anthracene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Benzo(a)pyrene | | 0.01 | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Benzo(b)fluoranthene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Benzo(g,h,i)perylene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Benzo(k)fluoranthene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Chrysene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Dibenz(a,h)anthracene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Dibenzofuran | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Fluoranthene | | | 640 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Fluorene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| * Indeno(1,2,3-cd)pyrene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Naphthalene | 160 | | 160 | **0.0078 J** | **0.023** | **0.016** | **0.015 J** | **0.011 J** | **0.01 J** | **0.0089 J** | **0.0088 J** |
| Phenanthrene | | | | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| Pyrene | | | 480 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| **NWTPH-Dx (µg/L)** | | | | | | | | | | | |
| Diesel Range Hydrocarbons | 500 | | | < 25 | < 22 | < 48 | < 34 | < 29 | < 24 | < 21 | < 23 |
| Residual Range Organics (RRO) | 500 | | | < 44 | < 64 | < 59 | < 85 | < 110 | < 74 | < 38 | < 69 |
| **Conventionals** | | | | | | | | | | | |
| Hardness as $CaCO_3$ (mg/L) | | | | **60** | **87** | **112** | **113** | **126** | **127** | **96** | **68** |
| pH | | | | **6.57 J** | **6.51** | **6.68** | **6.7 J** | **6.37 J** | **6.39 J** | **6.72 J** | **6.59 J** |
| Field Turbidity (NTU) | | | | **2.75** | **3.39** | **1.27** | **23.8** | **4.08** | **4.08** | **2.29** | **2.49** |

**Shaded and Bold -** Value exceeds Method B CUL (or Method A if no Method B value is available)
**Bold -** Value dectected above the MRL
J - Estimated concentration (value less than calculated reporting limit)
* cPAH

## Table F-4-5 Groundwater Analytical Results: Total Metals Results Compared to Surface Water Toxic Substance Critera (WAC 173-201A-240) (August 2008)

| | | | | | | Fresh Water Toxic Substance Criteria | |
|---|---|---|---|---|---|---|---|
| **Pollutant** | **Monitoring Well #** | **Hardness (µg/L)** | **Conversion Factor Acute** | **Conversion Factor Chronic** | **Analytical Value (µg/L)** | **Acute (µg/L) Upper Limit** | **Chronic (µg/L) Upper Limit** |
| **Arsenic** | **3** | **60** | — | — | 0.770 | 360.000 | 190.000 |
| | **4** | 87 | — | — | 0.660 | 360.000 | 190.000 |
| | **5** | 112 | — | — | 2.760 | 360.000 | 190.000 |
| | **8** | 113 | — | — | 0.920 | 360.000 | 190.000 |
| | **9** | 127 | — | — | 0.220 | 360.000 | 190.000 |
| | **9** | 126 | — | — | 0.320 | 360.000 | 190.000 |
| | **10** | 96 | — | — | 0.590 | 360.000 | 190.000 |
| | **11** | 68 | — | — | 0.330 | 360.000 | 190.000 |
| **Cadmuim** | **3** | 60 | 0.965 | 0.930 | < 0.024 | 1.304 | 1.495 |
| | **4** | 87 | 0.950 | 0.915 | < 0.027 | 1.950 | 1.968 |
| | **5** | 112 | 0.939 | 0.904 | < 0.039 | 2.565 | 2.373 |
| | **8** | 113 | 0.939 | 0.904 | < 0.010 | 2.589 | 2.388 |
| | **9** | 127 | 0.934 | 0.899 | < 0.020 | 2.939 | 2.603 |
| | **9** | 126 | 0.934 | 0.899 | < 0.020 | 2.914 | 2.588 |
| | **10** | 96 | 0.946 | 0.911 | < 0.010 | 2.170 | 2.117 |
| | **11** | 68 | 0.960 | 0.925 | 0.066 | 1.493 | 1.640 |
| **Chromium**** | **3** | 60 | — | — | < 0.420 | 15.000 | 10.000 |
| | **4** | 87 | — | — | < 0.450 | 15.000 | 10.000 |
| | **5** | 112 | — | — | < 0.270 | 15.000 | 10.000 |
| | **8** | 113 | — | — | < 0.700 | 15.000 | 10.000 |
| | **9** | 127 | — | — | < 0.410 | 15.000 | 10.000 |
| | **9** | 126 | — | — | < 0.460 | 15.000 | 10.000 |
| | **10** | 96 | — | — | < 0.570 | 15.000 | 10.000 |
| | **11** | 68 | — | — | < 0.350 | 15.000 | 10.000 |
| **Copper** | **3** | 60 | — | — | < 0.340 | 11.444 | 9.079 |
| | **4** | 87 | — | — | < 0.300 | 16.242 | 12.472 |
| | **5** | 112 | — | — | < 0.300 | 20.606 | 15.476 |
| | **8** | 113 | — | — | < 0.570 | 20.779 | 15.594 |
| | **9** | 127 | — | — | < 0.440 | 23.196 | 17.231 |
| | **9** | 126 | — | — | < 0.470 | 23.024 | 17.115 |
| | **10** | 96 | — | — | < 0.230 | 17.820 | 13.566 |
| | **11** | 68 | — | — | < 0.260 | 12.877 | 10.104 |
| **Lead** | **3** | 60 | 0.865 | 0.865 | < 0.026 | 24.754 | 0.398 |
| | **4** | 87 | 0.811 | 0.811 | < 0.025 | 37.240 | 0.598 |
| | **5** | 112 | 0.774 | 0.774 | < 0.023 | 49.034 | 0.788 |
| | **8** | 113 | 0.773 | 0.773 | < 0.054 | 49.509 | 0.796 |
| | **9** | 127 | 0.756 | 0.756 | < 0.020 | 56.181 | 0.903 |
| | **9** | 126 | 0.757 | 0.757 | < 0.007 | 55.704 | 0.895 |
| | **10** | 96 | 0.797 | 0.797 | < 0.019 | 41.466 | 0.666 |
| | **11** | 68 | 0.847 | 0.847 | < 0.026 | 28.418 | 0.457 |
| **Mercury** | **3** | 60 | — | — | < 0.200 | 2.100 | 0.012 |
| | **4** | 87 | — | — | < 0.200 | 2.100 | 0.012 |
| | **5** | 112 | — | — | < 0.200 | 2.100 | 0.012 |
| | **8** | 113 | — | — | < 0.200 | 2.100 | 0.012 |
| | **9** | 127 | — | — | < 0.200 | 2.100 | 0.012 |
| | **9** | 126 | — | — | < 0.200 | 2.100 | 0.012 |
| | **10** | 96 | — | — | < 0.200 | 2.100 | 0.012 |
| | **11** | 68 | — | — | < 0.200 | 2.100 | 0.012 |
| **Nickel** | **3** | 60 | — | — | 4.610 | 547.514 | 85.283 |
| | **4** | 87 | — | — | 11.600 | 749.744 | 116.783 |
| | **5** | 112 | — | — | 2.080 | 928.363 | 144.606 |
| | **8** | 113 | — | — | 2.740 | 935.371 | 145.698 |
| | **9** | 127 | — | — | 4.630 | 1032.518 | 160.829 |
| | **9** | 126 | — | — | 4.740 | 1025.635 | 159.757 |
| | **10** | 96 | — | — | 2.500 | 814.856 | 126.926 |
| | **11** | 68 | — | — | 3.300 | 608.670 | 94.809 |
| **Selenium** | **3** | 60 | — | — | < 0.200 | 20.000 | 5.000 |
| | **4** | 87 | — | — | < 0.300 | 20.000 | 5.000 |
| | **5** | 112 | — | — | < 2.000 | 20.000 | 5.000 |
| | **8** | 113 | — | — | < 1.000 | 20.000 | 5.000 |
| | **9** | 127 | — | — | < 1.000 | 20.000 | 5.000 |
| | **9** | 126 | — | — | < 1.000 | 20.000 | 5.000 |
| | **10** | 96 | — | — | < 0.400 | 20.000 | 5.000 |
| | **11** | 68 | — | — | < 1.000 | 20.000 | 5.000 |
| **Silver** | **3** | 60 | — | — | < 🟨 0.020 | 0.013 | — |
| | **4** | 87 | — | — | < 0.020 | 0.025 | — |
| | **5** | 112 | — | — | < 0.020 | 0.038 | — |
| | **8** | 113 | — | — | < 0.020 | 0.039 | — |
| | **9** | 127 | — | — | < 0.020 | 0.048 | — |
| | **9** | 126 | — | — | < 0.020 | 0.047 | — |
| | **10** | 96 | — | — | < 0.020 | 0.029 | — |
| | **11** | 68 | — | — | < 🟨 0.020 | 0.016 | — |
| **Zinc** | **3** | 60 | — | — | < 2.320 | 65.099 | 60.351 |
| | **4** | 87 | — | — | < 2.500 | 89.187 | 82.682 |
| | **5** | 112 | — | — | < 2.060 | 110.471 | 102.414 |
| | **8** | 113 | — | — | < 1.550 | 111.306 | 103.188 |
| | **9** | 127 | — | — | < 1.040 | 122.885 | 113.922 |
| | **9** | 126 | — | — | < 1.390 | 122.065 | 113.162 |
| | **10** | 96 | — | — | < 2.060 | 96.945 | 89.874 |
| | **11** | 68 | — | — | < 2.040 | 72.382 | 67.103 |

🟨 If the Analytical Value is greater than the Chronic or Acute value.

** Note: Analytical results are reported as total chromium. The Toxic Substance Criteria chromium values are reported as either trivalent or hexavalent chromium. Hexavalent is more restrictive and used as the comparison in this table.

