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Chevron Environmental Management Company

Final Feasibility Study Work Plan

Former Unocal Edmonds Bulk Fuel Terminal
11720 Unoco Road
Edmonds, Washington

October 5, 2012

ARCADIS

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Figures

Appendices

1. Introduction

On behalf of Chevron Environmental Management Company (Chevron), ARCADIS U.S., Inc. (ARCADIS) has prepared this Feasibility Study Work Plan (FS Work Plan) for additional sampling activities at the Lower Yard of the Former Unocal Edmonds Bulk Fuel Terminal (Site), located at 11720 Unoco Road, Edmonds, Washington (**Figure 1**). The additional activities will be conducted to gather the data necessary to address the various concerns of stakeholders regarding known and potentially remaining impacts at the Site and to update and refine the Conceptual Site Model (CSM) as part of the FS.

Proposed activities include characterization of groundwater and sediments at the Site by installing new monitoring wells, adding existing wells to regularly scheduled groundwater monitoring events, and collecting additional sediment data points. This FS Work Plan provides the technical basis for and the procedures that will be used to complete investigation activities at the Site and provides an outline for the upcoming FS.

2. Background

Background information for the Site is provided in the following sections.

2.1 Site Description

The Lower Yard occupies approximately 22 acres. It is surrounded by BNSF Railway (BNSF) property to the west-northwest, Edmonds Marsh (also known as the Union Oil Marsh) and a drainage ditch (Willow Creek) to the north, and the Upper Yard to the south (**Figure 2**). The southwest corner of the Lower Yard boundary is approximately 160 feet from the Puget Sound shoreline.

There are no permanent aboveground structures at the Site. A temporary storage shed is located along Unoco Road in the southern portion of the Lower Yard. Previous structures in the Lower Yard included petroleum storage and transfer equipment (including aboveground storage tanks and piping), two truck loading racks, several office buildings, a railcar loading and unloading station, a stormwater conveyance system (including two 10,000-gallon stormwater detention tanks and two 500-gallon vapor recovery tanks), an air-blown asphalt plant, and an asphalt packaging warehouse.

Two stormwater detention basins (Detention Basin No.1 [DB-1] and Detention Basin No. 2 [DB-2]) are located along the north and northeast boundaries of the Lower Yard. DB-2 serves as a stormwater collection area from which Site stormwater is discharged into Willow Creek under an Industrial Stormwater General Permit (SO3-002953C). DB-1 borders Edmonds Marsh and Willow Creek and acts as a retention pond for overflow from DB-2 during storm events.

2.2 Site History

Union Oil Company of California (Unocal) operated the bulk fuel terminal from 1923 to 1991. Fuel was brought to the terminal on ships, pumped to the storage tanks in the Upper Yard, and loaded from the tanks into rail cars and trucks for delivery to customers. In addition, an asphalt plant operated at the Lower Yard from 1953 to the late 1970s. In 1991, Unocal ceased all fuel storage and distribution activities as well as asphalt operations at the facility.

2.3 Property Transfer

In January 2005, the Washington State Department of Transportation (WSDOT) and Unocal signed an Agreement of Sale of Real Property and Escrow Instructions (Agreement). The Agreement, and the two amendments to the Agreement sets forth the conditions precedent to the transfer of the property. Unocal's first step is the preparation of a Proposed Interim Action Report. This report sets forth the Capital Remediation Work Unocal is to perform. That report was submitted to Ecology as the Interim Action Report - Work Plan for 2007 Lower Yard Interim Action and is included in the Agreed Order. Once the work is performed, the Agreement calls for a Proposed Remediation Plan. This plan will take the form of the FS, and will identify a set of remedial alternatives and monitoring work. The FS, if required by Ecology, may also include additional Capital Remediation Work. Once the FS is approved, a Cleanup Action Plan (CAP) is prepared. Upon approval of the CAP, Unocal completes the requirements therein. Once Ecology is satisfied that the requirements of the CAP have been met, the Agreement calls for Ecology to provide a written acknowledgment that Unocal has completed the Capital Remediation Work, that Ecology's confirmation is deemed conclusive evidence that Unocal has satisfied its obligations to perform the Capital Remediation Work called for under the Agreement, and that WSDOT is required to consummate the property transfer.

Appendix A contains copies of three template letters which were drafted as part of the Agreement and are intended to provide a proposed template to Ecology for their written confirmation of the completion of work by Unocal as part of the property transfer.

2.4 Site Cleanup Activities

Site cleanup activities began under the oversight of the Washington Department of Ecology (Ecology) in 1993 in accordance with Agreed Order No. DE 92TC-N328. Properties that were the subject of the Agreed Order included the Upper Yard, the Lower Yard, and a smaller parcel now the location of a fish hatchery. Interim Actions in the Upper Yard were completed in 2001, and the property was sold and redeveloped for residential use.

2.4.1 Interim Actions under Agreed Order No. DE 92TC-N328

In 2001, Unocal conducted an Interim Action in the Lower Yard, removing light nonaqueous phase liquid (LNAPL) and petroleum-impacted soil and groundwater from

four areas. The results of the 2001 Interim Action are summarized in the Lower Yard Interim Action As-built Report, Unocal Edmonds Terminal – Volume 1 (Maul Foster and Alongi, Inc. [MFA] 2002). Additional Interim Actions conducted in 2003 included soil excavations in the Southwest Lower Yard and DB-1. The results of the 2003 Interim Action are summarized in the 2003 Lower Yard Interim Action As-Built Report, Detention Basin No. 1, Southwest Lower Yard, Metals Area 3, and Storm Drain Line Excavations – Volume 1 (MFA 2004). Previous excavations are shown on **Figure 2**.

2.4.2 Interim Actions under Agreed Order No. DE4460

In June 2007, Unocal entered into Agreed Order No. DE4460 (Agreed Order), superseding the previous order and requiring Unocal to conduct an Interim Action in the Lower Yard (Ecology 2007). Specific objectives of the Interim Action included:

- Remediation of the petroleum hydrocarbon-impacted soil within the Lower Yard that contains petroleum hydrocarbon concentrations above the soil remediation levels (RELs) or soil cleanup levels (CULs) based on direct contact
- Removal of LNAPL
- Extraction of groundwater that is in contact with LNAPL
- Removal of soil with arsenic concentrations in excess of the soil CUL based on natural background
- Removal of the sediment in the drainage ditch (Willow Creek) at locations near the Site's two stormwater outfalls that failed toxicity tests in 2003
- Obtaining the data necessary to determine if the remaining soil concentrations are sources of LNAPL on the groundwater table
- Obtaining the data necessary to determine if the remaining soil concentrations will cause an exceedance of the groundwater CULs at the groundwater points of compliance (POCs)
- Obtaining the data necessary to determine if the petroleum hydrocarbon concentrations in the groundwater beneath the Lower Yard will naturally attenuate to below the CULs at the groundwater POCs

The 2007 Agreed Order Interim Actions were conducted in two phases: from July 2007 to April 2008 (Phase I) and from July 2008 to October 2008 (Phase II).

2.4.2.1 Phase I Interim Action

Phase I Interim Action work consisted of the removal of 108,000 tons of petroleum-impacted soil for offsite disposal, the removal of approximately 9,700 gallons of LNAPL, and the extraction of approximately 2 million gallons of groundwater in contact with LNAPL. The complete results of the 2007 Phase I Interim Actions are summarized in the Phase I Remedial Implementation As-Built Report, Unocal Edmonds Bulk Fuel Terminal Lower Yard (ARCADIS 2009).

During Phase I excavation activities, 470 confirmation soil samples were collected from the floors and sidewalls of the excavation areas. Eight of the confirmation samples contained concentrations of indicator hazardous substances (IHSs) exceeding applicable CULs/ RELs, but they were not able to be over-excavated during Phase I activities. Three of these samples were later over-excavated during Phase II activities; however, five of the locations were not over-excavated due to their proximity to the WSDOT stormdrain line. The remaining five soil sample locations containing IHS concentrations greater than Site CULs/RELs are located to the north of the WSDOT stormdrain line, in the southern portion of the Lower Yard, adjacent to lower Unoco Road (**Figure 3**).

The groundwater that was extracted during Phase I Interim Action construction activities was treated onsite and discharged under a National Pollutant Discharge Elimination System (NPDES) Permit to Willow Creek.

In 2008, additional soil investigation activities were conducted to collect data and evaluate the nature and extent of remaining petroleum impacts in various areas of the Lower Yard, including the areas to the south and southwest of the WSDOT stormdrain line and the Former Asphalt Warehouse Area, near monitoring well MW-129R. Fourteen soil borings were advanced to the south and southwest of the WSDOT stormdrain line, five of which contained soil with concentrations of IHSs exceeding Site CULs/RELs, as shown on **Figure 3**. Three soil borings collected in the Former Asphalt Warehouse Area contained soils with concentrations of IHSs exceeding Site CULs/RELs. These three soil borings were subsequently excavated during Phase II excavation activities. The complete results of the 2008 investigation activities are

summarized in the 2008 Additional Site Investigation and Groundwater Monitoring Report, Former Unocal Edmonds Bulk Fuel Terminal (Lower Yard) (ARCADIS 2010a).

2.4.2.2 Phase II Interim Action

Phase II Interim Action work consisted of the removal of 14,825 tons of petroleum-impacted soil for offsite disposal, the removal of approximately 875 tons of concrete and metal debris, the removal of 131 gallons of LNAPL, the extraction of approximately 520,000 gallons of groundwater, the removal of 2,000 tons of impacted sediments, and the installation of 29 monitoring wells. The complete results of the 2008 Phase II Interim Action, including monitoring well installation activities, are summarized in the FINAL – Phase II Remedial Implementation As-Built Report, Unocal Edmonds Bulk Fuel Terminal Lower Yard (ARCADIS, 2010b).

Petroleum-impacted soil was removed from the areas where three soil samples containing concentrations of IHSs greater than Site CULs/RELs were left in place during Phase I activities and from the Former Asphalt Warehouse Area discovered during the 2008 investigation activities. The concrete and metal debris were excavated from the southeast Lower Yard. During Phase II activities, 82 confirmation soil samples were collected from the floors and sidewalls of the excavation areas. One confirmation sample containing concentrations of IHSs was not over-excavated during Phase II. The location of this sample is in the southeast Lower Yard as shown on **Figure 3**.

The recovered LNAPL was taken offsite for recycling, and the extracted groundwater was treated onsite and discharged to Willow Creek under a NPDES permit. Following the removal of impacted sediments, approximately 420 feet of Willow Creek[1] was restored.

[1] Willow Creek sediment removal was conducted to address sediments impacted with carcinogenic polyaromatic hydrocarbons (cPAHs) identified in the creek bed. LNAPL was not observed in sediments of Willow Creek during the removal project and the entire length of Willow Creek along the northwestern and northeastern border of the Site has been inspected monthly since October 2008 for the possible presence of sheens; no sheens have ever been observed.

In October 2008, 29 monitoring wells were installed at the Lower Yard in three designated groundwater flow paths as outlined in the Agreed Order, to conduct groundwater monitoring upon completion of the Interim Actions. Soil samples were collected for laboratory analysis during the installation of four of the monitoring wells that were installed in non-excavated areas. Analytical results indicated that the soil sample collected during the installation of well MW-129R at a depth of 7 feet below ground surface (bgs) contained concentrations of total petroleum hydrocarbons (TPH) exceeding Site CULs/RELs, as shown on **Figure 3**.

2.4.3 Additional Site Investigation Activities

In 2011, Site investigation activities were conducted in the Lower Yard, including a tidal study, hydraulic conductivity testing, and soil boring advancement. Tidal study data was collected from 17 locations in Site monitoring wells and staff gauges in Willow Creek. Hydraulic conductivity pumping tests, including step tests, short-duration tests, and one long term test, were conducted in 10 Site monitoring wells. Soil investigation included the advancement of 17 soil borings in the vicinity of DB-2, monitoring well MW-510, and Willow Creek and the installation of nine piezometers in these same areas. LNAPL was observed in soil in eight of the 17 soil borings at the time of installation and subsequently was observed in groundwater in two of the piezometers. Soils containing concentrations of Site IHSs exceeding their respective CULs and/or RELs were encountered in 11 of the soil borings. Details of the 2011 Site investigation activities are summarized in the 2011 Site Investigations Completion Report (ARCADIS 2011b).

