Pilot Testing Work Plan
TX-03A Area
Shell Harbor Island Terminal
Seattle, Washington

July 2013

Prepared for:
Shell Oil Products US
HSE – Environmental Services

Prepared by:
URS
111 S.W. Columbia, Suite 1500
Portland, Oregon 97201-5814

URS Project Number: 46194348

URS

July 19, 2013

Ms. Maura S. O'Brien
Washington Department of Ecology
Northwest Region Office
3190 – 160th Avenue SE
Bellevue, Washington 98008

Re: Pilot Testing Work Plan
TX-03A Area
Shell Harbor Island Terminal
Seattle, Washington
Consent Decree No. 99-2-07176-0SEA

Dear Ms. O'Brien:

Enclosed please find a copy of the above referenced work plan for your review. This work plan was prepared on behalf of Shell Oil Products US. If you have any questions, please contact the undersigned at (503) 222-7200.

Sincerely,
URS Corporation

Brian Pletcher
Senior Project Manager

cc: Mr. Perry Pineda, Shell Oil Products (electronic copy)
Paul Katz, Seattle Terminal Manager – Shell Oil Products US

URS Corporation
111 SW Columbia, Suite 1500
Portland, OR 97201-5850
Tel: 503.222.7200
Fax: 503.222.4292

TABLE OF CONTENTS

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1.0 SITE BACKGROUND

1.1 Introduction

URS Corporation (URS) has prepared this work plan to describe proposed pilot testing field activities in the Main Tank Farm at the Shell Harbor Island Terminal in Seattle, Washington (here in referred to as the site; Figure 1). Pilot testing field activities are being proposed following the recent field activities that were performed by URS in accordance with the *Additional Subsurface Investigation Work Plan* (the work plan) prepared by URS dated October 23, 2012. The work plan was approved by the Washington State Department of Ecology (Ecology) in a letter dated October 23, 2012.

The results of the recent soil gas and monitoring well installations at the Site provided further delineation of the impacted soil gas and groundwater in the vicinity of the Main Tank Farm. The results of the recent field activities indicate additional remediation may be necessary to mitigate impacted soil and groundwater transport from the areas of impact identified within the Main Tank Farm. The field pilot testing activities presented in this Work Plan will provide additional information to select the most effective remedial strategy for the Site.

1.2 Site Location and Description

The site is a fuel distribution facility located on Harbor Island, which is approximately one mile southwest of downtown Seattle at the mouth of the Duwamish River (Figure 1). The site is comprised of three parcels located at 2555 13th Avenue SW, 1835 13th Avenue SW, and 1711 13th Avenue SW. These parcels are designated as the Main Tank Farm, the North Tank Farm, and the Shoreline Manifold Area, respectively. The TX-03A area is located between the Main Tank Farm and North Tank Farm; this location is also known as the north boundary area. The area north of the Main Tank Farm includes a City of Seattle public parking lot. A pipeline that connects two BP tank farms runs west to east under the Seattle public parking area (Figures 2 through 5).

1.2.1 Background

During the US Environmental Protection Agency (EPA) 5-Year review of the Harbor Island Superfund Site Tank Farms Operable Unit 2 (TF-OU2), the north boundary area was identified for additional evaluation. According to the Ecology letter to the EPA dated February 7, 2011 concerning the status of TF-OU2, Shell is continuing their supplemental investigation from 2009 to assess the north boundary area.

Monitoring well TX-03 was located north of the Main Tank Farm area was installed in 1991 as part the EPA’s evaluation of the north boundary area. This well was abandon during the improvements to SW Florida Street and the City of Seattle public parking lot in 2001. Monitoring well TX-03A was installed in 2002 to replace well TX-03. Monitoring well TX-03A is located approximately 40 feet south of the former monitoring well TX-03 location. Monitoring well locations are included on Figure 2. Monitoring well TX-03A has been monitored frequently from 1993 to 2012. Concentrations of gasoline-range hydrocarbons (gasoline) and benzene, toluene, ethylbenzene, and total xylenes (BTEX) in groundwater at monitoring well TX-03A have been in general decline since peak concentrations were detected in October 2002 (URS, 2012b).

Aboveground storage tanks (ASTs) 31538 and 113000 are located south of monitoring well TX-03A within the Main Tank Farm. According to Shell Harbor Island Terminal personnel, these two ASTs have stored unleaded gasoline since the early 1990s. In 2003, a remedial soil excavation was performed in the area northwest of AST 31538 within the North Tank Farm to remove soil which contained 20,000 milligrams per kilogram (mg/kg) or more gasoline. Soil was excavated to a depth of approximately 8 feet below ground surface (bgs). This excavation area is indicated on Figure 5.

Monitoring wells MW-301 through MW-304 were installed within the TX-03A area in November 2011 (URS, 2012a) to further assess the TX-03A area. Monitoring wells MW-307 through MW-310 were installed in November 2012 in the TX-03A area. Soil gas testing was conducted in May 2013, in accordance with the approved Soil Gas Assessment Work Plan for the TX-03A Area (URS, 2013), to delineate the extent of petroleum hydrocarbon impacts in the soil and source of groundwater impacts in the Main Tank Farm.

1.3 Geology and Hydrogeology

The 405 acre Harbor Island was constructed during the early 1900s in an area consisting of intertidal wetlands at the mouth the Duwamish River. The island was created using sediments dredged to facilitate navigation in the lower Duwamish River and West Waterway (KJC, 1990c).

Soil underlying the site consists of man-emplaced grade and dredge fill overlying native estuarine deposits (LCI and EMCON, 1997). The uppermost grade fill unit consists of coarse-grained fill varying from less than one foot to approximately two feet thick. The dredge fill unit was created when estuarine deposits near the site were dredged and used as fill. The contact between the dredge fill and native estuarine units is not well defined due to similar properties of the two units. The dredge fill appears to vary from approximately 8 to 20 feet thick at the site. It consists of fine- to medium-grained sand with some gravel. Native estuarine deposits underlie the dredge fill at depths of approximately 8 to 20 feet below grade. These deposits are composed of primarily fine- to medium-grained sand with thin silt interbeds.

Groundwater occurs as a thin lens of fresh water overlying brackish water at depth. The water table occurs within the dredge fill 4 to 8 feet bgs. According to the boring and well construction logs for MW-307 through MW-310, soils encountered were predominately sand with gravel above fine to medium sand. Groundwater was encountered during drilling activities at depths of 6.5 and 7 feet bgs.

Groundwater within the dredge fill unit occurs under unconfined conditions. The native estuarine deposits are fully saturated, and groundwater within this unit is unconfined. Water quality and water elevations within this unit can be influenced by surrounding surface water bodies and associated tidal fluctuations. Groundwater recharge in the shallow dredge fill is primarily through infiltration of precipitation through unpaved areas in the center of Harbor Island. This shallow groundwater flows in a radial fashion to the north and to the south from a potentiometric high located within the Main Tank Farm area (Figure 2). The underlying estuarine deposits are fully saturated and unconfined.

1.3.1 Groundwater Quality

This section presents general results for the groundwater monitoring events conducted in the TX-03A area for 2012 and 2013. Groundwater monitoring occurred generally on quarterly basis. The recent monitoring results are presented in Table 2 and the groundwater monitoring results for the May 2013 results are presented on Figure 2 through Figure 4.

Northern Boundary – Main Tank Farm

Historically, monitoring well TX-03A was the representative sampling point for assessing the quality of groundwater flowing across the northern boundary of the Main Tank Farm. Monitoring wells MW-301 through MW-304 were installed in November 2011 and monitoring wells MW-307 through MW-310 were installed in November of 2012, in the vicinity of monitoring well TX-03A to assist in determining the nature and extent of contamination observed in TX-03A.

During the monitoring year, samples collected from monitoring wells TX-03A, MW-301 through MW-304, MW-307, MW-308, and MW-310 contained concentrations of gasoline and benzene above the site cleanup levels.

Further evaluation of the northern boundary included delineation within the tank farm upgradient to the new monitoring well MW-307 through MW-310 through completion of a soil gas survey. The survey results indicated the groundwater was sufficiently delineated in the vicinity of the Northern Boundary of the Main Tank Farm.

1.4 Objectives and Scope of Work

Residual hydrocarbons are present above the cleanup levels at the Site down gradient of the source areas identified at the Main Tank Farm, with consistent trends between sampling events. Therefore, it is recommended that pilot scale testing be performed to evaluate potential remedial options for treating the residual hydrocarbons. The data collected to date indicate the primary target for treatment is the dissolved phase constituents present in the groundwater above the cleanup levels. A list of potential treatment technologies is presented in Table 1.

The following pilot tests will be conducted to provide additional information to fill the data gaps related to the feasibility of specific treatment technologies and to provide additional information about the physical conditions at the Site;

- Air sparging (AS);
- Soil vapor extraction (SVE);
- Groundwater pumping; and,
- Enhanced bioremediation.

The primary objective of the pilot testing at the Site is to get sufficient data to evaluate the effectiveness of each of the technologies tested to select the best technology or combination of technologies for implementation at the Site. Subtasks to support the overall objective of the pilot test include the following:

- Gain additional data to evaluate the volatile organic constituent (VOC) mass present in the vapor and dissolved phases at the Site;
- The optimal operating parameters for potential remediation technologies including AS, biosparging, and SVE.
- Gain information about the aquifer and vadose zone properties, including groundwater velocity, and storage parameters and overall soil porosity;
- Determine the total carbon content, including the soil oxidant demand, to use for estimating the potential nutrient requirements and to estimate the rate of contaminant removal, retardation, and migration;
- Determine potential in-situ degradation rates within the test area; and,
- Determine concentrations of potential waste by-products, such as extracted vapor concentrations and groundwater concentrations generated by the remedial actions.

The project preparation and pilot testing procedures are described in the following sections of the work plan.

2.0 FIELD WORK PREPARATION

This section of the report describes specific tasks that will be conducted before beginning the pilot tests. Specific tasks include the installation of test wells and monitoring wells, as well as other activities, such as data collection and waste management. All work will be completed in accordance with the current Site-specific Health and Safety Plan.

2.1 Utility Locating

The Utility Notification Center will be notified 72 hours prior to the field activities. URS will also contract a private underground utility locating service to clear the boring locations of potential underground utilities immediately prior to initiating the soil borings.

An air knife will be used to clear each of the proposed well installation locations, to a depth of 5-feet below grade, to ensure the protection of underground utilities.

2.2 Well Installations

URS proposes to install the following wells:

- One (1), 1-inch Air Sparging Well (ASW-1);
- One (1), 4-inch Soil Vapor Extraction Well (SVE-1)
- Two (2), ¾” permanent soil vapor (PSV) monitoring wells (PSV-1 and PSV-2); and,
- One (1), 4-inch diameter pumping test well (TW-01).

The locations of the proposed wells are shown on Figure 5. The proposed monitoring wells, including PSV-01 and PSV-02 and the three proposed test wells, ASW-1, SVE-1, and TW-01 have been located near the existing wells, MW-302, MW-304, and MW-310 to provide monitoring locations at varying distances and directions from each test well. By collecting data from the different well positions, the aquifer homogeneity and storage effects can be evaluated. Also, in addition to providing information about the aquifer homogeneity, the test data collected from the proposed PSV monitoring well PSV-2 and existing groundwater monitoring well, MW-304, will provide information about the influence of the BP Pipeline on the localized air and fluid transport conditions.

The proposed well installation details for the monitoring and test wells are presented on Figure 6. The proposed air sparging well, ASW-1, will be constructed from 1-inch PVC schedule 40 casing set between the ground surface and 13 feet below grade. A screened interval, with a 0.010 inch slot size, will be installed between 13 feet and 14 feet below grade to allow air injection at approximately 5-feet below the water table during the air sparing pilot test. Silica sand will be placed in the annulus around the exterior of the screened section with one additional foot of silica sand above the screened section. To seal the screened interval from the surface, bentonite chips will be poured into the annular space above the silica sand to within 1-foot of the ground surface. The chips will be hydrated with potable water. A concrete seal will be installed in the upper 1-foot of the well. The well will be finished with a lockable expansion plug and a 12-inch flush-mounted protective well monument.

One 4-inch SVE test well, SVE-1, will be installed using an air knife. The two, ¾-inch schedule 40 PVC soil gas monitoring wells, PSV-1 and PSV-2, will also be installed using an air knife. All three soil vapor wells, SVE-1, PSV-1, and PSV-2, will be installed to a maximum depth of 4 feet bgs with a 1-foot screened interval between 3 to 4 feet below grade. Silica sand will be placed around the screened interval between 2.5 and 4 feet bgs. Bentonite chips will be placed in the annulus between the silica sand to within 1-foot below grade. A 4-inch PVC monument and cap will be placed around the well casing at the surface of PSV-1 and PSV-2 and set into concrete to provide protection and security for the well. SVE-1 and the two PSV wells will be completed with a flush-mounted monument at the surface.

The proposed pumping test well will be installed using hollow-stem drilling methods and used for the SVE and pumping tests. TW-01 will be constructed using threaded 4-inch PVC schedule 40 casing set between the ground surface and three feet. A screened section, with a 0.010 inch slot size, will be placed between 4 feet to 14 feet below ground surface. Silica sand will be backfilled in the annulus around the exterior of the screened section. The soil boring annulus above the silica sand granular backfill will then be filled with one additional foot of silica sand above the screened section. To seal the screened interval from the surface, 1-foot of bentonite chips will be poured into the annular space to approximately 3.5 foot bgs. The chips will be hydrated with potable water. The remaining annular space will be filled with a concrete seal to the surface. The well will be completed with a lockable expansion plug and a flush-mounted protective well monument.

During the installation of the proposed pumping test well, TW-01, soil cores will be collected every two feet between the ground surface, to 8-feet below grade, using a split-spoon sampling device. Soil core handling and sampling will be conducted in accordance with SOP-1 (Appendix A). Reusable sampling equipment will be decontaminated between sample intervals, following the procedure described in SOP-1 (Appendix A). The boring will be documented on a standard field form included in Appendix B.

The soil cores will be screened based on visual observations, organic vapor monitoring (OVM), and pan water sheen testing. Field observations, OVM readings, and sheen test results will be recorded in the field logs. OVM will be performed with a photoionization detector (PID) calibrated against isobutylene reference gas as a head space analysis; soil will be placed in a plastic sample bags, shaken, and the PID probe will then be inserted in the bag and the concentration of volatile organic vapors was measured in parts per million (ppm). Water pan sheen testing will also be conducted, and will consist of placing a small amount of soil in a black pan half filled with water and observing for a silvery, metallic, colored or iridescent sheen. The following sheen descriptions were used:

- None (N);
- Slight (S): Light, colorless, dissipating film, spotty to globular;
- Moderate (M): Light to heavy irregular film with some color or iridescence; and
- Heavy (H): Heavy, colorful, iridescence film which spreads rapidly; sheen flows off the sample.

One soil sample will be collected from the soil/water interface (at a depth of about 6 to 8 feet bgs) for the following analysis:

- BTEX by EPA 8260B;
- Gasoline-range hydrocarbons by NWTPH-Gx;
- Total organic carbon (TOC) by SM 5310B;
- Biological oxygen demand (BOD) by SM 5210B; and
- Chemical oxygen demand (COD) by EPA Method 410.4.

During collection, the soil will be transferred from the split spoon to the pre-labeled laboratory approved containers as specified by standard sample handling procedures. Samples will be documented following the procedures described in Section 2.4 below and SOP-3 (Appendix A). For the volatile analyses, URS will collected the soil sample from the soil core using a zero headspace extraction sampling device (e.g., EnCore sampler) following the EPA 5035 method. All soil samples will be placed in a cooler with ice after collection to maintain proper temperature to the laboratory.

Waste soil cuttings generated during the well installation activities will be collected and managed as described below in Section 2.6 and described in SOP-4 (Appendix A).

2.2.1 Development of Testing Well ASW-1 and TS-01

The test wells, S ASW-1 and TW-01, will be developed to improve well performance and connectivity between the well and the aquifer. Each well will be developed by installing a surge block and gently flushing water through the screen and into the formation immediately around the well, as described in SOP-5 (Appendix A).

Developing ASW-1 and TW-01 will be considered complete when the water removed from the well is clear, with a measured turbidity of less than 10 nephelometric turbidity units (NTUs) and the pH and specific conductivity measurements are consistent with the measurement requirements listed on SOP-5. Following well development, baseline groundwater samples will be collected from the newly installed test wells as described in Section 2.3. Field parameters, including dissolved oxygen, oxidation reduction potential, conductivity, temperature, pH, and ferrous iron, will also be collected from each test well.

2.2.2 Soil Vapor Well Baseline Sampling

Soil vapors wells SVE-1, PSV-1 and PSV-2, will be purged and sampled following installation using a peristaltic pump. The purge volume will be a minimum of four volumes at each well. Following purging, a baseline soil gas sample will be collected from each of the wells following the procedure described in SOP-6 (Appendix A).

The baseline well samples will be collected into 1-liter summa canisters through dedicated Teflon-lined tubing. Each sample will be labeled with the sampling date, time and initials of the field sampler. To ensure the soil gas sample is representative of the air in the well and not ambient air, the sample will also be analyzed for fixed gases (oxygen, methane, and nitrogen).

The fixed gas analysis will be used to serve as a quality assurance/quality control measure to verify the integrity of the well seals.

The summa canisters will be shipped to the Eurofins Air Toxics, Inc. Laboratory, located in Folsom, California, under chain-of-custody documentation for VOC analysis by TO-15 (5&20), including TPH-G and fixed gas analysis by ASTM D-1946. All field sampling activities and weather conditions at the time of the sampling event will also be documented in a field notebook.

2.2.3 Well Surveying

URS will survey the locations of the newly installed wells, ASW-1, SVE-1, PSV-1, PSV-2, and TW-01. Each well will be located horizontally and vertically. The surveyor will mark a notch on the top of each well casing indicating the surveyed position. The surveyed coordinates will be conducted to the nearest 0.01 feet. The top of well casing elevations will reported in North American Vertical Datum of 1988 (NAVD88) survey feet to the nearest 0.01-feet.