## Table F-4-6 Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) (August 2008)

| Location ID | | | | MW-3 | | | | MW-4 | | | | MW-5 | | | | MW-8 | | | | MW-9 | | | | MW-9 | | | | MW-10 | | | | MW-11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | | | | MW-3-081908 | | | | MW-4-082008 | | | | MW-5-082008 | | | | MW-8-081908 | | | | MW-9-081908 | | | | MW-90-081908 | | | | MW-10-081908 | | | | MW-11-081908 | | |
| Sample Date | | | | 8/19/2008 | | | | 8/20/2008 | | | | 8/20/2008 | | | | 8/19/2008 | | | | 8/19/2008 | | | | 8/19/2008 | | | | 8/19/2008 | | | | 8/19/2008 | | |
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | pg/L | < | 5.01 | 0.0008 | U | | **106** | **0.0318** | | | **366** | **0.1098** | | < | 15.9 | 0.002385 | U | | **292** | **0.0876** | J | | **51.2** | **0.01536** | J | | **7570** | **2.271** | | < | 4.86 | 0.000729 | U |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | pg/L | < | 1.14 | 0.0002 | U | < | 15.3 | 0.00230 | U | < | 27 | 0.00405 | U | < | 3.06 | 0.00046 | | < | 21.8 | 0.00327 | U | < | 7.04 | 0.001056 | U | | **505** | **0.1515** | | < | 0.44 | 0.000066 | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | pg/L | < | 1.43 | 0.0072 | U | < | 15.2 | 0.076 | U | | **37.1** | **0.371** | | < | 6.26 | 0.0313 | U | | **39.4** | **0.394** | | < | 12.3 | 0.0615 | U | | **723** | **7.23** | | < | 1 | 0.005 | U |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | pg/L | < | 0.757 | 0.003785 | U | < | 3.12 | 0.01560 | U | < | 4.57 | 0.023 | U | < | 0.91 | 0.00455 | | < | 5.42 | 0.0271 | U | < | 0.971 | 0.004855 | | | **78** | **0.78** | | < | 0.398 | 0.00199 | U |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | pg/L | < | 0.333 | 0.001665 | | < | 0.952 | 0.005 | | < | 0.948 | 0.005 | | < | 1.19 | 0.006 | | < | 0.493 | 0.002465 | | < | 1.27 | 0.00635 | | | **4.13** | **0.0413** | J | < | 0.343 | 0.001715 | |
| 1,2,3,4,7,8-HxCDD | 0.1 | pg/L | < | 0.367 | 0.02 | | < | 1.08 | 0.05 | | < | 0.992 | 0.05 | | < | 0.965 | 0.05 | | < | 0.596 | 0.03 | | < | 1.53 | 0.08 | | | **2.64** | **0.26** | J | < | 0.4 | 0.02 | |
| 1,2,3,4,7,8-HxCDF | 0.1 | pg/L | < | 0.265 | 0.01 | | < | 0.494 | 0.02 | | < | 0.697 | 0.03 | | < | 0.534 | 0.03 | | < | 0.328 | 0.02 | | < | 0.771 | 0.04 | | | **1.86** | **0.19** | J | < | 0.211 | 0.01 | |
| 1,2,3,6,7,8-HxCDD | 0.1 | pg/L | < | 0.3 | 0.0 | | < | 1.07 | 0.05 | | < | 0.983 | 0.05 | | < | 0.956 | 0.05 | | < | 1.49 | 0.07 | U | < | 1.52 | 0.08 | | < | 15.7 | 0.79 | U | < | 0.327 | 0.02 | |
| 1,2,3,6,7,8-HxCDF | 0.1 | pg/L | < | 0.247 | 0.01 | | < | 0.516 | 0.03 | | < | 0.727 | 0.04 | | < | 0.558 | 0.03 | | < | 0.306 | 0.02 | | < | 0.805 | 0.04 | | | **0.716** | **0.07** | NJ+ | < | 0.197 | 0.01 | |
| 1,2,3,7,8,9-HxCDD | 0.1 | pg/L | < | 0.329 | 0.0 | | < | 1.08 | 0.05 | | < | 0.995 | 0.05 | | < | 0.968 | 0.05 | | < | 0.532 | 0.03 | | < | 1.54 | 0.08 | | | **8.01** | **0.80** | J | < | 0.357 | 0.02 | |
| 1,2,3,7,8,9-HxCDF | 0.1 | pg/L | < | 0.304 | 0.0152 | | < | 0.638 | 0.03 | | < | 0.899 | 0.04 | | < | 0.689 | 0.03 | | < | 0.377 | 0.02 | | < | 0.994 | 0.05 | | < | 0.459 | 0.02 | | < | 0.243 | 0.01 | |
| 1,2,3,7,8-PeCDD | 1 | pg/L | < | 0.41 | 0.2 | | < | 0.714 | 0.4 | | < | 0.761 | 0.4 | | < | 0.997 | 0.5 | | < | 0.377 | 0.2 | | < | 0.735 | 0.4 | | | **1.05** | **1.1** | NJ+ | < | 0.372 | 0.2 | |
| 1,2,3,7,8-PeCDF | 0.03 | pg/L | < | 0.268 | 0.00402 | | < | 0.598 | 0.009 | | < | 0.342 | 0.005 | | < | 0.526 | 0.008 | | < | 0.258 | 0.00387 | | < | 0.544 | 0.00816 | | < | 0.322 | 0.00483 | | < | 0.269 | 0.004035 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | pg/L | < | 0.279 | 0.01395 | | < | 0.546 | 0.03 | | < | 0.77 | 0.04 | | < | 0.59 | 0.03 | | < | 0.346 | 0.02 | | < | 0.851 | 0.04 | | | **1.24** | **0.12** | J | < | 0.223 | 0.01 | |
| 2,3,4,7,8-PeCDF | 0.3 | pg/L | < | 0.262 | 0.04 | | < | 0.588 | 0.09 | | < | 0.337 | 0.05 | | < | 0.516 | 0.08 | | < | 0.252 | 0.04 | | < | 0.534 | 0.08 | | < | 0.313 | 0.05 | | < | 0.262 | 0.04 | |
| 2,3,7,8-TCDD | 1 | pg/L | < | 0.345 | 0.2 | | < | 0.7 | 0.35 | | < | 0.699 | 0.35 | | < | 0.765 | 0.38 | | < | 0.311 | 0.16 | | < | 0.567 | 0.28 | | < | 0.384 | 0.19 | | < | 0.346 | 0.17 | |
| 2,3,7,8-TCDF | 0.1 | pg/L | < | 0.34 | 0.017 | | < | 1.02 | 0.051 | | < | 0.825 | 0.041 | | < | 0.443 | 0.022 | | < | 0.314 | 0.0157 | | < | 0.667 | 0.03335 | | < | 0.401 | 0.02005 | | < | 0.276 | 0.0138 | |
| **Total TCDD TEQ (1)** | | | | | **0.556** | | | | **1.26** | | | | **1.64** | | | | **1.30** | | | | **1.11** | | | | **1.26** | | | | **14.04** | | | | **0.52** | |
| **Total TCDD TEQ (2)** | | | | | **NA** | | | | **0.032** | | | | **0.481** | | | | **NA** | | | | **0.482** | | | | **0.015** | | | | **12.97** | | | | **NA** | |

**Notes**

Total TCDD and TCDF equivalents calculated using WHO 2005 Toxicity Equivalency Factors (MTCA, 2007).

(1) One-half the estimated detection limit used for non-detect results

(2) Non-detect results excluded from TEQ calculation

Qualifiers

J = estimated concentration (value less than calculated reporting limit)

N = analyte is tentatively identified (validator qualifier)

J+ = estimated concentration, biased high

U = false positive; non-detect at the original result

Method B CUL - 5.8 pg/L

▨ Shaded value exceeds MTCA Method B CUL

# Table F-4-7 Groundwater Analytical Results: Metals, PCP, TPH-Dx and Conventionals (December 2008)

| | | | Location ID | MW-2 | MW-6 | MW-7 | MW-7 | MW-10 |
|---|---|---|---|---|---|---|---|---|
| | | | Sample ID | LL-MW2-120308 | LL-MW6-120308 | LL-MW70-120308 | LL-MW7-120308 | LL-MW10-120308 |
| | | | Sample Date | 12/3/2008 | 12/3/2008 | 12/3/2008 | 12/3/2008 | 12/3/2008 |
| **Chemical Name** | **MTCA A** | | **MCTA B Non-Carcinogenic** | | | | | |
| **Conventionals** | | | | | | | | |
| Antimony | | | 6.4 | NA | **0.139** | < 0.05 U | < 0.05 U | NA |
| Arsenic | 5 | 0.058 | 4.8 | NA | **0.73** | **0.6** | **0.7** | NA |
| **Metals EPA Method 6020/7470A (µg/L)** | | | | | | | | |
| Beryllium | | | 32 | NA | **0.016 J** | < 0.02 | < 0.02 | NA |
| Cadmium | 5 | | 8 | NA | **0.178** | < 0.02 | **0.01 J** | NA |
| Chromium | 50 | | | NA | **1.15** | < 0.2 U | < 0.2 U | NA |
| Copper | | | 590 | NA | **7.91** | **0.21** | **0.19** | NA |
| Lead | 15 | | | NA | **0.117** | < 0.02 U | **0.023 J+** | NA |
| Mercury | 2 | | 4.8 | NA | < 0.2 | < 0.2 | < 0.2 | NA |
| Nickel | | | 320 | NA | **14.3** | **2.09** | **2.13** | NA |
| Selenium | | | 80 | NA | < 1 | < 1 | < 1 | NA |
| Silver | | | | NA | **0.153** | < 0.02 U | < 0.02 U | NA |
| Thallium | | | 1.1 | NA | < 0.02 U | < 0.02 | < 0.02 U | NA |
| Zinc | | | 4800 | NA | **3.7** | **1.3 J** | **2.7 J** | NA |
| **Semi-volatile Organic Compound EPA Method 8151M (µg/L)** | | | | | | | | |
| Pentachlorophenol | | 0.73 | 480 | < 0.50 U | < 0.5 U | < 0.5 | < 0.5 | NA |
| **NWTPH-Dx (ug/L)** | | | | | | | | |
| Diesel Range Hydrocarbons | 500 | | | NA | **3,600 J** | **13 J** | **19 J** | NA |
| Residual Range Organics (RRO) | 500 | | | NA | **710 NJ** | < 520 U | < 520 U | NA |
| **Conventionals** | | | | | | | | |
| pH | | | | **6.5 J** | **6.07 J** | **6.82 J** | **6.87 J** | **6.8 J** |
| Total Organic Carbon (mg/L) | | | | **0.7** | **14** | **0.6** | **0.6** | **0.33 J** |
| Total Suspended Solids (mg/L) | | | | < 5 | **21** | < 5 | < 5 | < 5 |