2.5 Groundwater Monitoring

In accordance with the Agreed Order, groundwater monitoring was reinitiated in 2008 and is ongoing following completion of the interim remedial excavation activities. Groundwater sampling events were originally planned to be conducted every other month (bi-monthly) over a two year period at wells within three groundwater flow paths and at the 21 POC wells. Groundwater flow paths were established within the interior of the Site, and each groundwater flow path consisted of seven monitoring wells (an upgradient well, three source area wells, and three downgradient wells). The groundwater flow paths and the frequency of groundwater monitoring events were established to provide sufficient data to utilize Ecology's Natural Attenuation Analysis Tool Package A (Modules 1, 2 and 3).

The locations of the wells inside the three groundwater flow paths were based on the presence of LNAPL on groundwater prior to remedial activities. Prior to the 2007/2008 Interim Action remedial excavations, the groundwater flow paths were believed to fit the established model of upgradient, source area, and downgradient wells. However, during the 2007/2008 Interim Actions, remedial excavations extended beyond the mapped flow path areas, and it was determined that the resulting monitoring well arrangement was not suitable for use with Ecology's Natural Attenuation Analysis Tool Package A. As a result of the source removal, LNAPL is no longer observed across most of the Site, and the flow paths as previously defined do not contain monitoring wells that could provide upgradient and downgradient water quality data in relation to specific source areas. Therefore, the monitoring well plan outlined in the Agreed Order was no longer applicable for a spatial evaluation of natural attenuation away from the source, as required for use with Ecology's Natural Attenuation Analysis Tool Package A. As a result, revisions to the monitoring program were proposed to and approved by Ecology in December 2009. The monitoring well network was considered insufficient to monitor and evaluate the status of the overall dissolved-phase impacts by Ecology's Natural Attenuation Tool Package A. Stakeholders and Ecology have agreed and the quality of the Site groundwater is now being evaluated on a well-by-well basis.

In July 2009, eight piezometers were installed in the southeast Lower Yard, in the vicinity of monitoring wells MW-500 and MW-501 to investigate the apparent groundwater mound in the area. The piezometers were installed in pairs with one deep well and one shallow well. Soil samples were not collected for laboratory analysis during the piezometer installations. Details of the southeast Lower Yard piezometer installation activities are summarized in the 2009 Annual Groundwater Monitoring Report (ARCADIS, 2011a).

Currently, groundwater sampling events are conducted on a quarterly basis, with POC wells sampled during first and third quarter events, and all Site wells (POC and interior wells) sampled during second and fourth quarter events. LNAPL was present in one monitoring well (MW-510) from October 2009 to December 2010 and was not present during the June 2011 and December 2011 sampling events.

2.6 Site Geology

Five hydrostratigraphic units have been identified in the Lower Yard and are discussed in detail below:

- *2008 Fill*. The 2007/2008 Interim Action excavations were backfilled to 6 to 12 inches above the observed groundwater table in the open excavations with poorly graded coarse gravels (⅜ to 1 inch) with little to no fines. Backfill material above the coarse gravel to ground surface was a mixture of very fine to medium sand, trace silt, and fine to medium gravel materials. Hydraulic conductivity in the 2007/2008 Fill material is between approximately 5.9 to 13 feet per day (ARCADIS, 2011b).

- *1929 Fill*. This unit consists of silty sands with gravel and sandy silts with gravel. During the 2007/2008 Interim Action excavations, subsurface materials encountered from the ground surface to depths of 8 to 15 feet bgs were mostly fill material placed circa 1929 or later, during the creation of the Lower Yard facility. Hydraulic conductivity in the 1929 Fill material is approximately 0.3 feet per day (ARCADIS, 2011b).

- *Marsh Deposits*. In many areas of the Lower Yard, beneath the 1929 Fill, there is a layer approximately 6 to 12 inches thick composed of silt and sandy silt with large amounts of organic matter such as peat, wood debris, and decomposing vegetation. This layer is encountered at depths ranging from 8 to 15 feet bgs, directly below the 1929 Fill material, and is interpreted to be representative of the former marsh horizon beneath the Lower Yard. Hydraulic conductivity in the Marsh Deposit material is approximately 0.1 feet per day (ARCADIS, 2011b).

- *Beach Deposits*. Below the 1929 Fill and Marsh Deposits, a poorly graded sand formation of very fine to medium sand with fine gravel is present that contains organic material such as driftwood and seashells. This layer is interpreted to be representative of the former beach environment in the area prior to creation of the Lower Yard. Hydraulic conductivity in Beach Deposit material is approximately 11 feet per day (ARCADIS, 2011b).

- *Whidbey Formation*. This material is a poorly graded sand layer consisting of very fine to medium sand with fine gravel and is distinct from the overlying materials in the Lower Yard. It is present to the maximum explored depth of 41.8 feet bgs by Unocal. This unit contains interbedded sand with silt, and interbedded silt and sandy silt are also present. The interbeds range in thickness from less than 1 inch to several feet, and appear to be laterally discontinuous. This unit is interpreted to be alluvium, and is likely part of the Whidbey Formation. Hydraulic

conductivity in the Whidbey Formation material is estimated to be approximately 10 feet per day.

The current lithology of the Lower Yard consists primarily of 2008 Fill. All of the 2007/2008 Interim Action excavations were extended to reach Beach Deposits or Whidbey Formation materials. Remaining un-excavated areas are most likely 1929 Fill material, underlain by the hydrostratigraphic units described above.

3. Work Plan Objectives

The objective of the proposed work is to gather data necessary to address the various concerns of stakeholders regarding known and potentially remaining impacts at the Site and to update and refine the CSM as part of the FS.

Stakeholder concerns regarding the remaining and potentially remaining impacts at the Site have been raised in written comments, discussions at stakeholder meetings, and in response to interim action activities and additional Site investigation activities conducted from 2007 to 2011, as discussed in Section 2.4 and reported in the Phase I Remedial Implementation As-Built Report (ARCADIS 2009a), Phase II Remedial Implementation As-Built Report (ARCAIDS 2010b), 2008 Additional Site Investigation and Groundwater Monitoring Report (ARCADIS 2010a), 2009 Annual Groundwater Monitoring Report (ARCADIS 2011a) and 2011 Site Investigation Report (ARCADIS 2011b). A discussion of stakeholder concerns and the proposed work activities to address these concerns are detailed in the sections below.

3.1 Potential Offsite Migration of Dissolved Concentrations in Groundwater into Willow Creek

The potential for contaminant migration in groundwater offsite into Willow Creek from the DB-2 and monitoring well LM-2 areas has been identified as a stakeholder concern. Although soil borings were installed in the creek bank directly adjacent to DB-2 during 2011 investigation activities and inspected for the possible presence of petroleum hydrocarbons in unsaturated and saturated soil, there are remaining concerns for potential ongoing migration of dissolved phase constituents in groundwater in this area as well as in the northernmost corner of the Site, near well LM-2. Therefore, Ecology has requested additional investigation in these areas to develop a complete CSM for the Site.

As reported in the 2011 Site Investigation Report, additional activities were conducted in the unexcavated areas surrounding DB-2, including the installation of 17 soil borings and eight piezometers. LNAPL was observed in soil in eight of the soil borings, and soils containing concentrations of Site IHSs exceeding their respective CULs and/or RELs were encountered in 11 of the soil borings (**Figure 3**; ARCADIS 2010a, et. al). LNAPL subsequently was observed in groundwater in two of the piezometers, which were both located within 20 feet of monitoring well MW-510, located near DB-2. In addition, LNAPL was present on groundwater in monitoring well MW-510 in the

October 2009 to December 2010, September 2011 and June 2012 groundwater monitoring rounds.

Monitoring well LM-2 is located adjacent to Willow Creek and DB-1 in the northernmost portion of the Site. Well LM-2 has contained concentrations of dissolved-phase hydrocarbons exceeding their respective CULs during 11 of the16 groundwater monitoring events conducted at the Site since October 2008.

To investigate the potential for contaminant migration offsite in groundwater into Willow Creek, two monitoring wells will be installed in the bank of Willow Creek, adjacent to the LM-2 and DB-2 areas. A description of the proposed well installation plan is included in Section 4.1.

3.2 Dissolved Groundwater Concentrations in the Southeast Lower Yard

Stakeholders have expressed concern that the dissolved concentrations in groundwater beneath the southeast Lower Yard are possibly due to remaining impacted soils in the area of monitoring wells MW-135 and MW-136. Therefore, Ecology has requested additional investigation to evaluate whether there is a potential upgradient source contributing to the elevated dissolved-phase groundwater concentrations.

Prior to 2004, TPH concentrations in groundwater samples collected from wells MW-135 and MW-136 have contained concentrations of TPH in excess of the groundwater CULs. However, between periods of ground disturbing activities (2004 through 2007), both wells either maintained concentrations of TPH below the CULs or showed marked declines to levels below the TPH CULs. Based on historical soil borings, excavations were completed in close proximity to wells MW-135 and MW-136 (Excavation areas B1, B2, and B3) in 2007 and 2008. Approximately 5,000 tons of impacted soils, approximately 875 tons of concrete, wood, metal debris, and 18 steel drums and drum remnants were removed from excavation areas B1, B2, and B3. Confirmation soil samples confirmed that the potential source area which contributed to the dissolved TPH in groundwater in the southeast Lower Yard was removed. Dissolved concentrations in wells MW-135 and MW-136 have exceeded Site CULs during 10 and 12 of the past 16 groundwater monitoring events, respectively. Dissolved concentrations in both MW-135 and MW-136 were at a maximum during the June 2009 monitoring event. However, dissolved concentrations in groundwater from monitoring well MW-135 have shown a significant decreasing trend since November 2010 and

have not exceeded Site CULs since June 2011. Concentrations in groundwater from monitoring well MW-136 have also shown a significant downward trend, with exception of the March 2012 event in which concentrations of TPH increased to 835 micrograms per liter (µg/L).

To identify potential remaining soil and groundwater impacts upgradient of monitoring wells MW-135 and MW-136, two monitoring wells will be installed in the southeast Lower Yard (**Figure 2**). Soil samples will be collected during well installation, and a description of the proposed work is included in Section 4.2.1.

3.3 Impacted Soils in the WSDOT Stormdrain Line Area

The WSDOT-owned, 72-inch concrete stormdrain line runs across the Lower Yard along Lower Unoco Road and out to Puget Sound. During the 2007/2008 Interim Action excavation activities, impacted soils were encountered adjacent to the 72-inch stormdrain line. Soil samples collected on the excavation sidewalls, approximately 10 feet from the WSDOT stormdrain line contained concentrations exceeding Site CULs and/or RELs (ARCADIS 2009). Soils along the stormdrain line, including those with CUL/REL exceedances, were left in place in order to protect the integrity of the line.

Stakeholder concerns regarding the impacted soils left in place along the WSDOT stormdrain line during the Phase I Interim Action excavation activities (ARCADIS 2009a) and 2008 Site assessment activities (ARCADIS 2010b) are inconsistent with the agreement of the parties under the Purchase and Sale Agreement for the Site. That agreement recognized that certain structures on the property would present an obstacle to remediation in the immediate area of those structures. The parties agreed that when such obstacles were encountered, Union Oil could leave contamination in place so as to avoid disturbing the structures. The stormdrain line is such a structure.

To investigate the remaining soil and groundwater impacts in the vicinity of the WSDOT stormdrain line, four monitoring wells will be installed adjacent to the WSDOT stormdrain line. Soil samples will be collected during well installation, and the wells will be added to the groundwater monitoring schedule, as described in Section 4.2.2.