2.3 Monitoring Well Network Baseline Sampling

Before conducting the pilot tests at the site, baseline groundwater sampling will be conducted at nearby Site monitoring wells following the procedures described in SOP-7 (Appendix A).. The baseline groundwater samples will be used as a reference to identify changes in the water quality in the nearby wells, following each of the pilot tests.

2.3.1 Groundwater Depths and Elevations

A comprehensive round of depth to water measurements will be collected from the monitoring well network, including MW-101, MW-102, MW-201 through MW-204, MW-206A, TX-03A, MW-301 through MW-304, MW-307 through MW-310, ASW-1 and TW-01, shown on Figure 5, before the pilot testing is started. The depths to water measurements will be recorded in the Field Log Book. URS will measure the depth to water from the survey notch located on the monitoring well top of casing (TOC) and will be reported to the nearest 0.01 feet. The depth to water measurements will be converted to elevations above mean sea level by subtracting the measured value from the TOC elevation.

2.3.2 Groundwater Baseline Sampling

Groundwater baseline samples will be collected from ASW-1 and TW-01 following installation and well development, using a standard low-flow sampling technique and a down-hole peristaltic pump. This technique provided representative water quality data and greatly reduced the amount of purge water requiring storage and disposal. Groundwater baseline samples will also be collected from several well in close proximity to the test wells, including MW-302, MW-304, MW-307, and MW-310. Field parameter measurements and other observations will be entered in a field log-book.

Baseline groundwater samples collected at the site will be submitted for the following analysis:

- BTEX by EPA 8260B;
- Gasoline-range hydrocarbons by NWTPH-Gx; and

- Dissolved iron and manganese by EPA 6000 series.

The baseline sample collected from ASW-01 will also be analyzed for the following bench tests:

- TOC by surface water method SW9060;
- BOD by EPA 5210B; and,
- COD by SM 5220D.

One trip blank will be provided by the laboratory to accompany the sample containers and collected samples during transport to the laboratory. The purpose of collecting the trip blank is to determine if cross-contamination may have occurred during the sample transport. The trip blank will be provided by the laboratory and transported with the other samples in the cooler and throughout shipping.

One field duplicate will be collected during the baseline sampling event and analyzed for TPH-Gx. The purpose of a co-located field duplicate sample is to determine the precision associated with the analytical method. The results of additional laboratory control samples and laboratory control sample duplicate results (LCS/LSCS) and surrogate recoveries will also be reported by the laboratory.

The samples will be documented and handled considering SOP-2 (Appendix A). Each groundwater sample will be uniquely labeled and tightly sealed the sample jars and bottles specified in Table 3. The samples will be stored on ice for transportation to the laboratory. URS will submit the samples to Accutest Laboratories, Inc., in San Jose, California for the requested analytes, under documented chain-of-custody procedures. The analytical results will be reported in a standard 14-day turn-around time.

The purge water from the well development and sampling will be collected and managed as Investigation Derived Waste per SOP-4 (Appendix A).

2.4 Field Documentation

Field personnel will document all sampling activities in the field notebook. Each entry will include date, weather, URS personnel, subcontractor personnel, activities conducted, measurements made (including instrument calibration), deviations from the Work Plan (if any), and descriptions of any concurrent site operations activities that might affect sample collection.

During the collection of all groundwater samples, the following information, at a minimum, will be recorded on the monitoring well sampling field form:

- Date and time of sample collection;
- Sample location and depth (if applicable);
- Sampling personnel;
- Type and number of sampling containers and parameters to be analyzed;
- Sampling method used;

- Field measurements (i.e., PID readings, pH, temperature, oxidation-reduction potential (ORP), conductivity);
- Visual observations and odors, if any; and,
- Problems or conditions existing during sampling which may affect the analytical results, if any.

Copies of all records will be maintained at the site while testing is being conducted and will be kept on record with appropriate information provided in subsequent reporting.

2.5 Decontamination Procedures

All non-disposable sampling equipment and PPE will be decontaminated between each use to prevent cross-contamination during completion of the field activities. Decontamination water will be obtained from an on-site source supplied by the municipality. Smaller non-disposable equipment will be cleaned, at a minimum, with a detergent/water bath and subsequently rinsed with distilled water, as described in SOP-2 (Appendix A).

Non-disposable sampling equipment used during drilling and sample collection will be decontaminated using a steam pressure washer or the following procedure: 1) tap water rinse, 2) deionized water with Alconox solution rinse, and 3) deionized water final rinse.

2.6 Investigative Derived Waste

URS anticipates generating IDW, which includes disposable personal protective equipment (PPE), tubing, purge water, decontamination water from monitoring well development and sampling, and water generated during completion of the pilot tests. Additionally, soil cuttings from the well installation activities will be generated at the Site during implementation of the Work Plan.

SOP-4 in Appendix A describes the general procedures for handling IDW at the Site. Pumped groundwater and decontamination water will initially be stored in a poly tank at the site. Depending on the quantity of water produced during the pilot testing, the purge water and decontamination water may be transferred to 55-gallon steel drums and stored at the site or, otherwise, will remain in a poly tank at the site, before being transferred to a local recycling facility for recycling under an approved material profile.

Soil cuttings will be contained in 55-gallon steel drums. Each drum will be labeled with the date of generation and a description of the contents and stored in the terminal waste storage area pending receipt of the analytical results and profiling. Each drum generated at the site will be added to the Investigative Derived Waste Form included in Appendix B.

Disposable PPE, tubing, and other materials IDW materials that may be generated during sampling activities will be disposed in the terminal municipal trash dumpster.

2.7 Project Schedule

URS anticipates beginning the field work activities within the third quarter 2013, following approval of this Work Plan by Ecology. The field work will be scheduled to occur during a period of dry weather conditions.

3.0 AS/SVE PILOT TESTS

AS and SVE is a technology primarily used for remediation of VOCs and semi-volatile organic constituents (SVOCs). The primary mechanism for the AS and SVE technologies is volatilization of the VOC and SVOCs, however, enhanced biodegradation may also occur because oxygen is being induced into the subsurface.

The AS and SVE pilot tests will be conducted in an impacted area of the plume. The tests will be conducted using a self-contained pilot testing trailer supplied by Global Remediation Solutions, LLC. The equipment and trailer details are shown in Appendix C. The trailer includes a rotary vain blower, capable of producing air flow rates up to 55 cubic feet per minute (CFM) and a 1322 AV rotary claw vacuum pump that is capable of moving air at 200 actual cubic feet per minute (ACFM) under a vacuum of up to 25.5-in. mercury (hg), which is equivalent to 347 in. of water (in. WC). The testing trailer is also equipped with an air stripper tower, however, granular activated carbon will be used for all air treatment during the pilot scale testing in lieu of the air stripper.

Shorter duration AS and SVE testing will be completed in one workday. The shorter duration tests will be conducted for up to 4 hours, to determine the feasibility of each of these technologies at the targeted operating rates. Following completion of the short duration testing, the combined test will be conducted, on a second workday, to evaluate differences in the application of the combined technology.

For both tests, direct-read level loggers will be installed at TW-01, MW-302, MW-304, and MW-310 to allow for real-time monitoring during each test. Magnehelic^{TM} (or equivalent) differential pressure gauges will also be installed at PSV-1 and PSV-2.

3.1 Short-Duration SVE Test Procedure

A SVE test will be conducted at the Site, to determine the effectiveness of inducing a vacuum to recover soil vapors at the Site, the radius of influence at an applied vacuum, and the concentration of the recovered vapors. The first stage of the SVE test will be conducted by inducing a vacuum of 40 in. WC at test well SVE-1 until the vacuum in the nearby soil gas monitoring wells, PSV-1 and PSV-2 stabilizes, or for up to 3 hours, whichever occurs first. The vacuum pump will be mounted to a trailer. A moisture knock-out tank will be installed in-line, before the vacuum pump and the total moisture recovered will be measured at the end of the test. The vapors recovered during the SVE test will be routed from the pump through an activated carbon vessel for treatment, prior to discharge to ambient air.

Before beginning the test, baseline vacuum/pressure measurements will be collected from the test well and at nearby soil gas monitoring wells, PSV-1 and PSV-2 using gauges capable of measuring a change in vacuum of 0.01 in. of water. While the vacuum of approximately 40 in. water column (WC) is applied to SVE-1; the vacuum readings at the surrounding PSV wells will be recorded at 30-minute intervals. Performance measurements will be collected from the test well SVE-1 throughout the tests to monitor the performance of the extraction during the pilot tests including the following: vacuum, air velocity, VOC concentrations, air temperature, and relative humidity. The vacuum will be recorded using a Magnehelic^{TM} (or equivalent) vacuum gage at a sample port capable of reading up to 150 in. of water. The velocity measurement will be collected using an anemometer or Pitot Tube™ combined with a differential pressure gauge located near the sample port. Flow rates will be calculated based on the velocity measurement and the 4-inch pipe diameter at the sample measurement location. After the first stage of the test, the flow rate will be varied to provide additional information about the vadose zone properties. The second stage flow rate will be determined in the field considering the response observed during the first stage of the SVE test.

The readings at SVE-1 and the PSV wells will be collected concurrently with the direct-read, water level measurements at the nearby monitoring wells, MW-303, MW-304, MW-310 and TW-01 obtained from transducers installed in the wells. Solonist, Levelogger Gold Series 3001 (or equivalent), will be deployed using direct read cables, to allow for real-time viewing of the data at each of the monitoring locations during the pilot tests. Manual depth to water readings may be collected during the test at a wider network of groundwater monitoring wells, depending on the observations at the nearby wells. After completion of the SVE test at SVE-1, the well vacuums will be allowed to equilibrate in PSV-1 and PSV-2. VOC concentrations will be monitored using a PID after the blower and before the carbon treatment system. Air recovered from the subsurface during the SVE pilot test will be directed through the carbon treatment system. The recovered air stream effluent VOC concentrations were monitored using a PID every 30 minutes, at a minimum, throughout the duration of the test. The readings will be summarized in a field log-book.

One untreated air sample will be collected after 2-hours of operating the SVE test. The air effluent sample will be collected directly from the sample port, located before the GAC treatment unit, into a 1-liter summa canister to determine concentrations removed in the extracted vapors. A PID reading will be collected at the same time as the sample collection to provide a correlation between the PID readings and the total VOC concentration in the effluent. Each sample will be labeled with the sampling date, time and initials of the field sampler. The summa canister will be shipped to Eurofins Air Toxics, Inc. laboratory under chain-of-custody documentation for VOC analysis by TO-15 (5&20), including TPH-G and fixed gas analysis of oxygen, methane, and nitrogen by ASTM D-1946. All field sampling activities will be documented in a field notebook.

3.2 Short-Duration AS Step Test Procedure

Data from the AS pilot test will be used to determine the efficiency of oxygen delivery to the subsurface; radius of air sparging influence; overall effect on influence of different flow rates; and will also determine if there is significant influence due to the utility lines. The first step of the AS test consists of injecting air at ASW-1 using an air compressor, at a flow rate of approximately 10 cubic feet per minute (cfm). The resulting subsurface pressure, in pounds per square inch (psi) will be recorded.(psi). Throughout the test the pressure will be monitored to maintain a maximum allowable injection pressure of less than 1 psi per foot, in accordance with the U.S. Bureau of Reclamation guidance, to avoid fracturing the subsurface. The final injection pressure will be determined in the field, depending on the above-ground height of the equipment, and will not exceed 15 psi at during any step of the AS test.

The air will continue to be injected at the constant rate until the field parameters stabilize, or a period of 2-hours is reached. Changes in the following parameters will be measured at 15 minute intervals, at a minimum, during the first step of the test to evaluate the radius of influence (ROI) of the air sparging:

- Dissolved oxygen concentration at MW-302, TW-01, MW-310, and MW-304;
- Groundwater pressure (changes in groundwater elevation) at MW-302, TW-01, MW-310, and MW-304;
- Changes in visible conditions of well (such as bubbles) at TW-01Vadose zone pressure at PSV-1 and PSV-2,
- Changes in VOC field vapor concentration at PSV-1 and PSV-2.

During the second step of the AS test, the flow rate at ASW-1 will be increased from 10 cfm to 20 cfm. The resulting changes to the subsurface pressure will be monitored and recorded for the test well and in the surrounding well, as indicated in Step 1. The aquifer conditions will be observed over a period of 1-hour under the Step 2 conditions, unless the groundwater pressures stabilize in the surrounding wells before that time.

Following Step 2, Step 3 will consist of increasing the flow rate from 20 cfm to 30 cfm. The resulting pressure changes in the aquifer will be monitored and recorded as indicated for Step 1.

If the injection pressure within the test well ASW-1 increases to 15 psi during any of the Step tests, the flow rate will be reduced by 5 cfm and the test will be continued at the lowered flow rate. The results will be documented in a field notebook.

3.3 Combined AS/SVE Test Procedure

Following the completion of the individual short-duration pilot AS and SVE tests a combined AS/SVE test will be conducted. The operating rates of the combined test will be begin at the same Step 1 conditions observed during the individual test (assuming the initial conditions used for both short-duration tests were achievable), which includes the following:

- ASW-1: Air injected at 10 cfm and 10 psi;
- SVE-1: Air evacuated at vacuum the maximum achievable air flow rate.

The combined test will provide additional information about potential mass recovery, flow rates, and radius of influence at the Site, and moisture generated from the operation of both technologies simultaneously.

Measurements collected during the combined AS/SVE test will be consistent with each of the individual tests. Barometric pressure and ambient weather conditions, including temperature, relative humidity, precipitation, wet bulb and dew point data will be collected on an hourly basis during the course of the combined AS/SVE test.

Changes in pressure will be monitored during the combined test at PSV-1 and PSV-2 using a differential pressure gage, capable of reading pressure changes of 0.01 in. of water. Direct read pressure transducers will also be installed at surrounding groundwater monitoring wells MW-302, MW-304, MW-310, and TW-01.

The pilot test will be operated at the Step 1 operating rates for a minimum of 2-hours. One untreated air sample will be collected after 2-hours of operating the combined AS/SVE test. The air effluent sample will be collected directly from the sample port, located before the GAC unit, into a 1-liter summa canister to determine concentrations removed in the extracted vapors. Each sample will be labeled with the sampling date, time and initials of the field sampler.

After 2-hours, if conditions in the subsurface have stabilized, the operating rates will be varied to provide additional information about pressure changes in the subsurface and VOC removal rates of the combined system. If the conditions have not stabilized the test will be continued up to a maximum period of 4- hours. The operating conditions will be changed during the second stage of the test, to increase the air flow rate, injected at ASW-01, to the optimal level, determined during the short-duration test. The flow rate will be maintained at the optimal rate for a period of not less than 2-hours.

Before changing the operating conditions at any time during the test, an untreated air sample will be collected directly from the air effluent sample port, located before the inlet to the GAC, into a 1-liter summa canister, for VOC analysis by TO-15 (5&20), including TPH-G. The depth of water within the knockout tank will also be recorded, to determine the volume of water removed by the system under the conditions of operation.

After the pilot test, the summa canister samples will be shipped to the Eurofins Air Toxics, Inc. laboratory under chain-of-custody documentation for VOC analysis. All field sampling activities will be documented in a field notebook.

4.0 GROUNDWATER PUMPING PILOT TESTS

The hydraulic properties of the aquifer have been estimated in the past, however, the actual groundwater zone of influence and specific pumping capacity are unknown in the immediate vicinity of the Main Tank Farm. The pumping tests will be conducted at the Site to obtain the aquifer properties in the TX-03 area of the main tank farm. Data gathered during the pumping test will support determination of the following:

- The hydraulic properties of the aquifer, including conductivity, transmissivity, and storativity;
- Conditions of homogeneity within the aquifer;
- Optimal sustainable pumping rate at the site; and,
- Zone of influence for an individual extraction well at a sustainable pumping rate.

The following sections describe the technical approach and procedures that will be used to perform the aquifer pumping tests. Two aquifer pumping tests will be conducted at the Site, including: a step-drawdown test; and, a constant rate test.

4.1 Step Drawdown Pumping Test Procedure

A step-drawdown test will be performed to determine the optimal pumping rate that will be used to conduct the constant rate test and will also be used to estimate aquifer hydraulic properties. The step-drawdown test will consist of pumping groundwater from the test well, TW-01, starting at a low pumping rate, then pumping at successively higher rates and measuring the corresponding water level drawdown within the pumping well and at the adjacent monitoring wells.

The pumping rates that will be step-tested are 1 gallon per minute (gpm), 3gpm and 6 gpm using a Grundfos™ pump and controller. A valve will be installed in-line to control the flow. The pump will be connected to a gasoline-powered generator, located down-wind from the extraction well. Pumped groundwater will be directed into a storage tank for the duration of the test. The pumping rate will be maintained for a period of 2-hours at each step. If the pumping rate cannot be maintained for the duration of the test between the first and second step, then the second step will be decreased by 1 gpm. If the test cannot be maintained for the duration of the second test then the test will be terminated.

Base-line groundwater levels will be collected, as described in Section 2, before beginning the step-drawdown pumping tests. Water levels will be collected manually within the pumping well at 15 minute intervals for the duration of the test. Water levels may also be collected using a pressure transducers installed in select wells, to obtain data at the nearby wells at a more frequent interval at the following groundwater monitoring wells located in the vicinity of the extraction well: TX-03A, MW-302, MW-304, MW-310, and MW-307.

A groundwater sample will be collected from the test well, TW-01, following the completion of each step, immediately before the step is increased. The sample collection will follow the SOP described in Section 2. The groundwater samples will be analyzed for BTEX.

At the completion of the step test, or upon termination, the aquifer recovery will be monitored. The measurements will be collected every 5 minutes until the groundwater has recovered to within 10% of the original pre-test groundwater level measurement.

4.2 Constant Rate Pumping Test Procedure

A constant rate pumping test will be conducted to determine the efficiency and production rate of groundwater extraction at the Site as well as determine the zone of influence at a sustainable pumping rate. The constant rate test will consist of pumping groundwater from the proposed extraction well at a constant rate for a period of 6-hours and measuring the water level drawdown in the surrounding wells.