**Shaded and Bold=** Value exceeds Method B CUL (or Method A if no Method B value is available)
**Bold=** Value dectected above the MRL
J= Estimated concentration
J+= Estimated concentration, biased high
N= Analyte is tentatively identified
U= False positive; non-detect at the original result
FD= Field duplicate

# Table F-4-8    Groundwater Analytical Results: Dioxin-Furan Total Toxic Equivalency Quotient (TEQ) (December 2008)

| Location ID<br>Sample ID<br>Sample Date | | | MW-2<br>LL-MW2-120308<br>12/3/2008 | | | MW-6<br>LL-MW6-120308<br>12/3/2008 | | | MW-7<br>LL-MW7-120308<br>12/3/2008 | | | MW-7 DUP<br>LL-MW70-120308<br>12/3/2008 | | | MW-10<br>LL-MW10-120308<br>12/3/2008 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Name** | **TEFs** | **Unit** | | | | | | | | | | | | | | | |
| **Dioxins/Furans** | | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | | **Reported Value** | **TEQ** | |
| 1,2,3,4,6,7,8,9-OCDD | 0.0003 | pg/L | **< 10.9** | **0.001635** | **U** | **< 11.5** | **0.001725** | **U** | **< 6.47** | **0.0009705** | **U** | **< 82.7** | **0.012405** | **U** | **< 9.73** | **0.0015** | **U** |
| 1,2,3,4,6,7,8,9-OCDF | 0.0003 | pg/L | **< 0.934** | **0.00014** | **U** | **< 1.08** | **0.000162** | **U** | < 0.295 | 0.00004 | **U** | **< 9.21** | **0.0013815** | **U** | < 0.392 | 0.0001 | **U** |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | pg/L | **< 1.78** | **0.0089** | **U** | **< 1.39** | **0.00695** | **U** | **< 1.01** | **0.00505** | **U** | **< 15.6** | **0.078** | **U** | **< 1.78** | **0.0089** | **U** |
| 1,2,3,4,6,7,8-HpCDF | 0.01 | pg/L | **< 0.417** | **0.00209** | **U** | < 0.23 | 0.001 | | < 0.159 | 0.000795 | | **< 2.02** | **0.0101** | **U** | **< 0.36** | **0.0018** | **U** |
| 1,2,3,4,7,8,9-HpCDF | 0.01 | pg/L | < 0.298 | 0.001 | | < 0.313 | 0.002 | | < 0.216 | 0.001 | | < 0.835 | 0.004175 | | < 0.292 | 0.00146 | |
| 1,2,3,4,7,8-HxCDD | 0.1 | pg/L | < 0.222 | 0.01 | | < 0.289 | 0.01 | | < 0.162 | 0.01 | | < 0.329 | 0.02 | | < 0.231 | 0.01 | |
| 1,2,3,4,7,8-HxCDF | 0.1 | pg/L | < 0.106 | 0.01 | | < 0.189 | 0.01 | | < 0.129 | 0.01 | | < 0.383 | 0.02 | | < 0.156 | 0.01 | |
| 1,2,3,6,7,8-HxCDD | 0.1 | pg/L | < 0.197 | 0.01 | | < 0.256 | 0.01 | | < 0.143 | 0.01 | | < 0.292 | 0.01 | | < 0.205 | 0.0 | |
| 1,2,3,6,7,8-HxCDF | 0.1 | pg/L | < 0.102 | 0.01 | | < 0.182 | 0.01 | | < 0.124 | 0.01 | | < 0.368 | 0.02 | | < 0.149 | 0.01 | |
| 1,2,3,7,8,9-HxCDD | 0.1 | pg/L | < 0.214 | 0.01 | | < 0.277 | 0.01 | | < 0.156 | 0.01 | | < 0.317 | 0.02 | | < 0.223 | 0.0 | |
| 1,2,3,7,8,9-HxCDF | 0.1 | pg/L | < 0.132 | 0.01 | | < 0.236 | 0.01 | | < 0.162 | 0.01 | | < 0.479 | 0.02 | | < 0.195 | 0.00975 | |
| 1,2,3,7,8-PeCDD | 1 | pg/L | < 0.238 | 0.1 | | < 0.245 | 0.1 | | < 0.225 | 0.1 | | < 0.354 | 0.2 | | < 0.227 | 0.1 | |
| 1,2,3,7,8-PeCDF | 0.03 | pg/L | < 0.189 | 0.003 | | < 0.215 | 0.003 | | < 0.147 | 0.002 | | < 0.295 | 0.004425 | | < 0.179 | 0.002685 | |
| 2,3,4,6,7,8-HxCDF | 0.1 | pg/L | < 0.114 | 0.01 | | < 0.202 | 0.01 | | < 0.138 | 0.01 | | < 0.411 | 0.02 | | < 0.167 | 0.00835 | |
| 2,3,4,7,8-PeCDF | 0.3 | pg/L | < 0.187 | 0.03 | | < 0.213 | 0.03 | | < 0.146 | 0.02 | | < 0.292 | 0.04 | | < 0.177 | 0.03 | |
| 2,3,7,8-TCDD | 1 | pg/L | < 0.167 | 0.08 | | < 0.228 | 0.11 | | < 0.148 | 0.07 | | < 0.148 | 0.07 | | < 0.198 | 0.1 | |
| 2,3,7,8-TCDF | 0.1 | pg/L | < 0.214 | 0.011 | | < 0.26 | 0.013 | | < 0.206 | 0.010 | | < 0.147 | 0.00735 | | < 0.179 | 0.009 | |
| **Total TCDD TEQ (1)** | | | | **0.31** | | | **0.38** | | | **0.28** | | | **0.54** | | | **0.331** | |

**Notes**

Total TCDD and TCDF equivalents calculated using WHO 2005 Toxicity Equivalency Factors (MTCA, 2007).

(1) One-half the estimated detection limit used for non-detect results

Method B CUL - 5.8 pg/L

Qualifiers

**B** **Organic**: The analyte was found in the associated method blank at a level that is significant relative to the sample result.

**J** The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

**U** Evaluated to be undetected at the reporting limit/concentration, due to evidence of contamination

# Figures

LEGEND:

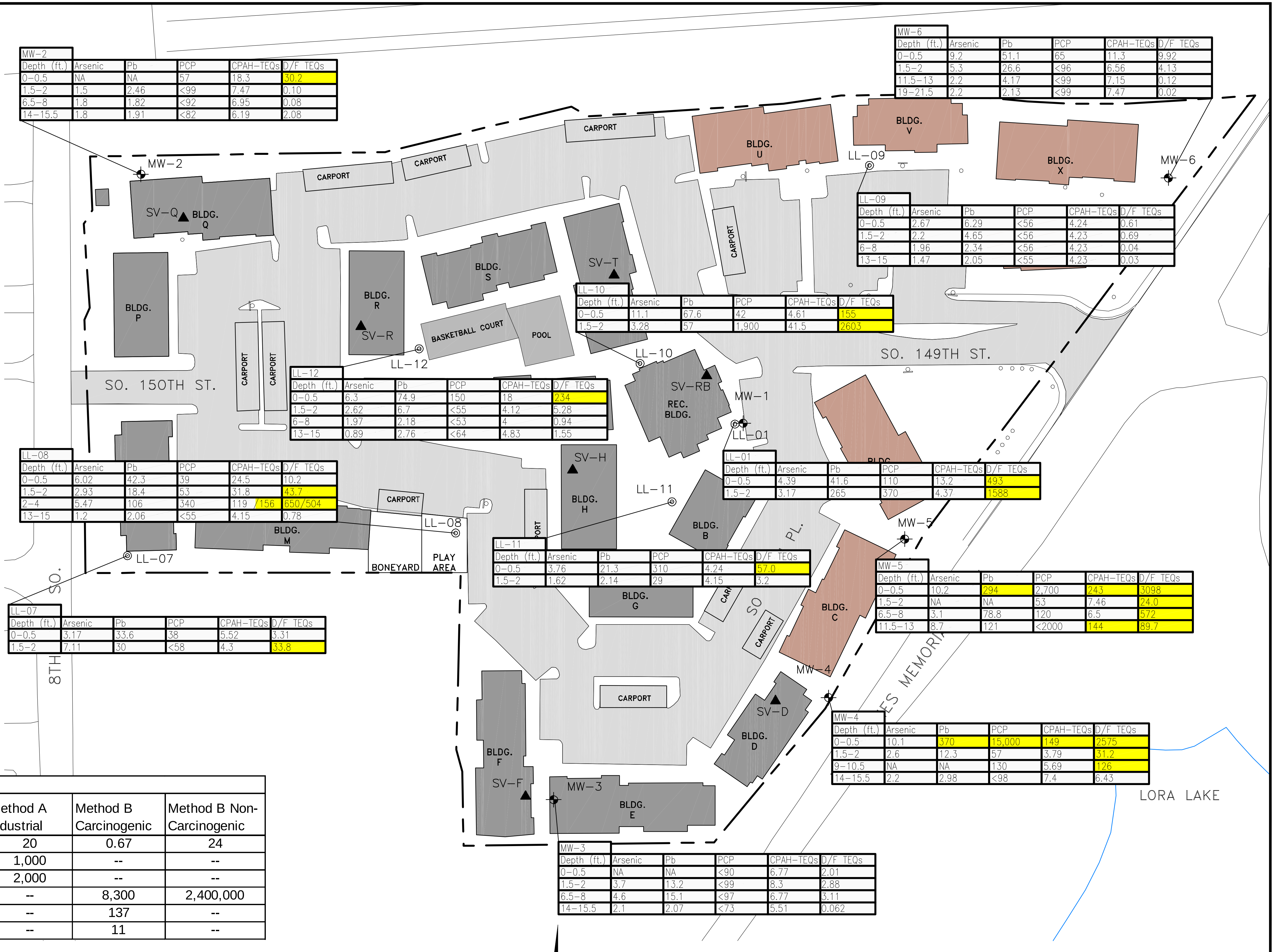
| | |
|---|---|
| ▨ | BUILDING STRUCTURES |
| ▨ | OTHER STRUCTURES |
| ▨ | PAVEMENT |
| ▨ | FOUNDATION ONLY |
| ⌖ | MONITORING WELLS |
| ◎ | GEOPROBE LOCATIONS |
| ▲ | SUBSLAB VAPOR SAMPLE LOCATIONS |
| — — — | PROPERTY BOUNDARY |