The proposed monitoring wells will establish whether the concentrations of TPH in soils surrounding the WSDOT stormdrain line are indicative of LNAPL, however soil impacts in excess of the site RELs are still present. Options for addressing these soil exceedances include:

- Limitation of usage and access through a Restrictive Covenant as allowed for in the Purchase and Sale Agreement between WSDOT and Unocal
- Encapsulation of remaining soil impacts
- In-situ remediation of remaining soil impacts through soil vapor extraction
- Excavation of remaining soil impacts.

The above alternatives will be evaluated in the FS, and a final remedy will be chosen.

3.4 Willow Creek 2003 Bioassay Sample Failure

Stakeholders have expressed concerns regarding sediment quality since the sediment sampling activities conducted in 2003 (Integral Consulting Inc. 2003). Therefore, Ecology has requested additional sediment data from the area of Willow Creek northeast of monitoring well MW-135.

In 2003, sediment samples were collected from 16 locations (US-01 through US-16) in Willow Creek. These samples were analyzed for a suite of chemical analyses, conventional testing, and bulk chemistry analyses as described in the Final Work Plan for Additional Lower Yard Assessment (MFA 2003a). Due to elevated TPH concentrations, Ecology determined that bioassay toxicity testing was needed on sediment samples from six of the locations. This included one upstream location (US-15) to use as a background location where concentrations of total TPH and total organic carbon (TOC) were low (Integral Consulting Inc, 2003). The toxicity tests consisted of 10-day amphipod survival, 48-hour bivalve larvae survival and development, and 20-day polychaete growth tests. Sediment collected from three of the locations failed at least one of the toxicity tests (SLR 2005). Two of the sample locations were located near the Lower Yard outfalls into Willow Creek, which were removed during the 2007/2008 sediment excavation activities. The remaining sample location in Willow Creek that failed toxicity testing (US-15) is located near the southeast Lower Yard, to the northeast of monitoring well MW-135, as shown on **Figure 3**.

To evaluate the potential remaining toxicity levels in Willow Creek sediments, additional sediment sampling will be conducted in the vicinity of sediment sampling location US-15, as described in Section 4.3. It is worth noting that Willow Creek in this location receives stormwater flows from upstream locations other than the Site.

3.5 Potential Upgradient Source Area

Stakeholders have discussed concerns regarding the dissolved phase TPH concentrations in groundwater present in upgradient sampled wells (MW-143, MW-502, and MW-511). Their concern is that the concentrations could be indicative of a source area which was not removed during the 2007/2008 Interim Action excavation activities. To provide additional data on upgradient groundwater quality and to assess whether TPH concentrations in groundwater attenuate prior to the POC, four existing monitoring wells will be added to the quarterly sampling program, as described in Section 4.4.

4. Proposed Work

With the objective to address stakeholder concerns and provide the necessary information to complete a comprehensive and updated CSM, additional investigation activities are being proposed and are discussed in the sections below.

4.1 Groundwater Monitoring Well Installation Adjacent to Willow Creek

ARCADIS proposes to install two monitoring wells adjacent to Willow Creek to collect and sample groundwater in proximity to Willow Creek. The wells will be installed to depths of approximately 7 feet bgs (0 foot above mean sea level [amsl]) and will be sampled on a quarterly basis as part of the current groundwater monitoring program. Data collected from these wells will be compared to data from upgradient wells and used to evaluate the potential groundwater migration pathway from the Site to the creek and the potential for groundwater/surface water mixing.

The proposed monitoring wells will be located downgradient of monitoring wells LM-2 and MW-510 (**Figure 2**). Groundwater concentrations of TPH in these wells exceeded the CUL established for the eastern portion of the Site (506 µg/L).

4.1.1 Willow Creek Monitoring Well Installation

ARCADIS will oversee the installation of two wells (MW-529 and MW-530) by a licensed driller along the east side of the Willow Creek, as shown on **Figure 2**. The wells will be installed during low tide using a hand auger or manually operated power equipment (e.g., power hammer). The monitoring wells will be offset approximately 1 foot east of Willow Creek and screened from approximately 2 to 7 feet bgs (0 to 5 amsl). To expedite well installation, the driller will install 1-inch-diameter wells with pre-packed screen intervals.

Each monitoring well will be constructed with a 5-foot-long, 1-inch screen that is pre-packed with a 2-inch annulus of sand filter material (Monterey 20/10, or similar) extending 6 inches above the top of screen, and 1-inch Schedule 40 polyvinyl chloride (PVC) threaded riser pipe. The riser pipe will extend to a total height of 5 feet above ground surface (12.5 ft amsl) and will be fitted with an expansion plug and locked to prevent surface water from entering the monitoring well during high tide. The pre-packed screen assembly will be placed into a borehole, and the native sediments will be allowed to surround the pre-pack screen assembly as the temporary outer casing is

extracted. Hydrated granular bentonite will be placed above the pre-pack screen assembly from approximately 6 inches bgs to the surface. Granular bentonite will be hydrated with potable water to complete hydration prior to completion of the monitoring well.

The monitoring wells will be developed as described in the Standard Operating Procedure (SOP) for Well Development (**Appendix B**). After well installation activities have been completed, a licensed land surveyor will survey the locations and elevations.

4.1.2 Sample Collection

Groundwater samples will be collected at monitoring wells LM-2 and MW-510 (assuming LNAPL is not present) and newly installed wells MW-529 and MW-530 to evaluate groundwater quality. Wells MW-529 and MW-530 will be treated as POC wells and will be sampled on a quarterly basis.

Groundwater within the vicinity of Willow Creek may consist of a mixture of discharging upgradient groundwater and infiltrating surface water. The relative proportions of upgradient groundwater and surface water present in Willow Creek groundwater are likely to vary throughout the tidal cycle, as the relative hydraulic head difference between the surface water and upgradient groundwater fluctuates with the tide. In an effort to characterize groundwater in the vicinity of Willow Creek when it contains the maximum contribution of upgradient groundwater, sampling will occur during low tide.

Monitoring wells will be sampled by low-flow methods in accordance with the SOP for groundwater sampling (**Appendix C**) during the quarterly monitoring events conducted at the Site. Special care will be taken to minimize drawdown in monitoring wells adjacent to Willow Creek during sampling to avoid drawing in surface water. This may require very slow pumping and will likely require the collection of samples during several low tide cycles. Pumping rate, total volume of water purged, and duration of purging will be recorded during purging of monitoring wells.

4.1.3 Chemical Analysis

Groundwater will be analyzed for the following chemical analytical suite:

- Gasoline-Range Organics (GRO) by Ecology Methods NWTPH-Gx

- Diesel-Range Organics (DRO) and Heavy Oil-Range Organics (HO) by Ecology Method NWTPH-Dx (after silica gel cleanup)

Field readings for water quality and geochemical parameters, including dissolved oxygen (DO), oxidation reduction potential (ORP), pH, conductivity, and temperature will also be collected at the time of sampling and recorded on field data sheets.

4.2 Groundwater Monitoring Well Installation in the Southeast Lower Yard and Near the WSDOT Stormdrain Line

In addition to the monitoring wells to be installed adjacent to Willow Creek, six monitoring wells will be installed, two in the southeast Lower Yard area and four near the WSDOT stormdrain line.

4.2.1 Southeast Lower Yard

To help evaluate the potential source of dissolved phase TPH levels in groundwater collected from monitoring wells MW-135 and MW-136, two groundwater monitoring wells (MW-527 and MW-528) will be installed in the southeast Lower Yard. The wells will be installed upgradient of wells MW-135 and MW-136 (**Figure 2**).

4.2.2 WSDOT Stormdrain Line

To monitor for the possible presence of LNAPL and dissolved-phase TPH concentrations in groundwater, two wells (MW-525 and MW-526) will be placed to the north of the WSDOT stormdrain line in the southern portion of the Site (**Figure 2**). Groundwater elevation data in these new wells will also be used to determine the effects on groundwater flow directions from polyethylene sheeting that remains from the 2007/2008 Interim Action excavation activities. At the request of WSDOT, an additional two monitoring wells (MW-531 and MW-532) will be installed to the south and southwest of the WSDOT stormdrain line, in between the WSDOT stormdrain line and the Point Edwards stormwater line. Well MW-531 will be used to assess groundwater conditions at the end of the 2007/2008 polyethylene sheeting. The well to the south (MW-532) will assess groundwater conditions in the area of soil boring SB-66 conducted during the 2008 Site investigation.

4.2.3 Monitoring Well Installation

Six monitoring wells (MW-525 to MW-528, MW-531 and MW-532) will be advanced to a depth of 13 to 15 feet bgs at the locations shown on **Figure 2**. The initial 8 feet will be cleared using an air knife and vacuum truck to reduce the potential for damage to underground improvements. The wells will be advanced using a hollow stem auger rig with 8-inch hollow stem augers. The Sampling and Analysis Plan, which is included as Appendix L of the 2007 Interim Action Report (Ecology 2007) and in Exhibit B of Agreed Order No. DE 4460 (SLR 2007b), specifies that wells will be advanced with a geoprobe. Use of an 8-inch-diameter hollow-stem auger is a variance from the original plan.

4.2.4 Soil Sample Collection and Analysis

During well installation, soils will be classified using the Unified Soil Classification System (USCS). Field screening of soil samples will include the use of a photo-ionization detector (PID) as well as visual observations of potentially impacted soil, visual observations of the presence of LNAPL or sheen, and observations of odor. When PID readings in excess of 25 parts per million (ppm) are encountered or when field screening indicates the potential presence of LNAPL or petroleum hydrocarbon-related soil impacts, soil samples will be collected and submitted for laboratory analysis. At each well location, a minimum of two soil samples (one from the approximate smear zone and another from the saturated zone) will be submitted for laboratory analysis. Samples will be placed in laboratory-provided containers and stored in an ice-chilled cooler prior to delivery to the analytical laboratory. PID readings, soil types, and other pertinent geologic data will be recorded on the boring log.

The collected soil samples will be submitted to a state-certified laboratory and analyzed for the following constituents, per the Sampling and Analysis Plan (SLR 2007b):

- Benzene by United States Environmental Protection Agency (USEPA) Method 8021B
- GRO by Ecology Method NWTPH-Gx
- DRO and HO by Ecology Method NWTPH-Dx (after silica gel cleanup)

Any samples that contain detectable DRO and/or HO concentrations greater than Site RELs will also be analyzed for cPAHs by USEPA Method 8270C.

4.2.5 Monitoring Well Construction

The proposed monitoring wells will be constructed of 2-inch Schedule 40 PVC pipe with 0.02-inch slotted screen. Based on previous groundwater levels observed at the Site, the screen interval will be set from 3 to 13 feet bgs, however, the screen interval may be altered based on observations during drilling. Sand packs will be constructed of 2/12 silica sand and extend from one foot above the screened interval to the total depth of the well. Each of the monitoring wells will be completed with hydrated bentonite chips to one foot bgs, with flush-mount well monuments set in concrete at the ground surface.

The monitoring wells will be developed as described in the SOP for Well Development (**Appendix B**). After monitoring well installation activities have been completed, a licensed land surveyor will survey the locations and elevations.

4.2.6 Groundwater Sample Collection and Analysis

Following the completion of well installation and development, monitoring wells MW-525 through MW-528, MW-531 and MW-532 will be added to regularly scheduled, quarterly groundwater monitoring events at the Site. Wells MW-525 through MW-528, MW-531 and MW-532 will be sampled in accordance with the interior monitoring well sampling schedule. The sampling schedule is described in Section 4.4.1.

4.3 Willow Creek Sediment Sampling

To assess the potential remaining presence of IHSs and toxicity levels in Willow Creek sediments, two sediment samples will be collected in the vicinity of former sediment sampling location US-15, as shown on **Figure 2**. Sediment samples will be collected from one downstream location (US-17) and one upstream location (US-18).