During the 6-hour constant rate pump test, water levels will be recorded at 20 minute intervals from the pumping well. Groundwater level measurements will be collected manually every 60 minutes or using pressure transducers installed within the following groundwater monitoring wells located in the vicinity of the extraction well: MW-302, MW-304, MW-310, TX-03A, and MW-307. Barometric pressure and ambient weather conditions, including temperature, relative humidity, precipitation, wet bulb and dew point data will be collected on an hourly basis during the course of the test.

One groundwater sample will be collected after pumping approximately 5-hours at the test well, TW-01, for analysis of TPH-Gx and BTEX.

Following the completion of the pumping test, the groundwater levels in the extraction well will be monitored for rebound at 10 minute intervals, until the groundwater levels have returned to within 10% of the groundwater elevation recorded before the constant rate pumping test was started.

The water generated during the pumping tests will be contained in a poly tank or 55-gallon drums for transport to a recycling facility.

5.0 BIOREMEDIATION TESTING

Currently there are several lines of evidence that indicate biodegradation is occurring at the site, including a decrease in the constituent concentrations over time and trends in the geochemical parameters monitored at the Site, such as dissolved oxygen, ORP, ferrous iron and sulfate. An enhanced bioremediation test will be conducted to provide the following additional data:

- Evidence that natural degradation is occurring;
- The rate of enhanced biodegradation, under aerobic conditions; and,
- The effective radius of influence of treatment from the test well, TW-01.

The enhanced bioremediation test will be started in November, approximately 3-monthsafter the AS/SVE and pumping tests are completed at the Site, and after pre-bioremediation groundwater sampling occurs at the Site.

5.1 Groundwater and Soil Gas Pre-Enhanced Bioremediation Testing

Groundwater samples will be collected from MW-304, MW-302, TW-01, and MW-310 using a standard low-flow sampling technique and a down-hole peristaltic pump. Groundwater static water level measurements will be collected before groundwater sampling begins at each location and field parameter measurements will be collected groundwater elevation, dissolved oxygen, ORP, conductivity, pH, temperature and ferrous iron. The groundwater monitoring data will be entered in a field log-book.

The pre-enhanced bioremediation groundwater samples will be submitted for the following analysis:

- BTEX by EPA 8260B;
- Gasoline-range hydrocarbons by NWTPH-Gx; and
- Dissolved iron and manganese by EPA 6000 series.

One trip blank and one duplicate sample will be collected for VOC analysis. The samples will be documented and handled considering SOP-2 (Appendix A). Each groundwater sample will be uniquely labeled and tightly sealed the sample jars and bottles. The groundwater samples will be stored on ice for transportation to the laboratory. URS will submit the samples to Accutest Laboratories, Inc., in San Jose, California for the analysis, under documented chain-of-custody procedures. The analytical results will be reported in a standard 14-day turn-around time.

The purge water generated during the sampling event will be collected and managed as Investigation Derived Waste per SOP-4 (Appendix A).

Two pre-enhanced bioremediation soil gas samples will be collected from wells PSV-1 and PSV-2, using a peristaltic pump. The purge volume will be a minimum of four volumes of the well. Following purging, a baseline soil gas sample will be collected from each of the PSV wells following the procedure described in SOP-6 (Appendix A).

Samples will be collected into 1-liter summa canisters. Each sample will be labeled with the sampling date, time and initials of the field sampler. To ensure the soil gas sample is representative of the air in the well, a tracer gas (propane) will be applied to the top of the well casing. The tracer gas will be used to serve as a quality assurance/quality control measure to verify the integrity of the samples. The soil gas samples will be shipped to the Eurofins Air Toxics, Inc. laboratory under chain-of-custody documentation for VOC analysis by TO-15 (5&20), including TPH-G. All field sampling activities will be documented in a field notebook.

5.2 Enhanced Bioremediation Test

An ancillary effect of conducting the AS/SVE and pumping pilot test at the site is an increase in the airflow within the subsurface, providing oxygen to stimulate biodegradation, especially for contaminants that are less volatile. The longer-term effects of the AS/SVE and pumping pilot tests will be evaluated, considering the results of the pre-enhanced bioremediation groundwater monitoring results that will be collected approximately 45 days after the AS/SVE and groundwater pumping pilot scale test are completed.

After the period of equilibration within the aquifer to observe the longer-term effects of the AS/SVE and pumping test , an enhanced biodegradation test will be conducted at the test site. The enhanced bioremediation test will be conducted by installing Adventus®, EHC-O™ at pumping test well, TW-01. The EHC-O™ will be gradually administered into the test well over a period of 3-months using the O-SOX™ delivery system, which includes installing a 4-inch EHC-O™ sock, inside a canister within the test well. An example of the EHC-O™ sock is shown in Appendix C.

Static water levels and groundwater field parameter measurements will be collected in the test area on a monthly basis, beginning one month following the installation at MW-304, MW-302, ASW-1 and MW-310 to determine trends in the following: groundwater elevation, dissolved oxygen, ORP, conductivity, pH, temperature and ferrous iron.

After a duration of 3-months, the canister and EHC-O™ sock will be removed from the test well and a post-enhanced bioremediation groundwater sampling will be conducted at the Site, during the at MW-304, MW-302, ASW-1, MW-310, and test well TW-01. The post-enhanced bioremediation groundwater samples collected at the site will be submitted for the following analysis:

- BTEX by EPA 8260B;
- Gasoline-range hydrocarbons by NWTPH-Gx; and
- Dissolved iron and manganese by EPA 6000 series.

The post-bioremediation samples will be collected using low-flow groundwater sampling methods. Field parameters will be recorded at each of the groundwater monitoring locations for ORP, conductivity, pH, temperature, and ferrous iron.

The sock and other waste generated during the test will be contained in a 55-gallon drum for disposal. All field sampling activities will be documented in a field notebook.

6.0 REPORTING

A report will be prepared summarizing the results of the field work. In general, the report will include:

- A summary of the field work and field methods;
- Figures showing sampling locations and final well installation locations;
- Well logs;
- Copies of the laboratory reports; and
- Tables summarizing field data generated during the pilot testing activities.

The additional findings for each of the pilot tests that will be described in the report are summarized in the following sections.

6.1 AS/SVE Pilot Tests

Vacuum and pressure data collected from the test wells and surrounding wells during the AS and SVE and combined AS/SVE pilot tests will be evaluated to determine the effectiveness of each of the technologies. The key parameters that will be reported from the AS and SVE tests will include the following:

- Optimal well configurations;
- Achievable and optimal air flow rates and equipment requirements to achieve optimal air flow rates;
- Effective radius of influence for individual and combined AS and SVE treatment systems;
- Air discharge treatment requirements; and,
- Quantity of condensate water generated by system.

The results will also be reviewed to qualitatively determine differences in permeability and soil heterogeneities within the subsurface. Specifically, for data generated by the SVE test, the baseline and final VOC air sampling results will be used to calculate the VOC mass present in the subsurface. A comparison of the baseline VOC concentrations and the final VOC concentrations at the test well will be used to evaluate the overall performance of the SVE and provide additional information about the potential rate of treatment using a full-scale system.

6.2 Pumping Pilot Tests

URS will also generate several localized groundwater elevation contour maps for the shallow water zone beneath the TX-03A area using to compare the baseline data to the data collected at individual times throughout the pump tests.

Aquifer tests from the pumping tests will be analyzed to estimate the hydraulic properties in the aquifer, including groundwater velocity, porosity, and storativity. If needed, the aquifer test data will be corrected for barometric pressure and tidal effects, prior to data analysis. The analytical solutions to the hydraulic properties will be determined from the following methods, depending on the final data set:

- Theis (1935) type curve solution (Theis, 1935);
- Cooper-Jacob (1946) straight line solution (Cooper-Jacob,1946);
- Theis straight line solution for residual drawdown during recovery (Theis, 1935);
- Neuman unconfined aquifer solution with consideration for delayed yield (Neuman, 1975); and,
- Theis type curve solution for drawdown in a pumping well during a step drawdown test including linear and non-linear well losses (Theis, 1935).

Curve matching will be performed using the visual AQTESOLV™ aquifer test software. The results of the analytical solution and determination of the hydraulic properties will be compiled to determine the following:

- The optimal pumping rate for the system;
- Infrastructure requirements for a full-scale system, based on the pumping rate;
- Number of pumping wells needed for a system to obtain plume capture; and,
- Groundwater treatment requirements for pumped groundwater.

6.3 Enhanced Bioremediation Test

The results of the enhanced bioremediation tests will be used to calculate site-specific biodegradation rates of dissolved hydrocarbons (BTEX) in ground water, considering EPA guidance (EPA, 1999), and other technical literature that describe the methods for deriving rates constants based on the observed concentration trends.

Data trend charts will be created to evaluate the concentration versus time at each of the individual wells tested and concentration versus distance for each of the constituents evaluated. The EPA natural attenuation model, BIOSCREEN, will also be used to simulate the first-order attenuation of the dissolved contaminants at the Site.

The overall time for clean-up using enhanced aerobic biodegradation will be estimated, considering the predications of the degradation rate constants and the overall radius of influence of the enhanced biodegradation considering the site specific aquifer properties obtained from the groundwater pumping tests.

7.0 REFERENCES

Cooper, H.H. and C.E. Jacob, 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History, Am. Geophys. Union Trans., vol. 27, pp 526-534.

Ecology, 1998. Exhibit B, Cleanup Action Plan (CAP), Equilon Seattle Sales Terminal, Harbor Island Site, Seattle, Washington. Issued by Washington State Department of Ecology (Ecology), September 28.

Ecology, 2012. *Ecology Recommendations for Proposed Additional Subsurface Investigation at TX-03A Area at Shell Seattle Distribution Terminal Harbor Island*, Consent Decree No. 99-2-07176-0SEA. October 23.

EMCON, 1997. *Remedial Investigation Report, Texaco Harbor Island Terminal, Seattle, Washington*. Prepared by Emcon for Texaco Refining and Marketing, Inc. May 13, 1997.

EPA, 1999, *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies:* Washington, D.C., U.S. Environmental Protection Agency.

KJC, 1990a. Seattle Engineering Department. *Attachment I, Sediment Sampling and Analysis Program. Harbor Island Storm Drain System.* September.

KJC, 1990b. Seattle Engineering Department. *Attachment II, Stormwater Sampling and Analysis Program. Harbor Island Storm Drain System.* September (partial report only).

KJC, 1990c. *Contaminant Source Tracing Investigation. Harbor Island Storm Drain System.* September.

Lovely Consulting, Inc. (LCI) and EMCON. 1997. *Final Focused Feasibility Study Report*, Texaco Harbor Island Terminal, Seattle, Washington. May 15.

Neuman, S.P., 1975. Analysis of Pumping Test Data from Anisotropic Unconfined Aquifers Considering Delayed Yield, Water Resources Research, Vol. 11, no. 2, pp. 329-342.

SPU, 2012. Public records from the Drainage and Wastewater Engineering Section of Seattle Public Utilities. November 19.

Theis, C.V., 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage, AM. Geophys. Union Trans., vol. 16 pp.519-524.

URS, 2012a. *Limited Subsurface Investigation,* Shell Harbor Island Terminal, Well TX-03A Area, Seattle, Washington. January 19.

URS, 2012b. *Annual Compliance Monitoring Report – 2010-2011.* Shell Seattle Distribution Terminal, Seattle, Washington. February.

URS, 2012c. *Work Plan, Additional Limited Subsurface Investigation*, TX-03A Area, Shell Harbor Island Terminal, Seattle, Washington. October 23.

URS, 2013. *Work Plan, Soil Gas Assessment*, TX-03A Area, Shell Harbor Island Terminal, Seattle Washington, March 27, 2013.

TABLES

TABLE 1
Summary of Source Identification Tasks and Potential Remedial Technologies by Media
for Shell Harbor Island Terminal

		Description	General Costs	Cost Drivers	Advantages	Disadvantages	Unknowns	Additional Data Requirements/Proposed Activities
1) POTENTIAL SOIL TREATMENT TECHNOLOGIES								
1a	Soil Vapor Extraction (SVE)	Shallow SVE wells would be placed within the source area. Wells would be spaced approximately 40 feet apart and screened between 4 feet and 6 feet bgs or in shallow horizontal trenches along property boundaries. The system would remove volatile vapors from the SVE wells at approximately 40-inches of water.	$20-$40/CF Treated Estimate of approximately $60,000 for a 5-VE well system without treatment. (Does not include follow-up monitoring.)	Quantity of material to be treated Soil Type Exhaust treatment requirements	Reduces VOC mass through less invasive treatment approach. Installation can be completed to minimize intrusion. Reduced worker exposure during implementation.	Implementation may take longer than a year, during which time additional VOC leaching to groundwater might occur. Limited effectiveness for heaver petroleum carbon fractions. VOC rebound may occur in the subsurface. Additional treatment requirements for extracted vapors. Does not provide definitive confirmation of remedy completeness.	Source area and location is not known, so actual SVE configuration cannot be determined. Actual effectiveness and radius of influence of the SVE within the are of impacted soil. VOC concentrations in off-gas is not known, so cannot determine if off-gas treatment is necessary, which greatly affects the cost. Timeframe to complete the remedy depends on the source conditions. Availability of electrical connections.	Conduct Soil Vapor Extraction Pilot Test (Assumes up to two shallow wells for test and exhaust sample analysis).
1b	Excavate and Off-Site Disposal	VOC impacted soil would be excavated in the vicinity of the source area, up to an estimated maximum depth of up to 10 feet below grade. Clean fill would be replaced in the excavation. The impacted soil would be transferred off-Site to the transfer facility and transferred from there to a permitted landfill as a non-hazardous waste. Shoring may be required around the perimeter of the excavation.	$175-$350/CY Area of 30X50 Estimated to be about $260/CY	Total Quantity/weight Accessibility Disposition	Removes VOC mass at the Site through soil excavation and reduces future potential for VOCs leaching to groundwater. Similar approach to prior successful remedy implementation at the Site near MW-308. Provides easy access to impacted groundwater in the vicinity of excavation for additional dissolved phase treatment. Sidewall samples can be collected easily to verify all the impacted soil is removed. Readily available equipment, personnel and proven technology.	Shoring requirements may be necessary during excavation. VOCs may not be accessible if they are located below tanks. Does not actually reduce mass, just transfers mass to landfill.	The source area is not known. The density of the soil to be removed is not known. The concentrations of the waste and waste disposition are not known. Ability to remove all soil even if shoring is placed.	Collect soil sample (hand auger) from up to two source areas to determine Waste disposition and soil density.
2) POTENTIAL GROUNDWATER TREATMENT TECHNOLOGIES								
2a	Enhanced Bioremediation	Installation of nutrient injection wells, at an estimated spacing of 15-feet within source area. Nutrients would be administered to each of the injection wells. Additive choices may include: RPI BOS200® or FMC EHC-O.	$40-$80/ 1000 Gallons Treated BOS200 - $5.50/Lb ECH-O - $5.00/Lb Estimate of $100,000 to $125,00 for source area of 30 x 50 feet. (Does not include follow-up monitoring.)	Surface Area for Treatment Depth to Groundwater Residual TPH and BTEX Concentrations Product selected	Low cost treatment approach. Conditions in the impacted areas, including the former excavation area are favorable to support enhanced bioremediation. Health and safety concerns are minimized during implementation. Can be used in combination with excavation by placing amendment at bottom of excavation. Application of BOS200 would only require one injection. Benefits larger area as GW migrates downgradient.	Implementation may take longer than a year, during which time groundwater migration may occur. May not be effective in acidic groundwater environments. Additional monitoring parameters are required to provide evidence of progress.	Colony count for petroleum degrading bacteria, nitrogen data and COD/BOD or Fraction of organic carbon is not available for the Site to determine organic demand and the optimal remediation product. Timeframe for the biodegradation is not known and may be difficult to predict if trespasser plumes occur during treatment timeframe. Aquifer properties are not known, for injection purposes.	Collect soil sample near the groundwater interface and analyze for TOC and COD. Collect groundwater sample in the vicinity of up to two source areas and analyze for BTEX/TPH and natural attenuation parameters including: colony count, manganese, nitrate, sulfate and TOD/COD Conduct injection or pump test to verify aquifer properties to determine effectiveness.
3b	Air Sparging	Inject air into subsurface to strip VOCs from groundwater. Air would be injected at about 5 CFM per well through stingers installed by HSA at depths of approximately 15-18 feet below grade. Air would be injected using a compressor routed through above grade piping to the subsurface wells spaced at approximately 25 foot radii, assuming homogeneous subsurface conditions with effective porosity of approximately 35% and good accessibility.	$20 - $60/CY Treated Estimate of approximately $90,000 for a 6-sparge well system. (Does not include follow-up monitoring.)	Treatment Area Residual TPH and BTEX Concentrations Depth to Groundwater	Proven technology to reduce VOC concentrations in groundwater. Remedy takes approximately up to 2 years. Easy to install and operate. Can enhance natural attentuatio by supplying additional oxygen to the subsurface.	Rebound may occur, requiring longer time periods for treatment. Additional recovery and treatment of vapors may be necessary.	Source areas are not entirely delineated. Actual number of wells and size of system will be based on radius of influence determined from a pilot test and overall source area. Actual porosity and homogeneity of subsurface is not known.	Conduct Air Sparging Pilot Test to determine radius of influence for Air Sparging and optimal delivery rate (may be conducted in concert with SVE pilot test).
2c	SVE	Shallow SVE wells would be placed within the source area. Wells would be spaced approximately 40 feet apart and screened between 4 feet and 6 feet bgs or installed as horizontal recovery trenches along property boundaryies. The system would remove volatile vapors from the SVE wells at approximately 40-inches of water.	$20-$40/CF Treated Estimate of approximately $60,000 for a 5-VES well system without treatment. (Does not include follow-up monitoring.)	Residual TPH and BTEX Concentrations Soil Type Exhaust treatment requirements	Reduces VOC mass through less invasive treatment approach. Can be used in combination with other technologies to reduce overall cleanup time. Installation can be completed to minimize intrusion. Reduced worker exposure during implementation.	Implementation may take longer than a year, during which time additional VOC leaching to groundwater might occur. Limited effectiveness for heaver petroleum carbon fractions. VOC rebound may occur in the subsurface. Additional treatment requirements for extracted vapors may be necessary. Under anisotropic conditions vapors may migrate away from the Site. Does not provide definitive confirmation of remedy completeness.	Source areas are not entirely delineated. Actual radius of influence of the SVE within the are of impacted soil is needed to determine SVE system layout requirements and effectiveness. Effect of utilities in creating preferential pathways for impacted vapors is not known. VOC concentrations in extracted vapors is not known, so cannot determine if off-gas treatment is necessary, which greatly affects the cost.	Conduct Soil Vapor Extraction Pilot Test (Assumes up to three shallow soil gas monitoring wells for test).
2d	Groundwater Extraction and Treatment	VOC-impacted groundwater would be pumped from extraction wells for aboveground treatment through cascading sparge stripper or granular activated carbon. Lateral hydraulic control is established by pumping.	$0.25/Gallon Treated Current volume of groundwater estimated at approximately $4Million gallons, assuming porosity of 40%.	Pumping Rate Groundwater Concentrations Presence of Iron (groundwater quality)	Effective and proven technology at removing VOCs from subsurface. Permeable aquifer would produce higher volume for more effective removal. Surfactant could be employed to enhance residual removal from smear zone.	Long time period required to implement remedial action. May cause VOCs from other source areas, to migrate into pumping zone. High operation and maintenance costs. Iron fouling may occur in pumping wells requiring routine maintenance.	Source areas are not entirely delineated. Actual aquifer properties, including velocity and storativity are not known. Actual radius of influence of the pumping well is not known.	Conduct Pumping Drawdown Test (assumes installation of up to one additional test well).
2e	In-Situ Oxidation	Injection of persulfate, activated with high pH or peroxide into source areas. Injection points would be space at approximately 15 feet, assuming an effective porosity of 35%, hydraulic conductivity of 7.5 feet per day and a maximum injection pressure of 7 pounds per square inches, assuming injection between 7 feet and 12 feet below grade. Would likely require up to three rounds of in-situ oxidant injections may be conducted over a period of 1-2 years.	**Not Currently Retained for Further Consideration:** General costs for implementation are $40-$170/ 10,000 gallons of groundwater treated, however, proximately to pipeline results in additional health and safety considerations.	Volume of material to be treated Concentrations of impacted groundwater Naturally occuring soil demand	Rapidly and completely degrades benzene and TPH in groundwater. Proven history for success at treating constituents of concern.	Change in aquifer pH and redox state may increase metal mobility temporarily. Precipitates may foul aquifer and reduce porosity locally. Solution may be corrosion of exiting utility lines and pipeline. Possibilooity of rebound for VOCs, requiring additional injections. Flammable hazard exists if fueling occurs in close proximity. Higher health and safety requirements to implement the treatment.	NA	NA