NOTE:

METALS REPORTED IN mg/kg
VOCs/SVOCs REPORTED IN µg/kg
DIOXIN/FURAN TEQs REPORTED IN ng/kg

SHADED CONCENTRATION VALUES EXCEED METHOD B CUL

PCP - PENTACHLOROPHENOL
cPAH - CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS
D/F - DIOXINS/FURANS
TEQ - TOTAL TOXICITY EQUIVALENCE



| MW-2 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | NA | NA | 57 | 18.3 | 30.2 |
| 1.5-2 | 1.5 | 2.46 | <99 | 7.47 | 0.10 |
| 6.5-8 | 1.8 | 1.82 | <92 | 6.95 | 0.08 |
| 14-15.5 | 1.8 | 1.91 | <82 | 6.19 | 2.08 |

| MW-6 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 9.2 | 51.1 | 65 | 11.3 | 9.92 |
| 1.5-2 | 5.3 | 26.6 | <96 | 6.56 | 4.13 |
| 11.5-13 | 2.2 | 4.17 | <99 | 7.15 | 0.12 |
| 19-21.5 | 2.2 | 2.13 | <99 | 7.47 | 0.02 |

| LL-09 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 2.67 | 6.29 | <56 | 4.24 | 0.61 |
| 1.5-2 | 2.2 | 4.65 | <56 | 4.23 | 0.69 |
| 6-8 | 1.96 | 2.34 | <56 | 4.23 | 0.04 |
| 13-15 | 1.47 | 2.05 | <55 | 4.23 | 0.03 |

| LL-10 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 11.1 | 67.6 | 42 | 4.61 | 155 |
| 1.5-2 | 3.28 | 57 | 1,900 | 41.5 | 2603 |

| LL-12 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 6.3 | 74.9 | 150 | 18 | 234 |
| 1.5-2 | 2.62 | 6.7 | <55 | 4.12 | 5.28 |
| 6-8 | 1.97 | 2.18 | <53 | 4 | 0.94 |
| 13-15 | 0.89 | 2.76 | <64 | 4.83 | 1.55 |

| LL-08 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 6.02 | 42.3 | 39 | 24.5 | 10.2 |
| 1.5-2 | 2.93 | 18.4 | 53 | 31.8 | 43.7 |
| 2-4 | 5.47 | 106 | 340 | 119 /156 | 650/504 |
| 13-15 | 1.2 | 2.06 | <55 | 4.15 | 0.78 |

| LL-01 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 4.39 | 41.6 | 110 | 13.2 | 493 |
| 1.5-2 | 3.17 | 265 | 370 | 4.37 | 1588 |

| LL-11 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 3.76 | 21.3 | 310 | 4.24 | 57.0 |
| 1.5-2 | 1.62 | 2.14 | 29 | 4.15 | 3.2 |

| MW-5 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 10.2 | 294 | 2,700 | 243 | 3098 |
| 1.5-2 | NA | NA | 53 | 7.46 | 24.0 |
| 6.5-8 | 3.1 | 78.8 | 120 | 6.5 | 572 |
| 11.5-13 | 8.7 | 121 | <2000 | 144 | 89.7 |

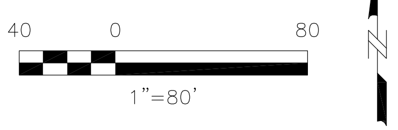
| LL-07 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 3.17 | 33.6 | 38 | 5.52 | 3.31 |
| 1.5-2 | 7.11 | 30 | <58 | 4.3 | 33.8 |

| MW-4 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | 10.1 | 370 | 15,000 | 149 | 2575 |
| 1.5-2 | 2.6 | 12.3 | 57 | 3.79 | 31.2 |
| 9-10.5 | NA | NA | 130 | 5.69 | 126 |
| 14-15.5 | 2.2 | 2.98 | <98 | 7.4 | 6.43 |

| MW-3 | | | | | |
|---|---|---|---|---|---|
| Depth (ft.) | Arsenic | Pb | PCP | CPAH-TEQs | D/F TEQs |
| 0-0.5 | NA | NA | <90 | 6.77 | 2.01 |
| 1.5-2 | 3.7 | 13.2 | <99 | 8.3 | 2.88 |
| 6.5-8 | 4.6 | 15.1 | <97 | 6.77 | 3.11 |
| 14-15.5 | 2.1 | 2.07 | <73 | 5.51 | 0.062 |

| Soils | | | | |
|---|---|---|---|---|
| Detected analytes | Method A Residential | Method A Industrial | Method B Carcinogenic | Method B Non-Carcinogenic |
| Arsenic (mg/kg) | 20 | 20 | 0.67 | 24 |
| Lead (mg/kg) | 250 | 1,000 | -- | -- |
| TPH-D (mg/kg) | 2,000 | 2,000 | -- | -- |
| Pentachlorophenol (ug/kg) | -- | -- | 8,300 | 2,400,000 |
| cPAHs (TEQ) (ug/kg) | -- | -- | 137 | -- |
| Dioxin/Furan (TEQ)( ng/kg) | -- | -- | 11 | -- |

AECOM



LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

## SOIL ANALYTICAL RESULTS
## MARCH 17-18, 2008

DATE: 02/19/09
DRWN: E.M./SEA

FIGURE F-3-1

File: L:\Lora Lake\soils(c).dwg Layout: ANSL_BI-CP User: MarshallE Plotted: Mar 23, 2009 – 2:38pm Xref's:

LEGEND:

| | |
|---|---|
| ▨ | BUILDING STRUCTURES |
| ▨ | OTHER STRUCTURES |
| ▨ | PAVEMENT |
| ▨ | FOUNDATION ONLY |
| ⌖ | MONITORING WELLS |
| ◎ | GEOPROBE LOCATIONS |
| ▲ | SUBSLAB VAPOR SAMPLE LOCATIONS |
| — — — | PROPERTY BOUNDARY |

NOTE:

As - ARSENIC REPORTED IN µg/L
TPH-D - DIESEL REPORTED IN µg/L
PCP - PENTACHLOROPHENOL REPORTED IN µg/L
CPAH - CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS REPORTED IN µg/L
D/F - DIOXINS/FURANS REPORTED IN pg/L
TEQ - TOTAL TOXICITY EQUIVALENCE

NC - NOT CALCULATED

TWO VALUES PROVIDED FOR D/F TEQ; ONE USING ½ DL FOR NON-DETECTS AND ONE USING ZERO FOR NON-DETECTS.

SHADED CONCENTRATION VALUE EXCEEDS METHOD B CUL

| MW-2 | |
|---|---|
| As | 0.33 |
| TPH-D | 39 |
| PCP | <0.95 |
| CPAH-TEQ | 0.06 |
| D/F TEQ | 0.87/0.023 |

| MW-6 | |
|---|---|
| As | 1.66 |
| TPH-D | 7,300 |
| PCP | <5 |
| CPAH-TEQ | NC |
| D/F TEQ | 0.70/0.017 |

| MW-1 | |
|---|---|
| As | 10.5 |
| TPH-D | 6,300 |
| PCP | 16 |
| CPAH-TEQ | 1.0 |
| D/F TEQ | 234/234 |

| MW-5 | |
|---|---|
| As | 2.4 |
| TPH-D | 94 |
| PCP | 1.0 |
| CPAH-TEQs | 0.06 |
| D/F TEQs | 0.60/0.001 |

| MW-4 | |
|---|---|
| As | 1.38 |
| TPH-D | 19 |
| PCP | <0.97 |
| CPAH-TEQ | 0.07 |
| D/F TEQ | 0.72/0.033 |

| MW-3 | |
|---|---|
| As | 1.39 |
| TPH-D | 18 |
| PCP | <0.99 |
| CPAH-TEQ | 0.17 |
| D/F TEQ | 0.72/0.00052 |

| Groundwater<br>Selected analytes | Method A Residental | Method B Carcinogenic | Method B Non-Carcinogenic |
|---|---|---|---|
| Arsenic (ug/L) | 5 | 0.058 | 4.8 |
| TPH-D (ug/L) | 500 | -- | -- |
| Pentachlorophenol (ug/L) | -- | 0.73 | 480 |
| cPAHs (TEQ) (ug/L) | -- | 0.012 | -- |
| Dioxin/Furan (TEQ)( pg/L) | -- | 5.8 | -- |

40 0 80
1"=80'
N

AECOM

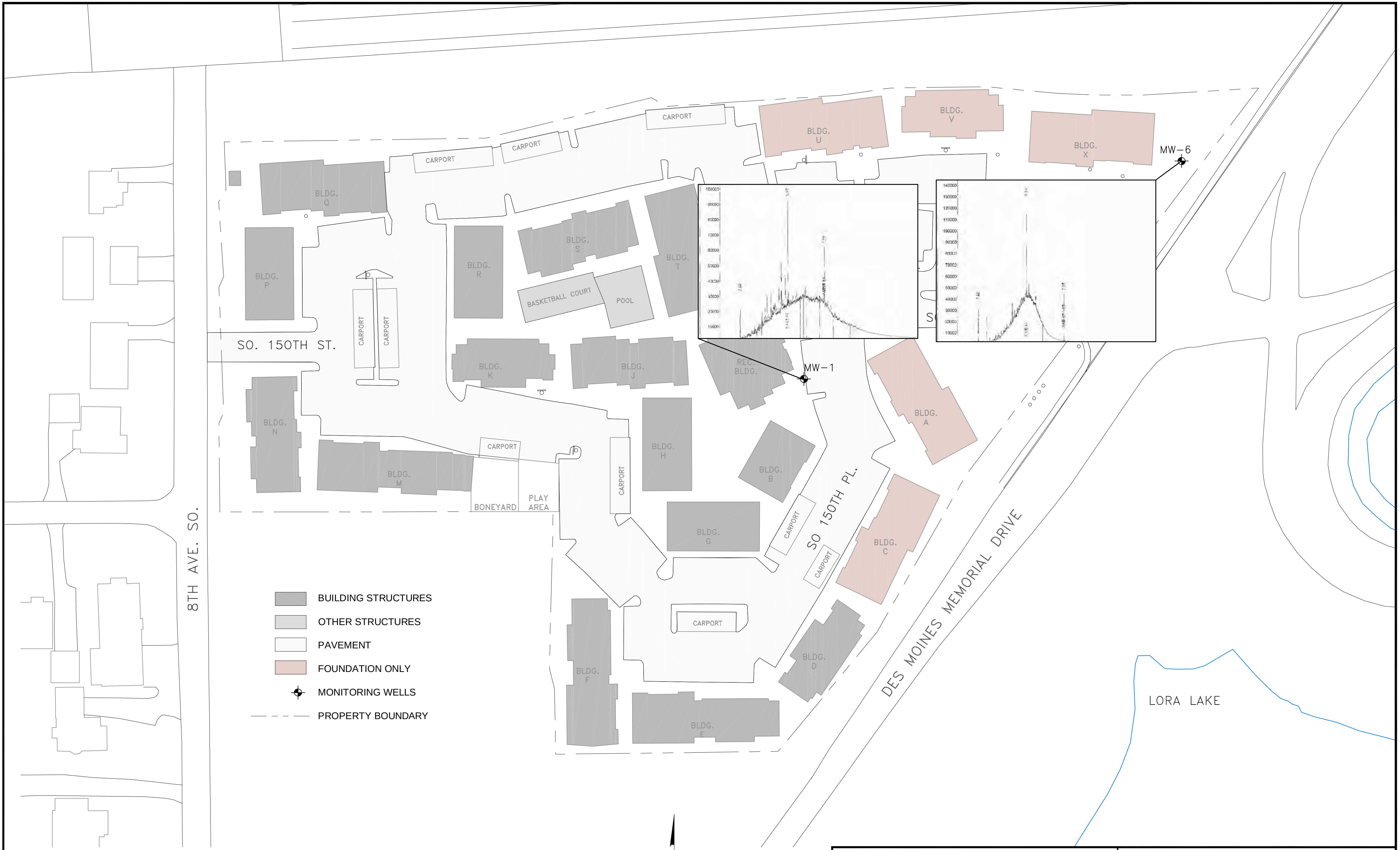
LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

## GROUNDWATER ANALYTICAL RESULTS
## MARCH 27-28, 2008

DATE: 02/19/09
DRWN: E.M./SEA

**FIGURE F-4-1**

File: L:\Lora Lake\GW_ANALYTICAL(F).dwg Layout: ANSI_BI-CP User: MarshallE Plotted: Mar 23, 2009 - 2:39pm Xref's:



AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
BURIEN, WASHINGTON

**NWTPH-Dx CHROMATOGRAMS**

DATE: 02/19/09

DRWN: E.M./SEA

**FIGURE F-4-2**

File: L:\Lora Lake\CHROMATOGRAMS.dwg Layout: fig F-4-2 User: MarshallE Plotted: Mar 23, 2009 - 2:41pm Xref's:

LEGEND:

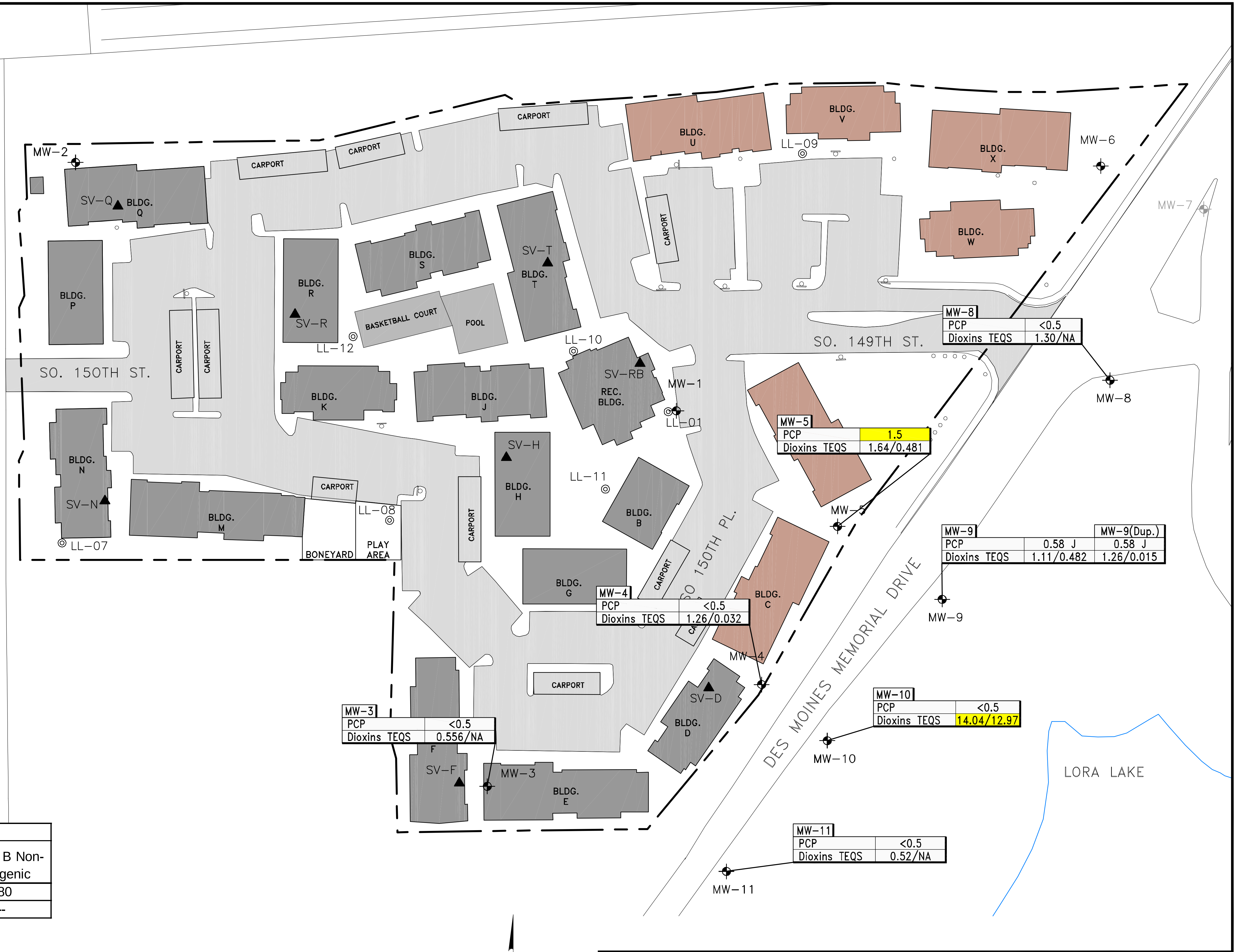
- ▨ BUILDING STRUCTURES
- ▨ OTHER STRUCTURES
- ▨ PAVEMENT
- ▨ FOUNDATION ONLY
- ⊕ MONITORING WELLS
- ⊕ FUTURE MONITORING WELL
- ◎ GEOPROBE LOCATIONS
- ▲ SUBSLAB VAPOR SAMPLE LOCATIONS
- — — — PROPERTY BOUNDARY

NOTE:

PCP - PENTACHLOROPHENOL REPORTED IN µg/L
D/F - DIOXINS/FURANS REPORTED IN pg/L
TEQ - TOTAL TOXICITY EQUIVALENCE

TWO VALUES PROVIDED FOR D/F TEQ; ONE USING ½ DL FOR NON-DETECTS AND ONE USING ZERO FOR NON-DETECTS.

SHADED CONCENTRATION VALUE EXCEEDS METHOD B CUL



| Groundwater | | |
|---|---|---|
| Selected analytes | Method B Carcinogenic | Method B Non-Carcinogenic |
| Pentachlorophenol (ug/L) | 0.73 | 480 |
| Dioxin/Furan (TEQ)( pg/L) | 5.8 | -- |

40 0 80
1"=80'
N

**AECOM**

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE, BURIEN, WA
05482-025

**GROUNDWATER ANALYTICAL RESULTS**
**ANALYTES EXCEEDING MTCA B CULs**
**AUGUST 19-20, 2008**

DATE: 02/19/09 DRWN: E.M./SEA

**FIGURE F-4-3**

File: L:\Lora Lake\GW_ANALYTICAL-analytes.dwg Layout: ANSI_B1-CP User: MarshallE Plotted: Mar 23, 2009 - 2:41pm Xref's:

LEGEND:

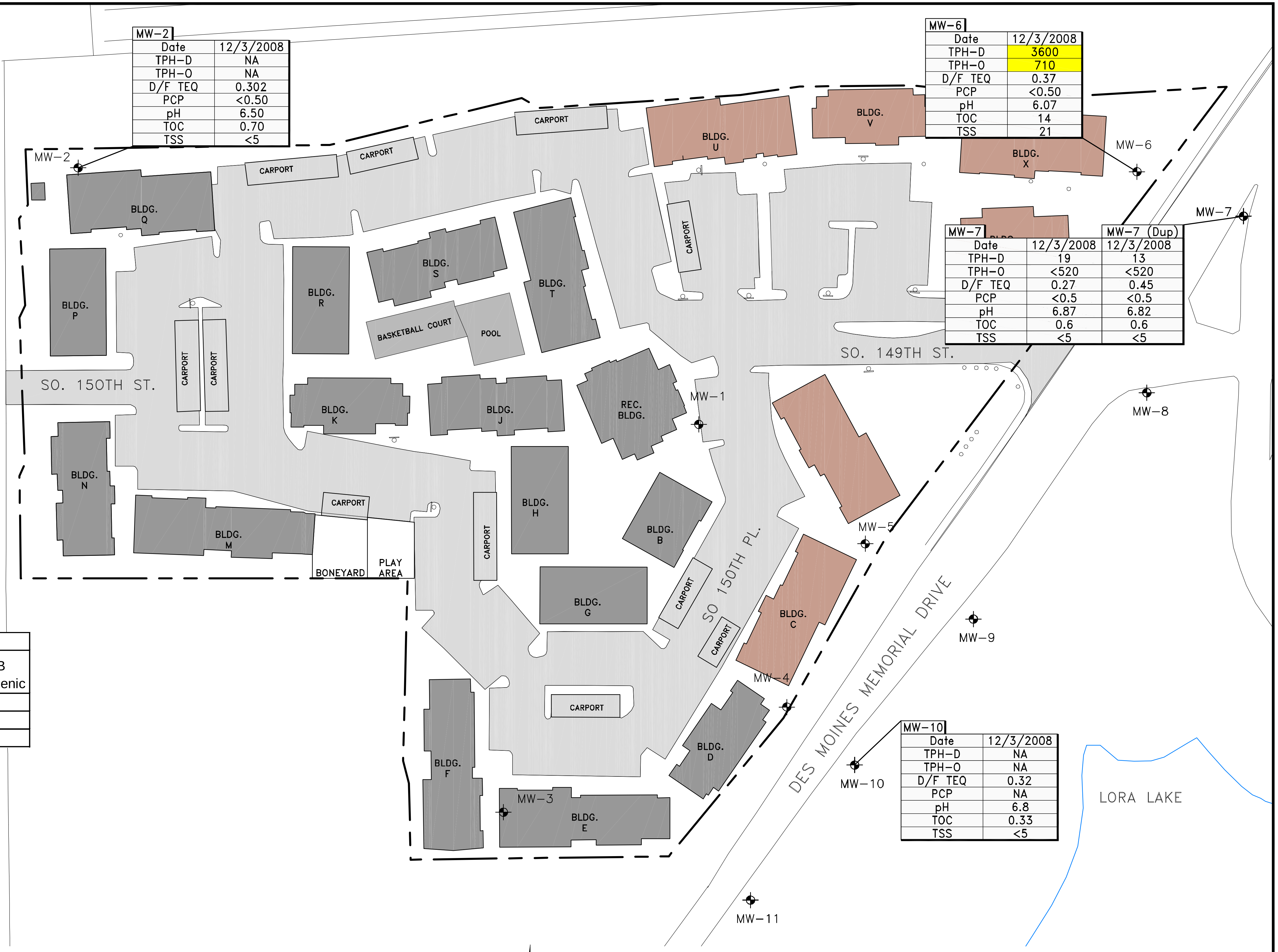
- ▩ BUILDING STRUCTURES
- ▩ OTHER STRUCTURES
- ▩ PAVEMENT
- ▩ FOUNDATION ONLY
- ⌖ MONITORING WELLS
- — — — PROPERTY BOUNDARY

NOTE:

TPH-D - DIESEL REPORTED IN µg/L
TPH-O - RESIDUAL RANGE ORGANIC REPORTED IN µg/L
D/F - DIOXINS/FURANS REPORTED IN pg/L
TEQ - TOTAL TOXICITY EQUIVALENCE
PCP - PENTACHLOROPHENOL REPORTED IN µg/L
TOC - TOTAL ORGANIC CARBON REPORTED IN mg/L
TSS - TOTAL SUSPENDED SOLID REPORTED IN mg/L

NA - NOT ANALYZED

SHADED CONCENTRATION VALUE EXCEEDS METHOD A CUL



| MW-2 | |
|---|---|
| Date | 12/3/2008 |
| TPH-D | NA |
| TPH-O | NA |
| D/F TEQ | 0.302 |
| PCP | <0.50 |
| pH | 6.50 |
| TOC | 0.70 |
| TSS | <5 |

| MW-6 | |
|---|---|
| Date | 12/3/2008 |
| TPH-D | 3600 |
| TPH-O | 710 |
| D/F TEQ | 0.37 |
| PCP | <0.50 |
| pH | 6.07 |
| TOC | 14 |
| TSS | 21 |

| | MW-7 | MW-7 (Dup) |
|---|---|---|
| Date | 12/3/2008 | 12/3/2008 |
| TPH-D | 19 | 13 |
| TPH-O | <520 | <520 |
| D/F TEQ | 0.27 | 0.45 |
| PCP | <0.5 | <0.5 |
| pH | 6.87 | 6.82 |
| TOC | 0.6 | 0.6 |
| TSS | <5 | <5 |

| MW-10 | |
|---|---|
| Date | 12/3/2008 |
| TPH-D | NA |
| TPH-O | NA |
| D/F TEQ | 0.32 |
| PCP | NA |
| pH | 6.8 |
| TOC | 0.33 |
| TSS | <5 |

| Groundwater CUL | | |
|---|---|---|
| Selected analytes | Method A | Method B Carcinogenic |
| TPH-D (ug/L) | 500 | -- |
| PCP (ug/L) | | 0.73 |
| Dioxin/Furan (TEQ)( pg/L) | | 5.83 |

40 0 80
1"=80'
N

AECOM

LORA LAKE APARTMENTS
15001 DES MOINES MEMORIAL DRIVE
05482-025-5000

DATE: 2/19/09
DRWN: E.M./SEA

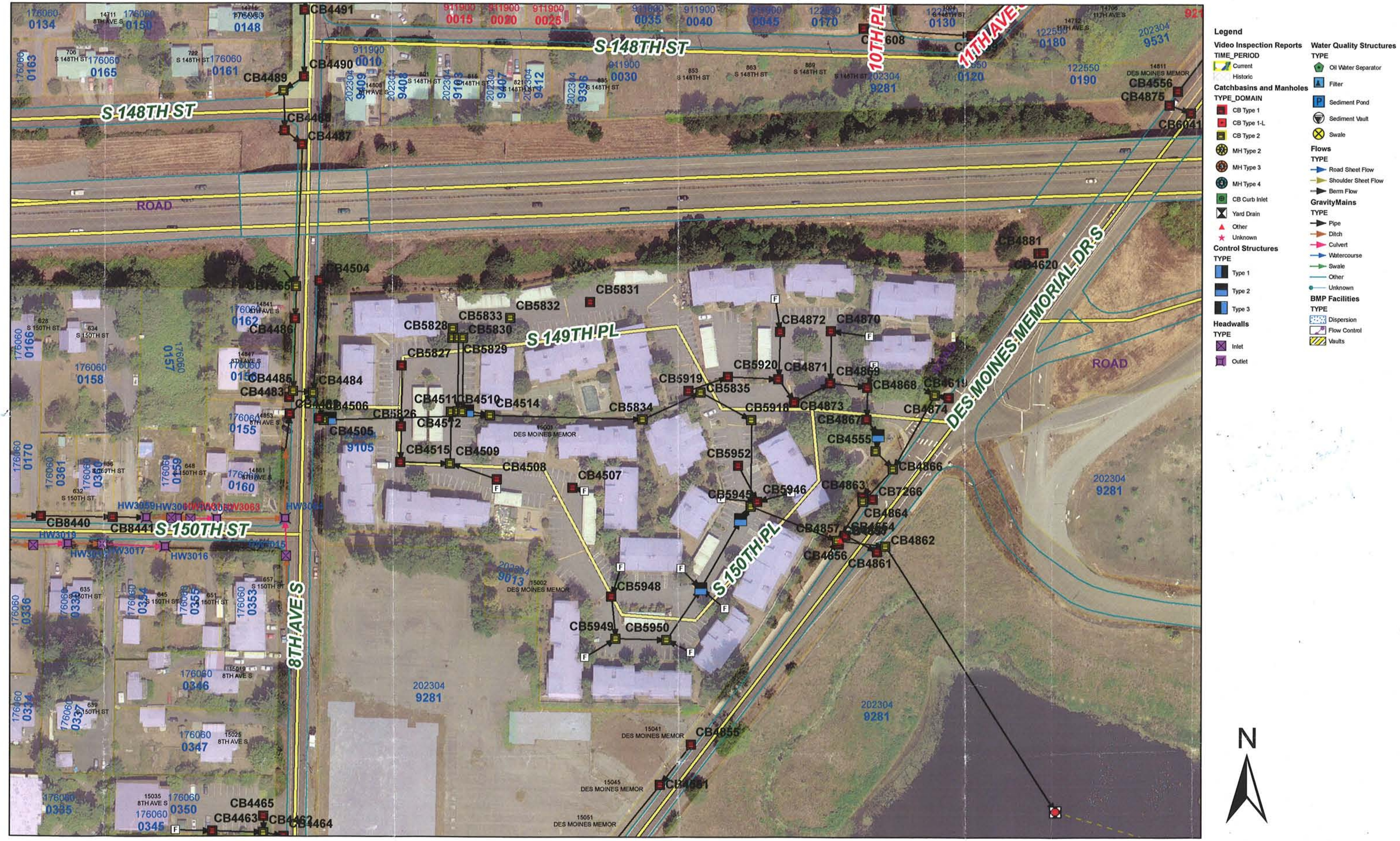
**GROUNDWATER ANALYTICAL RESULTS**
**DECEMBER 3, 2008**

**FIGURE F-4-4**

File: L:\Lora Lake\GW_ANALYTICAL_12-08.dwg Layout: ANSI_B1-CP User: MarshallE Plotted: Mar 23, 2009 - 2:43pm Xref's:

Appendix F-2 March 2008 data validation report.

Due to size constraints, this report is available on request.



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# Chemicals of Potential Concern (COPCs)

## 1.0 Arsenic

Arsenic is classified chemically as a metalloid, having both properties of a metal and a nonmetal; however, it is frequently referred to as a metal. Elemental arsenic, which is also referred to as metallic arsenic, (As(0)) normally occurs as the α-crystalline metallic form, which is a steel gray and brittle solid. The β-form is a dark gray amorphous solid. In compounds, arsenic typically exists in one of three oxidation states, -3, +3, and +5 (ATSDR, 2007).

While arsenic is released to the environment from natural sources such as wind-blown soil and volcanoes, releases from anthropogenic sources far exceed those from natural sources. Anthropogenic sources of arsenic include nonferrous metal mining and smelting, as a byproduct of the smelting of copper, lead, cobalt, and gold ores in coal and wood combustion and it accumulates in the flue dust. It is used in the production of wood preservatives, and agricultural chemicals, including herbicides and insecticides. In site soils, arsenic was present at concentrations consistent with area background values for the central Puget Sound region; only one ground water sample had elevated concentrations.

Arsenic found in soil either naturally occurring or from anthropogenic releases forms insoluble complexes with iron, aluminum, and magnesium oxides found in soil surfaces, and in this form, arsenic is relatively immobile. However, under reducing conditions, arsenic can be released from the solid phase, resulting in soluble mobile forms of arsenic, which may potentially leach into groundwater or result in runoff of arsenic into surface waters. Arsenic may undergo a variety of reactions in the environment, including oxidation-reduction reactions, ligand exchange, precipitation, and biotransformation (ATSDR, 2007). These reactions are influenced by Eh (the oxidation-reduction potential), pH, metal sulfide and sulfide ion concentrations, iron concentration, temperature, salinity, and distribution and composition of the biota (ATSDR, 2007). Much of the arsenic will adsorb to particulate matter and sediment.

Arsenic in soil may be transported by wind or in runoff or may leach into the subsurface soil. However, because many arsenic compounds tend to partition to soil or sediment under oxidizing conditions, leaching usually does not transport arsenic to any great depth (ATSDR, 2007). Arsenic is largely immobile in agricultural soils; therefore, it tends to concentrate and remain in upper soil layers indefinitely. Downward migration has been shown to be greater in a sandy soil than in a clay loam. The effect of soil characteristics, namely pH, organic matter content, clay content, iron oxide content, aluminum oxide content, and cation exchange capacity (CEC) are the main parameters to consider for the mobility of arsenic in soil. (ATSDR, 2007).

Transport and partitioning of arsenic in water depends upon the chemical form (oxidation state and counter ion) of the arsenic and on interactions with other materials present. Under oxidizing and mildly reducing conditions, groundwater arsenic concentrations are usually controlled by adsorption rather than by mineral precipitation. The extent of arsenic adsorption under equilibrium conditions is characterized by the distribution coefficient, $K_d$, which measures the equilibrium partitioning ratio of adsorbed to dissolved contaminant. The value of $K_d$ depends strongly upon the pH of the water, the arsenic oxidation state, and the temperature.

Arsenic in water can undergo a complex series of transformations, including oxidation-reduction reactions, ligand exchange, precipitation, and biotransformation. Rate constants for these various reactions are not readily available, but the factors most strongly influencing fate processes in water include Eh, pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, distribution and composition of the biota, season, and the nature and concentration of natural organic matter (ATSDR, 2007).

## 2.0 cPAHs

PAHs are a group of organic compounds that vary in their molecular structure and physical and chemical properties. PAH compounds are composed of two or more aromatic, or benzene rings, which vary in number, structure, and position on the parent ring system. The physical and chemical properties, and consequently the fate and transport, of PAHs tend to vary by molecular weight. This section discusses the environmental fate of the cPAHs as that is the PAH group that was identified in the site media as COPCs. In general, the PAH compounds may be colorless, yellow to yellow-green, orange, or white solids with a faint aromatic odor (ATSDR, 2007). PAHs derive from natural and synthetic sources; synthetic sources constitute the largest volume of PAH releases. The largest single source of PAHs is from the burning of wood in homes (ATSDR, 2007). Automobile and truck emissions are also a major source.

The transport and fate of PAHs in the environment are largely determined by their physical and chemical properties (e.g., Henry's law constant and organic carbon-water partition coefficient [$K_{oc}$]). These properties are approximately correlated to their molecular weights; therefore, PAHs are typically grouped according to their molecular weights (e.g., low, medium, and high molecular weight compounds). PAH compounds are grouped as follows:

- The low molecular weight PAH compounds (LPAHs) are 1-methylnaphthalene, 2-methylnaphthalene, 2-chloronaphthalene, acenapthene, acenaphthylene, anthracene, dibenzofuran, fluorene, naphthalene, and phenanthrene
- The medium molecular weight PAHs (MPAHs) are fluoranthene and pyrene
- The high molecular weight PAHs (HPAHs) are benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene.

The low and medium molecular weight compounds constitute the non-carcinogenic PAHs (nPAHs), while the high molecular weight compounds, with the exception of benzo[g,h,i]perylene (nPAH), constitute the carcinogenic PAHs (cPAHs). cPAHs were encountered in soil and groundwater at the site. nPAHs were not identified as COPCs at the site and, therefore, are not considered further in this section.

PAHs have moderate to strong soil sorption and low water solubility; therefore, they are fairly immobile in soil and do not readily leach to groundwater. HPAHs ($K_{oc}$ 105-106) have the greatest adsorption potential among the PAHs. Therefore, they are virtually immobile in soil and virtually insoluble. Once sorbed to soil, they are unlikely to remobilize in any appreciable quantity.

The principal process for degradation of PAHs in soil is microbial metabolism. Photolysis, hydrolysis, and oxidation may also occur, but are generally not considered to be important degradation processes. Biodegradation half-lives are considerably longer for PAHs with more than three rings (>20 to hundreds of days) than for PAHs with three or fewer rings. Degradation rates are affected by the degree of contamination, environmental factors, the soil organic content, the soil structure and particle size, characteristics of the microbial population, the presence of contaminants toxic to microorganisms, and the physical and chemical properties of the PAHs (ATSDR, 2007).

## 3.0 Total Petroleum Hydrocarbons

TPH originates from crude oil, which is generally a brown to black liquid to semi-solid. TPH is a complex mixture of several hundred hydrocarbon compounds. TPH compounds may be light, volatile, short-chained organic compounds or heavy, long-chained, branched compounds. The general term TPH includes a variety of petroleum products, which differ in composition due to the source of the crude oil from which they were refined, and the refining process used to produce the product (ATSDR, 2007).

These petroleum products include automotive gasoline, Stoddard solvent, jet fuel, fuel oils, and mineral oils (ATSDR, 2007). Many of the individual components of TPH have been extensively studied, but little research exists on the potential health effects of TPH itself.

This section broadly discusses the fate and transport processes for TPH in the environment. The complex nature of petroleum products, combined with the complexity of the interactions of its many components with the environment, is best dealt with through modeling. In general, petroleum products will migrate through the soil as bulk oil by gravity and capillary action, bulk oil may be retained by the soil as it flows as “residual saturation”, or the individual compounds which comprise the TPH may dissolve into air or water (ATSDR, 2007). When light products (LNAPLs) encounter the water table, they may float, whereas product that is denser than water (DNAPLs) will continue to flow until an impermeable boundary is encountered.

The fate of individual compounds that may separate from the bulk oil depends on their volatility, solubility, and sorption potential. The volatility of a compound depends on the properties of the compound and environmental conditions. Compounds with higher vapor pressures, which are typically lighter, have a greater tendency to volatilize. Environmental conditions that affect the volatilization rate include air and soil temperature, humidity, wind speed, soil type, moisture content, oil composition, solar radiation, and thickness of the oil layer (ATSDR, 2007).

Product solubility is also a determinant in the fate of petroleum-related compounds. Compounds with greater solubility are more likely to dissolve into infiltrating water or groundwater and migrate away from the release area. Solubility depends on molecular weight, whether the hydrocarbons are aromatic or aliphatic, branched or straight-chained, and the presence of other hydrocarbons (ATSDR, 2007).

The sorption potential of a compound, as predicted by the $K_{oc}$, determines whether a compound will partition to water or to organic carbon in soil. Chemicals with higher attraction to soil will be more likely to sorb, and persist in soils, and will be less likely to leach. On the other hand, more mobile compounds will migrate readily to groundwater. In general, compounds with higher solubility and volatility usually sorb less (lighter products, e.g., gasoline); whereas those with lower solubility and volatility usually sorb more (denser products, e.g., fuel oil) (ATSDR, 2007).

The tendency for a petroleum product to biodegrade depends on its chemical composition and a number of site-specific environmental factors. Straight chain hydrocarbons and aromatics degrade more readily than highly branched aliphatics; hydrocarbons with condensed ring structures, e.g., PAHs with 4 or more rings, are resistant to biodegradation. The following environmental factors also affect biodegradation rates: oxygen content, pH, moisture content, temperature, nutrient concentrations, and microbes (ATSDR, 2007). Biodegradation rates are very low under anaerobic conditions. The following conditions promote biodegradation: neutral pH (6-8), optimal moisture content (50-70% of the water holding capacity), temperatures from 18-30º C, the presence of nutrients essential for microbe growth (e.g., nitrogen, phosphorus, potassium, sodium, etc.); an oil concentration less than saturation (typically less than 30-50% oil); and low heavy metal concentrations (ATSDR, 2007).

# 4.0 Pentachlorophenol

Pure pentachlorophenol (PCP) exists as colorless crystals. It has a very sharp characteristic phenolic smell when hot but very little odor at room temperature. Most people can begin to smell PCP in water at less than 12 parts PCP per million parts of water (ppm). Impure PCP (the form usually found at hazardous waste sites) is dark gray to brown and exists as dust, beads, or flakes. PCP can be found in two forms: PCP itself or as the sodium salt of PCP. The sodium salt dissolves easily in water, but PCP does not. These two forms have some different physical properties, but are expected to have similar toxic effects. Humans are generally exposed to technical-grade pentachlorophenol, which usually contains such toxic impurities as polychlorinated dibenzo- p-dioxins and dibenzofurans (ATSDR, 2007).

PCP was widely used as a pesticide and wood preservative. Since 1984, the purchase and use of pentachlorophenol has been restricted to certified applicators. It is no longer available to the general public due to the chemical's hazardous nature, abundance in the environment, and low biodegradation rates. PCP was detected above the screening concentration only in groundwater in the center of the site and on the eastern site boundary.

Volatilization of PCP from soil is not expected to be a major transport pathway (ASTDR 2007). Purified PCP is practically insoluble in water. PCP is usually applied to wood products after dilution in solvents such as mineral spirits, No. 2 fuel oil, or kerosene. The sorption or mobility of PCP in soils is controlled primarily by soil pH (ATSDR 2007). The amount of PCP sorbed at a given pH increases with increasing organic content of the soil. Maximum adsorption has been reported at soil pH values of 4.6 – 5.1, with no adsorption above pH 6.8. The presence of cosolvents such as alcohols or petroleum hydrocarbons decreases the adsorption of pentachlorophenol to soils by increasing its effective solubility. The mobile phase is more likely to leach to groundwater where it could partition into the aqueous phase. PCP readily degrades in the environment by chemical, microbiological, and photochemical processes (ASTDR 2007). In soils, reductive dehalogenation appears to be the most significant PCP degradation pathway ultimately leading to ring cleavage, liberation of chloride, and carbon dioxide evolution. Degradation is more rapid in flooded or anaerobic soils than in aerobic moist soils. Biodegradation is considered the major transformation mechanism for PCP in soil, with half lives usually on the order of 2 – 4 weeks (ATSDR 2007).

Plant uptake and transformation of PCP are inconsistent among studies and are inconclusive with regard to the abilities of specific plants to take up the compound (ATSDR 2007). The log octanol-water coefficient (log $K_{ow)}$ for PCP in the un-ionized form is fairly high (5.01) suggesting that it will bioaccumulate. However, the extent of bioaccumulation will depend on the pH of the medium and physiological pH, since at higher pH levels, PCP converts to the more water-soluble pentachlorophenate anion. Biomagnification of PCP in terrestrial or aquatic food chains has not been observed.

PCP is a stable chemical with a high persistence in soils. It can be biodegraded when no other carbon source is available and there is a long acclimation period or when a common activated sludge is acclimated when the initial PCP concentration is low. Several aerobic microorganisms can biodegrade PCP, including *Pseudomonas, Arthrobacter, Flavobacterium*, and *Rhodococcus sp*. High PCP biodegradation rates have been reported for a variety of biological systems, including batch reactors, activated sludge systems, fluidized beds, and airlift reactors (ATSDR 2007).

# 5.0 Dioxins and Furans

Dioxins and furans are two classes of similar chemicals that both contain two carbon benzene ring structures. All dioxins include two oxygen atoms, while all furans include one oxygen atom. There are 75 unique dioxin compounds, each called a "congener." Congeners differ from each other in the number and position of chlorine atoms on the benzene rings. There are 135 furan congeners.

Dioxin and furan congeners can contain one to eight chlorine atoms, so there are eight homologue groups for dioxins and furans, ranging from monochlorodibenzo-*p*-dioxins (MCDDs) and monochlorodibenzofurans (MCDFs) to octachlorodibenzo-*p*-dioxins (OCDDs) and octachlorodibenzofurans (OCDFs). Although there are 210 unique dioxin and furan congeners, only 17 of these, all of which have chlorine atoms attached in the 2,3,7 and 8 positions, are typically evaluated because the U.S. Environmental Protection Agency (EPA) and the World Health Organization consider them the most toxic.

Dioxins and furans make their way up into the environment from a variety of sources. Dioxins have never been purposely manufactured. They can be anthropogenically and naturally produced as trace impurities or incidental byproducts in chlorophenols, chlorinated herbicides, and commercial Aroclor

(PCB) mixtures, bleached paper production or combustion (e.g., forest fires) (ASTDR 2007). They can also be produced during incineration of wood, oil and wastes. Dioxins and furans were encountered in soil more broadly across the site than the other COPCs. They were identified in groundwater in only one location on site.

Federal and state environmental regulatory and health agencies are interested in dioxins and furans because they are toxic to humans and wildlife. Once released to the environment, dioxins and furans resist biodegradation, do not dissolve in water and attach strongly to particles, such as soil, dust and sediment. This means they are persistent and can bioaccumulate in people and animals. Because they are persistent, dioxins and furans can be measured in the environmental media long after they have been released. Despite the persistence and ubiquitous presence, levels of dioxins and furans in the environment have been declining since the 1970s due to improvements in air pollution control technologies for combustion and incineration facilities and cleanup of dioxin-contaminated areas (ATSDR, 2007).

Dioxins, especially TCDD, are characterized by extremely low vapor pressures, high log $K_{ow}$, high organic-carbon coefficients ($K_{oc}$), and extremely low water solubilities (ATSDR, 2007). These factors indicate a strong affinity for sediments, particularly sediments with high organic content. Their strong adsorption to soil, low water solubilities, and high $K_{oc}$ values indicate that the rate of transport from unsaturated zone soils to the water table via rain infiltration would be extremely low. Once sorbed to particulate matter or bound in the sediment organic phase, they exhibit little potential for leaching or volatilization. They are highly stable in all environmental media, with persistence measured in decades. The only environmentally significant transformation process for these congeners is believed to be photodegradation of chemicals not bound to particles in the gaseous phase or at the soil or water air interface (ATSDR, 2007). Bacterial degradation of dioxins and furans is possible, but is a very slow process.

Also, TCDD has been shown to biomagnify in terrestrial organisms. However, all dioxin isomers do not biomagnify in plant and animal tissues to the extent of TCDD. There are limited data which suggest that bioaccumulation of TCDD does not occur in crop plants (ATSDR 2007). Although studies investigating the effects of dioxin ingestion on wildlife species are limited, dioxins have been found to be highly toxic relative to most chemicals in many animals that have been studied (ATSDR, 2007).

# 6.0 Lead

Lead is a heavy, low melting, bluish-gray metal that occurs naturally in the Earth's crust. However, it is rarely found naturally as a metal. It is usually found combined with two or more other elements to form lead compounds.

Lead occurs naturally in the environment. However, most of the high levels found throughout the environment come from human activities. Lead compounds are used as a pigment in paints, dyes, and ceramic glazes and in caulk. The amount of lead used in these products has been reduced in recent years to minimize lead’s harmful effect on people and animals. Tetraethyl lead and tetramethyl lead were once used in the United States as gasoline additives to increase octane rating. However, their use was phased out in the United States in the 1980s, and lead was banned for use in gasoline for motor vehicles in 1996 (ATSDR, 2007). Lead was detected at the site above the screening concentration in near-surface soils on the east side of the property.

The fate of lead in the environment varies accordingly to the media where it is transported. In the atmosphere, non-organic compounds of lead exist primarily in the particulate form. Upon release to it, lead particles are dispersed and ultimately removed from the atmosphere by wet or dry deposition. An important factor in determining the atmospheric transport of lead is particle size distribution.

In soil the fate of lead is affected by the adsorption at mineral interfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. These processes are dependent on such factors as soil pH, soil type, particle size, organic matter content of soil, the presence of inorganic colloids and iron oxides, cation exchange capacity (CEC), and the amount of lead in soil. (ATSDR, 2007). Lead is strongly sorbed to organic matter in soil, and very little is transported through runoff to surface water or leaching to groundwater except under acidic conditions. Although not subject to leaching, it may enter surface waters as a result of erosion of lead-containing soil particulates. The accumulation of lead in most soils is primarily a function of the rate of deposition from the atmosphere.

The amount of soluble lead in surface waters depends upon the pH of the water and the dissolved salt content. Sulfate ions, if present in soft water, limit the lead concentration in solution through the formation of lead sulfate. A significant fraction of lead carried by river water is expected to be in an undissolved form, which can consist of colloidal particles or larger undissolved particles of lead carbonate, lead oxide, lead hydroxide, or other lead compounds incorporated in other components of surface particulate matters from runoff. Lead may occur either as sorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended living or nonliving organic matter in water (ATSDR, 2007).

The chemistry of lead in aqueous solution is highly complex because this element can be found in multiple forms. Lead has a tendency to form compounds of low solubility with the major anions found in natural waters. The amount of lead dissolved in surface waters is dependent on the pH and the dissolved salt content of the water. In the environment, the divalent form (Pb2+) is the stable ionic species of lead. Hydroxide, carbonate, sulfide, and, more rarely, sulfate may act as solubility controls in precipitating lead from water. The relatively volatile organolead compound, tetramethyl lead, may form as a result of biological alkylation of organic and inorganic lead compounds by microorganisms in anaerobic lake sediments; however, if the water over the sediments is aerobic, volatilization of tetramethyl lead from the sediments is not considered to be important because the tetramethyl lead will be oxidized (ATSDR, 2007). The organolead compounds also undergo photolysis and other reactions in the atmosphere to form lead carbonates, oxycarbonates, and oxides. Once these compounds encounter components of the soil, further reactions can occur, resulting in a complex variety of lead compounds (ATSDR, 2007). The speciation of lead in soils is dependent upon the properties of the soil.