4.3.1 Sample Collection

To remain consistent with the 2003 sediment sampling event, the sediment samples will be collected in the manner described below.

A minimum of three grab samples will be collected at each sediment sampling location and will be combined to form a composite sample for that location. Grab samples will be collected using a clean 4-inch diameter PVC tube. Sediment from the surface to a depth of approximately 10 centimeters (cm) will be transferred from the PVC sampler into a clean stainless steel bowl for compositing. The sediment in the stainless steel bowl will be mixed until the color and texture are homogeneous. The sediment will then be transferred directly from the stainless steel bowl to the sample containers. One field duplicate sample will be collected for chemical analysis.

4.3.2 Chemical Analysis

To remain consistent with the 2003 sediment sampling event, the sediment samples will be analyzed for chemical and toxicity analysis described below as per the SAP (MFA 2001) that the sediment sampling was original conducted under.

The following analyses will be performed on the sediment samples collected from sample locations US-17 and US-18:

- Benzene, toluene, ethylbenzene and xylenes by USEPA Method 8060
- GRO by Ecology Method NWTPH-Gx
- DRO and HO by Ecology Method NWTPH-Dx (after silica gel cleanup)
- cPAHs by USEPA Method 8270C
- Total metals (lead, zinc, copper and arsenic) by USEPA 6000/7000
- Total sulfides by EPA Method SW846 9030
- Ammonia by EPA Method 350.1M
- Grain size distribution by ASTM Method D422
- TOC by Method SW846 9060

As in the 2003 sediment sample set, organic carbon normalization will be used to reduce variability in sediment concentrations that is associated with sediment organic

content and to focus on patterns of hydrocarbon distribution in sediments that is independent of the sediment organic carbon content. Therefore, compounds associated with petroleum hydrocarbons will be expressed as carbon normalized values.

Upon receipt from the laboratory, analytical results will be submitted to Ecology for review. The submittal will include a summary of the previous chemical results and bioassay tests for comparison.

Based on the results, Ecology will determine if bioassay testing is necessary. If bioassay testing is necessary, the following tests will be conducted for both acute and chronic biological toxicity testing:

- Amphipod mortality using the test species *Eohaustarius estuaries*
- Bivalve larvae abnormality/mortality using the test species *Mytilus edulis*
- Juvenile polychaete biomass using the test species *Neanthes arenaceodentata*.

4.4 Additional Groundwater Monitoring

Existing wells MW-13U, MW-126, MW-134X, and MW-203 (**Figure 2**) will be added to the regularly scheduled groundwater monitoring program. These additional monitoring wells will be considered interior monitoring wells and will be sampled during the second and fourth quarter sampling events. Data from these wells will be evaluated for the following purposes:

- Data from monitoring wells MW-126, MW-13U, MW-134X, and MW-203 will be used to provide upgradient data for ground water entering the Lower Yard.
- Data from all of the proposed wells will be used to complete a comprehensive CSM for the Site.

These wells will follow the current sampling schedule as described below.

4.4.1 Sampling Schedule

The following analytes and parameters are collected during the first, second, and third quarter sampling events:

- GRO by Ecology Methods NWTPH-Gx
- DRO and HO by Ecology Method NWTPH-Dx (after silica gel cleanup)
- Benzene by USEPA Method 8021B for MW-20R only
- Water quality and geochemical parameters including DO, ORP, pH, conductivity, and temperature

During the fourth quarter monitoring event, monitoring wells that are part of the monitoring program and do not contain LNAPL are sampled for the full suite of analytes listed above as well as the following:

- Benzene by USEPA Method 8021B
- cPAHs, plus naphthalene, by USEPA Method 8270C
- Sulfate by USEPA Method 300.0
- Nitrate by USEPA Method 300.0
- Alkalinity by USEPA Method 310.0
- Dissolved methane by USEPA Method RSK 175
- Dissolved manganese by USEPA Method 200.8

5. Schedule and Reporting

The activities discussed in this FS Work Plan will start within 30 days of receiving approval from Ecology. Installation of groundwater monitoring wells is tentatively scheduled for June 2012.

If the proposed work is completed in June 2012, the additional existing upgradient wells (MW-13U, MW-126, MW-134X, and MW-203) will be sampled during the third quarter 2012 event. If the new wells are not installed by June 2012, the existing upgradient wells will be sampled during the fourth quarter 2012 event.

The results of this investigation will be reviewed as analytical data are obtained. Data collected during the FS Work Plan implementation will be analyzed and presented in the updated CSM which is scheduled for submittal at the beginning of the fourth quarter 2012.

5.1 Interim Deliverables

Following the submittal of the Final FS Work Plan and prior to the submittal of the Draft FS, the following interim deliverables will be submitted:

- Monthly progress reports
- Additional site characterization and CSM update
- Proposed CULs and RELs
- Results of FS technology screening
- Proposed groundwater capture modeling
- Results of groundwater capture modeling

5.1.1 Monthly Progress Reports

Monthly progress reports will continue to be submitted during the interim period between submittal of the Final FS Work Plan and the Draft FS. The Monthly Progress Reports will summarize monthly Site activities, and if applicable, include a summary of data collected. Monthly Progress Reports will be submitted by the 15th of each month.

5.1.2 Additional Site Characterization and Conceptual Site Model Update

This deliverable will summarize results from Site characterization activities conducted as specified in the FS Work Plan and will update the CSM. The CSM will provide information on source characterization, fate and transport of constituents of concern (COCs), a list of IHSs, potential receptors (human and ecological), and potential current and potential future exposures to receptors. A draft version of this deliverable will be submitted during the fourth quarter 2012, following completion of the proposed assessment activities described in this FS Work Plan. Following a comment and review period that will include Ecology and other stakeholders, the final version of this deliverable will be submitted in the first quarter 2013.

5.1.3 Determination of Cleanup and Remedial Levels

Proposed CULs and RELs will be established for COCs in sediment, surface water, groundwater, and soil. A draft version of this deliverable will be submitted during the second quarter 2013. Following a comment and review period that will include Ecology and other stakeholders, the final version of this deliverable will be submitted during the second quarter 2013.

5.1.4 FS Screening Technologies

ARCADIS will prepare an interim deliverable that indentifies which remedial alternatives (as described in Section 6.1) and combination of remedial alternatives will be evaluated in the FS. This deliverable will be submitted during the second quarter 2013.

5.1.5 Groundwater Capture Modeling

Groundwater capture modeling will be conducted to assist with the design of some remedial alternatives that will be considered in the Draft FS. ARCADIS proposes to use the MODFLOW (McDonald and Harbaugh, 1988) code or similar (e.g. MODLFOW-SURFACT), if needed for saturated-unsaturated subsurface flow analysis, to simulate groundwater flow and potential groundwater-surface water interactions at the Site and surrounding areas. MODFLOW has the flexibility to handle the boundary conditions found at the Site and can simulate various external stresses such as tidal influences, groundwater extraction wells, and distribution recharge.

The results from the modeling will be presented as an interim deliverable. A draft version of this deliverable will be submitted at the end of the third quarter 2013. Following a comment and review period that will include Ecology and other stakeholders, the final version of this deliverable will be submitted during the fourth quarter 2013.

In addition to the draft and final reports on groundwater capture modeling the following deliverables also will be provided to Ecology:

- A meeting to discuss the modeling proposed, including the specific computer model(s) that will be used. Ecology must approve of the computer model.
- A report discussing the hydrostratigraphy to be modeled, parameters for each hydrostratigraphic unit, and cross-sections and maps showing the hydrostratigraphy to be modeled.
- A report of anticipated output, including sensitivity analyses.

6. Feasibility Study Report

The purpose of the FS is to develop sufficient information for Ecology to select a cleanup action. The FS will evaluate the effectiveness of cleanup actions conducted to date and will establish remedial alternatives for bringing the Site to regulatory closure through a final Cleanup Action Plan. The FS will be conducted under the assumption that, at the conclusion of the cleanup, the Site will be suitable for any use consistent with Site zoning. Current zoning of the Lower Yard is MP2 (Master Plan Hillside Mixed Use) and current zoning of the Upper Yard is MP1 (Master Plan Hillside Mixed Use). Data collected during the work described in this FS Work Plan and from previous investigations including the 2011 aquifer testing, the 2011 DB-2 investigation, confirmation soil sampling during the 2007/2008 Interim Action excavations, and groundwater monitoring data collected post-remedial excavation as well as historical soil, sediment, groundwater, and surface water data will be used and analyzed to establish a preferred remedial alternative which, if approved by Ecology, will be adopted as the final cleanup action. The final cleanup action will be documented in a final As-Built Report.

6.1 Draft FS Outline

The Draft FS will be submitted to Ecology at the end of the fourth quarter 2013. As mentioned above, the FS will evaluate the effectiveness of cleanup actions conducted to date in both the Lower and Upper Yards, as well as to establish remedial alternatives for bringing the Site to regulatory closure through a final Cleanup Action Plan. A draft outline of the Draft FS is presented below:

Section 1, Introduction.

Section 2, Background.

This section will include a description of land use and zoning, utilities and easements, physical characteristics, regional and Site environmental setting, and the Lower Yard and Upper Yard interim action work.

Section 3, Nature and Extent of Impacts

This section will present the types and extent of impacts in soil, groundwater, surface water, and sediment. This section will also discuss the presence of LNAPL at the Site.

Section 4, Conceptual Site Model.

An updated CSM will be developed as an FS interim deliverable. The CSM will provide information on source characterization, fate and transport of COCs, a list of IHSs, potential receptors (human and ecological), and potential, current, and potential future exposures to receptors. The updated CSM will be provided in the Draft FS.

Section 5, Cleanup Levels.

Section 5.1, Cleanup Levels for Constituents of Concern (COCs).

Cleanup standards will be established for COCs in sediment, surface water, groundwater, and soil. Cleanup levels will be protective of human health and the environment and will take into account POCs and other potentially applicable or relevant and appropriate requirements. CULs will be established and discussed in an interim deliverable prior to submittal of the Draft FS. The Draft FS will summarize the CULs.

Section 6. Development of Remedial Alternatives.

This section will describe the development of remedial alternatives. This section will discuss technology screening, the approach for developing remedial alternatives including RELs, and remedial alternatives that will be considered for the Site.

Section 6.1, Technology Screening.

Consistent with Washington Administrative Code (WAC) 173-340-350(8)(b)—Screening of Alternatives, individual cleanup technologies will be reviewed and screened to identify applicable methods for remediating soil and groundwater beneath the Lower and Upper Yards and for remediating sediment in Willow Creek. The technologies will initially be identified using the Federal Remediation Technologies Roundtable (FRTR) screening matrix (FRTR 2002, Table 3-2), as well as knowledge of commonly used remediation methods. Effectiveness and feasibility of these technologies will be assessed for the COCs in each medium, resulting in a

list of technologies that will be retained for further consideration. Per Ecology's request, technologies that will be screened include the following:

- Monitored natural attenuation
- Excavation
- Focused enhanced bio-oxidation
- Surfactant flushing
- Groundwater containment with closely spaced wells
- Groundwater containment trench
- Interceptor trench with impermeable barrier on the downgradient extent
- Funnel and gate groundwater extraction system
- Funnel and gate with permeable sorptive walls at gates

Section 6.2, Approach to Developing Remedial Alternatives.

Remedial alternatives will be developed using the individual cleanup technologies that remain after the technology screening (Section 6.1) and by:

- Subdividing the Lower Yard into remediation areas based on distribution and chemical composition of the contaminants
- Considering standard and conditional POCs for each affected medium
- Developing RELs based on direct contact exposure pathways
- Combining individual cleanup technologies from Section 6.1 into remedial alternatives that meet CULs and/or RELs
- Specifying the types, levels, amounts, and locations of hazardous substances remaining on site and the measures that will be used to prevent their migration for each alternative that involves on site containment.
- Identifying needed administrative controls such as deed restrictions

Section 6.2.1, Remediation Levels—Soil.