Notes:

AS = air sparging

SVE = soil vapor extraction

VOCs = volatile organic compounds

% = percent

TOC = Total Organic Carbon
BOD = Biological Oxygen Demand
COD = Chemical Oxygen Demand
TPH = Total Petroleum Hydrocarbons
BTEX = Benzene, Toluene, Ethylbenzene, and Xylene

Table 2
BTEX, TPH, and Natural Attenuation Parameters in Groundwater
TX-03A Area
Seattle, Washington

Well ID/ TOC Elevation	Depth to Water (ft)	Groundwater Elevation (ft)	Sample Date	Chemical (mg/L)												
				Benzene	**Toluene**	**Ethylbenzene**	**Total Xylenes**	**Gasoline Range Hydrocarbons**	**Diesel Range Hydrocarbons**	**Motor Oil Range Hydrocarbons**	**Methane**	**Carbon Dioxide**	**Iron**	**Total Hardness**	**Total Alkalinity**	**Sulfate**
MW-101	12.18	6.03	10/27/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.0936	< 0.10	NA	NA	NA	NA	NA	NA	NA
18.21	9.95	8.26	11/26/12	<0.00020	<0.00020	<0.00020	<0.00046	0.188 j	0.0937 j	<0.10	NA	NA	NA	NA	NA	NA
	10.24	7.97	02/21/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	10.89	7.32	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-102	9.59	6.01	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.113	NA	NA	NA	NA	NA	NA	NA
15.60	7.08	8.52	11/28/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050 uj	<0.050	NA	NA	NA	NA	NA	NA	NA
	7.88	7.72	02/21/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	8.40	7.20	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-201	13.10	7.08	11/27/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	0.122	<0.10	NA	NA	NA	NA	NA	NA
20.18	13.74	6.44	02/21/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	14.45	5.73	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-202	14.53	5.33	10/26/11	NA	NA	NA	NA	**4.3**	1.02	NA	NA	NA	NA	NA	NA	NA
19.86	13.6	6.26	03/01/12	0.0053	0.0019	0.0107	0.0013 j	**3.87**	NA	NA	NA	NA	NA	NA	NA	NA
	13.75	6.11	06/13/12	NA	NA	NA	NA	**3.31**	1.54	NA	NA	NA	NA	NA	NA	NA
	14.42	5.44	09/26/12	0.0058	0.0029 j	0.0378	<0.0018	**4.07**	NA	NA	NA	NA	NA	NA	NA	NA
	13.09	6.77	11/27/12	0.0113	0.0034	0.0274	0.0022	**6.07**	2.67	<0.30	1.07	10.6	35.9	101	110	15.0
	13.27	6.59	02/21/13	NA	NA	NA	NA	**NA**	NA	NA	NA	NA	NA	NA	NA	NA
	13.80	6.06	05/15/13	NA	NA	NA	NA	**3.83**	1.62	<0.19	NA	NA	NA	NA	NA	NA
MW-203	8.53	5.46	10/26/11	NA	NA	NA	NA	**1.38**	0.262	NA	NA	NA	NA	NA	NA	NA
13.99	7.70	6.29	06/13/12	NA	NA	NA	NA	0.459	0.134	NA	NA	NA	NA	NA	NA	NA
	7.25	6.74	11/27/12	NA	NA	NA	NA	**1.05**	0.0943 j	<0.10	0.582	16.7	21.2	140	170	24.4
	7.26	6.73	02/21/13	NA	NA	NA	NA	**NA**	NA	NA	NA	NA	NA	NA	NA	NA
	7.80	6.19	05/15/13	NA	NA	NA	NA	0.144 j	< 0.048	< 0.19	NA	NA	NA	NA	NA	NA
MW-204	10.81	6.46	11/27/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	0.975	<0.10	NA	NA	NA	NA	NA	NA
17.27	10.81	6.46	02/21/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	11.30	5.97	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-206A	10.31	5.59	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.141	NA	NA	NA	NA	NA	NA	NA
15.90	9.05	6.85	11/27/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	0.116	0.111 J	NA	NA	NA	NA	NA	NA
	9.04	6.86	02/21/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	8.44	7.46	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-301	6.91	5.62	11/08/11	**0.174**	0.012	0.0098	0.011	**2.77**	0.274	NA	NA	NA	NA	NA	NA	NA
12.56	5.98	6.58	03/01/12	**0.24**	0.0138	0.0099	0.0212	**3.37**	NA	NA	NA	NA	NA	NA	NA	NA
	6.08	6.48	06/12/12	**0.57**	0.0156	0.0183	0.0244	**4.18**	NA	NA	NA	NA	NA	NA	NA	NA
	6.83	5.73	09/25/12	**0.333**	0.0131	0.0186	0.0192	**4.02**	NA	NA	NA	NA	NA	NA	NA	NA
	5.32	7.24	11/28/12	**0.241**	0.0099	0.0125	0.0106	**2.76**	NA	NA	NA	NA	NA	NA	NA	NA
	5.66	6.90	02/21/13	**0.659**	0.0175	0.0264	0.0173 J	**3.98**	0.315	<0.10	NA	NA	NA	NA	NA	NA
	6.14	6.42	05/15/13	**0.357**	0.0122	0.0231	0.0145	**3.63**	NA	NA	NA	NA	NA	NA	NA	NA
MW-302	7.29	5.56	11/08/11	**0.787**	0.0187	0.156	0.149	**5.46**	0.721	NA	NA	NA	NA	NA	NA	NA
12.85	6.4	6.45	03/01/12	**0.831**	0.0275	0.213	0.248	**5.33**	NA	NA	NA	NA	NA	NA	NA	NA
	6.58	6.27	06/28/12	**1.23**	0.0437	0.403	0.289	**5.65**	NA	NA	NA	NA	NA	NA	NA	NA
	7.21	5.64	09/25/12	**0.657**	0.0247	0.180	0.106	**4.07**	NA	NA	NA	NA	NA	NA	NA	NA
	5.93	6.92	11/25/12	**0.449**	0.0152	0.191	0.177	**4.58**	NA	NA	NA	NA	NA	NA	NA	NA
	6.10	6.75	02/22/13	**0.393**	0.0149	0.124	0.116	**4.15**	0.435	<0.10	NA	NA	NA	NA	NA	NA
	6.61	6.24	05/14/13	**0.873**	0.0231	0.236	0.145	**4.19**	NA	NA	NA	NA	NA	NA	NA	NA
MW-303	6.93	5.71	11/08/11	**1.37**	0.0358	0.295	0.11	**8.57**	0.799	NA	NA	NA	NA	NA	NA	NA
12.64	4.94	7.70	03/01/12	**3.13**	0.0759	0.76	0.232	**12.3**	NA	NA	NA	NA	NA	NA	NA	NA
	6.06	6.58	06/13/12	**2.90**	0.0957	0.884	0.268	**12.5**	NA	NA	NA	NA	NA	NA	NA	NA
	6.84	5.80	09/25/12	**1.83**	0.0635	0.474	0.146	**9.14**	NA	NA	NA	NA	NA	NA	NA	NA
	5.20	7.44	11/28/12	**1.94**	0.0873	1.18	0.319	**12.6**	NA	NA	NA	NA	NA	NA	NA	NA
	5.58	7.06	02/21/13	**2.34**	0.0955	1.29	0.338	**12.8**	0.674	<0.10	NA	NA	NA	NA	NA	NA
	6.10	6.54	05/16/13	**1.900**	0.0864	0.983	0.272	**10.6**	NA	NA	NA	NA	NA	NA	NA	NA
MW-304	7.01	5.69	11/08/11	**0.74**	0.0164	0.0723	0.0652	**4.24**	0.675	NA	NA	NA	NA	NA	NA	NA
12.70	6.06	6.64	03/01/12	**0.686**	0.0351	0.214	0.264	**5.64**	NA	NA	NA	NA	NA	NA	NA	NA
	6.20	6.50	06/12/12	**1.04**	0.0408	0.270	0.218	**5.98**	NA	NA	NA	NA	NA	NA	NA	NA
	6.96	5.74	09/25/12	**0.630**	0.0240	0.198	0.105	**3.93**	NA	NA	NA	NA	NA	NA	NA	NA
	5.41	7.29	11/28/12	**0.411**	0.0244	0.306	0.252	**5.89**	NA	NA	NA	NA	NA	NA	NA	NA
	5.78	6.92	02/22/13	**0.507**	0.0225	0.208	0.149	**5.56**	0.762	0.186 j	NA	NA	NA	NA	NA	NA
	NA	NA	05/16/13	**0.645**	0.0283	0.209	0.144	**4.73**	NA	NA	NA	NA	NA	NA	NA	NA
MW-307	7.95	7.67	11/26/12	**2.15**	0.0858	0.833	0.513	**10.9**	NA	NA	7.92	16.0	33.5	84.9	144	1.5
15.62	8.42	7.20	02/22/13	**0.497**	0.0358	0.226	0.145	**6.02**	0.604	<0.094	NA	NA	NA	NA	NA	NA
	8.91	6.71	05/15/13	**0.437**	0.0461	0.167	0.120	**4.56**	NA	NA	NA	NA	NA	NA	NA	NA
MW-308	7.90	7.69	11/26/12	**0.144**	0.0010 j	0.0072	0.0013 j	0.778	NA	NA	2.49	6.17	0.542	384	298	97.0
15.59	8.22	7.37	02/22/13	**0.668**	0.0078 j	0.0443	0.0059 j	**3.48**	0.354	<0.10	NA	NA	NA	NA	NA	NA
	8.80	6.79	05/15/13	**0.392**	0.0052 j	0.0427	<0.0046	**2.54**	NA	NA	NA	NA	NA	NA	NA	NA
MW-309	5.38	7.29	11/28/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	NA	NA	0.188	7.34	36.6	94.7	84.0	32.1
12.67	5.73	6.94	02/21/13	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	0.0790 j	<0.10	NA	NA	NA	NA	NA	NA
	6.21	6.46	05/17/13	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	NA	NA	NA	NA	NA	NA	NA	NA
MW-310	6.40	7.12	11/28/12	**0.86**	0.0265	0.211	0.147	**5.74**	NA	NA	6.7	13.3	29.3	132	158	<0.50
13.51	6.78	6.73	02/21/13	**1.8**	0.0768	0.506	0.18	**8.37**	0.603	<0.10	NA	NA	NA	NA	NA	NA
	7.20	6.31	05/14/13	**0.993**	0.0703	0.654	0.175	**6.49**	NA	NA	NA	NA	NA	NA	NA	NA
TES-MW-1	10.45	5.59	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	< 0.10	< 0.20	NA	NA	NA	NA	NA	NA
16.15	8.62	7.53	11/26/12	<0.00020	<0.00020	<0.00020	<0.00046	<0.050	<0.050	<0.10	NA	NA	NA	NA	NA	NA
	9.46	6.69	05/16/13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TX-03A	-	-	10/27/11	**3.44**	0.0712	0.147	0.111	**8.51**	NA	NA	NA	NA	NA	NA	NA	NA
12.26	5.84	6.42	03/01/12	**1.74**	0.0261	0.0272	0.0345 j	**5.58**	NA	NA	NA	NA	NA	NA	NA	NA
	5.97	6.29	06/12/12	**1.57**	0.020 j	0.0139 j	0.030 j	**6.78**	NA	NA	NA	NA	NA	NA	NA	NA
	6.66	5.60	09/25/12	**1.70**	0.0298	0.0410	0.0501	**5.53**	NA	NA	NA	NA	NA	NA	NA	NA
	5.20	7.06	11/28/12	**1.18**	0.0188 j	0.0232	0.0357 j	**4.91**	NA	NA	6.08	16.4	33.9	127	164	<0.50
	5.55	6.71	02/21/13	**2.81**	0.0403	0.0421	0.0489 j	**8.2**	0.32	<0.10	NA	NA	NA	NA	NA	NA
	6.01	6.25	05/15/13	**2.15**	0.0459 j	0.189	0.0643 j	**3.11**	NA	NA	NA	NA	NA	NA	NA	NA
Cleanup Level^a (mg/L)				0.071	200	29	NE	1	10	10	NE	NE	NE	NE	NE	NE

Notes:

Bolded values indicate concentrations exceeding the associated Cleanup Level.
< = concentration undetected at the method detection limit.
[a] Cleanup levels per the Cleanup Action Plan (Ecology, 1998).
BTEX = Benzene, Toluene, Ethylbenzene, Total Xylenes
ft = feet
j = Laboratory qualifier; indicates an estimated value
mg/L = milligrams per liter
NA = Not Analyzed
NE = Not Established
TOC = Top of Casing
TPH = Total Petroleum Hydrocarbon
uj = The analyte was not detected above the sample method detection limit; however, the method detection limit is approximate.
aj = Diesel pattern is not present; higher boiling gasoline compounds in Diesel range.

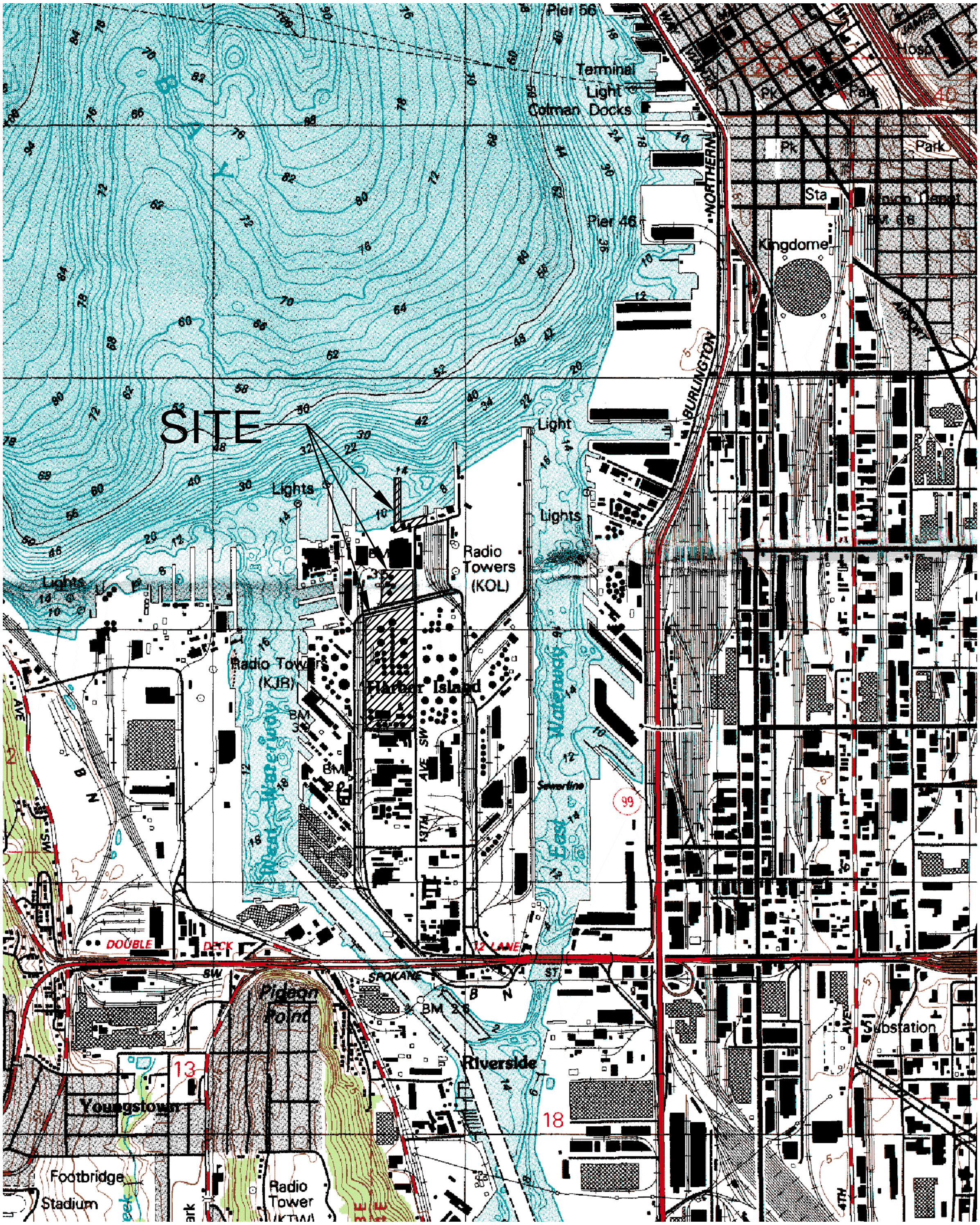
Table 3
Samples Containers, Methods, and Hold Time Requirements