Soil RELs will be established and discussed in an interim deliverable prior to submittal of the Draft FS. The Draft FS will summarize established soil RELs. RELs are used at sites where a combination of cleanup actions (e.g., soil removal and capping) are used to achieve CULs at the POCs (WAC 173-340-355[1]). Potential exposure pathways and applicable CULs will be considered when developing RELs. This section will discuss how RELs and remedial alternatives will affect and address the following final end points: residual saturation and vapor pathways.

Section 6.2.2, Remediation Levels—Groundwater.

Groundwater RELs will be established and discussed in an interim deliverable prior to submittal of the Draft FS. The Draft FS will summarize established groundwater RELs. Groundwater RELs will be established using a one-dimensional steady-state natural attenuation model. Groundwater RELs will be the maximum concentration at a specific location away from the POC that would naturally attenuate to a concentration at or below the CUL at the downgradient compliance well.

Section 6.3, Description of Remedial Alternatives.

This section will describe remedial alternatives developed for the Lower Yard. Further alternative development is not anticipated for the Upper Yard. Alternatives will include a combination of individual technologies that remain after preliminary technology screening. This section will provide LNAPL, soil, and groundwater remediation components of the remedial alternatives. This section will also provide preliminary design data for each remedial alternative, which will be used to develop cost estimates needed for evaluation of the alternatives. At least one permanent alternative will be developed.

Section 7, Evaluation of Remedial Alternatives.

Remedial alternatives will be evaluated based on the Model Toxics Control Act's minimum requirements for cleanup actions per WAC 173-340-360(2). These requirements include threshold requirements, other requirements (as defined by WAC 173-340-360(2)(b), and requirements presented in WAC 173-340-360(2)(c) to (f).

Section 7.1, Threshold Requirements.

Per WAC-173-340-360(2)(a), a cleanup action shall meet threshold requirements including:

- Protect human health and the environment
- Comply with cleanup levels
- Comply with applicable state and federal laws
- Provide for compliance monitoring

This section will evaluate each remedial alternative to determine the extent that these threshold requirements are met.

Section 7.2, Other Requirements.

Cleanup action alternatives that fulfill the threshold requirements shall also meet the following requirements, which are presented in WAC-173-340-360(2)(b):

- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration time frame
- Consider community concerns

A disproportionate cost analysis will be used to determine whether a cleanup action uses permanent solutions to the maximum extent practicable. A disproportionate cost analysis will evaluate a remedial alternative based on the following criteria (per WAC 173-340-360(3)(f)): protectiveness, permanence, cost, effectiveness over the long term, management of short-term risks, technical and administrative implementability, and consideration of public concerns. This section will evaluate each remedial alternative to determine the extent that these requirements are met, and a disproportionate cost analysis will be performed for each remedial alternative. Evaluations will consider Ecology's expectations for cleanup actions as presented in WAC 173-340-370.

At least one permanent alternative will be carried forward into the evaluation process. A permanent alternative will be used as the baseline alternative against which other alternatives are compared.

Section 7.3, Requirements Presented in WAC 173-340-360(2)(c) to (f).

Per WAC 173-340-360(2)(c) to (f), a cleanup action shall also meet the following requirements:

- Groundwater cleanup actions
- Cleanup actions for soil at current or potential future residential areas and for soil at schools and child care centers
- Institutional controls
- Releases and migration
- Dilution and dispersion

- RELs

This section will evaluate each remedial alternative to determine the extent that these requirements are met.

Section 8, Recommended Alternative.

This section will summarize the evaluation of remedial alternatives and will identify the final recommended remedial alternative.

6.2 Feasibility Study Schedule

As discussed in Section 5, the draft FS is scheduled for submittal by the end of the fourth quarter 2013. A schedule to the FS is included in **Appendix D**. This schedule is intended to show the critical paths and estimated time frame for submittal of the interim deliverables.

The proposed schedule dates assumes 90 days from DOE for final comments but may need to be extended should the time needed for comments be greater than 90 days

7. References

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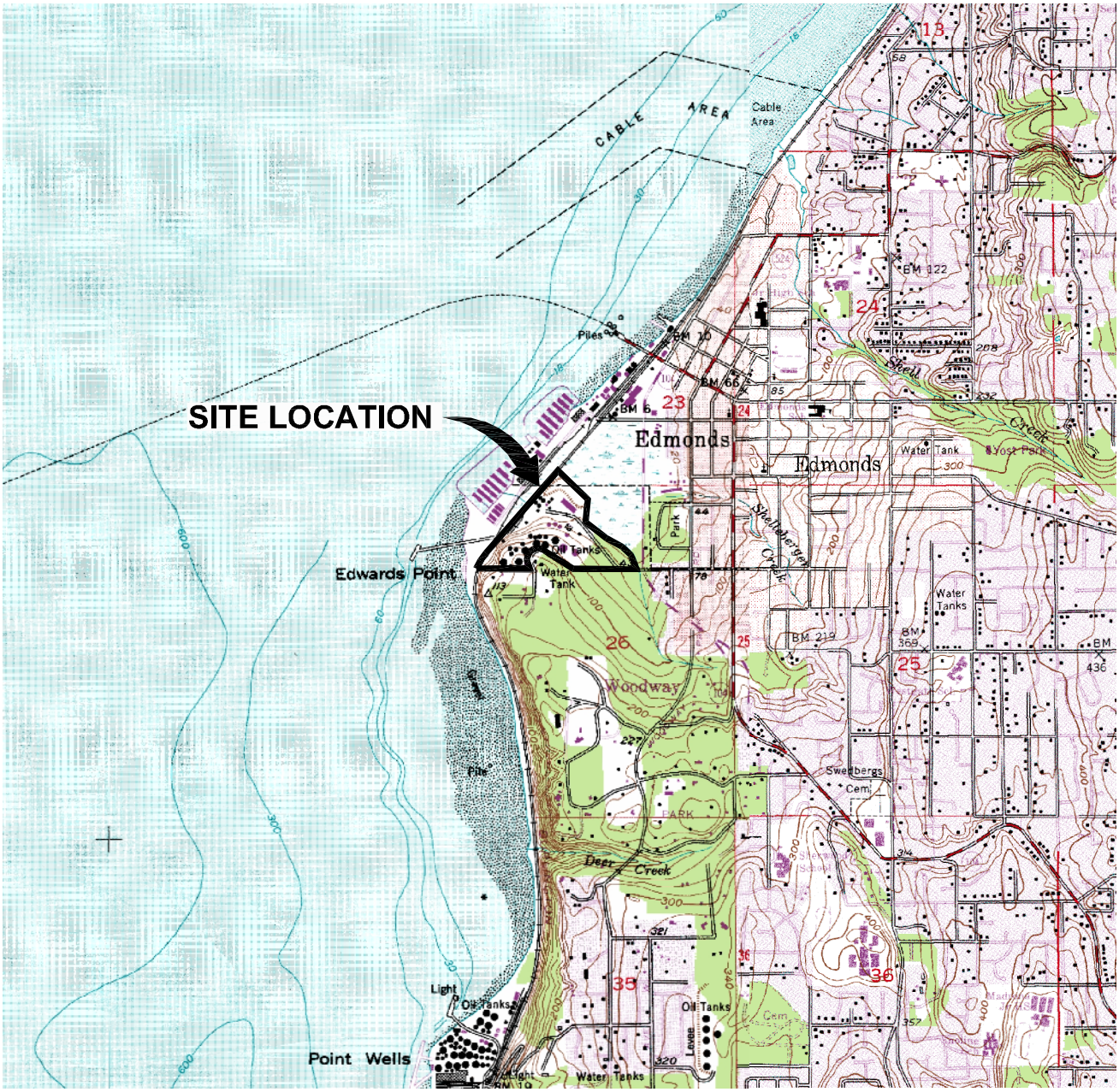
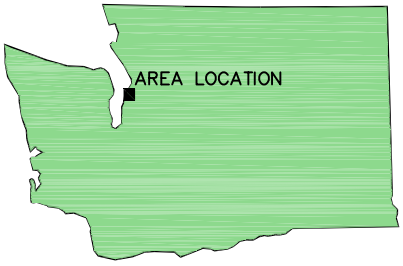


REFERENCE: USGS QUADS., 7.5 MIN. SERIES (TOPOGRAPHIC) - EDMONDS EAST, WASH. AND EDMONDS WEST, WASH.

0 0.5 1.0

Approximate Scale: 1"=0.5 Miles



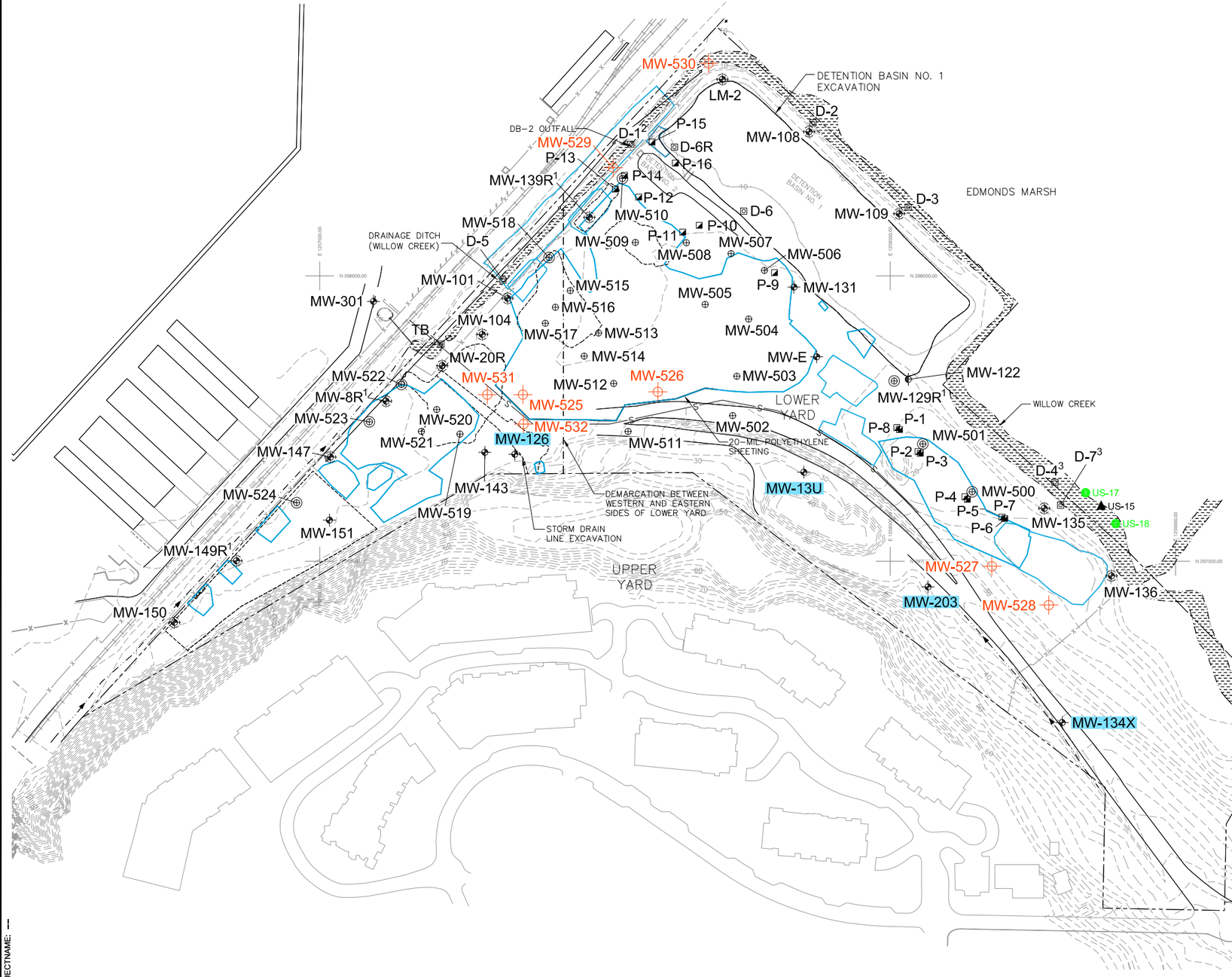
WASHINGTON

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
FORMER UNOCAL TERMINAL
EDMONDS, WASHINGTON

SITE LOCATION MAP

ARCADIS

FIGURE
1



LEGEND:

MW-203	MONITORING WELL LOCATION AND DESIGNATION
MW-122	DEEP MONITORING WELL LOCATION AND DESIGNATION
MW-109	EXISTING SURFACE WATER COMPLIANCE MONITORING WELL LOCATION AND DESIGNATION
MW-518	SURFACE WATER COMPLIANCE MONITORING WELL LOCATION INSTALLED OCTOBER 2008
MW-521	MONITORING WELL LOCATION INSTALLED OCTOBER 2008
P-11	PIEZOMETER
D-1	STAFF GAUGE
	2001 AND 2003 SOIL EXCAVATIONS BELOW GROUNDWATER TABLE
	LOWER YARD PROPERTY BOUNDARY
S	STORM DRAIN LINE
	2007/2008 EXCAVATION BOUNDARIES
	ADDITIONAL GROUNDWATER MONITORING WELLS
MW-528	PROPOSED MONITORING WELLS
	SEDIMENT SAMPLE COLLECTION LOCATION THAT FAILED 2003 TOXICITY TESTS
	PROPOSED SEDIMENT SAMPLE LOCATION

NOTES:

1. MONITORING WELLS MW-129R, MW-139R, MW-8R, AND MW-149R WERE ABANDONED DURING INTERIM ACTION AND REPLACED IN OCTOBER 2008.
2. STAFF GAUGE D-1 RE-ESTABLISHED PRIOR TO JUNE 2009 SAMPLING EVENT.
3. STAFF GAUGE D-4 WAS ESTABLISHED PRIOR TO JUNE 2009 SAMPLING EVENT TO REPLACE STAFF GAUGE D-7 WHICH IS NOT WITHIN THE WILLOW CREEK CHANNEL.
4. STAFF GAUGES WERE RESURVEYED BY OTAK INCORPORATED JUNE 1, 2009. STAFF GAUGES WERE SURVEYED FROM TOP OF GAUGE AND WATER LEVELS ARE NOW MEASURED FROM TOP DOWN TO WATER.
5. 20-MIL POLYETHYLENE SHEETING INSTALLED UPON COMPLETION OF PHASE I EXCAVATION. SHEETING REACHES TO APPROXIMATELY 10 FT BGS.

0 100' 200'
GRAPHIC SCALE

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
FORMER UNOCAL EDMONDS TERMINAL, LOWER YARD
EDMONDS, WASHINGTON
FEASIBILITY STUDY WORK PLAN

PROPOSED MONITORING MAP

ARCADIS

FIGURE
2

CITY: (TAMPA, FL) SYRACUSE, NY GROUP: ENVCAD DB: (J. RICHARDS), K. DAVIS, P. LISTER PM: R. ANDRESEN TM: S. ZORN TR: D. RASAR LYR: ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0045362\0003\0017\DWG\FS-WP45362B10.dwg LAYOUT: 2 SAVED: 7/18/2012 10:49 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: --- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 7/18/2012 10:49 AM BY: SCHILLING, ADAM
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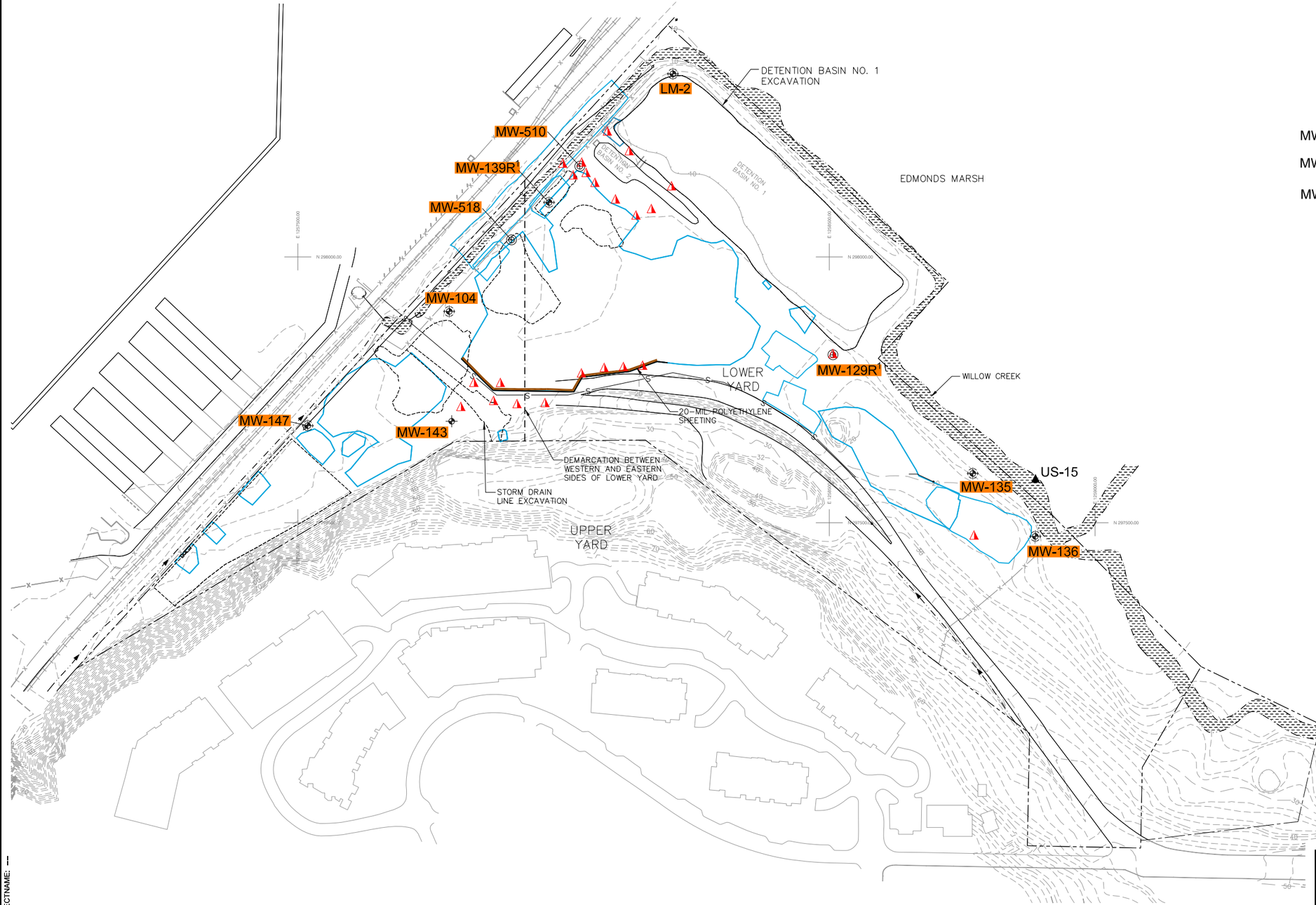
45362X02
45362X00
45362X03



LEGEND:

- MW-203 — MONITORING WELL LOCATION AND DESIGNATION
- MW-109 — EXISTING SURFACE WATER COMPLIANCE MONITORING WELL LOCATION AND DESIGNATION
- MW-518 — SURFACE WATER COMPLIANCE MONITORING WELL LOCATION INSTALLED OCTOBER 2008
- SEDIMENT SAMPLE COLLECTION LOCATION THAT FAILED 2003 TOXICITY TESTS.
- SOIL SAMPLE COLLECTION LOCATION WITH CONCENTRATIONS OF TOTAL TPH AND/OR CPAHS EXCEEDING APPLICABLE SITE CULs AND/OR RELs.
- 2001 AND 2003 SOIL EXCAVATIONS BELOW GROUNDWATER TABLE
- LOWER YARD PROPERTY BOUNDARY
- 2007/2008 EXCAVATION BOUNDARIES
- —S— STORM DRAIN LINE

NOTES:

1. MONITORING WELLS MW-129R, MW-139R, MW-8R, AND MW-149R WERE ABANDONED DURING INTERIM ACTION AND REPLACED IN OCTOBER 2008.
2. STAFF GAUGE D-1 RE-ESTABLISHED PRIOR TO JUNE 2009 SAMPLING EVENT.
3. STAFF GAUGE D-4 WAS ESTABLISHED PRIOR TO JUNE 2009 SAMPLING EVENT TO REPLACE STAFF GAUGE D-7 WHICH IS NOT WITHIN THE WILLOW CREEK CHANNEL.
4. STAFF GAUGES WERE RESURVEYED BY OTAK INCORPORATED JUNE 1, 2009. STAFF GAUGES WERE SURVEYED FROM TOP OF GAUGE AND WATER LEVELS ARE NOW MEASURED FROM TOP DOWN TO WATER.
5. 20-MIL POLYETHYLENE SHEETING INSTALLED UPON COMPLETION OF PHASE I EXCAVATION. SHEETING REACHES TO APPROXIMATELY 10 FT BGS.
6. HIGHLIGHTED WELL LOCATION INDICATES AN EXCEEDENCE OF THE TPH CUL DURING ONE OR MORE 2011 GROUNDWATER MONITORING EVENT.

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
FORMER UNOCAL EDMONDS TERMINAL, LOWER YARD
EDMONDS, WASHINGTON
FEASIBILITY STUDY WORK PLAN

REMAINING SOIL AND GROUNDWATER IMPACTS

ARCADIS

FIGURE 3

CITY: Syracuse GROUP: EnvCAD DB: K. DAVIS, P. LISTER, A.Schilling, R. BASSETT PM: RAndresen TM: S.Zorn LYR: ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACTIB\004536200\03\000017\DWG\FS-WP\45362B03.dwg LAYOUT: 3 SAVED: 7/18/2012 10:47 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---
XREFS: IMAGES: PROJECTNAME: ---
45362X02
45362X00
45362X03

ARCADIS

Appendix A

Ecology Letter Templates

*FOR USE IF ECOLOGY DETERMINES THAT ADDITIONAL GROUNDWATER REMEDIATION IS **NOT** REQUIRED*

DATE

Mr. Mark Stella
Chevron EMC
6001 Bollinger Canyon Road
San Ramon, CA 94583

RE: *Completion of Remedial Actions Required by Work Plan for 2007 Lower Yard Interim Action, Unocal Edmonds Bulk Fuel Terminal*

Dear Mr. Stella:

With this letter, the Department of Ecology acknowledges that Union Oil Company of California (Unocal) has successfully completed the Capital Remediation Work identified in the Work Plan for 2007 Lower Yard Interim Action ("Work Plan") for the Edmonds Lower Yard, dated [DATE], as required by MTCA Agreed Order No. DE _____. The Work Plan, prepared for Unocal by SLR International Corp., was approved by Ecology on [DATE].

Unocal has now completed all cleanup activities proposed for the Lower Yard under the Work Plan, including (and as further described in the Work Plan):

- Excavation and removal of soils with concentrations of total petroleum hydrocarbons at or above 2,975 mg/kg TPH; total carcinogenic PAHs at or above 0.14 mg/kg; benzene at or above 6.23 mg/kg; and arsenic at or above 20 mg/kg;

- Extraction and removal of petroleum free product and hydrocarbon-impacted groundwater;

- Excavation and removal of sediment in the vicinity of site stormwater outfalls #001 and #002;

- Groundwater monitoring to determine whether remaining concentrations of petroleum hydrocarbons in soil will cause future exceedances of groundwater cleanup levels (CULs) at groundwater points of compliance (POCs); and

- Groundwater monitoring to determine if the petroleum hydrocarbon concentrations in the groundwater will naturally attenuate to levels below the CULs at the groundwater POCs.