Analysis	Analytical Method	Containers per Sample[1]	Preservation	Holding Time
Soil sample from TW-01 at well installation				
BTEX	EPA 8260B	1, 10 g EnCore Sampler	4±2ºC, MeOH	14 days to extract 40 days to analyze
Gasoline Petroleum Hydrocarbons	NWTPH-Gx			
TOC	SM5310B	8 oz WMGJ	4±2ºC	28 days
COD	EPA 410.4			
Percent Solids	EPA 1613B			
Soil vapor well samples from SVE-1, PSV-1, and PSV-2 and Untreated air effluent				
VOCs, including TPH-G	TO-15 (5&20)	1-L summa canister	None	30 days
Fixed Gas (Oxygen, Nitrogen, and Methane)	ASTM D-1946			
Groundwater Samples at test wells, ASW-1 and TW-01, and monitoring wells, MW-302, MW-304, MW-310, and MW-307				
BTEX	EPA 8260B	4-40 mLVOA vials	4±2ºC, HCL	14 days to extract 40 days to analyze
NWTPH-Gx	NWTPH-Dx			
Dissolved Iron and manganese	EPA 6020	1, 250-mL Poly , Field Filtered	4±2ºC, HNO3 to pH<2	6 months
TOC	SW9060	200 mL Poly	4±2ºC	28 days
BOD	SM 5210B	1000 mL Poly	4±2ºC	48 hours
COD	SM5220D	100 mL Poly	4±2ºC, H2SO4 to pH<2	28 days

Notes:

EPA = Environmental Protection Agency
WMGJ = Wide-mouth glass jar with Teflon-lined lid.
AG = amber glass
EPA = Environmental Protection Agency
TOC = total organic carbon
ml = milliliters
L = liter
°C = degrees celcius
H2SO4 = Sulfuric acid
HNO3 = nitric acid
BTEX = benzene, toluene, ethylbenzene, and xylene
SM = standard method
TPH-Gx = total petroleum hydrocarbon, gasoline fraction
BOD = biological oxygen demand
COD = Chemical oxygen demand
VOC = volatile organic compounds
MeOH = methanol

FIGURES



SOURCE: SEATTLE SOUTH, WASHINGTON USGS TOPOGRAPHIC QUADRANGLE 1983.

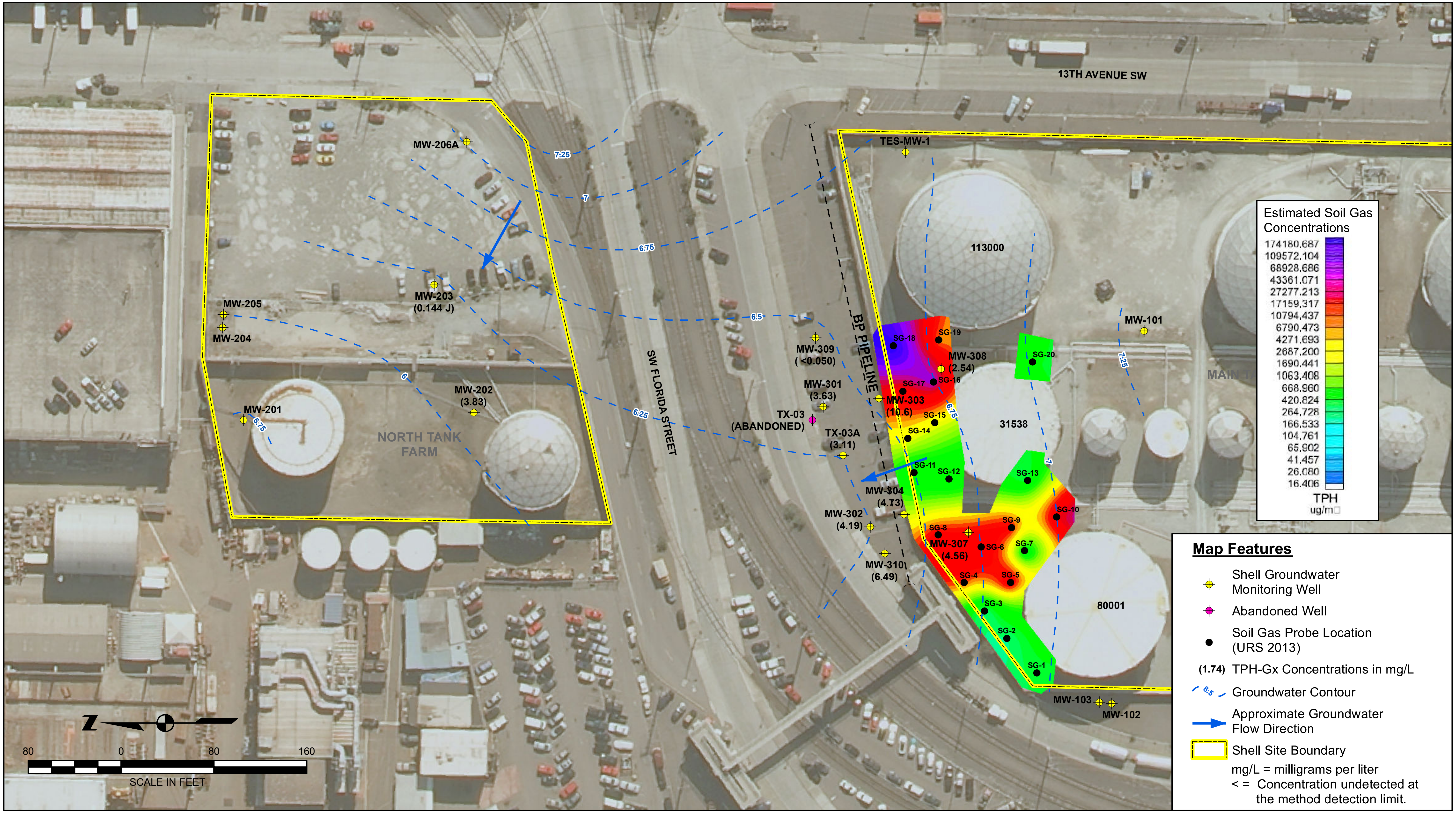
SITE VICINITY MAP

SHELL - HARBOR ISLAND TERMINAL
ANNUAL GROUNDWATER REPORT
SEATTLE, WASHINGTON

MARCH 2013
46194348

URS

FIGURE 1



Source: USGS, 2009.

K:\46194268_Seattle_Terminal\MXD\2013\2Q13\Fig 2 Gx Concentrations.mxd

URS

TX-03 AREA TPH CONCENTRATION MAP - MAY 2013

JUNE 2013
46194348

SHELL
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

FIGURE 2

Source: USGS, 2009.

K:\46194268_Seattle_Terminal\MXD\2013\2Q13\Fig 3 BTEX Concentrations.mxd

URS

TX-03 AREA BTEX CONCENTRATION MAP - MAY 2013

JUNE 2013
46194348

SHELL
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

FIGURE 3

Map Features

⊕	Shell Groundwater Monitoring Well
⊕	Abandoned Well
●	Soil Gas Probe Location (URS 2013)
(2.15)	Benzene Concentrations in mg/L
6.5	Groundwater Contour
→	Approximate Groundwater Flow Direction
▭	Shell Site Boundary

mg/L = milligrams per liter
< = Concentration undetected at the method detection limit.

Source: USGS, 2009.

TX-03 AREA BENZENE CONCENTRATION MAP - MAY 2013

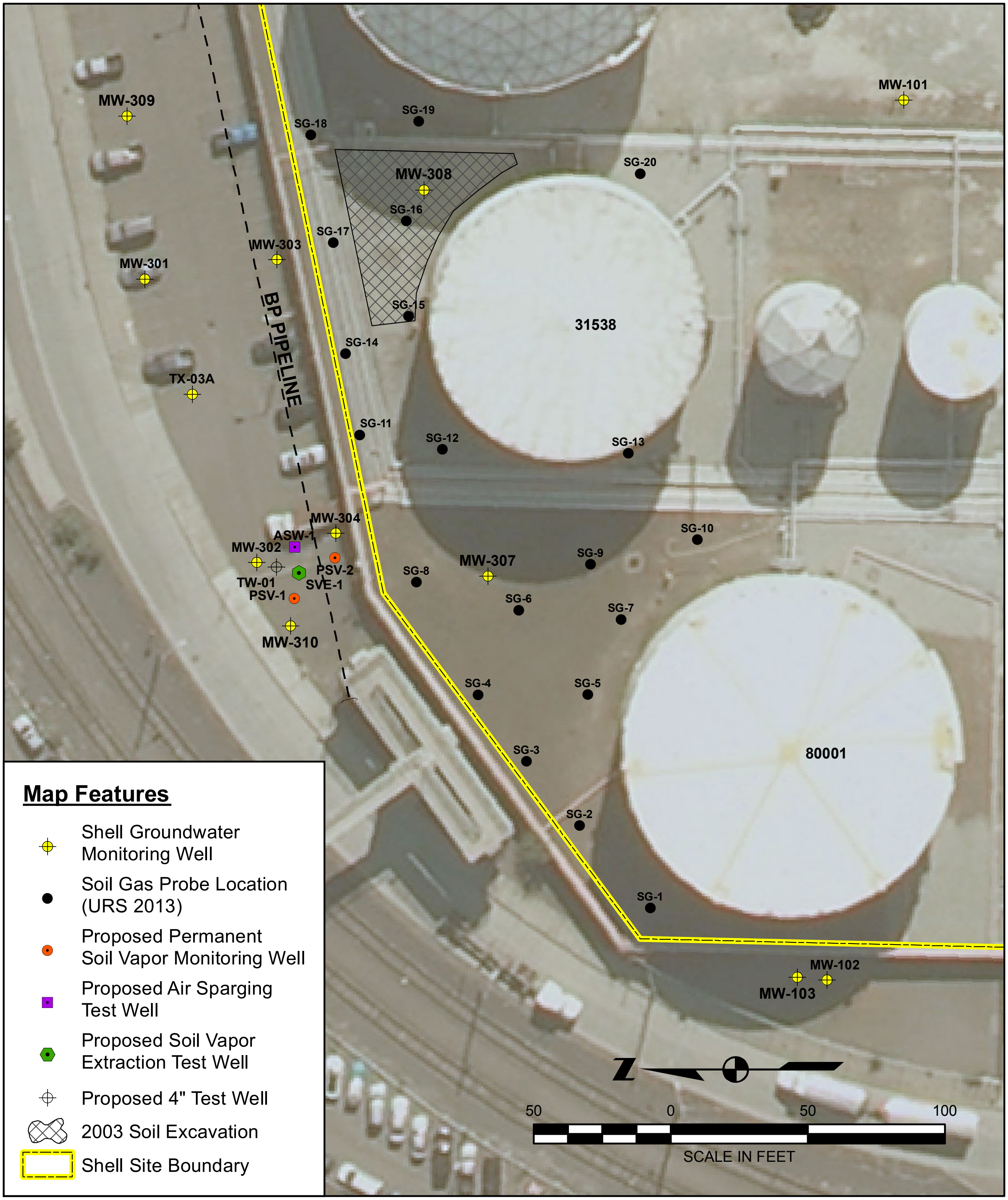
JUNE 2013
46194348

SHELL
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

URS

FIGURE 4

K:\46194268_Seattle_Terminal\MXD\2013\2Q13\Fig 4 Benzene Concentrations.mxd



Source: USGS, 2009.

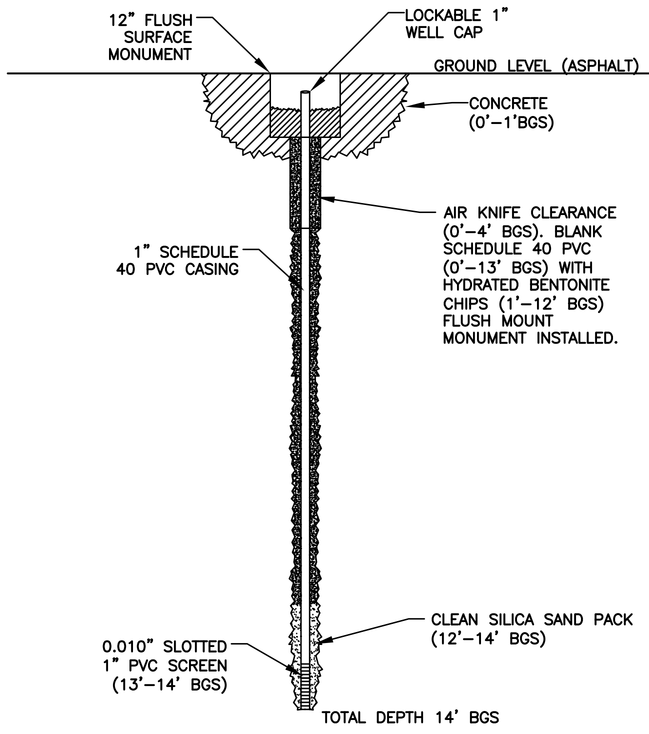
PROPOSED PILOT TEST WELL LOCATIONS

JULY 2013
46194348

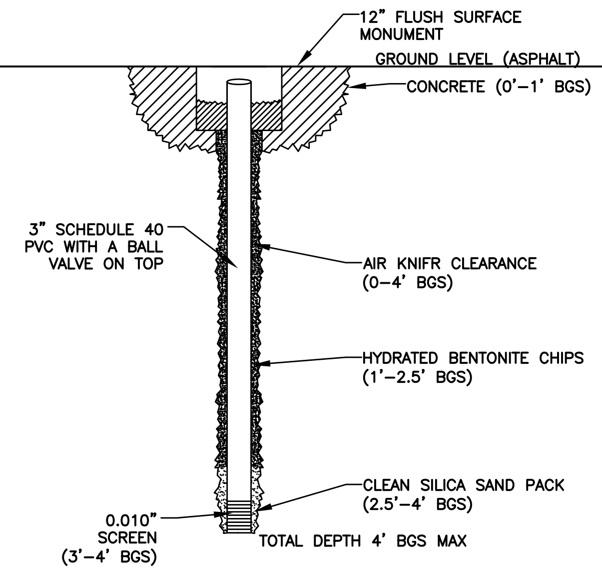
SHELL
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

FIGURE 5

K:\46194268 Seattle Terminal\MXD\2013\Proposed Pilot Test Wells.mxd

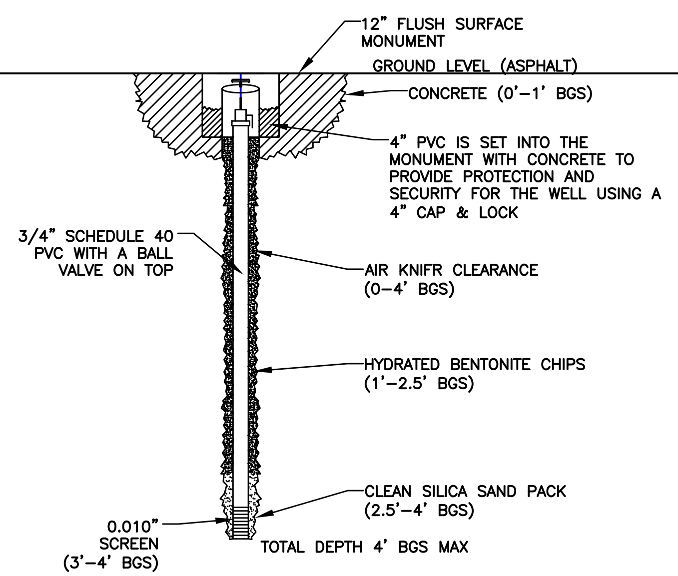


AIR SPARGING TEST WELL ① –
N.T.S.



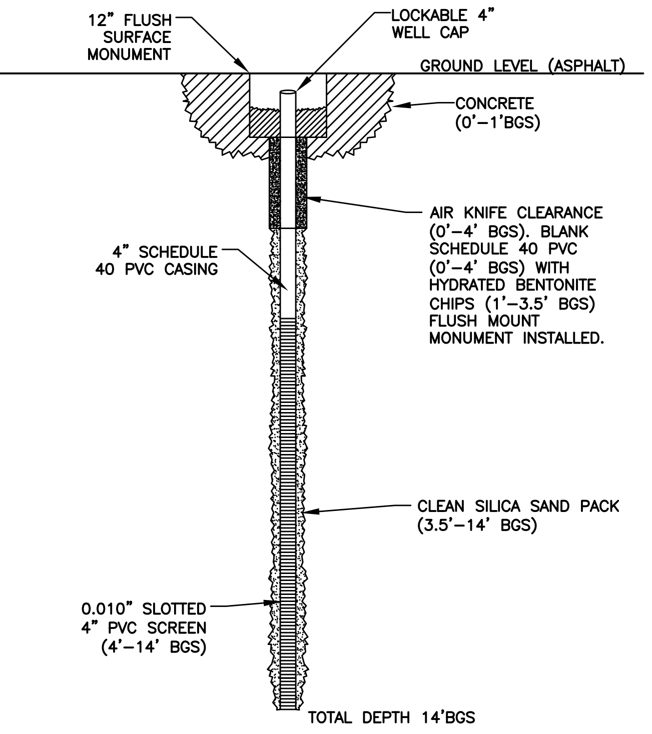
BGS= BELOW GROUND SURFACE

SOIL VAPOR EXTRACTION TEST WELL ② –
N.T.S.



BGS= BELOW GROUND SURFACE

PERMANENT SOIL VAPOR MONITORING WELL ③ –
N.T.S.



PUMPING TEST WELL ④ –
N.T.S.

URS

MONITORING WELL DIAGRAMS

SHELL
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

JULY 2013
46194348

FIGURE 6

O:\25211158 Shell\2012\2012 Terminals\46194315 Seattle Terminal\5000 Technical\TX-03A Area\Figures\Fig A Soil Gas Monitoring Well Diagram.dwg Jul 16, 2013 – 9:37am

SOIL CLASSIFICATION AND LOGGING OF SUBSURFACE CONDITIONS

Soil characteristics will be visually examined and described in the field in general accordance with the Unified Soil Classification System.

Specific sample criteria to be noted includes:

- Soil Name
- USCS Group Symbol
- Color (Munsell Soil Color Charts, revised 1992)
- Grain size and distribution
- Soil particle lithology
- Gradation
- Plasticity
- Bedding or sedimentary structures
- Chemical precipitates
- Organic material
- Moisture content
- Background odor

Other observations, such as field screening data, visual evidence of contamination or lack thereof, the presence of debris or seepage horizons will also be noted. Observations will be recorded on a Soil Boring Log form for future reference. When groundwater is first encountered during drilling activities, drilling will be stopped to measure the depth to groundwater below ground surface. Other information to be noted on the Soil Boring Logs include:

- Project name and location
- Project number
- Field technician's name
- Drilling rig and sampling method
- Date of drilling start and completion
- Boring number
- Boring location
- Sample collection intervals and identification numbers
- Water level measurement (date and time)

Activities of the Observing Technician During Drilling:

1. Record the name of the drilling contractor, the driller, driller's helper(s).
2. Record the type and make of the drill rig used.
3. Note the weather or any special external conditions, which influence the drilling.

4. Check the driller's daily records to verify their accuracy.
5. Examine soil samples and cuttings and make preliminary logs as the core is advanced.
6. Note date and time of all activities associated with the drilling.
7. Check that the methods used for drilling, well construction and decontamination conform to the project specifications.
8. Check that well construction materials conform to the project specifications.
9. The technician's daily record shall include, but may not be limited to, the following items:
   (a) Date and depth of hole at start and end of working day or shift.
   (b) Type and condition of bit.
   (c) Drilling rate.
   (d) Gain or loss of water, mud or air flush; type of cuttings.
   (e) Static water level at start and end of each working period.
   (f) Description of soil or strata penetrated.
   (g) Location of samples.
   (h) Details of delays and breakdowns.
   (i) Details of in-situ tests and instrumentation installed.
   (j) Backfilling and grouting.

GENERAL NOTES

Included under general notes shall be all significant observations that do not readily fit elsewhere on the log sheet.

SOIL SAMPLE SCREENING

Soil samples will be screened for evidence of volatile organic compounds using a portable photoionization detector or flame ionization detector. Before use, the instrument will be calibrated to a known concentration of calibration gas, in accordance with the manufacturer's specifications.

The manufacturer and model number of the instrument used will be recorded in the field logbook.

The following sequential steps will be completed for each soil sample analyzed:

1. Place a representative portion of freshly exposed, uncompacted soil into a clean resealable plastic bag. Fill the bag to approximately 50 percent capacity.
2. Seal the bag.
3. Allow the bag to sit at ambient temperature for three to five minutes.
4. Carefully insert the intake port of the analytical instrument through the plastic bag.
5. Record the sample concentration observed on the Soil Boring Log.

Calibration procedures:

Photoionization Detector: Initially, the PID will be zeroed using ambient air from the general area where the work will be done. A standard gas of 100 ppm isobutylene gas is then used to calibrate the PID. If questionable readings are encountered, the PID will be recalibrated using new 100 ppm isobutylene gas.

STANDARD OPERATING PROCEDURE
DECONTAMINATION

OVERVIEW

The purpose of this procedure is to ensure that all non-dedicated sampling, field screening, and water filtering equipment that contacts the sample material is clean and does not cause cross contamination between samples.

MOBILIZATION

Assemble the appropriate equipment.

- Alconox detergent (or equivalent)
- Potable water
- De-ionized water
- Three 5-gallon or larger buckets
- Two brushes
- 5-gallon garden sprayer
- Plastic sheeting
- Sealing plastic bags
- Drilling contractor provided equipment
- Steam cleaner
- Visqueen plastic
- Containment for steam cleaning water and removed soil

DECONTAMINATION

1) Drilling and well installation equipment:

- Set up a decontamination station at the location(s) designated by the Site representative.
- Verify that the drilling contractor has required equipment at the designated decontamination area and *thoroughly* cleans the equipment (inside and outside) with a high-pressure steam cleaning unit (water at 200° F and 1500 psi) prior to use at each boring/well location. All augers, drill steel, and drill casing should be decontaminated prior to use in each boring. Cleaned equipment should be placed on a visqueen covered surface following decontamination. Samplers can also be steamed clean in lieu of the decontamination procedure outlined below.
- Verify proper containment of water and soils generated by steam cleaning.
- Document decontamination procedures in the daily field report.

2) Sampling equipment during sampling:

- Rinse thoroughly with potable water.
- Scrub with Alconox/water wash to remove any visible dirt.

- Rinse with potable water.
- Double-rinse with deionized water.
- Replace wash and rinse water prior to sampling near each SWMU/AOC, or more often if warranted.
- Store in a clean area on visqueen plastic sheeting during sampling.
- Wrap in plastic for storage unless equipment will be used immediately.
- Document decontamination procedures in the daily field report.

DOCUMENTATION AND SAMPLE HANDLING

This section describes documentation and sample handling procedures. The procedures described are designed to provide a thorough record of events surrounding the collection of each sample, and to ensure, as far as can be accomplished in the field, that data collected are useable.

SAMPLE IDENTIFICATION AND LABELING

To provide a sample tracking mechanism, each sample collected will be given a sample identification number consisting of the well number. The site name and sampling date will not be included in the sample identification number because this information will be recorded in the field notes and on the sample label and chain-of-custody form.

Sample labels, whether blank or pre-printed, will contain an abbreviated summary of the logbook entry for the sample. The following information should be included on sample container labels:

- Sample identification number
- Date and time of sampling
- Type of sample preservatives added (if any)

SAMPLE CONTAINERS

Groundwater samples will be collected in glass or plastic containers, as specified in the analytical method, supplied by the contract analytical laboratory. The containers will have screw-type lids to assure adequate sealing of the bottles. Teflon inserts located inside the lids of the containers will prevent sample reaction with the lid and improve the quality of the seal.

The containers will be precleaned and certified under chain-of-custody. Commercially available precleaned jars are acceptable. The contract laboratory’s bottle shipment documentation will record batch numbers for the bottles. With this documentation, bottles can be traced and bottle wash analyses can be reviewed. The bottle wash analyses will be retained in the project file.

SAMPLE PRESERVATION

Prior to shipping sample bottles to the field, the contract laboratory will add the required preservatives to the sample bottles that will be used for groundwater. The laboratory will affix waterproof labels to the bottles on which the type of preservative will be written.

Sample preservation procedures are used to maintain the original character of analytes during storage and shipment. Regardless of the nature of the sample, absolute stability for all constituents cannot be achieved. Preservation techniques, such as pH control and refrigeration, may retard physicochemical and biochemical changes. As a general rule, analyzing the sample as soon as possible is the best way to minimize physicochemical and biochemical changes.

All samples will be placed in the appropriate sample container and refrigerated with wet ice immediately upon sample collection. The samples will be transferred to the contract laboratory as soon as possible, preferably the same day as collection. The contract laboratory will meet all specified holding times and should make every effort to prepare and analyze the samples immediately after they are received.

STORAGE REQUIREMENTS

Samples will remain in the possession of the sampling personnel or be placed in secure, storage facility until they are shipped or delivered to the laboratory. Immediately after collection, and during shipment to the analytical laboratory, samples will be stored in coolers on ice at approximately 4°C ± 2°. Ice packaged in plastic storage bags will be used to maintain the temperature in the shipping containers at approximately 4°C ± 2°. Ice will be replenished as necessary to ensure adequate cooling of samples during storage and shipping.

SAMPLE DOCUMENTATION

Entries into the logbook or other field sampling forms for sampling events will include, but not necessarily be limited to, the following:

- Project name, location, and number.
- Date and time of sampling.
- Sample numbers.
- Cross-reference of numbers for split and blank samples.
- Media sampled.
- Geographical location of the sampling point in reference to site facilities.
- Physical location of the sampling point, such as depth below ground surface (bgs).
- Method of sampling, including procedures, equipment, and any departure from the procedures specified in this Sampling and Analysis Plan.
- Results of field measurements (e.g., PID readings).
- Sample preservation.
- Weather conditions at the time of sampling and previous events that may influence the representative nature of a sample. At a minimum, include temperature, approximate wind speed and direction, and sky cover.
- Photographic information. Briefly describe what was photographed and why, the date and time, the compass direction of the picture, number of the frame on the roll, and roll number.
- Sketches, when appropriate, with reference points tied to existing structures in the area (i.e., trees, roads).
- Analyses requested.
- Airbill number of sample shipment, when applicable.
- Other pertinent observations, such as the presence of other persons on the site (those associated with the job or members of the press, special interest groups, or passersby), and actions by others that may affect performance of site tasks.
- Name(s) of sampling personnel.

CHAIN-OF-CUSTODY PROCEDURES

Verifiable sample custody is an integral part of field and laboratory operations associated with this site investigation. The primary purpose of the chain-of-custody procedures is to document the possession of the samples from collection through storage and analysis to reporting. Chain-of-custody forms will become the permanent records of sample handling and shipment. The Field Investigation Manager or his/her designee will be responsible to the Project Manager for monitoring compliance with chain-of-custody procedures.

Field sampling personnel are responsible for the care and security of samples from the time the samples are collected until they have been turned over to the shipping agent or laboratory. A sample is considered to be in one’s custody if it is in plain view at all times, in the physical possession of the sampler, or stored in a locked place where tampering is prevented.

Empty coolers containing ice will be available at the study area for use each day in the field. Samples collected during the day will be stored in shipping coolers beginning at the time of collection.

Chain-of-custody forms will be filled out starting when the first sample of each batch is collected. Each chain-of-custody form will contain the following information:

- Sample identification numbers.
- Date and time of sampling.
- Type of sample and number of sample containers associated with each sampling point.
- List of analyses requested.
- Name of sampling personnel.
- Spaces for transfer of custody acknowledgment.

When a complete batch has been collected and the chain-of-custody form is complete, field team members will crosscheck the form for possible errors. Any corrections will be made to the record with a single strike mark that is dated and initialed. The person who initials corrections will be the same person that relinquishes custody of the batch. An example of a chain-of-custody form is included in Appendix B.

LABORATORY CUSTODY PROCEDURES

The laboratory will fill out a cooler receipt form. Upon receipt by the laboratory, custody seals will be inspected and the chain-of-custody form signed and dated by laboratory personnel. Laboratory personnel will verify the sample number and the condition of each cooler. Shipping manifests and chain-of-custody forms signed and dated by laboratory personnel will be considered sufficient documentation of sample custody transfer from the sampler, through the shipping agent, to the analyst in the contracted analytical laboratory.

A copy (pink) of each chain-of-custody form will be retained by the sampling team for the project file and the original (yellow and white) will be sent with the samples. Bills of lading will also be retained as part of the documentation for the chain-of-custody records. In conjunction with data reporting, the analytical laboratory will return the original chain-of-custody forms to the project manager for inclusion into the central project file.

SHIPPING PROCEDURES

Samples will be transported to the project analytical laboratory in complete batches. The chain-of-custody form that accompanies each shipping container from the time of sample collection will be signed and dated, placed in a resealable plastic bag, and taped to the inside lid of one of the coolers.

Along with samples and ice, a temperature blank provided by the laboratory will be placed in each cooler. The temperature blank will consist of a labeled vial filled with laboratory-provided deionized water. Upon receipt of coolers at the laboratory, the temperature of the cooler will be measured by checking the temperature of the water in the temperature blank.

After the samples have been packaged and the chain-of-custody forms have been completed and sealed in the coolers, sampling personnel will affix dated custody seals to each cooler so that if it is opened the seals will be broken. Custody seals will contain the sample team member's signature (signature must match signature on chain-of-custody form) and date.

INVESTIGATION DERIVED WASTE (IDW) MANAGEMENT

It is anticipated that three types of waste will be generated, which includes disposable personal protective clothing and sampling equipment, decontamination water, and purge water from groundwater sampling.

EXPECTED TYPES OF IDW

Personal Protective Equipment and Disposable Sampling Equipment

Disposable personal protective equipment (PPE) used during sample collection will include nitrile gloves.

Disposable sampling equipment may include polyethylene bailers, bailer twine, plastic bags and glass jars

Decontamination Water

Sampling equipment such as an electronic water level indicator and non-disposable PPE will be decontaminated between each use and/or at the end of each day. The decontamination water will contain a minimum of phosphate-free detergent (Alconox or equivalent) and trace quantities of soil. Minimal amounts of decontamination water (<1 gallon) are expected to be generated during sampling procedures.

Purge Water

During groundwater sampling, water will be purged from each sampling point in an effort to remove suspended sediment from the sample.

HANDLING AND STORAGE OF IDW

In order to insure IDW is handled in a protective manner, URS personnel will adhere to the following procedures until disposal options are evaluated.

Personal Protective Equipment and Disposable Sampling Equipment

Disposable sampling equipment and PPE will be double-bagged after use or at the end of each workday. The disposable bags will be tied shut and disposed of in a city garbage container.

Decontamination Water

Decontamination water generated during sampling activities will be containerized in DOT-approved 55-gallon steel drums. It is anticipated that less than 1 gallon of decontamination water will be generated during sampling activities. This water will be collected and stored on site pending shipment to an approved facility.

Purge Water

Purge water generated during groundwater sampling activities will be collected and disposed of in the same manner as the decontamination water.

DRUM LABELING

The waste drum will be clearly labeled with the following information.

- Generator’s name
- Description of contents
- Date

Labeling information along with copies of field documentation related to the drum contents will be kept in the project file. The drum will be stored in a location approved by the site contact. Prior to storage, the exterior of the drum will be cleaned and dried. Analytical data from this investigation will be used in evaluating disposal options.

URS STANDARD OPERATING PROCEDURES

GROUNDWATER MONITORING WELL DEVELOPMENT

Development should not be implemented until the seal has cured and settled. Ideally, a settling time of 24 to 48 hours is recommended.

Monitoring well development is an attempt to remove fine particulate matter, commonly clay and silt, from the geologic formation near the well intake. If particulate matter is not removed, as water moves through the formation into the well, the water sampled will be turbid, and the viability of the water quality analyses will be impaired. The four most suitable methods for monitoring well development are bailing, surge block surging, pumping/overpumping/backwashing, and combinations of these three methods.

The new monitoring wells will be developed by the easiest, least expensive and most commonly employed technique, pumping. The recommended approach is to begin pumping at the top of the screen with low pumping rates and incrementally work down the well screen. The process should then be repeated in reverse, from the bottom of the well to the top. Either a centrifugal or submersible pump can be used to develop the monitoring wells. Prior to and after development, the pump should be decontaminated in a manner consistent with the procedures described in SOP-2.

Development should proceed until the following criteria are met:

1. A representative sample can be collected. In general, representative conditions can be assumed when the water is visually clear of sediments (e.g., turbidity is 10 NTU) and pH, temperature, and specific conductance have stabilized over at least three successive well volumes. Stability criteria of water quality parameters listed below can be used to determine when development objectives have been met. The duration and measurements should be record on the well development sheet (Appendix C).

Parameter	Stabilization Criteria
Turbidity	± 10%
pH:	± 1.0
Conductivity:	± 3%
Temperature:	± 1°C

2. In some instances, collection of a sample with a turbidity of 10 NTU is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met.
    a. Several procedures have been tried,
    b. Proper well construction has been verified,
    c. Turbidity has stabilized within 10% over three successive well volumes, and
    d. Conductivity and pH have stabilized over at least three successive well volumes.
3. A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus, assuming 30 percent annular porosity) should be removed.

URS STANDARD OPERATING PROCEDURE
SOIL GAS SAMPLING

1.0 SUMMARY

This Standard Operating Procedure (SOP) describes the procedures for the collection of soil gas samples using Summa canisters and dedicated sample manifolds. The SOP will provide methodology, equipment, field procedures, and documentation necessary to collect representative soil gas samples.

2.0 EQUIPMENT

The following types of equipment are generally required to conduct the soil gas sampling:

- Soil gas sample location (temporary soil gas boring or permanent soil gas well including well casing, screen, and vault),
- Teflon tubing,
- Peristaltic pump,
- Leak check enclosure,
- Zip lock bags,
- Helium leak check equipment (if helium is available) (helium tracer gas and helium detector),
- Rubbing alcohol (2-propanol) (if helium is not available),
- Laboratory-supplied Summa canisters (6 liter [L] -10% certified),
- Laboratory-supplied sampling manifolds with vacuum gauge and flow restrictor set to sampling flow rate of 167 milliliters per minute (ml/min) (here in referred to as manifolds),
- Appropriate packing and shipping material provided by laboratory,
- Miscellaneous tools (i.e. appropriate wrenches for ¼” fittings),
- Weatherproof, bound field logbook or daily quality control reports,
- Soil gas sampling form, and
- Permanent/indelible ink pens.

3.0 PROCEDURES

3.1 System Set-up

1. Confirm that the Summa canister valve is closed (knob should already be tightened clockwise).
2. Remove the brass cap from the Summa canister.
3. Attach Summa canister to the first outlet of the manifold using provided swagelok (or similar stainless steel connectors).
4. <u>Note</u>: One manifold should be dedicated to a single sample location.

5. Record manifold and Summa canister serial number in field notes or sample form.
6. Verify and record the initial vacuum of the Summa canister.
7. Assemble the purge pump (peristaltic pump or purging Summa canister) to the second manifold outlet.