As a result of these activities, the remaining concentrations of petroleum hydrocarbons in soil appear to be protective of groundwater, and the remaining concentrations of petroleum hydrocarbons in groundwater appear to be protective of the surface water in Willow Creek. Ecology has determined, based on information currently available, that it is not necessary to construct a groundwater recovery/treatment system for the Lower Yard.

Should you have any questions, please call me at 425-649-7200 or email me at dsou461@ecy.wa.gov.

Sincerely,

David L. South
Senior Engineer

cc: Leslie Seffern
Tim McGuigan
John White, P.E.
Patricia K. Nightingale
Richard F. Chatfield-Taylor
Rebecca Andressen

***FIRST** OF TWO LETTERS TO BE ISSSUED IF ECOLOGY REQUIRES ADDITIONAL GROUNDWATER REMEDIATION*

DATE

Mr. Mark Stella
Chevron EMC
6001 Bollinger Canyon Road
San Ramon, CA 94583

RE: *Completion of Remedial Actions Required by Work Plan for 2007 Lower Yard Interim Action, Unocal Edmonds Bulk Fuel Terminal*

Dear Mr. Stella:

With this letter, the Department of Ecology acknowledges that Union Oil Company of California (Unocal) has successfully completed the Capital Remediation Work identified in the Work Plan for 2007 Lower Yard Interim Action ("Work Plan") for the Edmonds Lower Yard dated [DATE], as required by MTCA Agreed Order No. DE _____. The Work Plan, prepared for Unocal by SLR International Corp., was approved by Ecology on [DATE].

Unocal has now completed all cleanup activities proposed for the Lower Yard under the Work Plan, including (and as further described in the Work Plan):

- Excavation and removal of soils with concentrations of total petroleum hydrocarbons at or above 2,975 mg/kg TPH; total carcinogenic PAHs at or above 0.14 mg/kg; benzene at or above 6.23 mg/kg; and arsenic at or above 20 mg/kg.

- Extraction and removal of petroleum free product and hydrocarbon-impacted groundwater;

- Excavation and removal of sediment in the vicinity of site stormwater outfalls #001 and #002;

- Monitoring to determine whether remaining concentrations of petroleum hydrocarbons in soil will cause future exceedances of groundwater cleanup levels (CULs) at groundwater points of compliance (POCs); and

- Groundwater monitoring to determine if the petroleum hydrocarbon concentrations in the groundwater will naturally attenuate to levels below the CULs at the groundwater POCs.

Based on these activities, Ecology cannot conclude that remaining concentrations of petroleum hydrocarbons in soil are protective of groundwater. Ecology will issue a Cleanup Action Plan that describes further remedial actions that are necessary to protect human health and the environment.

Should you have any questions, please call me at 425-649-7200 or email me at dsou461@ecy.wa.gov.

Sincerely,

David L. South
Senior Engineer

cc: Leslie Seffern
Tim McGuigan
John White, P.E.
Patricia K. Nightingale
Richard F. Chatfield-Taylor
Rebecca Andressen

SECOND *OF TWO LETTERS TO BE ISSSUED IF ECOLOGY REQUIRES ADDITIONAL GROUNDWATER REMEDIATION*

DATE

Mr. Mark Stella
Chevron EMC
6001 Bollinger Canyon Road
San Ramon, CA 94583

RE: *Completion of Remedial Actions Required by Work Plan for 2007 Lower Yard Interim Action, Unocal Edmonds Bulk Fuel Terminal*

Dear Mr. Stella:

With this letter, the Department of Ecology acknowledges that Union Oil Company of California (Unocal) has successfully completed construction of the groundwater treatment system as required by the Cleanup Action Plan (CAP) for the Edmonds Bulk Fuel Terminal, Lower Yard, dated [DATE], and in accordance with plans and specifications approved by Ecology on [DATE].

In addition, based on [INSERT NAME OF REPORT TO BE SUBMITTED BY UNOCAL] dated [DATE], Ecology acknowledges that the treatment system's hydraulic capture zone is calculated and confirmed by field measurement to be at least as large as the zone described in the CAP. Ecology further acknowledges receipt of Discharge Monitoring Reports prepared by Unocal demonstrating that the treatment system meets effluent limits established in NPDES Permit Number [INSERT].

Should you have any questions, please call me at 425-649-7200 or email me at dsou461@ecy.wa.gov.

Sincerely,

David L. South
Senior Engineer

cc: Leslie Seffern
Tim McGuigan
John White, P.E.
Patricia K. Nightingale
Richard F. Chatfield-Taylor
Rebecca Andressen

ARCADIS

Appendix B

SOP: Monitoring Well Development

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Monitoring Well Development

Rev. #: 2.2

Rev. Date: March 22, 2010

Approval Signatures

Prepared by:  Date: 03/22/2010

Reviewed by:  Date: 03/22/2010

(Technical Expert)

I. Scope and Application

Monitoring wells (or piezometers, well points, or micro-wells) will be developed to clear them of fine-grained sediment to enhance the hydraulic connection between the well and the surrounding geologic formation. Development will be accomplished by evacuating well water by either pumping or bailing. Prior to pumping or bailing, the screened interval will be gently surged using a surge block, bailer, or inertia pump with optional surgeblock fitting as appropriate. Accumulated sediment in the bottom of the well (if present) will be removed by bailing with a bottom-loading bailer or via pumping using a submersible or inertia pump with optional surge-block fitting. Wells will also be gently brushed with a weighted brush to assist in removing loose debris, silt or flock attached to the inside of the well riser and/or screen prior to development. Pumping methods will be selected based on site-specific geologic conditions, anticipated well yield, water table depth, and groundwater monitoring objectives, and may include one or more of the following:

- submersible pump
- inertial pump (Waterra™ pump or equivalent)
- bladder pump
- peristaltic pump
- centrifugal pump

When developing a well using the pumping method, the pump (or, with inertial pumps, the tubing) is lowered to the screened portion of the well. During purging, the pump or tubing is moved up and down the screened interval until the well yields relatively clear water.

Submersible pumps have a motor-driven impeller that pushes the groundwater through discharge tubing to the ground surface. Inertial pumps have a check valve at the bottom of stiff tubing which, when operated up and down, lifts water to the ground surface. Bladder pumps have a bottom check valve and a flexible internal bladder that fills from below and is then compressed using pressurized air to force water out the top of the bladder through the discharge tubing to the ground surface. These three types of pumps have a wide range of applicability in terms of well depth and water depth.

Centrifugal and peristaltic pumps use atmospheric pressure to lift water from the well, and therefore can only be practically used where the depth to water is less than 25 feet.

II. Personnel Qualifications

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

Materials for monitoring well development using a pump include the following:

- health and safety equipment, as required by the site Health and Safety Plan (HASP):
- cleaning equipment
- photoionization detector (PID) to measure headspace vapors
- pump
- polyethylene pump discharge tubing
- plastic sheeting
- power source (generator or battery)
- field notebook and/or personal digital assistant (PDA)
- graduated pails
- appropriate containers

- monitoring well keys
- water level indicator

Materials for monitoring well development using a bailer include the following:

- personal protective equipment (PPE) as required by the HASP
- cleaning equipment
- PID to measure headspace vapors
- bottom-loading bailer, sand bailer
- polypropylene or nylon rope
- plastic sheeting
- graduated pails
- appropriate containers
- keys to wells
- field notebook and/or PDA
- water level indicator
- weighted brush for well brushing

IV. Cautions

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Project Manager (PM) must be notified and the PM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the PM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

V. Health and Safety Considerations

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

The procedures for monitoring well development are described below. (Note: Steps 7, 8, and 10 can be performed at the same time using an inertial pump with a surge-block fitting.)

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

4. Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

5. Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

6. Prior to redeveloping older wells that may contain solid particulate debris along the inside of the well casing and screen, gently lower and raise a weighted brush along the entire length of the well screen and riser to free and assist in removing loose debris, silt or flock. Perform a minimum of 4 “passes” along the screened and cased intervals of the well below the static water level in the well. Allow the resulting suspended material to settle for a minimum of one day prior to continuing with redevelopment activities.

7. Lower a surge block or bailer into the screened portion of the well. Gently raise and lower the surge block or bailer within the screened interval of the well to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

8. Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce the bailer, pump, pump tubing on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and the bottom of the well feels solid. Alternatively, measurement of the well depth with a water level indicator can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

9. After surging the well and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

10. Remove formation water by pumping or bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least

once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Field Sampling Plan (FSP) are reached. Record the total volume of water purged from the well.

11. If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

12. Contain all water in appropriate containers.

13. When complete, secure the lid back on the well.

14. Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer.

VII. Waste Management

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan or Field Sampling Plan.

VIII. Data Recording and Management

Well development activities will be documented in a proper field notebook and/or PDA. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

IX. Quality Assurance

All reused, non-disposable, downhole well development equipment will be cleaned in accordance with the procedures outlined in the Field Equipment Cleaning-Decontamination SOP.

X. References

Not applicable.

ARCADIS

Appendix C

SOP: Standard Groundwater Sampling for Monitoring Wells

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Standard Groundwater Sampling for Monitoring Wells

Rev. #: 1

Rev Date: July 16, 2008

Approval Signatures

Prepared by: _____ Date: 7/16/08

Reviewed by: _____ Date: 7/16/08
(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to be used to collect groundwater samples using traditional purging and sampling techniques. For low-flow purging techniques, please refer to the Low Flow Purging SOP. Monitoring wells must be developed after installation at least 1 week prior to groundwater sample collection. Monitoring wells will not be sampled until the well has been developed. During precipitation events, groundwater sampling will be discontinued until precipitation ceases or a cover has been erected over the sampling area and monitoring well.

Both filtered and unfiltered groundwater samples may be collected using this SOP. Filtered samples may be obtained using a 1.0-, 0.45-, or 0.1-micron disposable filter.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. Field employees with less than 6 months of experience should be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

III. Equipment List

The following materials shall be available, as required, during groundwater sampling:

- site plan of monitoring well locations and site Field Sampling Plan (FSP);
- appropriate health and safety equipment, as specified in the site Health and Safety Plan (HASP);
- photoionization detector (PID) or flame ionization detector (FID), as needed, in accordance with the HASP;
- monitoring well construction logs or tables and historical water level information, if available;
- dedicated plastic sheeting or other clean surface to prevent sample contact with the ground;
- if bailers are to be used in sampling:

  - appropriate dedicated bottom-loading, bottom-emptying bailers (i.e., polyvinyl chloride [PVC], Teflon, or stainless steel);
  - polypropylene rope;
- if submersible pumps are to be used in sampling:
  - dedicated tubing and other equipment necessary for purging;
  - generator or battery for operation of pumps, if required;
  - a pump selected in accordance with the FSP or Work Plan (parameter-specific [e.g., submersible, bladder, peristaltic]);
- graduated buckets to measure purge water;
- water-level or oil/water interface probe, in accordance with the FSP or Work Plan;
- conductivity/temperature/pH meter;
- down-hole dissolved oxygen meter, oxidation reduction potential meter, and/or turbidity meter, if specified in the FSP;
- water sample containers appropriate for the analytical method(s) with preservative, as needed (parameter-specific);
- filter, as needed, in accordance with the analytical method and parameter;
- appropriate blanks (trip blank supplied by the laboratory), as specified in the FSP;
- Ziploc-type freezer bags for use as ice containers;
- appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials;
- appropriate groundwater sampling log (example attached);
- chain-of-custody forms;
- site map with well locations and groundwater contour maps;

- keys to wells and contingent bolt cutters for rusted locks and replacement keyed-alike locks; and

- drums or other containers for purge water, as specified by the site investigation derived waste (IDW) management plan.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Remember that field logs and some forms are considered to be legal documents. All field logs and forms should therefore be filled out in indelible ink.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Check monitoring well logs for use of bentonite pellets. Make note of potential use of bentonite pellets on the groundwater sampling log. Coated bentonite pellets have been found to contaminate monitoring wells with elevated levels of acetone.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to more impacted based on previous analytical data. If no analytical data are available, samples are to be collected in the following order:

1. First sample the upgradient well(s).

2. Next, sample the well located furthest downgradient of the interpreted or known source.

3. The remaining wells should be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can impair the integrity of the seal.