3.2 System Leak Checking and Purging

1. First perform the leak check of the manifold:
    a) Confirm that there is a brass cap secured at the inlet of the manifold creating an air tight train.
    b) Confirm that the purge valve located just before the purge pump (peristaltic pump or purging Summa canister) is open.
    c) Now operate the purge pump to achieve a vacuum gauge reading of 10 inches of mercury (Hg) or to a vacuum that will be encountered during sampling, whichever is greater.
    d) A leak free system will be evident by closing off the purge valve and observing no loss of vacuum within the manifold. Try refitting the connections and/or tightening them until the vacuum needle holds steady.
    e) Record the leak check date and time on the sampling log.
    f) Close the purge valve and turn off the pump.
2. Once the sample train is airtight remove the brass cap from the manifold inlet, connect the sampling tubing to the manifold inlet.
3. Second perform the leak check of the sample line and begin purging:
    a) If using helium, use the following technique.
        i. Attach tubing to the flow meter on the helium tank regulator and the other end thread into the top of the leak check enclosure. Attach the exhaust tube to the enclosure and position the other end as far away as possible to avoid detection by the helium leak detector.
        ii. Set up and turn on the helium detector on the exhaust line from the peristaltic pump.
        iii. Open the helium tank and set the flow meter for approximately 200 ml/min. Allow it to flow for 1 minute to fill the leak check enclosure before turning on the peristaltic pump and purge valve. Make sure that the detector is not reading any helium before starting the purge.
        iv. Calculate required purge volume (assumes ¼ inch diameter tubing):

v. Commence purging at a rate of between 100 and 200 ml/min for a time period sufficient to purge at least the above calculated purge volume.

vi. While purging, fill a zip lock bag with soil gas from the purge line.

vii. While purging, measure the helium content using the helium detector (in parts per million [ppm]) within both the leak check enclosure and the zip lock bag.

viii. Calculate the % leakage:

3. When sampling is complete close the valve, remove the canister, and replace the brass cap on the canister. Record the final vacuum of the canister on the sampling form.
4. Fill out the canister sample tag, place in laboratory-supplied shipping box, in the shade, without ice.
5. Make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC and sample form exactly.

3.4 Duplicate Soil Gas Sample Collection

1. Complete the steps of Sections 3.1 and 3.2.
2. Before filling the primary Summa canister, remove the purge pump or purge canister, open the purge valve, and attach the duplicate Summa canister to the second outlet of the manifold.
3. Don’t forget to record initial vacuum of the duplicate Summa canister.
4. Proceed with the steps in Section 3.3, above, but turn valves on the primary and duplicate Summa canisters concurrently.

4.0 DOCUMENTATION

Additional field notes will contain the following information:

- Date, time, and location
- Weather
- Personnel on site and performing the sampling
- Site location description
- General observations
- Unusual events
- Visitors to the site

All entries in the field notes must be legibly printed in indelible ink.

URS STANDARD OPERATING PROCEDURES

GROUNDWATER SAMPLING

Groundwater samples will be collected using new disposable polyethylene bailers using the following procedure.

- Remove the well cap and measure the depth from the top of casing (TOC) to the static water level. Depth to water measurements will be made using an electronic water level indicator capable of measuring to within 0.01 of a foot. Record the depth to water level measurement on the groundwater sampling form. Calculate the casing storage volume.
- Remove three saturated casing volumes of water using a disposable polyethylene bailer. Well purge water will be placed in a labeled Department of Transportation (DOT)-approved 55-gallon drum and stored on site pending disposal at an approved facility.
- If the well does not produce sufficient water for three saturated casing volumes, purge the well dry and sample as soon as the well recovers sufficiently.
- Before collecting samples, sampling personnel will don clean, nitrile or equivalent protective gloves. Transfer groundwater from the well into the appropriate laboratory provided sample bottles using the disposable polyethylene bailer. Volatile organic samples will be collected first, as they are the most sensitive to volatilization. While filling VOC sample bottles, attempts will be made to pour down the inside of the container to minimize turbulence while sampling. While filling the sample vial for VOC analysis, a positive meniscus should be formed over the mouth of the vial to eliminate the formation of air bubbles and headspace prior to capping.
- Place all properly labeled and packaged sample containers in a cooler with ice. Each cooler should contain enough ice to maintain the samples at $4^{o}C \pm 2^{\circ}$ during continued sample collection and shipping. Add additional ice as needed, but do not freeze the samples.
- Record all sampling data on the groundwater sampling form.
- All non-disposable field equipment will be decontaminated prior to use at each well location.

APPENDIX B

Field Forms

Project: ______________________

Project Location: ______________________

Project Number: ______________________

Log of Boring / Well ______

Sheet 1 of ____

Date(s) Drilled and Installed	Logged By	Reviewed By
Drilling Method	Drilling Contractor	Total Depth of Borehole
Sampling Method	Groundwater Level(s)	Top of Casing Elevation
Size and Type of Well Casing	Screen Perforation	Ground Surface Elevation
Seal or Backfill	Location	

Depth, feet	SAMPLES			USCS Code	MATERIAL DESCRIPTION	Well Completion Schematic	FIELD NOTES AND WELL DETAILS
	Type and Number	Recovery, %	Headspace PID, ppm				
0							
5							
10							
15							
20							
25							
30							

Report: ENV_12AS/W_PORT_FIELD; File: WC_CORP2.GPJ; 3/24/2004 -

URS

Project: ____________________	**Log of Boring / Well** ______
Project Location: ____________________	Sheet 2 of ____
Project Number: ____________________	

Depth, feet	SAMPLES Type and Number	Recovery, %	Headspace PID, ppm	USCS Code	**MATERIAL DESCRIPTION**	Well Completion Schematic	**FIELD NOTES AND WELL DETAILS**
30							
35							
40							
45							
50							
55							
60							
65							

Report: ENV_12AS/W_PORT_FIELD; File: WC_CORP2.GPJ; 3/24/2004 -

Project: ____________________

Project Location: ____________________

Project Number: ____________________

Log of Boring / Well ______

Sheet 3 of ____

Depth, feet	SAMPLES			USCS Code	MATERIAL DESCRIPTION	Well Completion Schematic	FIELD NOTES AND WELL DETAILS
	Type and Number	Recovery, %	Headspace PID, ppm				
65							
70							
75							
80							
85							
90							
95							
100							

Project: ______________________________
Project Location: ____________________________
Project Number: ____________________________

Log of Boring / Well ______

Sheet 4 of ____

Depth, feet	SAMPLES			USCS Code	MATERIAL DESCRIPTION	Well Completion Schematic	FIELD NOTES AND WELL DETAILS
	Type and Number	Recovery, %	Headspace PID, ppm				
105							
110							
115							
120							
125							
130							
135							

URS

DATE ____________________

DAY

S	M	T	W	TH	F	S

PROJECT MANAGER:

PROJECT:

JOB NO.:

URS FIELD REP:

WEATHER	BRIGHT SUN	CLEAR	OVERCAST	RAIN	SNOW
TEMP	To 32	32-50	50-70	70-85	85 up
WIND	Still	Moder	High	Report No.	
HUMIDITY	Dry	Moder	Humid		

SUB-CONTRACTORS ON SITE:
EQUIPMENT ON SITE:
WORK PERFORMED:

SHEET _____ OF _____

DAILY QUALITY CONTROL REPORT

PROJECT: ________________ REPORT NO. ________________

JOB NO.: ________________ DATE ________________

PROBLEMS ENCOUNTERED/CORRECTION ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY ________________ TITLE ________________

SHEET _____ OF _____

Investigative Derived Waste Form

Project Description: ____________________

Project Location: ____________________

URS Project Number: ____________________

URS Field Personnel: ____________________

Drum Label		Date Generated	Contents		Waste Profile Sample ID
			Water/Soil	Description	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					

Levelogger Gold

Model 3001

The Levelogger® Gold is completely designed, developed and manufactured in-house, in the tradition of all Solinst high quality products. Due to the Solinst commitment to providing leading-edge instruments designed for repeatable accuracy, the Levelogger Gold is always advancing.

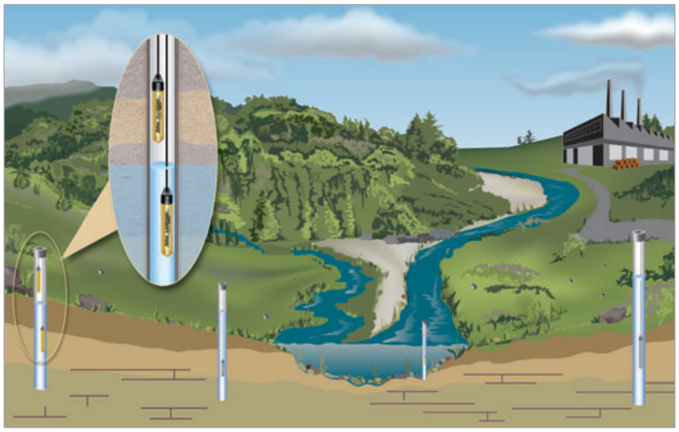
The Levelogger Gold is a water level and temperature recording device. It combines a datalogger, 10-year battery, pressure transducer and temperature sensor, in a small, minimal maintenance, 7/8" x 6" (22 mm x 154 mm) stainless steel housing. The sealed Faraday cage design greatly simplifies maintenance and provides protection against electrical spikes caused by lightning. A Zirconium Nitride coating resists corrosion.

The Levelogger Gold offers high resolution and reliability with an accuracy of 0.05%. The Levelogger Gold has excellent transducer, temperature and clock accuracies. Altitude, water density, temperature and barometric compensations also add to the accuracy and instrument stability.

High accuracy, long-term stability and an internal battery that lasts for 10 years when reading every minute, make Leveloggers the ideal devices for recording water levels. A Barologger provides the easiest and most accurate method of barometric compensation.

Applications

- Pumping and slug tests
- Watershed, drainage basin and recharge monitoring
- Stream gauging, lake and reservoir measurement
- Harbor and tidal fluctuation monitoring
- Wetlands and stormwater run-off monitoring
- Tank level monitoring
- Input water level data to SCADA/PLC systems
- Long-term water level monitoring in wells, surface water bodies and seawater environments



Get Quote | More Info

Features

- Self-test capability
- Maintenance-free, waterproof design
- Protected from power surges, such as lightning
- Real-time viewing; data can be exported
- Radio, satellite or cellular telemetry
- SDI-12 compatible, up to 1500 ft (450 m)
- User-selectable, 30 line sampling schedule

Robust Memory

The Levelogger Gold memory allows a maximum of 40,000 readings of level and temperature, set up in individual logs. The user has a choice of slate or continuous logging when operating in linear mode. In event-based and schedule sampling, memory is a form of circular slate, which starts logging from the end of the last log and wraps around to eventually overwrite older logs, but which will stop at the start of the current log. A separate redundant memory provides backup of the last 1200 readings, which can be accessed by a Diagnostic Utility program.

Downloading Options

The Levelogger Gold offers 4 download options: 'All Data' downloads the complete log, or the user can save time by selecting 'Append Data', when only new data is desired. A selected period of time prior to the last date stamp can be downloaded using 'Partial Download'. 'Recover Previous Log' is a safeguard in case the Levelogger has been restarted without downloading data. A complete data dump is also available as a feature of the Diagnostic Utility, which downloads all available memory in the Levelogger Gold.

High Accuracy

The Levelogger Gold has an accuracy of at least 0.05% net FS, a resolution of 0.0006 to 0.002% depending on range, a Barologger with algorithms based on air not water, enhanced altitude, density, temperature and barometric compensation, as well as a very accurate clock.

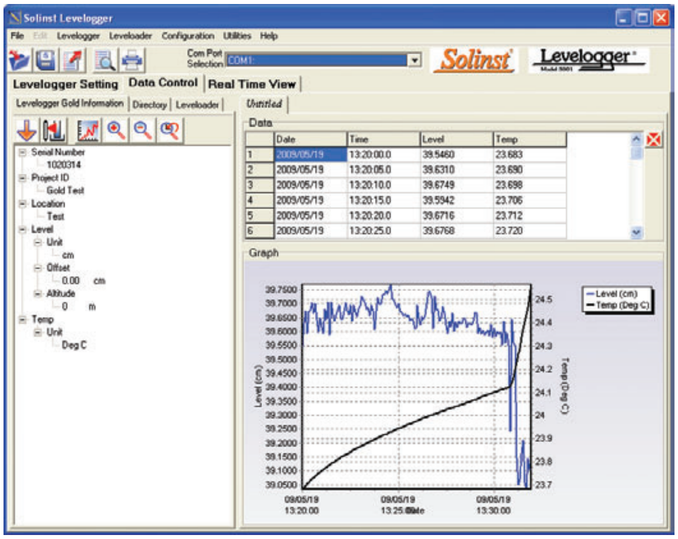
® *Solinst and Levelogger are registered trademarks of Solinst Canada Ltd.*

Levelogger Operation

Solinst has made programming the Levelogger Series extremely intuitive. Simply place the Levelogger in the optical reader or connect to the direct read cable. All in one screen, fill in the information fields for location, project ID, sample mode and rate, altitude, density adjustment and any desired offset.

Levelogger time may be synchronized to the computer clock, or the Leveloader Gold clock, or it can be user defined. There are options for immediate start or a future start time. The percentage battery life remaining and the amount of free memory are indicated on the settings screen.

A manual measurement of the initial water depth is usually taken at each location, and noted as a base line measurement. When a Barologger is used for barometric pressure measurement, it is set above high water level in one location on site. If direct read cables are being used, data can also be viewed, logged on demand and retrieved from the Levelogger at any time using a Leveloader or a portable computer.



Com Port Selection: COM1:

Serial Number
1020314
Project ID
Gold Test
Location
Test
Level
Unit
cm
Offset
0.00 cm
Altitude
0 m
Temp
Unit
Deg C

Data

	Date	Time	Level	Temp
1	2009/05/19	13:20:00.0	39.5460	23.683
2	2009/05/19	13:20:05.0	39.6310	23.690
3	2009/05/19	13:20:10.0	39.6749	23.698
4	2009/05/19	13:20:15.0	39.5942	23.706
5	2009/05/19	13:20:20.0	39.6716	23.712
6	2009/05/19	13:20:25.0	39.6768	23.720

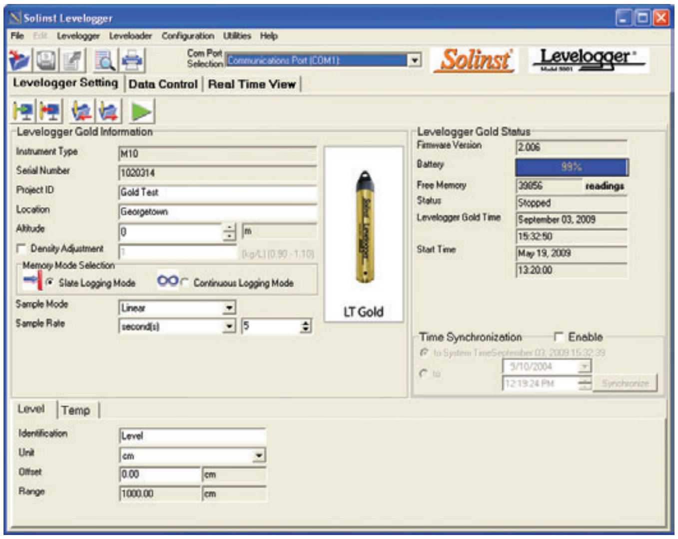
Real Time View Window

Convenient Sampling Options

Solinst includes a very flexible, user-selectable sampling schedule, as well as the standard linear and event-based sampling options. Linear sampling can be anywhere from 0.5 seconds to 99 hours.

Event-based sampling can be set to record when the level changes anywhere from 0.1% up to 25% of the full range of the logger. Readings will be checked at the selected time interval, but only recorded in memory if the condition has been matched or exceeded.

The Schedule option allows up to 30 schedule items, each with its own sampling rate of seconds, minutes or hours, and a duration of seconds, minutes, hours, days or weeks. A running total of sample time and number of readings available are indicated and updated. Templates of these Schedules, and Levelogger Settings, can be saved for easy re-use.



Com Port Selection: Communications Port (COM1):

Instrument Type: M10
Serial Number: 1020314
Project ID: Gold Test
Location: Georgetown
Altitude: 0 m
☐ Density Adjustment: 1 (kg/L) (0.90 - 1.10)
Memory Mode Selection: ● Slate Logging Mode ○ Continuous Logging Mode
Sample Mode: Linear
Sample Rate: second(s) 5

Firmware Version: 2.006
Battery: 99%
Free Memory: 39856 readings
Status: Stopped
Levelogger Gold Time: September 03, 2009 15:32:50
Start Time: May 19, 2009 13:20:00

Time Synchronization ☐ Enable
● to System Time September 03, 2009 15:32:39
○ to 5/10/2004 12:19:24 PM

Identification: Level
Unit: cm
Offset: 0.00 cm
Range: 1000.00 cm

Levelogger Settings Window

Data Download, Viewing and Export

Data is downloaded to a PC with the click of a screen icon or with the push of a button on the Leveloader. Collected data is retained in the Levelogger until it has been written over. The level data downloaded from a Levelogger has already been automatically compensated for temperature and altitude and the temperature data is also downloaded.

Barometric compensation of the Levelogger data is performed by a Wizard that can be used to input elevation offsets and adjust for Barometric efficiency. The software allows immediate viewing of the data in graph or table format using the 'Real Time View' option. It also allows easy export into a spreadsheet or database for further processing

Use of Direct Read Cables

When it is desired to get real-time data and communicate with Leveloggers without removal from the water, they can be deployed using direct read cables.

The lower end of the direct read cable has a miniaturized infra-red optical reader. The top cap of the Levelogger is removed and the direct read cable is threaded in its place. In turn, the upper end of the cable is attached to a portable computer or Leveloader, via a USB or RS232 PC Interface Cable. This allows viewing of the data, downloading and/or programming in the field.

Leveloggers can also be connected to an SDI-12 datalogger using the Solinst SDI-12 Interface Cable attached to a direct read cable.

The full benefits of a sealed Levelogger with no vent tube or electrical cable connection are also maintained. The logger is still sealed from all electrical interference through a Faraday cage design. Cable handling problems are minimized.

A Direct Read Cable with a Levelogger connected, attaches to a PC Interface Cable at a 2" Well Cap

PC Interface Cable connected to the Direct Read Cable

Enviro Cap™ lockable cap and key used with Wireline and Hooks

Helpful Utilities

The 'Self-Test Diagnostic Utility' can be used in case of an unexpected problem. It checks the functioning of the program, calibration, backup and logging memories, the pressure transducer, temperature sensor and battery voltage, as well as enabling a complete Memory Dump, if required. A Firmware Upgrade will be available from time to time, to allow upgrading of the Levelogger Gold, as new features are added.

Direct Read Cable Specifications

Direct read cables are available for attachment to any Levelogger, new or old, in standard lengths of: 15', 50', 100', 200', 250', 300' and 5 m, 15 m, 30 m, 60 m, 80 m, 100 m. Custom cable lengths up to 1500 ft (450 m) are also available to fit particular monitoring situations, as required. Cable markings are available upon request.

The 1/10" dia. (3 mm) coaxial cable has an outer polyethylene jacket for strength and durability. A stranded stainless steel braided conductor gives non-stretch accuracy.

The upper end of the direct read cable is fitted with a connector that can act as a well cap for a 1" well. This connector fits Solinst Levelogger well caps designed for 2" or 4" wells, and can easily be tethered at surface in other situations.

Use of Suspension Wireline and Kevlar Cord

Leveloggers may also be suspended in the water on a stainless steel wireline or Kevlar® cord. This is a very inexpensive method of deployment, and if in a well, allows the Levelogger to be easily locked, out of sight and inaccessible to anyone without a special key.

Solinst has adapted the Enviro Cap™ by adding a vent hole in the cap to allow for the equalization of barometric pressure in the well. The well cap has a convenient eyelet from which to suspend the Levelogger. It slips into the casing and is locked in place with the tamper-proof key, as shown.

The Enviro Caps are available sized for 2" and 4" wells. Well caps for other sizes of well can also be used.

Accurate Barometric Compensation

Leveloggers measure absolute pressure (water pressure + atmospheric pressure) expressed in feet, meters or centimeters of water column.

The most accurate method of obtaining changes in water level is to compensate for atmospheric pressure fluctuations using a Barologger. This avoids any time lag in the compensation calculation and any errors introduced due to moisture buildup, kinking or damage to vented cable. The Barologger Gold uses algorithms based on air rather than water pressure, which gives superior accuracy. The recorded barometric information can also be very useful to help determine barometric lag and/or barometric efficiency of the monitored aquifer.

The Data Compensation Wizard in the Levelogger software greatly simplifies the barometric adjustment of the water level measurements by using the synchronized data from one on-site Barologger with all the Leveloggers.

The overall results give more reliable, highly accurate level data than that obtained when using high maintenance and expensive vented cable.

® Kevlar is a registered trademark of DuPont Corp.

Levelogger Gold Specifications

Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Accuracy (Typical):	0.05% FS
Stability of Readings:	Superior, low noise
Resolution:	0.002 to 0.0006% FS
Normalization:	Automatic Temp Compensation
Temperature Sensor:	Platinum Resistance Temperature Detector
Temp. Sensor Accuracy:	± 0.05°C
Temp. Sensor Resolution:	0.003°C
Temp. Comp. Range:	-10 to +40°C
Battery Life:	10 Years - based on one reading/min
Clock Accuracy:	± 1 minute/year
Operating Temperature:	-20°C to 80°C
Maximum # Readings:	40,000 of level and temperature
Memory:	Superior reliability EEPROM (Slate or Continuous) plus redundant backup of last 1200 readings
Communication:	Optical Infra-Red Interface, Serial at 9600 Baud, Conversion to RS232 or USB Computer Connection
Size:	7/8" x 6" (22 mm x 154 mm)
Weight:	6.3 oz (179 grams)
Backwards Compatibility:	Full
Corrosion Resistance:	Zirconium Nitride (ZrN) Coating
Other Wetted Materials:	316-L Stainless Steel, Delrin®, Viton®
Sampling Modes:	Linear, Event and User-Selectable with 30 separate line items
Measurement Rates:	0.5 sec to 99 hrs
Barometric Compensation:	Software Wizard and one Barologger in local area (approx. 20 miles/30 km) radius

Models	Full Scale (FS)	Accuracy (typical)	Resolution
Barologger	4.92 ft., 1.5 m	± 0.003 ft., 0.1 cm	0.002% FS
F15, M5	16.4 ft., 5 m	± 0.010 ft., 0.3 cm	0.001% FS
F30, M10	32.8 ft., 10 m	± 0.016 ft., 0.5 cm	0.0006% FS
F65, M20	65.6 ft., 20 m	± 0.032 ft., 1 cm	0.0006% FS
F100, M30	98.4 ft., 30 m	± 0.064 ft., 1.5 cm	0.0006% FS
F300, M100	328.1 ft., 100 m	± 0.164 ft., 5 cm	0.0006% FS

Levelogger Junior: See Model 3001 Junior Data Sheet for details
Conductivity: See Model 3001 LTC Levelogger Junior Data Sheet

Leveloader Gold

The Leveloader Gold is a data transfer unit designed for use with all versions of the Solinst Levelogger, Barologger and Rainlogger. It is used to download and store multiple data files.

The 8 Mb FLASH memory stores up to 1,390,000 LT readings, 930,000 LTC readings, or 34 full Levelogger downloads. It can also be used to display data in real-time, and has optional password protection.

Simply use the connector cables for attachment to a Levelogger, or to a direct read cable, to allow downloading or reprogramming of the Levelogger settings in the field. It comes with cables for USB and RS232 connection to a PC for data transfer. (See Model 3001 Leveloader Gold Data Sheet.)

STS Telemetry

The STS Gold Telemetry System provides an economical and efficient method to access remote data instantly. Built for the Levelogger Series, the system combines high quality dataloggers, intuitive software and a variety of wireless communication options to create a remote monitoring solution.

CDMA and GSM digital cellular, satellite and radio wireless communication options give the flexibility to suit any project. Systems are suitable for both small to large networks. The STS Gold is designed to save costs by enabling the self-management of data, as well as remote collection of the data. Alarm notification, remote firmware upgrades and diagnostic reporting make system maintenance simple. (See Model 9100 Data Sheet.)

RRL Telemetry

The inexpensive RRL Gold Radio Telemetry is ideal for short range applications up to 1000 ft (300 m) or more. Distances can be increased by using some radios as 'repeater' stations. (See Model 9200 Data Sheet.)

® Delrin and Viton are registered trademarks of DuPont Corp.

Printed in Canada
May 31, 2010

Manufactured by

DURHAM GEO SLOPE INDICATOR

Developed by

ADVENTUS
Proven Soil, Sediment, and Groundwater Remediation Technologies

Distributed by

FIELD ENVIRONMENTAL INSTRUMENTS, INC.
www.fieldenvironmental.com
Tel: 1-800-393-4009

O-SOX™
Easiest Downwell Deployment of Dissolved Oxygen

Affordable and effective oxygen-releasing socks for stimulating aerobic biodegradation in ground water wells.

Applications:

Stimulation of aerobic biodegradation of groundwater contaminants using EHC-O™. EHC-O is deployed in remediation wells with the O-SOX™ delivery system.

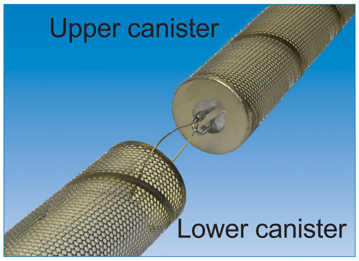
EHC-O is a proprietary field-proven compound that contains a long-term source of dissolved oxygen and nutrients. In the well, EHC-O reacts with water to release oxygen slowly. If necessary, exhausted socks may be replaced with new ones to continue treatment.

Organic constituents amendable to aerobic biodegradation processes are:

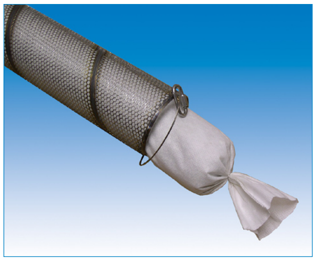
- Petroleum Hydrocarbons
- Light polycyclic aromatic hydrocarbons (PAHs)
- BTEX

Benefits of EHC-O™

- ❖ **Significant cost savings realized through the use of EHC-O due to its higher oxygen release rate and lower price.**
- ❖ **Contains nutrients. pH-buffered to reduce self-encapsulation.**
- ❖ **Estimated longevity of 3 to 6 months.**



Detail showing how two canisters are linked. Up to three canisters may be suspended in line to lengthen the active zone.



Detail showing the 4-in sock protruding slightly from the top of the canister.

Benefits of O-Sox™ Delivery System

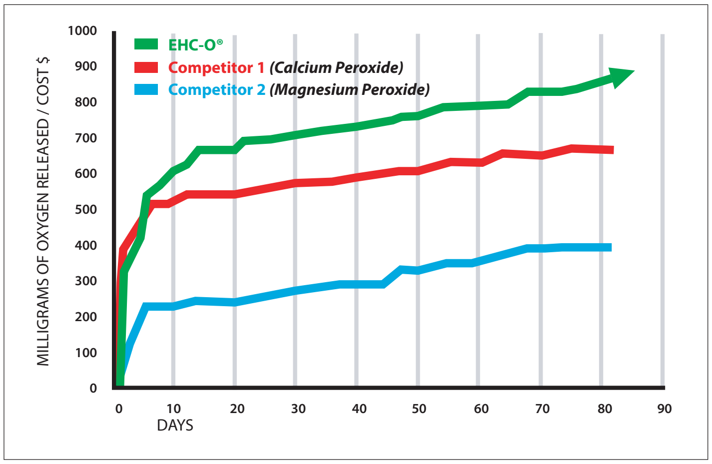
- ❖ **All the field proven benefits of EHC-O.**
- ❖ **Substantial time savings in the field because the reusable stainless steel canisters are easy to insert in and retrieve from the well compared to other methods. Recover the cost of the canister in your first installation!**

- ❖ **Ease of determining the exact depth at which the product is deployed.**
- ❖ **Socks and canisters available for 2” and 4” wells.**
- ❖ **Up to three canisters may be suspended in line to lengthen the active zone.**
- ❖ **Even distribution of the active material over the length of the canister(s) because the socks do not collapse or bunch up.**

O-SOX™ is a trademark of Durham Geo Slope Indicator. EHC-O™ is a trademark of Adventus Intellectual Property Inc.

O-SOX™ OXYGEN-RELEASING SOCKS

Comparative Rates of Oxygen Delivery and Costs



EHC-O™ O-Sox™ FAQs

1. **What are the main differences between O-Sox and comparable market alternatives?** EHC-O O-Sox contain a well-buffered source of controlled release oxygen plus inorganic nutrients (mainly nitrogen) that can accelerate the biodegradation of various organic compounds and enhance certain natural attenuation processes. In addition, the O-Sox technology is a superbly well designed stainless steel canister and sleeve system which greatly simplifies installation, removal and replacement.
2. **Do I need microbial inoculants?** In most cases, the naturally occurring (indigenous) microorganisms are well adapted to the organic constituents of interest and inoculants are not required.
3. **What contaminants are amenable to O-Sox treatment?** The rate and extent of removal of all organic compounds that are biodegraded under aerobic conditions are usually enhanced via the addition of oxygen and inorganic nutrients. Petroleum-based aromatic (e.g., benzene, toluene, xylene, phenol) and aliphatic hydrocarbon mixtures (e.g., gasoline, heating oil, Diesel fuel, jet fuel, kerosene) are primarily targets; lightly chlorinated ethenes (vinyl chloride), MTBE, dioxane, pentachlorophenol, and many other compounds are also potentially amenable to O-Sox treatment.
4. **How much do they cost?** O-Sox cost about 25% less than market alternatives.
5. **Why should I use the O-Sox technology?** It's a better product. And the superior design and ease of application will immediately translate into greatly reduced field time and frustration = reduced project cost.
6. **Is it easy to switch over to the O-Sox technology?** Yes. EHC-O has been accepted by many state regulatory authorities and it has been employed throughout the USA and Europe.
7. **How long do they last?** O-Sox are typically replaced every 3 to 6 months. Various site-specific factors will influence the effective lifetime of the O-Sox cartridge; mainly i) constituent type and concentration, and ii) hydrogeological features (groundwater flow rate, Eh, pH, temperature).
8. **Do I need to install new wells?** No. The O-Sox technology is designed to fit into standard 2-inch and 4-inch diameter groundwater monitoring wells. The canisters have a nominal outside diameter of 1.75 inches for the 2-inch size and 3.5-inches for the 4-inch size.
9. **What is the oxygen delivery rate?** The rated delivery is at least 15 lb of oxygen per 100 lb of EHC-O, after 200 days.

ORDERING INFORMATION

TR-410	2-in x 3-ft O-SOX (pail with 5 socks*)	31 lb
TR-411	2-in Canister#	1 lb
TR-412	4-in x 3-ft O-SOX (pail with 3 socks*)	31 lb
TR-413	4-in Canister#	2 lb
Accessories:		
TR-416	Nylon-covered stainless-steel suspension cable with swaged cable loop at one end (sold per ft)	
TR-414	2-in Well Cap with Cable Restraint	0.6 lb
TR-415	4-in Well Cap, Cable Restraint	1.2 lb
602528	Pail Opener	0.5 lb

(*) Only sold in pail quantities.
(#)*One-time cost: canisters can be re-used for subsequent applications.*

Notes:

- *Because O-SOX contains an oxidizing substance, it may be shipped only by motor freight.*
- *O-SOX is non-returnable and non-refundable.*

SPECIFICATIONS

Material:

Active compound	**EHC-O**™ calcium-peroxide based compound. Contains inorganic nutrients and a buffering agent .
Rated delivery	At least 15 lb of oxygen delivered per 100 lb of EHC-O product after 200 days.
Sock	non-woven polyethylene fabric, needle punched.
Canister	Stainless steel, type 304, perforated.

Dimensions, Weight and Volume

Size for O-SOX sock (dry) and canister

	Sock	Canister
2 in	1.5 in x 36 in approx.	1.75 in x 36 in approx.
4 in	3.0 in x 36 in approx.	3.5 in x 36 in approx.
Canister length*	2 in: 3 ft 4 in	4 in: 3 ft 4 in

*with suspension looploop and link extended

Total Ship. Volume

Pail	2 ft^3 Note: pail only is 12-in dia. x 16-in H
2-in canister	0.34 ft^3 (4 x 4 x 37 in)
4-in canister	0.77 ft^3 (6 x 6 x 37 in)

Weights

EHC-O (only) content per dry sock:

2-in socks	1.74 lb approximately
4-in socks	7.24 lb approximately

Total Ship. Wt (dry)

Pail w/ five 2-in socks	33 lb
Pail w/ three 4-in socks	33 lb
2-in canister (empty)	2 lb
4-in canister (empty)	3 lb

Manufactured by Durham Geo Slope Indicator
2175 West Park Court, Stone Mountain, GA 30087, USA
Tel: 800.837.0864 or 770.465.7557 **www.DGSI.info**

ISO
9001:2000
QMS

Printed in USA. (Ref: O-SOX rev1 Jan 07)

Sparge pump sound enclosure with
Intercooler and pressure gauge.

Main Control
Panel

Inside Control Panel, PLC, Scada system
and cellular communication system.

GLOBAL REMEDIATION SOLUTIONS, LLC
1081 COLUMBIA BLVD.
LONGVIEW, WA 98632

360-423-2245 - OFFICE
360-747-4983 - CHARLIE SWIFT

Remedial Services Dual Phase Extraction Pilot Testing Support

Our Pilot Test trailer offers consulting companies the opportunity to investigate and provide subsurface modeling. It is currently available for short and long term projects.

Pilot Testing Trailer, Basic Information

The trailer features a powerful Busch 1322 AV rotary claw vacuum pump capable of developing 25.5” Hg and moving air at a rate of 200 ACFM. Liquids and air are vacuumed into a knock out pot, the liquid phase is then pumped through a Pan America oil water separator where free product is skimmed off the water, the oil phase is stored in the separator and pumped to drums during demobilization. The water phase is pumped to a ShallowTray air stripping tower to remove dissolved hydrocarbon constituents before being pumped into an onsite holding tank or POTW if permitted. The liquid phase process is rated at approximately 10 gallons per minute. The air phase from the vacuum pump and the air stripping tower are combined and released to the atmosphere. If permitting requires, provisions can be made for pumping the exhaust air through carbon vessels, prior to release. Electric motors are rated for hazardous atmospheres and a Lower Explosive Limit (LEL) Meter is located in the product treating section of the trailer. The LEL meter is capable of shutting the system down automatically if the atmosphere exceeds 10% LEL. All the equipment is controlled by a state of the art PLC system minimizing risk of overflow and explosion.

A 55 CFM oil less rotary vain air sparge pump is also available for use when renting this trailer.

Busch Vacuum Pump (front left) , Knock Out Chamber (back left) and Air Stripping Tower (front right)

Front of 24’ trailer featuring power supply boxes and sparge room exhaust fan

Knock Out Chamber and Oil Water Separator

Air Stripper Blower

GLOBAL REMEDIATION SOLUTIONS, LLC
1081 COLUMBIA BLVD.
LONGVIEW, WA 98632

360-423-2245 - OFFICE
360-747-4983 - CHARLIE SWIFT

Poly Tank

EZ KLEEN® 2400

Overview:

The EZ KLEEN® 2400 Gallon Tank is made from cross-linked polyethylene for superior durability and safety. This tank is ideal for temporary storage of water, chemicals and other liquids. The EZ KLEEN 2400 is portable lightweight and ideal for use in construction, manufacturing, power plants and a variety of industrial applications.

Features:

EZ KLEEN Poly Tanks have two molded in 3 inch flanges on the bottom of every tank for superior drainage and ease of cleaning. Each EZ KLEEN tank comes with a pad standard.

Specs:

Material	Cross linked polyethylene
Capacity	2400 gallons
Dry weight	960 lbs.
Footprint:	102" x 75.6"

Accessories:

- Spillguard
- Suction and Discharge Hoses
- AOD pumps
- Level gauges