V. Health and Safety Considerations

If thunder or lighting is present, discontinue sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

VI. Procedure

The procedures to sample monitoring wells will be as follows:

1. Don safety equipment, as required in the HASP. Depending on site-specific security and safety considerations, this often must be done prior to entering the work area.

2. Review equipment list (Section III above) to confirm that the appropriate equipment has been acquired.

3. Record site and monitoring well identification on the groundwater sampling log, along with date, arrival time, and weather conditions. Also identify the personnel present, equipment utilized, and other relevant data requested on the log.

4. Label all sample containers with indelible ink.

5. Place plastic sheeting adjacent to the well for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.

6. Remove lock from well and if rusted or broken, replace with a new brass keyed-alike lock.

7. Unlock and open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting.

8. Set the sampling device,meters, and other sampling equipment on the plastic sheeting. If a dedicated sampling device stored in the well is to be used, this may also be set temporarily on the plastic sheeting, for convenience. However, if a dedicated sampling device is stored below the water table, removing it may compromise water-level data, so water level measurements should be taken prior to removing the device.

9. Obtain a water-level depth and bottom-of-well depth using an electric well probe and record on the groundwater sampling log using indelible ink. Clean the probe(s) after each use in accord with the FSP or the equipment

decontamination SOP.

Note: Water levels may be measured at all wells prior to initiating any sampling activities, depending on FSP requirements.

10. Calculate the number of gallons of water in the well using the length of water column (in feet). Record the well volume on the groundwater sampling log using indelible ink.

11. Remove the required purge volume of water from the well (measure purge water volume in measuring buckets). The required purge volume will be three to five well volumes (the water column in the well screen and casing) unless the well runs dry, in which case, the water that comes into the well will be sampled (USEPA, 1996). In any case, the pumping rate will be decreased during sampling to limit the potential for volatilization of organics potentially present in the groundwater.

12. Field parameter measurements will be periodically collected in accord with FSP specifications. The typical time intervals of field parameter measurement are (1) after each well volume removed, and (2) before sampling. If the field parameters are being measured above-ground (rather than with a downhole probe), then the final pre-sampling parameter measurement should be collected at the reduced flow rate to be used during sampling. The physical appearance of the purged water should be noted on the groundwater sampling log. In addition, water level measurements should be collected and recorded to verify that the well purging is in accord with the guidelines set forth in the previous step.

13. Unless otherwise specified by the applicable regulatory agencies, all purge water will be contained. Contained purge water will be managed in accordance with the FSP or Work Plan. If historical concentrations in the well are less than federal or state regulated concentrations appropriate for current land use, *and permission has been granted by the oversight regulatory agency* to dispose of clean purge water on the ground next to the well(s), then purge water will be allowed to infiltrate into the ground surface downgradient from the monitoring well after the well is sampled.

14. After the appropriate purge volume of groundwater in the well has been removed, or if the well has been bailed dry and allowed to recover, obtain the groundwater sample needed for analysis with the dedicated bailer or from the dedicated sampling tubing, pour the groundwater directly from the sampling device into the appropriate container in the order of volatilization sensitivity of

the parameters sampled, and tightly screw on the cap (snug, but not too tight). The suggested order for sample parameter collection, based on volatilization sensitivity, is presented below:

a. volatile organic compounds (VOCs);

b. semi-volatile organic compounds (SVOCs);

c. polychlorinated biphenyls (PCBs)/pesticides;

d. metals; and

e. wet chemistry.

15. When sampling for volatiles, water samples will be collected directly from the bailer or dedicated tubing into 40 mL vials with Teflon-lined septa.

16. For other analytical samples, sample containers for each analyte type should be filled in the order specified by the FSP. If a bailer is used, then the sample for dissolved metals and/or filtered PCBs should either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle. If dedicated sample tubing is used, then the filter should be installed in-line just prior to filtered sample collection.

17. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field utilizing a pump prior to preservation. Attach (clamp) a new 1.0-, 0.45-, or 0.1-micron filter to the discharge tubing of the pump (note the filter flow direction). Turn the pump on and allow 100 mL (or manufacturer recommended amount) of fluid through the filter before sample collection. Dispense the filtered liquid directly into the laboratory sample bottles. If bailers are used for purging and sampling, a proper volume of purge water will be placed in a disposable or decontaminated polyethylene container and pumped through the filter and into the sample container using a peristaltic pump.

18. Place the custody seal around the cap and the sampler container, if required. Note the time on the sample label. Secure with packing material and maintain at approximately 4°C on wet ice contained in double Ziploc-type freezer bags during storage in an insulated, durable transport container.

19. Replace the well cap and lock well, or install a new lock if needed.

20. Record the time sampling procedures were completed on the appropriate field logs (using indelible ink).

21. Complete the procedures for chain-of-custody, handling, packing, and shipping. Chain-of-custody forms should be filled out and checked against the labels on the sample containers progressively after each sample is collected.

22. Place all disposable sampling materials (such as plastic sheeting, disposable tubing or bailers, and health and safety equipment) in appropriate containers.

23. If new locks were installed, forward copies of the keys to the client Project Manager (PM) and ARCADIS PM at the end of the sampling activities.

VII. Waste Management

Purge water will be managed as specified in the FSP or Work Plan, and according to state and/or federal requirements. Personal protective equipment (PPE) and decontaminated fluids will be contained separately and staged at the sampling location. Containers must be labeled at the time of collection. Labels will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, groundwater, PPE). General guidelines for IDW management are set forth in a separate IDW management SOP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs. All field data should be recorded in indelible ink.

IX. Quality Assurance

Field-derived quality assurance blanks will be collected as specified in the FSP, depending on the project quality objectives. Typically, field rinse blanks will be collected when non-dedicated equipment is used during groundwater sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminates from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities.

X. References

USEPA. 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA. 1991. Handbook Groundwater, Volume ii Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

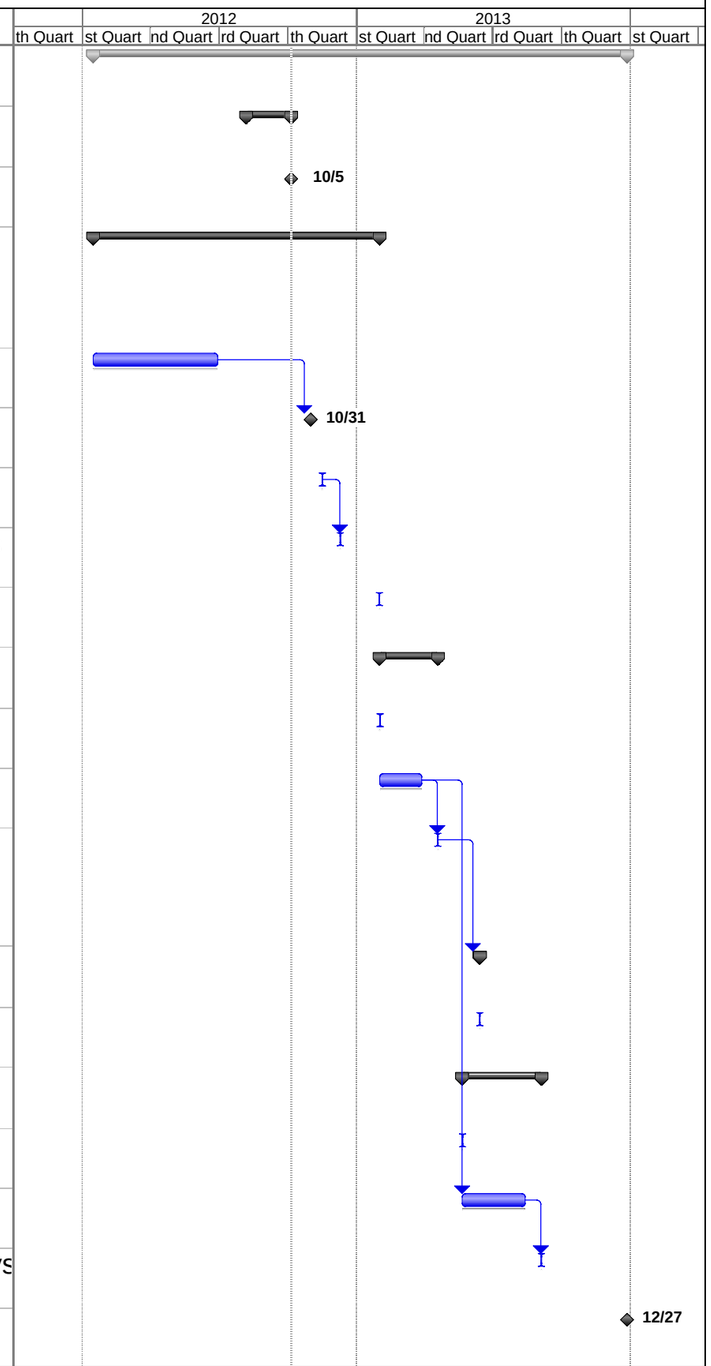
U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

Appendix D

Schedule to FS

Former Unocal Edmonds Terminal Schedule to FS

ID	Task Name	Duration	Start	Finish	Predecessors
0	**Former Unocal Edmonds Terminal - Schedule to FS**	**510 days**	**Mon 1/16/12**	**Fri 12/27/13**	
1	**FS Work Plan**	**44 days**	**Tue 8/7/12**	**Fri 10/5/12**	
2	Submit Final FS Work Plan	2.2 mons	Tue 8/7/12	Fri 10/5/12	
3	**Interim Deliverable - Additional Site Characterization and CSM Update**	**274 days**	**Mon 1/16/12**	**Thu 1/31/13**	
4	Additional Site Characterization	6 mons	Mon 1/16/12	Fri 6/29/12	
5	Submit SC/CSM Report	12 wks	Thu 8/9/12	Wed 10/31/12	4
6	DOE/Chevron/Stakeholder Mtg	1 day	Fri 11/16/12	Fri 11/16/12	
7	DOE - Final Comments	1 day	Mon 12/10/12	Mon 12/10/12	6FS+15 days
8	Final CSM Submittal	1 day	Thu 1/31/13	Thu 1/31/13	
9	**Interim Deliverable - CUL/REL Determination**	**56 days**	**Fri 2/1/13**	**Fri 4/19/13**	
10	CUL/REL Determination Stakeholder Meeting	1 day	Fri 2/1/13	Fri 2/1/13	
11	Draft Submittal to DOE	2 mons	Fri 2/1/13	Thu 3/28/13	
12	DOE/Chevron/Stakeholder Mtg - Discussion of CUL/REL and FS Screening Technologies	1 day	Fri 4/19/13	Fri 4/19/13	11FS+15 days
13	**FS Screening Technologies**	**1 day**	**Fri 6/14/13**	**Fri 6/14/13**	**12**
14	Draft Submittal FS Screening Technologies	1 day	Fri 6/14/13	Fri 6/14/13	
15	**Interim Deliverable - Groundwater Capture Modeling**	**76 days**	**Wed 5/22/13**	**Wed 9/4/13**	
16	Groundwater Capture Model Stakeholder Meeting	1 day	Wed 5/22/13	Wed 5/22/13	
17	Draft Submittal Groundwater Capture Model	3 mons	Wed 5/22/13	Tue 8/13/13	11
18	DOE/Chevron/Stakeholder Mtg	1 day	Wed 9/4/13	Wed 9/4/13	17FS+15 days
19	**Submittal of Draft FS**	3 mons	Mon 10/7/13	Fri 12/27/13	



Project: Former Unocal Edmonds Terminal - Sc
Date: Fri 10/5/12

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone