# REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT

# FOR THE

# NWTC PASCO TERMINAL

# Pasco, Washington

**Washington Department of Ecology**
**Agreed Order No. 7294**

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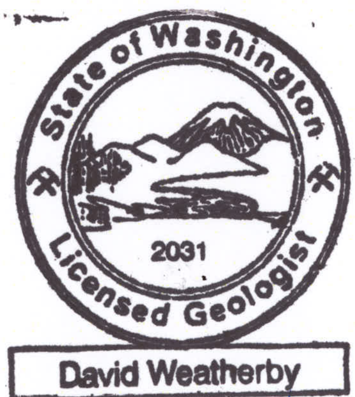
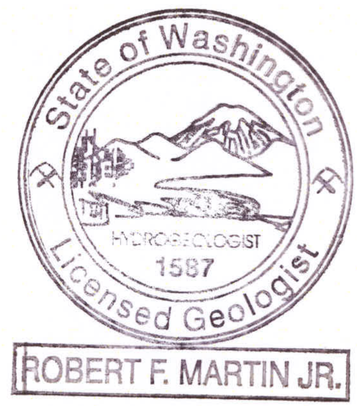
September 29, 2011

**This report was prepared under the supervision of licensed geologists employed by URS Corporation and CH2M HILL.**




**URS CORPORATION**




**CH2M HILL**

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# 1.0 Introduction

The Washington Department of Ecology (Ecology) issued Agreed Order (AO) No. 7294 effective December 4, 2009, which required performance of a site-wide Remedial Investigation/Feasibility Study (RI/FS) at the NWTC Pasco Terminal (the Site) in Pasco, Washington. The Potentially Liable Parties (PLPs) are Chevron Pipe Line Company (CPL) and Tidewater Terminal Company (Tidewater). As the first step in the RI process, the PLPs conducted a joint field investigation in June 2010 using the existing networks of CPL and Tidewater monitor wells. A second Site-wide sampling event was conducted at Ecology's request in December 2010. This *RI/FS Report* presents the results from the two groundwater monitoring events, and the evaluation of potential cleanup alternatives for the Site. The work was performed with the assistance of the consultants for the PLPs, URS Corporation (URS) for CPL, and CH2M HILL for Tidewater.

## 1.1 Statement of Work

The overall goal of the RI/FS is to collect, develop, and evaluate sufficient information to enable the selection of appropriate cleanup alternatives for the Site. To initiate the RI process, a joint field investigation was conducted by CPL and Tidewater in June 2010 to provide a comprehensive understanding of current Site groundwater conditions. The following tasks were performed in accordance with the *RI/FS Work Plan*, dated April 8, 2010, which was approved by Ecology on May 24, 2010 (Appendix A):

1. Inspected, repaired, and redeveloped existing monitor wells, as needed.
2. Surveyed the location, top-of-casing (TOC) and ground surface elevations of the existing CPL and Tidewater monitor wells to provide a common datum for preparation of groundwater elevation contour maps and hydraulic gradient calculations.
3. Measured the groundwater levels, total well depth, and phase-separated hydrocarbon (PSH) thickness (if present) in the existing CPL and Tidewater monitor wells.
4. Collected and analyzed one round of groundwater samples to establish the current concentrations of the constituents of concern (COCs) in groundwater, and the lateral extent of affected groundwater.
5. Compared the current groundwater COC concentrations against the appropriate Model Toxics Control Act (MTCA) cleanup levels. Recommendation of cleanup alternatives for the Site capable of meeting those cleanup levels is deferred to the FS portion of the work.

Following performance of the June 2010 RI field work, and validation of the laboratory data, the results of the initial RI program were submitted in a *Preliminary RI Report*, dated September 22, 2010, which enabled Ecology to evaluate the RI results, the nature and extent of the contamination, and provide comments on the Site-wide approach prior to completing the FS phase of the project. In addition to presentation in the RI/FS report, the data were submitted online in a format compatible with Ecology's Environmental Information Management System.

Data and information collected during the initial RI field program were compared to the historical data and release locations to identify potential data gaps in Site characterization. After review of the *Preliminary RI Report*, Ecology requested another sampling event, which was conducted in December 2010. The results of the second sampling event were submitted in an *Addendum to the Preliminary RI Report* dated February 24, 2011. The FS phase began in June 2011, after Ecology completed their review of the Addendum.

## 1.2 Report Overview

This combined *RI/FS Report* describes the results of the two groundwater sampling events conducted jointly by CPL and Tidewater in 2010, and the preparation steps that led to those events. Also provided are descriptions of previous investigations and remedial activities by both CPL and Tidewater that were originally presented in the Ecology-approved *RI/FS Work Plan*.

The remainder of this *RI/FS Report* is organized as follows:

Section 2 – Describes the location, history, and conditions of the Site, including the geologic setting;

Section 3 – Summarizes previous Chevron investigations and remedial activities;

Section 4 – Summarizes previous Tidewater investigations and remedial actions;

Section 5 – Describes the results and conclusions from the June 2010 Site-wide groundwater monitoring event;

Section 6 – Presents the results of the December 2010 Site-wide sampling event;

Section 7 – Identifies and evaluates potential cleanup alternatives, and represents the FS portion of the report;

Section 8 – Presents the proposed Performance Monitoring Plan for the recommended cleanup action; and

Section 9 – Lists the references cited in the *RI/FS Report*.

Appendices to the *RI/FS Report* contain supporting information, including agency correspondence, summary tables of historical analytical data, Site photographs, field sampling records and laboratory analytical reports from the 2010 sampling events, and graphs showing groundwater concentration trends. Also provided are the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the proposed Performance Monitoring Plan.

# 2.0 Site Location and Description

## 2.1 Site Location

The physical address of the NWTC Pasco Terminal is:

**Chevron Pipe Line Company**
**NWTC Pasco Terminal**
**2900 Sacajawea Park Road**
**Pasco, Washington 99301**

The Ecology Facility Site ID is **55763995.**

The Site is located southwest of the intersection of U.S. Highway 12 and Sacajawea Park Road, east of the City of Pasco in Franklin County, Washington (Figure 1). More specifically, the Site is situated in the north ½, southwest ¼, of Section 35, Township 9 North, Range 30 East (W.M.). The 33-acre Site is situated on the north bluff of the Snake River (Lake Wallula), and is surrounded by unimproved land to the southwest, north, and northeast (Figure 2). Sacajawea Park Road crosses the northern portion of the Site, and a rail spur runs along the river bank. The Tidewater Terminal is located approximately ¾ mile upstream of the Site. Ground surface elevations at the Site range from approximately 425 feet above National Geodetic Vertical Datum (NGVD, formerly referred to as Mean Sea Level) in the upland portion of the Site, to approximately 356 feet NGVD on the lower terrace adjacent to the river.

## 2.2 Site History

The Pasco Terminal has been in operation since September 1950, and is used for bulk storage of refined fuel products, which are delivered through pipelines and by barge. Pipelines transfer the product between the CPL terminal and a barge facility operated by Tidewater. Petroleum products (currently diesel, gasoline, and jet fuel) and ethanol are stored in 18 aboveground storage tanks. Tidewater (and its predecessors) own and operate pipelines that transfer products between the NWTC Terminal and the adjacent Tidewater Terminal. The Tidewater fuel transfer pipelines are located on an easement that crosses a portion of the CPL property. Other structures on-site include a truck loading rack, a pump station building, warehouses, workshops and storerooms, a welding shop, a garage, an office, and a lunch room. The Site layout is depicted on Figure 3.

Occasional releases of petroleum products from tanks, pipelines and other facilities have been documented over time at the NWTC Pasco Terminal. A timeline of each documented historical event, response actions undertaken, subsequent investigations and remediation (as necessary), are summarized chronologically in Tables 1 and 2. A brief discussion of select events is provided as follows:

- On March 23, 1976, Tank No. 8 was overfilled, resulting in a release of 665 barrels of diesel. An emergency response action was undertaken and resulted in recovery of approximately 80 barrels.

- On December 20, 1978 approximately 600 barrels of gasoline were released due to an incident where Tank No. 13 was overfilled. An estimated recovery of 200 barrels was achieved due to a subsequent emergency response action.

- On February 1, 1984, CPL reported a gasoline release of 610 barrels from Tank No. 17 when an internal roof drain line froze and cracked, which allowed gasoline to escape. An emergency response action was initiated, which resulted in the recovery of approximately 100 barrels of gasoline.

- On July 21, 2000, Tidewater identified a gasoline leak from one of their transfer lines, located approximately 60 feet west of CPL Tank No. 19, near the northwestern perimeter of the CPL property, and approximately 1,200 feet northwest of the Snake River (Figure 3). The amount lost to the subsurface was estimated at 35,000 to 41,000 gallons (833 to 976 barrels). Tidewater notified Ecology of the release, and initiated emergency response.

CPL and Tidewater have previously conducted soil and groundwater investigations and performed remedial activities to address their respective historical releases (Table 2). Documented releases that may have reached the subsurface soil and/or groundwater are depicted on Figure 3. The smaller spills, detailed in Table 1, were typically addressed immediately, thereby resulting in little to no residual product remaining in the subsurface. For example, a three-barrel diesel spill occurred on May 18, 1984, which was quickly remedied by the excavation and disposal of the diesel-affected soil. The locations of these types of spills, and other releases that were contained within the oil/water separator and wastewater system, are not illustrated on Figure 3.

Based upon the evidence to date, hydrocarbon products released from the tank area of the Pasco Terminal have not reached the near-shore sediments or surface water. Most documented releases, and all of the larger releases (Table 1 and Figure 3), occurred from tanks or pipelines located in the upland area, at least 400 feet from the shoreline. A few small releases have occurred at the barge dock, but impacts to surface gravel, riprap, or surface water were addressed at the time of each release. Periodic inspections have not identified a sheen on surface water attributable to groundwater seepage since the 1986 release of aviation fuel (Jet A) from a buried pipeline near the shoreline (Section 3.1).

## 2.3 Surrounding Land Use

The land surrounding the Pasco Terminal is currently used for a variety of purposes (Figure 2). The property immediately adjacent to the Pasco Terminal is vacant. Large parcels of land north and northwest of the Site are used for agriculture, as indicated by the irrigation circles on the aerial photograph (Figure 2). Much of the undeveloped land along Lake Wallula is public land used for recreational activities or for water-connected industrial development. Further inland, much of the undeveloped land is earmarked for commercial or residential development. Lakeview Trailer Court, a mobile home park, is located about 1,800 feet west of the Site.

Approximately ½ mile southwest of the Site, at the confluence of the Columbia and Snake Rivers, is Sacajawea State Park. This day-use park encompasses 284 acres of sand dunes interspersed with wetland ponds. The park provides habitat for many species of birds, including the yellow-rumped warbler, black-billed magpie, western meadowlark, common loon, and bald eagle (Opperman, 2003). The rivers are also a habitat for many species of fish and aquatic plants.

Since its construction and initial startup in September 1950, to the present day, the Pasco Terminal has operated as a bulk storage facility, primarily for the storage and distribution of refined petroleum products and, recently ethanol. There are no current plans to change or alter the facility operations, and therefore, the Pasco Terminal will continue to operate as a bulk storage facility into the foreseeable future.

## 2.4 Topography, Physical Setting, and Climate

The Site lies within the Columbia River/Snake River Plateau Physiographic Province (Hunt, 1974), which consists of very thick, laterally extensive group of Miocene basalt flows overlain by unconsolidated deposits. Post-depositional activity has created incised rivers, extensive plateaus, and anticlinal ridges rising more than 4,000 feet NGVD (Lasmanis, 1991). Structurally, the Site lies within the Pasco Basin as defined by Fenneman (1931).

The Site is located on gently south-southeast sloping surface near the confluence of the Columbia and Snake Rivers. The ground surface elevation adjacent to the Snake River is approximately 340 feet NGVD (depending on the pool elevation of Lake Wallula). An access road and rail spur occupy a narrow bench between the river and the upland part of the Site. The ground surface then rises rapidly to the northwest over a distance of 200-300 feet to an approximate elevation of 420 feet NGVD. Where not altered by construction of tank berms and other structures, the natural ground surface across most of the Site is nearly flat, ranging between elevations 420 and 425 feet NGVD.

The Site is in the rain shadow of the Cascade Range. Average precipitation is approximately 10 inches per year. Most precipitation occurs during the winter months (Patry, 1983). The arid to semi-arid climate generally supports only sagebrush, but irrigation has allowed the cultivation of wheat, alfalfa, and beans, and raising of cattle.

## 2.5 Regional Geology and Hydrogeology

The stratigraphy of the Pasco Basin consists of unconsolidated, sedimentary deposits underlain by a thick sequence of Miocene-age basalt known as the Columbia River Basalt Group (CRBG) (Figure 4). Unconsolidated deposits in the Pasco Basin include the Pliocene Ringold and the Pleistocene Hanford Formations. The Ringold deposits consist of gravel, sand, lacustrine, and alluvial fan deposits, and paleosols that formed as a result of soil formation during periods of non-deposition. The Hanford Formation was created from the Lake Missoula floods, which occurred between 12,700 and 15,300 years ago (Lasmanis, 1991). Where the floods slowed into eddies, giant gravel bars were deposited, such as in the Pasco area. Overlying these deposits are superficial layers of gravel, sand, silt, and clay deposited by both eolian and alluvial processes (Delaney et al., 1991).

The CRBG is made up of five formations (from oldest to youngest): Imnaha Basalt, the geographically limited Picture George Basalt, the Grande Ronde Basalt, the Wanapum Basalt, and the Saddle Mountain Basalt (Figure 4). The weight of these basalt flows initiated subsidence of the bedrock, creating the structural feature known as the Pasco Basin (Swanson and Wright, 1978). Geophysical evidence has shown that the CRBG reaches a maximum thickness of 16,000 feet in the Pasco Basin (Lasmanis, 1991). The basalt is black, dense and very fine grained and outcrops about five miles north of the Site. It is approximately 400 feet thick at the Site (Patry, 1983).

The Columbia Plateau regional aquifer system occupies about 50,000 square miles and covers a large part of southeastern Washington. The bulk of this aquifer system is comprised of the Miocene basalts. In some areas of the Columbia Plateau, the unconsolidated-deposit aquifers are much more important. The saturated part of these deposits is dominated by late Miocene to middle Pliocene alluvial-lacustrine deposits of the Ringold Formation. The Hanford Formation and related Pliocene-Pleistocene alluvium dominate the unsaturated part of this system, though perched water is common in silt-rich parts of the Hanford Formation (Lindsey et al, 1994).

Figure 5 indicates that unconsolidated-deposit aquifers in the Site area are 50 to 200 feet thick (Whitehead, 1994). Near Pasco, unconsolidated-deposit aquifers may yield as much as 3,900 gallons per minute (gpm) to wells in mostly sandy aquifers. However, high clay contents are common, greatly decreasing the well yields (Whitehead, 1994). Groundwater flow generally is controlled by grain size and the distribution of gravel-rich facies in the Ringold Formation. Consequently, fluvial tracts follow the structural grain of the Pasco Basin, forming preferred flow paths that typically follow synclinal axes. Basin-wide lacustrine fines and paleosols separate these tracts into a series of semi-confined aquifer zones that generally are isolated from near-surface recharge and contamination (Lindsey et al, 1994).

In the vicinity of Pasco, the Ringold Formation does not provide enough water for extensive withdrawals (Walters and Gralier, 1960). The Columbia River is the source of water for the cities of Pasco and Burbank, located across the Snake River from the Site. Water intakes for both cities are located upstream (west) of the Site, on the north side of the river bank, at the Cable Bridge in Pasco. Many of the industrial operations in the surrounding area, including feedlots, use water wells drilled into the CRBG to supply their water needs. Groundwater quality advisories have been issued for this area due to elevated nitrates that are attributed primarily to historical and ongoing agricultural practices.

No active potable water supply wells are known to be present in the immediate vicinity of the Site. From 1950 to 1993, the Pasco Terminal used a drinking water supply well (WAS 173-160-560) located in the portion of the Site, adjacent to the warehouse. Drilled during construction of the terminal, no construction or design information for this well is available. However, Rittenhouse-Zeman & Associates, Inc. (RZA) reported in a *Summary of Remedial Operations* dated October 29, 1993 that the well drew water from 180 feet below ground surface (bgs). A high suspended sediment content in the produced water caused the pump to be pulled and reset at a shallower depth in 1982. The well was plugged in 1993, and the Site converted to the use of water from the City of Pasco.

## 2.6 Site Geology and Hydrogeology

### 2.6.1 Site Geology

The Pasco Terminal is located on a bluff approximately 80 feet above the Snake River. Subsurface soil conditions have been determined through cuttings and soil cores obtained during installation of groundwater monitor wells at the Site by CPL and Tidewater. Two revised cross-sections, prepared using the soil data from monitor well installation, are presented as Figures 6 and 7. The locations of the cross-sections and monitor wells are indicated on Figure 3. All available boring logs, including those used to prepare the cross-sections, were provided in Appendix D of the *RI/FS Work Plan*. Table 3 provides an updated summary of monitor well construction details and survey data.

Based on the boring logs, the subsurface profile consists of the following two native units:

SAND: Brown to gray, fine- to coarse-grained, uncemented sand, which typically contains increasing amounts of gravel with depth. The sand varies greatly in thickness across the Site, ranging from less than 25 feet thick near the river, to a maximum of 82 feet thick in the upland part of the Site. Gravelly sand was often recorded on the boring logs just above the base of the sand unit, which occurs at an approximate elevation of 340 to 345 feet NGVD. Fill may be present at the ground surface at some locations within the Site, due to reworking of near surface soil during construction or maintenance activities. In addition, gravel lenses may be present locally, such as in CPL monitor well MW-7 at a depth of 30 to 31 feet bgs.

GRAVEL: Saturated, gray to red, dense, fine to coarse gravel, with sand and a small amount of silt (five percent or less). The gravel is commonly basalt, and is typically ¾ to 1½ inches in diameter, with some up to 2 inches. The contact with the overlying sand is relatively flat, and somewhat gradational. The base of the gravel unit was not encountered during installation of the Site monitor wells. The maximum thickness penetrated was 23 feet at CPL recovery well RW-1.

### 2.6.2 Site Hydrogeology

Groundwater levels at the Site have been monitored since 1983, when the first four CPL monitor wells were installed. Appendix B provides a cumulative summary of groundwater level measurements and their corresponding elevations in the CPL and Tidewater monitor wells. URS performed the annual groundwater monitoring of the CPL wells since 2002; data for prior monitoring events dating back to 1983 were provided by CPL. Tidewater monitor wells were gauged periodically after installation in 2000, with the exception of the 2007 and 2008 monitoring events, which were conducted by URS.

The uppermost aquifer at the Site is unconfined, and the top of the water table is usually near, or coincides with, the top of the gravel unit. Groundwater is typically encountered near the contact between the sand and gravel units, at a depth of approximately 80 feet bgs. Most monitor wells at the Site were installed with screens across the gravel and up into the overlying sand (Figures 6 and 7) to enable PSH (if present) to enter the monitor wells (CPL and Tidewater wells installed for soil venting or air sparging were screened over different intervals). Groundwater fluctuations over the more than 20-year period of water level measurement are generally in the range of 2.5 to 5.5 feet. (Note: Greater apparent fluctuations at three CPL wells may be due to undocumented changes in the top of casing.) Typical hydrographs for three wells located at varying distances from the river are presented in Figure 8. As expected, the lowest groundwater elevations occurred in the CPL monitor well closest to the river, MW-6. A similar pattern of elevation changes is observed for CPL monitor well MW-11, which is located approximately 450 feet from the river.

Based upon Site-wide groundwater elevation maps for the CPL groundwater monitoring events in 2007 and 2008 (refer to Figures 9 and 10, respectively, in the *RI/FS Work Plan*), groundwater beneath the Site generally flows to the southeast toward the Snake River. The magnitude of the hydraulic gradient varies with distance from the river. In the upland portion of the Site, where the tanks are located, the hydraulic gradient ranged from approximately 0.0002 to 0.0003 foot per foot for the 2007 and 2008 monitoring events. Closer to the river, the hydraulic gradient on both dates was approximately 0.002 foot per foot. Thus, the hydraulic gradient in the upland portion of the Site is approximately one order of magnitude lower than the hydraulic gradient closer to the river. These groundwater flow directions and hydraulic gradients are consistent with those of previous monitoring events. The flat hydraulic gradient is likely moderated by the reservoir conditions maintained in this reach of the Snake River due to the operations at McNary Lock and Dam.

## 2.7 Surface Water Conditions

The Pasco Terminal is located on the north bank of the impounded Snake River approximately 1.25 miles upstream from its confluence with the Columbia River. Discharge varies seasonally through the year, with peak flows generally in May to June from snow melt and winter rains, and low stages in August to October. River stage is controlled for navigational and hydroelectric purposes at McNary Lock and Dam. The normal operating pool of Lake Wallula ranges between 335 and 340 feet NGVD[1]. The normal pool elevation is between elevation 335 and 340 feet NGVD. River discharge commonly ranges from 20,000 cubic feet per second (cfs) to 200,000 cfs. Flood discharges can be substantially larger than 200,000 cfs. Overall, the water quality of the Snake River is very good, with low total dissolved solids content.

[1] http://www.nww.usace.army.mil/html/pub/pi/navigation/mcnary.htm

# 3.0 Previous Chevron Investigations and Remedial Activities

Prior to issuance of the AO, investigations and remedial activities were undertaken separately by CPL and Tidewater in response to their own releases. This section describes the work performed by Chevron through 2008. Tidewater activities are described in Section 4.

## 3.1 Monitor Well Installation

In response to the 1976 diesel release and 1978 gasoline release, four monitor wells were installed in vicinity of the tank farm in November 1983. The monitor wells were installed by Environmental Emergency Services, and designated as MW-1 through MW-4, the locations of which are depicted on Figure 3. During the July 14, 1986 groundwater measurement event, PSH was detected in MW-2. In an effort to expand the monitoring program in vicinity of the tank farm, Chevron USA Environmental completed installation of MW-5. A few months later, in November 1986, GeoEngineers, Inc. expanded the monitor well network with the installation of MW-6 through MW-9. Boring logs for these monitor wells were provided in Appendix D of the *RI/FS Work Plan*, and are not provided in this report. A log is not available for MW-5.

On July 14, 1986, a sheen was observed along the river bank during routine measurement of groundwater levels. As an emergency response to the surface water sheen, a "sea curtain" was deployed, consisting of an absorbent boom, to contain the suspected hydrocarbon. Terminal-related pipelines, and one of the two Salt Lake Pipelines, were located near the area of the sheen and were thus suspected of being the source of the surface water sheen. The terminal-related and Salt Lake Pipelines were exposed during excavation by Chevron during August 1986. A terminal-related pipeline dedicated to Jet A was found to be leaking. Soil contaminated by fuel products was removed, and the excavation was backfilled with clean soil. In response to this leak, CPL subsequently removed all of the terminal-related, subsurface pipelines near the sheen (except the sections beneath the rail spur), and placed them above ground for ease of inspection.

A sample of PSH was collected from MW-2 for purposes of forensic analysis in October 1986. It was determined that the PSH was consistent with unleaded gasoline and, therefore, not a contributable source of the sheen observed on the surface of the river. The forensic analysis was significant in that the results demonstrated two distinct sources of hydrocarbons: 1) a source for the sheen observed on the river, and 2) source for the PSH as measured in MW-2.

In an effort to contain the residual hydrocarbons near the river, and thus mitigate the sheen, groundwater was pumped from MW-5 in an attempt to create a cone of depression in the water table and, thus, cause a localized reversal in the direction of groundwater flow. The pumping system, oil/water separator, and water infiltration gallery were installed by Crowley Environmental Services in January 1987. The pumping system operated from January 9, 1987 to April 2, 1987. Prior to installation of the groundwater pumping system, it was estimated that a rate of 15 gpm would be necessary to reverse the groundwater flow direction. However, monitor well MW-5 was determined to be capable of producing only eight gpm. The cone of depression created in the water table was insufficient to cause an extensive reversal in groundwater flow direction. Therefore, the sheen persisted; however, PSH did not accumulate in MW-5 over the course of groundwater pumping.

When efforts to alter the direction of groundwater flow proved unsuccessful, an additional 1,900 cubic yards of soil were excavated from the shoreline between May 5 and 15, 1987. The general contractor for the project was 3-D Tank & Petroleum Equipment Co., Inc. A cone-shaped area of fuel-affected soil was observed, which started approximately three feet bgs. The cone was located approximately 30 feet west of monitor well MW-5. Approximately 500 cubic yards of fine to medium-grained sand were determined to be affected, and the maximum thickness was approximately 24 inches. The contaminated soil was stockpiled in Chevron's Marketing Terminal and replaced with clean fill. Based upon the hydrocarbon mass removed, and the location in relation to the river, it was concluded at the time that this area was the source of the sheen. Removal of the hydrocarbon-affected soil effectively eliminated the hydrocarbon source, and the sheen abated over time until it was no longer visible on the surface of the river. Monitor wells MW-5 and MW-9 were destroyed during the excavation. MW-5 was replaced with a 48-inch corrugated metal pipe. Slots were cut in the pipe and the pipe backfilled with washed pea gravel. Monitor well MW-9 was not replaced.

Between 1987 and 1988, monitor well MW-2 continued to exhibit a thin layer (approximately one foot or less) of PSH. A skimmer system was installed in MW-2 in December 1987. However, the system proved ineffective in recovering significant volumes of PSH. In January 1989, RZA installed monitor wells MW-10 through MW-14, to provide enhanced coverage of groundwater in vicinity of MW-2. In February 1989, an eight-inch diameter recovery well, RW-1, was designed and installed to be operated as a dual-phase PSH recovery system in conjunction with MW-2. (Logs of these six additional wells were also provided in Appendix D of the *RI/FS Work Plan*, and are not included in this report.) However, the dual-pumping PSH recovery system also proved ineffective, having produced less than 0.08 foot of drawdown after 19 hours of pumping at 100 gpm, and therefore other PSH recovery options were evaluated.

## 3.2 Soil Vapor Extraction Systems

Two soil vapor extraction (SVE) systems were installed in October 1989 by RZA to address the PSH in MW-2 and the residual hydrocarbons in the vadose zone. Inside the tank yard, monitor wells MW-2, MW-12, and MW-13 were manifolded together into one SVE system, with a gate valve at each well that allowed individual wells to be cut off from the SVE system. Because a containment dike was located between MW-10 and the other wells, a separate SVE system was set up to avoid excavating through and rebuilding a portion of the containment dike in order to run a vent line between MW-10 and MW-2.

Monitor well MW-2 was the only well in which PSH was observed when the SVE system was installed on October 17, 1989. At that time, 1.97 feet of PSH was measured in MW-2. Elevated petroleum hydrocarbon concentrations were observed in vadose zone soils and groundwater at monitor well MW-12. This well was screened in both the vadose zone and below the water table. Monitor well MW-13 was included in the SVE system because elevated concentrations of hydrocarbons were detected in vadose zone soils during drilling of MW-11. (MW-11 was not screened in the vadose zone. For this reason, MW-13 was screened only in the vadose zone, and the screened interval does not extend to the water table.) Groundwater samples recovered from MW-10 resulted in benzene, toluene, ethylbenzene, total xylenes (BTEX) and Total Petroleum Hydrocarbons (TPH) concentrations below the laboratory reporting limit. However, petroleum hydrocarbon odors and sheen were observed in soil samples collected during drilling for this well. Therefore, because MW-10 was located downgradient from MW-2, where PSH was known to exist, MW-10 was included as part of the SVE network. MW-10 was screened only in the vicinity of the water table.

Each SVE system had its own exhaust stack, condensate tank, particle filter, and blowers. Two 100 cubic feet per minute (cfm) blowers were used to vent three-well system for MW-2, MW-12, and MW-13. MW-10 was vented by one, 100-cfm blower. The condensate tanks prevented excessive moisture from entering the blowers. Electrical power for both systems was supplied at a control box located on top of the containment dike, which was previously used to house controls for the submersible pump in RW-1. Each system was also equipped with a dilution valve that allowed fresh air to enter the system ahead of the emissions stack, which allowed dilution of combustible gases if the concentration became elevated. After approximately 15 hours of operation, the combustible gas concentration emitted by the MW-10 system was measured at 52 percent of the lower explosive limit (LEL), while the concentration measured at the multi-well system was 81 percent LEL. These concentrations were measured with the dilution valves fully closed.

In mid-1991, the apparent PSH thickness in MW-2 increased to 3.35 feet. PSH was also encountered in monitor wells MW-3 and MW-11 for the first time. The skimmer system was re-installed in monitor well MW-2, while the SVE system continued to operate throughout this period. Overall, dissolved-phase hydrocarbon concentrations in groundwater remained consistent with concentrations previously observed.

In September 1992, the MW-10 SVE system was dismantled, and an air sparging system was added to supplement the multi-well SVE system. Air sparging was performed in monitor wells MW-2 and MW-11, with air supplied by the blower formerly used at MW-10. In addition, the skimmer system was moved from MW-2 to MW-3. The combination of air sparging and SVE, in addition to the skimmer system operation, significantly reduced the PSH thickness in all affected wells. In fact, by 2003 PSH in all previously affected monitor wells had been reduced to a non-measurable thickness, and has remained so up to present day.

Monitor well MW-3 was added to the multi-well SVE system on November 5, 1993 by RZA AGRA. The product recovery system located in MW-3 was removed and dismantled. A trench was dug from MW-3 to MW-11, and a two-inch line was run from the existing SVE line servicing MW-12 and MW-13 to MW-3. A one-inch PVC line was also connected to the existing air sparging lines, which serviced MW-11 and continued to MW-3. A ¾-inch rubber hose was connected to the 1-inch PVC and placed into MW-3 to a depth of approximately two feet below the water/product interface. Within two hours of initiation of air sparging, liquid hydrocarbons had been volatilized within the well. Volatiles in the soil gas around MW-3 were removed by the SVE system.

Chevron continued to operate the multi-well SVE/air sparging system from February 1994 through June 1998. Chevron personnel also measured the water levels and product thickesses in the monitor wells during this period. The SVE/air sparging system was adjusted on November 8, 1995 to optimize vapor recovery from this MW-3. By May 1996, the only well that still contained measurable PSH was MW-3 (Appendix B). Routine measurement of the wells and responsibility for operation and maintenance of the multi-well SVE/air sparge system was performed by Olympus Environmental, Inc. from June 1998 through October 1999, when Maxim Technologies (Maxim) assumed those responsibilities. By this time, quarterly measurements indicated that PSH was occasionally present in MW-3. Maxim observed a hydrocarbon-absorbing sock in MW-3 on June 8, 2000 (date installed is unknown). The SVE/air sparging system was turned off in July 2000.

### 3.3 Site Investigation Results

Prior to the RI described in Sections 5 and 6, Site investigation and groundwater monitoring activities were undertaken at the Site from 1983 through 2008, resulting in an extensive data set (Appendix B). Quarterly groundwater monitoring was conducted from June 1998 through September 2001, during which all existing monitor wells were gauged and most wells were sampled for BTEX, gasoline-range hydrocarbons (NWTPH-Gx), and diesel/heavy oil-range hydrocarbons (NWTPH-Dx). From 2002 through 2008, groundwater monitoring was performed annually, and the reports were submitted to Ecology. The groundwater elevations and analytical results from these monitoring events are summarized in Appendix B.

Since the inception of groundwater monitoring at the Site in 1983, the hydrocarbon-specific, dissolved-phase analytical parameters have included BTEX, and TPH. Prior to 2004, diesel- and heavy oil-range hydrocarbons (identified as NWTPH-Dx) were reported as a single, combined concentration. Beginning with the November 2004 report, diesel- (NWTPH-Dx) and heavy oil-range (NWTPH-Rx) hydrocarbons have been reported separately. Separate reporting conforms to MTCA Method A criteria that specify groundwater cleanup levels for both diesel- and heavy oil-range hydrocarbons at 500 micrograms per liter (μg/L). Methyl tert-butyl ether (MTBE) was added to the parameter list in 2005.

The highest concentrations of BTEX were found, not surprisingly, in monitor wells MW-2, MW-11, and MW-12, which are located within the tank farm and near the historical releases (Table 1 and Appendix B). The highest concentrations of BTEX were as follows: benzene in MW-12 at 430 µg/L (November 1990), toluene and ethylbenzene in MW-11 at 1,050 µg/L and 700 µg/L, respectively (January 1989), and xylenes in MW-12 at 2,900 µg/L (February 1991). MTBE has never been detected above its analytical reporting limit since 2005, when CPL began analyzing for this parameter. Concentrations of NWTPH-Gx and NWTPH-Dx were at their greatest in MW-3, as measured during the March 2000 (48,600 µg/L) and September 19, 1994 (1,165,000 µg/L) groundwater sampling events, respectively. Between 2002 and 2008, the maximum concentration of diesel range TPH was recorded in MW-2 (2,700 µg/L) during the July 2005 sampling event, while the highest heavy-oil range TPH measurement was documented in MW-11 (4,200 µg/L) during the same sampling event.

It is evident that remedial activities conducted at the NWTC Pasco Terminal since 1986 have been effective in removal of source hydrocarbons, and as such, have resulted in the eventual and significant decrease in dissolved-phase constituents over time. For instance, the maximum concentrations of BTEX as measured in MW-2, MW-11 and MW-12, described above, have decreased substantially since the remedial action program was instituted (Appendix B). Natural attenuation processes have contributed to the continued reduction in BTEX concentrations since the termination of active remediation in July 2000. At present, concentrations of BTEX in these wells are either below analytical reporting limits or below the Ecology Method A cleanup levels. Additional discussion of current conditions is provided in Section 5.2.2.

Consistent with the decreasing BTEX trend over time, the trends for TPH concentrations are likewise on the decline. From the October 2008 event, diesel- and heavy oil-range TPH in most monitor wells were documented to be near, or below, the analytical reporting limit for these hydrocarbon fractions. Further, as of the 2008 sampling event, only MW-02 and MW-12 exhibited TPH concentrations above the MTCA Method A criteria of 500 µg/L (Appendix B). Based upon these data, it was anticipated that the TPH concentrations remaining in MW-2 and MW-12 would continue to decline by means of natural attenuation, to below the MTCA Method A criteria, within two to four years.

### 3.4 Site Remediation Results

The SVE systems were estimated to have removed 252,375 pounds of petroleum hydrocarbons from the subsurface after 27 months of operation (i.e., through December 1991) (Chevron, April 16, 1992) After a total of 53 months of operation, the cumulative amount of petroleum hydrocarbons removed was estimated to be 257,819 pounds (RZA, October 29, 1993). The decline in the rate of removal resulted from reductions in the BTEX and TPH concentrations measured in the emissions from the SVE systems, as described below.

The MW-10 SVE system was dismantled on September 10, 1992. Analyses of off-gas samples from the system had exhibited low to non-detectable concentrations of petroleum hydrocarbons in the soil gas extracted from monitor well MW-10 over an extended period of time.

The multi-well SVE system inside the tank yard operated effectively and, by the end of 1990, resulted in a reduction in PSH thickness from 1.2 feet to 0.02 foot in MW-2. Initially, peak mass removal achieved was 16 pounds per day total BTEX. Concomitant with total mass removal over time, the removal rate decreased to 0.006 pound per day total BTEX by December 1992, demonstrating effective system design and operation. Performance of the SVE system was also evaluated by measuring the concentrations of the BTEX and TPH in off-gas samples collected from the system exhaust stack. Samples were collected in Tedlar gas sample bags previously purged with ultrapure air. The samples collected from the exhaust stack were sent to Analytical Technologies, Inc. laboratory in Pensacola, Florida for analysis of BTEX and TPH.

The apparent PSH thickness was reduced from approximately 0.39 feet and 1.7 feet in wells MW-2 and MW-11, respectively before air sparging, to no measurable thickness after approximately six days of sparging. The PSH recovery system was shut down and removed from monitor well MW-3 on November 5, 1993. Approximately 0.09 foot of PSH was measured in MW-3 on December 1, 1993. This is a decrease in PSH thickness from 1.31 feet measured on November 5, 1993, before sparging activities were initiated within MW-3. The decrease in PSH thickness resulted from air sparging in MW-3 on November 5, 1993. On December 28, 1993, no measurable PSH was observed in MW-3.

On November 5, 1993, the multi-well SVE system combustible gas indicator (CGI) registered a combustible vapor concentration of 6.0 percent LEL. An off-gas sample was collected immediately after the system was restarted, following the modifications to MW-3. Laboratory analysis indicated the following BTEX concentrations in the exhaust stack off-gas: benzene <0.001 parts per million (ppm); toluene <0.005 ppm; ethylbenzene <0.001 ppm; and total xylenes 0.015 ppm. TPH concentrations in this sample were below the method detection limit of 500 parts per billion (ppb). Vacuum within the system was measured at 21.5 inches of water for the left blower and 22.5 inches of water for the right blower, which corresponds to a flow rate of approximately 144 cfm. Total BTEX emissions were calculated to be approximately 0.00085 pound per day.

On December 28, 1993, the system's CGI was recalibrated and a combustible vapor concentration of 4.7 percent LEL was recorded. An off-gas sample was collected after the system was recalibrated. Laboratory analysis indicated the following BTEX concentrations in the exhaust stack off-gas; benzene <0.001 ppm; toluene 0.011 ppm; ethylbenzene 0.004 ppm; and total xylenes 0.050 ppm. TPH concentrations in this sample were below the method detection limit of 500 ppb. Vacuum in the system was measured at 13 inches of water in the right blower and 16 inches of water in the left blower, which corresponds to a flow rate of approximately 163 cfm. Total BTEX emissions were calculated to be approximately 0.00407 pound per day.

After the multi-well SVE system was modified by adding MW-3 as an extraction point, an increase was observed in the quantities of volatile organic compounds and TPH removed. Additional PSH thickness reductions were observed after air sparging hoses were added to MW-2 and MW-11 in September 1992, and to MW-3 in November 1993. The SVE/air sparging system was adjusted on November 8, 1995 to optimize vapor recovery from MW-3. By May 1996, the only well that still contained measurable PSH was MW-3 (Appendix B). Chevron continued to operate the multi-well SVE/air sparging system through July 2000. The SVE/air sparging system was turned off in July 2000. Routine measurements from 1998 through 2003 indicated that PSH was occasionally present in MW-3. Maxim reported that an absorbent sock was present in MW-3 in June 2000; its installation date is unknown. During well redevelopment activities for the RI, it was discovered that the absorbent sock was still in MW-3; it was removed on June 23, 2010.

### 3.5 Site Conditions as of 2008

Prior to the RI, CPL monitor wells were last sampled in October 2008. At that time, samples were collected from the nine CPL monitor wells that contained groundwater (MW-2, MW-4, MW-6, MW-7, MW-8, MW-10, MW-11, MW-12 and MW-14). The analytical results for the 2008 and previous monitoring events are summarized in Appendix B. For ease of comparison, groundwater cleanup levels published in MTCA Table 720-1 also are listed in Appendix B. In the following discussion of Site conditions, the greatest emphasis is placed on the more recent analytical results.

The TOC of CPL monitor well MW-4 had been damaged by fire and had an irregular top edge. The TOC of CPL monitor well MW-8 was cracked, and the measured groundwater level in this well may not be reliable. Therefore, groundwater levels from both wells in 2008 should be considered approximate.

Downward concentration trends for the COCs indicated that natural attenuation was occurring at the Site. COC concentrations were detected in fewer CPL monitor wells in November 2007 and October 2008 than in July 2006, and generally at lower concentrations. Recent analytical results for CPL monitor wells (through 2008) are summarized as follows:

- Toluene, ethylbenzene, total xylenes, and NWTPH-Gx concentrations were below laboratory reporting limits in all groundwater samples since September 2001.
- MTBE has not been detected in any CPL monitor well since analysis of this parameter began in 2005.

- Benzene was detected at a concentration of 0.3 µg/L in the 2008 groundwater sample from MW-12. This concentration is below the MTCA cleanup criterion of 5 µg/L. Prior to that date, benzene had not been detected in samples from any CPL monitor well since June 1999 (at MW-2).

- In October 2008, diesel-range TPH was detected above the laboratory reporting limit in samples from CPL monitor wells MW-2, MW-4, MW-11, and MW-12, at concentrations ranging from 160 µg/L in MW-11 to 1,200 µg/L in MW-2. Only the samples from MW-2 and MW-12 had results above the MTCA cleanup level of 500 µg/L. Diesel-range TPH concentrations at MW-2 and MW-12 have generally decreased since 2005.

- Diesel-range TPH was last detected in July 2006 in the groundwater sample from MW-14, in July 2005 in samples from MW-7 and MW-8, and in February 1991 from MW-10. This COC has not been detected in any groundwater sample from MW-6, which is the monitor well closest to the river.

- Heavy oil-range TPH was detected above the laboratory reporting limit in samples from monitor wells MW-2 and MW-12 in 2007 and 2008. Between 2007 and 2008, the detected concentrations decreased from 460 to 210 µg/L in MW-2, and from 490 to 220 µg/L in MW-12. These concentrations were below the MTCA cleanup level of 500 µg/L.

- Heavy oil-range TPH was last detected in July 2006 in the groundwater samples from MW-4 and MW-11, and in July 2005 in samples from MW-6, MW-7, MW-8, and MW-14.

- Ethanol was not detected in the groundwater samples from any of the CPL monitor wells in 2008 (first time analyzed after April 2008 release).

In summary, PSH was not observed at any CPL monitor well location between September 2003 and October 2008. Based on the analytical results from the 2007 and 2008 sampling events, dissolved-phase COC concentrations were not detected in groundwater samples, or were below MTCA Method A cleanup levels, with the exception of diesel-range TPH at MW-2 and MW-12. Reported diesel-range TPH concentrations have generally declined since 2005. Monitor wells downgradient from MW-2 and MW-12 did not have detectable concentrations of petroleum constituents.

Ethanol was not detected above the laboratory reporting limit in any samples from the CPL monitor wells in October 2008. Based upon these data, the ethanol released in April 2008 has not impacted groundwater at the Site.

## 4.0 Previous Tidewater Investigations and Remedial Actions

On July 21, 2000, Tidewater representatives identified a leak in one of their petroleum transfer pipelines that are used to transfer gasoline product from the NWTC Terminal to the nearby Tidewater Barge Lines facility. The fuel pipeline release occurred approximately 60 feet west of Chevron's bulk fuel storage Tank No. 19 (Figure 3). Localized galvanic corrosion of the fuel transfer pipe was the likely cause for the pipeline leak. Fuel transfer inventory records, and fuel quantity estimates derived from observations of free product and soil zone fuel concentrations indicated that the fuel release volume was approximately 976 barrels (41,000 gallons). Tidewater notified Ecology and initiated emergency response actions immediately after discovery of the release. Remediation activities at Tidewater's Pasco fuel release site have been conducted since 2000 and are described below.

### 4.1 Previous Documentation

Several documents were prepared during the course of the emergency response and interim remediation phase of work to satisfy client and regulatory agency reporting requirements. Collectively, these documents provide a description of site conditions observed during the original investigation phase, describe the major components of the interim remediation system, provide a chronological description of operational and treatment system modifications and adjustments that were required to optimize system operations, and provide estimates of the cumulative quantity of fuel hydrocarbons recovered from the subsurface by the interim remediation system. These documents give a detailed and comprehensive overview of the remediation activities and accomplishments over an approximate 10-year period. A list of the main documents generated by CH2M HILL and TCM Northwest during the course of the site cleanup and monitoring is presented below. Copies of these documents have been submitted to Tidewater and to Ecology (Eastern Regional Office - Voluntary Cleanup Program).

- August 15, 2000 - Status Report #1: Status of Site Investigation and Proposed Interim Fuel Recovery Measures: Tidewater Pipeline Release - Pasco, WA
- September 1, 2000 - Status Report #2: Tidewater Pipeline Fuel Release - Pasco, WA
- October 11, 2000 - Tidewater Pipeline Release July 21, 2000: Status Letter Report for Emergency Response Remedial Systems
- October 30, 2000 - Status Report #3: Tidewater Pipeline Fuel Release - Pasco, WA
- December 20, 2000 - Emergency Response Subsurface Site Investigation Report (prepared by TCM Northwest, Inc.)
- January 30, 2001 - Status Report #4: Tidewater Pipeline Fuel Release - Pasco, WA

- April 26, 2001 - Status Report #5 (August 2000 - February 2001): Tidewater Pipeline Fuel Release - Pasco, WA
- September 2001 - Construction, System Start-up and Operations Report
- October 2001 - Tidewater Remedial Action - Groundwater Sampling and Analysis Report
- February 2002 - Remediation Progress Summary and November 2001 Groundwater Sampling Results - Tidewater Barge Lines, Pasco Fuel Release Site
- June 2002 - Remediation Progress Summary and April 2002 Groundwater Sampling Results - Tidewater Barge Lines, Pasco Fuel Release Site
- October 2002 - Remediation Progress Summary and July 2002 Groundwater Sampling Results - Tidewater Barge Lines, Pasco Fuel Release Site
- January 2003 - Remediation Progress Summary and November 2002 Groundwater Sampling Results - Tidewater Barge Lines, Pasco Fuel Release Site
- May 2003 - Remediation Progress Summary and February 2003 Groundwater Sampling Results - Tidewater Barge Lines, Pasco Fuel Release Site
- June 2003 - Ecology Status Meeting and Presentation titled "Pasco Fuel Release: Site Review, Cleanup Status and Path Forward"
- July 2003 - June 2003 Groundwater Sampling Results, Tidewater Barge Lines, Pasco Fuel Release Site
- February 2004 - Rounds 3 and 4 Post-Remediation Sampling Results, Tidewater Barge Lines, Pasco Fuel Release Site
- June 2005 - Tidewater Remediation System Decommissioning and Performance Monitoring Plan, Tidewater Barge Lines, Pasco Fuel Release Site
- May 2006 - Supplemental Groundwater Sampling, Tidewater Barge Lines, Pasco Fuel Release Site
- April 2010 - *RI/FS Work Plan* for the NWTC Pasco Terminal, Pasco, Washington

## 4.2 Initial Response

The fuel release in July 2000 prompted an emergency response phase of operations, and oversight by representatives of Ecology. The primary goals during the emergency response phase were to (1) identify the extent of the fuel release through drilling and monitor well installation, (2) initiate immediate free product recovery efforts (that is, free product recovery pumps), and (3) install an interim remediation system to contain the free product pool and minimize the downgradient migration of the gasoline (both dissolved-phase and free product on top of the local water table).

The following actions were taken by Tidewater to address these emergency response requirements:

1. Coordination with Chevron to address site logistics and access considerations.

2. Installation of 12 monitor wells within the fuel release area to define the extent of the free product pool, and four vapor extraction wells within the soil plume (VE-1 through VE-4) to define the extent of the free product pool, and completion of additional borings to identify the extent of fuel contamination in the unsaturated soil zone. Logs of these and other borings installed for the Tidewater pipeline release are provided in Appendix D of the *RI/FS Work Plan*. Free product was found to extend over an oval to teardrop-shaped area measuring approximately 150 feet wide by 200 feet long.

3. Installation of total fluids (free product and groundwater) recovery pumps in several monitor wells located in the area of thickest free product, within two weeks of the fuel release event.

4. Installation of a SVE system, operated in combination with a thermal oxidation unit, within three weeks of the fuel release event. The thermal oxidation unit provided for high efficiency destruction of the fuel vapors recovered by the SVE system. A second thermal oxidation unit was brought on-site to help further expand the capabilities of the remediation system. This second thermal oxidation unit later was replaced by a catalytic oxidation treatment unit, supplied by Tidewater's insurance carrier (AIG).

5. Completion of pipeline pressure testing to verify the integrity of all Tidewater fuel transfer lines. Estimation of the fuel release quantity, based on a detailed evaluation of inventory records and other fuel transfer documentation. Based on this evaluation, Tidewater estimated that 41,000 gallons (976 barrels) were released from the leak in the fuel transfer pipeline.

## 4.3 Interim Remedial Actions

In September 2000, Ecology removed the Site from emergency response status after Tidewater demonstrated that effective containment of the free product pool had been achieved and active free product removal (both liquid and vapor phase) was occurring. Since September 2000, the ongoing interim remediation activities were administered under the Voluntary Cleanup Program (VCP). During Stage 2 of the cleanup, approximately 785 to 833 barrels (33,000 to 35,000 gallons) of fuel hydrocarbons were removed from the subsurface. Of this total, approximately 190 barrels (8,000 gallons) were removed as liquid-phase free product, using pneumatic total fluids pumps. The liquid-phase free product recovered during this period was sent offsite to a fuel recycling facility for reprocessing and reuse. Approximately 595 to 643 barrels (25,000 to 27,000) gallons of free-phase petroleum hydrocarbons were removed via vapor-phase recovery and treated destructively on-site, via thermal and catalytic oxidation.

Tidewater contracted with an independent pipeline testing contractor to pressure test all the active, operational fuel transfer lines in the pipeline easement that passed through the Chevron property. The pressure testing activities were conducted concurrent with the Stage 2 remedial actions. Selected sections of the fuel transfer lines were upgraded as a result of this testing, and improved inventory control and monitoring systems were installed. Some older, inactive fuel transfer lines, owned by Tidewater and located within the pipeline easement, also were formally abandoned during this period.

During this stage of operations and monitoring, a weathered, diesel-like hydrocarbon was identified in one of the Tidewater monitor wells (AR-7). Well AR-7 was installed in close proximity to the Tidewater fuel transfer line corridor. No evidence of petroleum hydrocarbons were observed in the vadose zone soils during the drilling of well AR-7. This finding suggested that a separate and unrelated release of petroleum hydrocarbons had occurred somewhere in the vicinity of well AR-7 and pre-dated the gasoline release from the Tidewater fuel transfer line.

Selected samples of groundwater and free product also were analyzed for the presence of MTBE. No MTBE was detected in these samples. According to CPL personnel (Anderson, 2010), the Pasco Terminal ceased handling refined products containing MTBE in March 2000, several months before the Tidewater release.

### 4.4 Extended Remedial Actions

In February and March 2001, additional Site investigation, drilling, and well installation work was performed at the Site, to support the design and installation of an air sparge remediation system. Specifically, an additional eight monitor wells (MW-series) and seventeen sparge points (SP-series) were installed within and around the free product pool. Air sparging, performed in conjunction with SVE, was determined to be a well-suited remedial technology that would enhance the removal of both dissolved-phase hydrocarbons in the groundwater and residual free product.

The air sparging operations initially were designed to help mobilize residual free product toward the active SVE wells, where the liquid fuel hydrocarbons were more readily volatilized. During later stages of remediation when the quantity of free product had been greatly reduced, the air sparge wells were used primarily to enhance the aerobic biodegradation processes by introducing oxygen into the upper zone of saturation.

SVE operations were shown to maintain an effective area of influence around the fuel release area. Influent flow rates were maintained at approximately 310 to 320 cfm, maintaining effective vacuum at individual vapor wells. Operating flow rates in individual wells ranged from 20 to 59 cfm (based on system measurements collected January 27, 2003). The SVE system operations were routinely optimized in response to decreasing free product presence in the wells and decreasing influent concentrations. Optimization resulted in a notable increase in the effective vacuum produced by the extraction system, and a slight increase in the air flow rate. Optimization measures included short-term (one to two weeks per well) deactivation of selected SVE wells within the vacuum influence area to serve as passive inlet wells. These passive inlet wells allow atmospheric air to route directly into the subsurface, under the influence of the induced vacuum created by the combined action of the other active SVE wells. Along with introducing oxygen-enriched air into the subsurface (enhancing aerobic biodegradation), the passive inlet wells help to establish new preferential air flow paths and encourage mobilization of residual fuel that can lie in isolated pockets outside the immediate influence of the primary flow paths.

Soil vapor extraction was resumed at the four shallow vapor extraction wells, completed in the mid to upper portions of the vadose zone in the immediate vicinity of the original fuel release. These SVE wells were operated intermittently during Stage 1 and Stage 2, and additional extraction was conducted during Stage 3 to further address remaining fuel residuals in this area.

As SVE operations continued, vapor concentrations in the shallow vadose zone wells within the plume (VE wells) ranged from 100 to 200 parts per million by volume (ppmv), down from several thousand ppmv, measured during the early stages of operation, indicating significant removal of free phase petroleum hydrocarbons from the vadose zone soils beneath the release area.

Free product thickness was measured routinely during the Stage 3 phase of operations. Free product levels decreased markedly during this period. By February 2003, free product was no longer detected at the monitor wells (other than a visible sheen), and approximately1,079 barrels (45,200 gallons) had been removed from the subsurface as part of the ongoing fuel recovery effort. The quantity removed slightly exceeded the estimated 976 barrels (41,000 gallons) that Tidewater estimated were released to the subsurface from the leak in the fuel transfer pipeline. However the removal estimate is based on remedial performance based data that, while consistent, included estimates based on vapor removal concentrations and rates.

In addition to the observations noted above at well AR-7, petroleum hydrocarbon contamination (having a diesel-like character) was detected in soil samples collected near the water table from the MW-5 borehole. Laboratory analysis confirmed the presence of a diesel-range hydrocarbon in the MW-5 soil sample, but the petroleum was thought to be considerably aged or "weathered," based on a chromatographic comparison to a fresh diesel standard. This diesel contamination was found outside of, but hydraulically downgradient/cross-gradient from, the inferred extent of the Tidewater free product pool. The field observations and laboratory analytical results demonstrated that the diesel contamination was neither caused by, nor was related to, the Tidewater unleaded gasoline release of July 2000. The appearance and odor of the MW-5 soil samples, and the absence of detectable petroleum hydrocarbon residues in the MW-5 groundwater sample imply that the observed contamination likely is related to an historical release event that occurred well in advance of the July 2000 Tidewater gasoline pipeline release.

### 4.5 Follow-on Monitoring

The groundwater monitoring results and free product measurements that were conducted from February 2003 through December 2003 demonstrated the ongoing success of the remediation efforts completed at the Site. Some immobile residual fraction of product remained in the formation, and this resulted in a small but measurable thickness (or sheen) of free product in selected wells. The areal extent of the dissolved phase plume was deemed stable and showed little or no evidence of downgradient migration from the leading edge of the former free product area.

Spatial variation in dissolved oxygen (DO) and nitrate concentrations (as measured upgradient of and within the area where active SVE/air sparging was occurring) confirmed that biodegradation processes were occurring and actively contributing to the removal of dissolved phase fuel hydrocarbons. Biodegradation of dissolved-phase constituents was active and ongoing, both within the former free product plume area and in areas on the immediate fringe. Biodegradation and associated natural attenuation processes are expected to continue, causing BTEX and TPH-Gx concentrations to decline progressively over time throughout the entire fuel hydrocarbon impact area.

### 4.6 2006 Supplemental Sampling

Groundwater sampling during March 2006 documented the distribution of petroleum hydrocarbons in the groundwater system beneath the Pasco fuel release site. Of the 20 wells located at the site, 13 were sampled during this monitoring event. Wells MW-7, MW-12, AR-7 and AR-8 were screened but not sampled due to the observed presence of a light or broken PSH sheen. Two wells (AR-1 and AR-3) were not sampled due to well integrity problems; well AR-2 apparently was buried during previous construction activities at the site, and therefore was not sampled.

Primary findings and conclusions from the March 2006 sampling event are presented below:

1. Residual dissolved-phase petroleum hydrocarbons were present in localized portions of the former free product plume area beneath the site. Highest fuel hydrocarbon concentrations were observed at wells AR-4 and MW-8. Field screening information suggested that elevated fuel hydrocarbon concentrations likely were also present in the vicinity of AR-1, MW-7, AR-12 and AR-7.

2. At well AR-4, the March 2006 concentrations of BTEX, TPH-Gx, and TPH-Dx were higher than the levels observed during the previous sampling round in September 2003. This localized increase in fuel hydrocarbon concentrations may have been caused by the higher than usual groundwater levels (as compared to historical levels) that were observed during the March 2006 sampling event. As areas of the capillary fringe/smear zone become saturated by a rising groundwater level, residual fuel hydrocarbons may be dissolved and mobilized, causing a localized, short-term increase in measured fuel hydrocarbon concentrations.

3. The lateral extent of the dissolved-phase plume has decreased, as evidenced by non-detect or below regulatory limit concentrations of fuel hydrocarbons in monitor wells immediately within and downgradient of the former free product area.

4. Measured concentrations of DO, nitrate, dissolved iron, dissolved manganese, and oxidation-reduction potential (ORP) as well as decreased lateral extent and concentration of petroleum hydrocarbons in the groundwater suggest that biodegradation processes are occurring within the Tidewater pipeline release area, and are contributing to the observed reduction in fuel hydrocarbon concentrations observed over much of that area. Biodegradation and associated natural attenuation processes are expected to continue, causing BTEX and TPH-Gx concentrations to decline progressively over time throughout the entire fuel hydrocarbon impact area.

A comparison of the 2003 and 2006 monitoring results demonstrates that concentrations of dissolved-phase fuel hydrocarbons have decreased in lateral extent and declined in concentration except for a single well, AR-4. At well AR-4, located within the central interior portion of the former free product plume, fuel hydrocarbon concentrations are elevated compared to corresponding measurements from September 2003. Groundwater levels during the March 2006 sampling event were approximately 0.5 foot higher than corresponding water levels measured during 2003. The higher than usual groundwater level may have caused dissolution of residual petroleum hydrocarbons in the capillary fringe/smear zone near AR-4. Consequently, these hydraulic changes may have produced the short-term increase in fuel hydrocarbon concentrations observed at this well.

### 4.7 2007 and 2008 URS Sampling of Tidewater Wells

To provide a comprehensive picture of Site conditions, URS sampled a limited number of Tidewater monitor wells in 2007 and 2008, at the same time the CPL monitor wells were sampled. Two of the 19 Tidewater monitor wells (AR-3 and AR-12) were dry during the November 2007 and October 2008 sampling events. Former remediation/current monitor well AR-1 is surrounded by a secure fence and was inaccessible to URS on both dates. Well AR-2 could not be found. CH2M HILL (2006) reported that, during the March 2006 sampling event, the screened interval of well AR-3 was found to be filled with sand and gravel.

Seven Tidewater monitor wells were sampled in November 2007, including five that were sampled in 2006: MW-1, MW-5, MW-7, MW-8, AR-4, AR-6, and AR-8. In October of 2008, URS sampled Tidewater monitor wells MW-2, MW-3, MW-4, MW-5, AR-4, and AR-5. The 2007 and 2008 analytical results for the Tidewater wells sampled by URS are included in Appendix B, and are summarized as follows:

- PSH was not observed in the 18 Tidewater monitor wells URS gauged in 2007 and 2008. However, a sheen was observed on the purge water from some of the wells, including MW-7, MW-8, AR-4, and AR-8.

- MTBE concentrations in groundwater were below laboratory reporting limits in all Tidewater samples during the 2007 and 2008 sampling events, although sample dilution for analysis resulted in elevated reporting limits for some samples. These results are consistent with historical Tidewater monitoring that did not detect MTBE in groundwater, or in screening analysis of free product samples.

- BTEX and gasoline-range TPH were not detected in Tidewater wells MW-2, MW-3, MW-4 or MW-5 during the 2007 or 2008 sampling events. These wells are located along the west and south sides of the Tidewater release area, and serve as downgradient or cross-gradient perimeter monitoring points.

- Benzene was detected above laboratory reporting limits in five of the seven Tidewater wells sampled in November 2007 (MW-7, MW-8, AR-4, AR-6 and AR-8), and in two of the five wells sampled in 2008 (AR-4 and AR-5). Benzene concentrations ranged from 0.6 µg/L in AR-6 to 640 µg/L in AR-4. Reported benzene concentrations at four of these wells (MW-7, MW-8, AR-4, and AR-8) exceeded the MTCA cleanup level of 5 µg/L. The only monitor well sampled during both events was AR-4; the benzene concentration at this well decreased from 640 to 340 µg/L between November 2007 and October 2008. Between 2006 and 2008, the benzene concentration decreased at MW-8 and AR-4, but increased slightly at AR-5 and AR-6; however, the benzene concentrations at AR-5 and AR-6 were an order of magnitude below the MTCA Method A cleanup level.

- Toluene was detected above laboratory reporting limits in samples from monitor wells MW-1, MW-7, MW-8, AR-4, AR-5, AR-6 and AR-8 at concentrations ranging from 0.2 µg/L in MW-1 to 2,800 µg/L in AR-4. The only monitor well sampled during both events was AR-4; the toluene concentration at this well decreased from 2,800 to 2,100 µg/L between November 2007 and October 2008. The samples from MW-8 and AR-4 exceeded the MTCA cleanup level of 1,000 µg/L for toluene; however, the reported concentrations at both wells were lower in 2007 than in 2006.

- Ethylbenzene was detected above laboratory reporting limits in 2007 and 2008 at the same Tidewater monitor wells as toluene, at concentrations ranging from 0.5 µg/L in MW-1 to 410 µg/L in MW-8. The only monitor well sampled during both events was AR-4; the ethylbenzene concentration at this well decreased from 220 to 170 µg/L between November 2007 and October 2008. All detected concentrations were below the MTCA ethylbenzene cleanup level of 700 µg/L.

- Xylenes were detected above laboratory reporting limits in 2007 and 2008 in samples from monitor wells MW-7, MW-8, AR-4, AR-5, AR-6, and AR-8 at concentrations ranging from 10 µg/L in AR-6 to 5,500 µg/L in MW-8. The only monitor well sampled during both events was AR-4; the xylenes concentration at this well decreased from 4,400 to 2,700 µg/L between November 2007 and October 2008. Between 2006 and 2008, the xylenes concentrations decreased at two wells (MW-1 and AR-4), but increased at three other wells (MW-8, AR-5 and AR-6). Only wells MW-8 and AR-4 were above the xylenes cleanup level.

- Gasoline-range TPH was detected above the laboratory reporting limit in five of the seven Tidewater wells sampled in November 2007 (MW-7, MW-8, AR-4, AR-6 and AR-8), and in two of the five wells sampled in 2008 (AR-4 and AR-5). Concentrations of this indicator parameter ranged from 65 µg/L in AR-6 to 36,000 µg/L in MW-8. The samples from four of the wells exceeded the MTCA cleanup level of 1,000 µg/L (800 µg/L when benzene is present); the concentrations at AR-5 and AR-6 were below the cleanup level. Between 2006 and 2008, the gasoline-range TPH concentration increased at MW-8 and AR-6. The only monitor well sampled during in 2006, 2007, and 2008 was AR-4; at this well, the gasoline-range TPH concentration increased slightly from 26,600 to 28,000 µg/L between March 2006 and November 2007, then decreased to 17,000 µg/L in October 2008. A light sheen observed on water purged from five wells sampled in 2007 (MW-7, MW-8, AR-4, AR-6, and AR-8) may have contributed to the detected concentrations.

- Diesel-range TPH was detected above the laboratory reporting limit in nine of the 11 wells sampled in either November 2007 or October 2008. Concentrations ranged from 78 µg/L in MW-2 to 23,000 µg/L in AR-8. The samples from MW-5, MW-7, MW-8, AR-4, AR-6, and AR-8 exceeded the MTCA cleanup level of 500 µg/L. Two wells (MW-5 and AR-4) exhibited concentration decreases from 2007 to 2008, with the concentration in MW-5 declining below the cleanup level. Because the 2006 results were reported as combined diesel- and heavy oil-range TPH, direct comparison of those results to the 2007 or 2008 data is not possible.

- Heavy oil-range TPH was detected above laboratory reporting limits in five of the 11 wells sampled in either 2007 or 2008, at concentrations ranging from 300 µg/L in MW-7 to 1,400 µg/L in AR-4. With the exception of MW-7, all of the samples exceeded the MTCA cleanup level of 500 µg/L. In two additional wells (MW-8 and AR-8), heavy oil-range TPH was not detected, but the detection limits were above the MTCA cleanup level. Two wells (MW-5 and AR-4) exhibited concentration decreases from 2007 to 2008, with the concentration in MW-5 declining below the cleanup level.

# 5.0 Results from the June 2010 Site-Wide Groundwater Monitoring

A joint RI field investigation was conducted by CPL and Tidewater in June 2010 to provide a comprehensive understanding of current Site groundwater conditions, the results of which were presented in a *Preliminary Remedial Investigation (RI) Report* that was submitted to Ecology on September 22, 2010. The work performed and findings from the June 2010 RI are described in this section.

COCs for the RI groundwater sampling program were established in the *RI/FS Work Plan*. They include BTEX, ethanol (for CPL wells only), and gasoline, diesel, and heavy oil fractions of TPH. Additional parameters were analyzed to demonstrate that active biodegradation and other natural attenuation processes are continuing across the Site. Analytical methods used in the RI were specified in the QAPP provided as Appendix B in the *RI/FS Work Plan*.

## 5.1 Well Maintenance

URS mobilized a field crew to perform maintenance on the CPL monitor wells as the first step of the RI. Field activities began June 22, 2010 and were performed by a licensed well drilling contractor, Environmental West Exploration, Inc. (EWE), and overseen by a URS geologist. The activities performed by URS prior to the sampling event are described below. At the beginning of the sampling event, CH2M HILL assessed the condition of the Tidewater wells to confirm the location of each well, and to verify the integrity of the wellhead.

### 5.1.1 Well Monument Repair

In order to ensure that monitor wells met Washington state codes, new concrete well pads were installed around ten CPL monitor wells, and new locking above-ground monuments were installed at nine wells (the monument for MW-14 did not need replacing). Old remediation equipment (piping, hoses, etc.) was removed from wells MW-3 and MW-12 and discarded before beginning the repairs. New concrete pads were not installed at MW-1 or RW-1 because these wells are located within the gravel berm/road in front of the CPL tanks. In addition, a new pad and monument were not installed at MW-13 because this well does not reach the water table and is not used for sampling. The TOC was damaged or was too short for the new monument at several well locations. In these cases, the existing TOC was cut level, and a PVC coupler and additional clean riser was added to raise the TOC to an appropriate height, typically 30 inches above ground surface. PVC couplers and riser were attached using small metal rivets to avoid the introduction of any chemicals into the well. Photographs of selected CPL monitor wells before and after replacement of the monuments appear in Appendix C.

Monitor wells MW-3, MW-6, and MW-8 also had new protective bollards installed around the monuments. These are the only wells where normal driving activities could have an effect on well conditions.

### 5.1.2 Camera Inspection

Well logs are not available for CPL monitor wells MW-1 through MW-4. The original installation report (Environmental Emergency Services Company, 1984) stated that these wells were completed with 20 feet of slotted screen, with the mid-point set at the water level encountered during drilling. In order to assess the need for redevelopment, the original completion depth needed to be established. URS used an intrinsically safe downhole camera in order to determine the depth of the top of screen. This camera was deployed in MW-1 through MW-4; RW-1 was also checked with the camera. The results of the camera survey are reported below (depths are below TOC after the well repairs were completed):

- MW-1 screen began approximately 74 feet below TOC (btc). The screen is slotted PVC and the visible portion appeared to be in good condition. However, the plastic housing protecting the top of the well had been crushed, and large road gravel was observed inside the well only 1.3 feet below the top of screen.

- MW-2 screen began at 66.1 feet btc, and is also slotted PVC in good condition. The depth to bottom was 78.2 feet btc.

- Visual inspection revealed an old absorbent sock floating in the well MW-3. After the sock was removed, the screen was observed to begin at 77.35 feet btc, and the gauged depth to bottom was 92.5 feet btc.

- MW-4 screen began at 59.2 feet btc. The screen is slotted PVC in good condition. Depth to bottom was 76.9 feet btc.

- RW-1 screen began approximately 64.5 feet bgs, and is 8-inch slotted PVC. The measured depth to the bottom of the well was gauged at approximately 103.5 feet bgs. The large steel and concrete manhole has been shifted (by road grading?), and is no longer centered over the vault in which the well was constructed. Road gravel was observed at the bottom of this well.

### 5.1.3 Well Redevelopment

The *RI/FS Work Plan* stated that an attempt would be made to redevelop a monitor well if more than two feet of sediment had accumulated in the bottom. Redevelopment of CPL wells MW-2, MW-3, and MW-4 was necessary based on the measurements documented above. Additional CPL wells that required redevelopment were MW-6 and MW-7. Redevelopment of MW-1 was not attempted due to the road gravel observed within the screen interval. According to the well drilling contractor, any force (air or water pressure) of sufficient strength to lift these gravels from the well would also be great enough to rupture the screen and/or casing, rendering the well useless. Redevelopment of RW-1 also was not attempted, due to the road gravel observed at the bottom of the well and large screen length. A discussion of the results of redevelopment for each well is presented below.

- MW-2 had approximately 12 feet of screen exposed prior to redevelopment. Only 0.65 foot of depth was gained during redevelopment, resulting in a depth to bottom of 78.5 feet btc.
- MW-3 had approximately 15 feet of screen exposed prior to redevelopment. Three feet of sediment were removed during redevelopment, resulting in a depth to bottom of 95.5 feet btc.
- MW-4 had approximately 18 feet of screen exposed prior to redevelopment. Only 0.10 foot of depth was gained during redevelopment activities, leaving the depth to bottom at 77.0 feet btc.
- MW-6 was redeveloped to a total depth of 27.9 feet btc, which appears to be its full completion depth. A total of 4.5 feet of sediment was removed during the redevelopment.
- MW-7 only had 1.9 feet of accumulated sediment, but redevelopment was attempted in order to account for any mistakes in measuring. The total depth was increased 0.75 foot to a new depth to bottom of 78.3 feet btc.

Redevelopment was difficult on most of the CPL wells. Common problems encountered were sand and silt clogging the pumps, causing them to rapidly overheat. While MW-6 contained silt which was easily suspended (and pumped), other wells such as MW-4 contained sand which was not so easily removed from the well. The length of redevelopment time, and amount of water purged, was determined on a well by well case. This was based on the amount of sediment seen in purge water and pump operation (overheating).

Based on the well rehabilitation work performed in June 2010, URS and CPL conclude that monitor wells MW-1 and MW-3 are not capable of yielding representative groundwater samples. All but the top 1.3 feet of the well screen in MW-1 is blocked with gravel, which was likely knocked into the well during routine road maintenance. Well MW-1 was last sampled in June 2000, and has been reported as dry during all but two subsequent sampling events, when groundwater rose above the gravel that had fallen inside the well screen. URS and CPL concur with the well drilling contractor that development techniques needed to remove the road gravel would destroy the monitor well. When URS removed the spent absorbent sock from MW-3, it was observed to be slowly releasing previously captured hydrocarbons, and had lost about a third of its sorbent material. The water initially purged from the well had a strong hydrocarbon odor, and contained small pieces of spent sorbent with PSH. A large amount of water was pumped from the well in an attempt to remove hydrocarbon-impacted water from the immediate vicinity of the well. The prolonged presence of the sock in the well, and its movement up and down the screen with fluctuating groundwater levels, may have caused the release of the sorbent material from the sock. It has likely also caused smearing of PSH inside the well screen, trapping of the PSH-saturated sorbent within the 0.030 inch screen slots, and perhaps also within the filter pack around the well screen. The extended purging effort was not successful in removing all of the sorbent material (and absorbed PSH). Remnants of the spent sorbent material (with absorbed PSH) were still present after more than 200 gallons were purged prior to the June 2010 RI sampling event.

### 5.1.4 Well Survey

Stratton Surveying and Mapping, PC (Stratton), of Pasco, Washington, surveyed all CPL and Tidewater monitor wells on June 29, 2010, to provide precise locations and a common datum for preparation of groundwater elevation contour maps and hydraulic gradient calculations. Stratton had established survey monuments on-site for previous engineering work at the Pasco Terminal. Survey data collected during the event included the XY locations of the north/top of internal PVC well casing, and elevations (Z) of the ground surface, north rim of PVC well casing, and top of lid of the well cover. All survey data were reported to the nearest 0.01 foot elevation (NGVD 29) and in compliance with Revised Code of Washington (RCW) 58.20.130 (i.e., standard Washington State Plane coordinate system). The locations and elevations from this survey are reported in Table 3. The most recent survey data have been utilized in preparing the new or updated figures that appear in this *RI/FS Report*. Groundwater elevations in the historical tables (Appendix B) have not been changed to reflect the new survey data.

## 5.2 Site Conditions

### 5.2.1 Static Water Level Measurement and PSH Screening

Groundwater levels in CPL and Tidewater monitor wells were measured on June 28, 2010. URS and CH2M HILL measured the depth-to-groundwater below TOC, total depth (TD) and, if present, PSH thickness in all accessible CPL and Tidewater monitor wells with an electronic water level meter or oil/water interface meter. The presence/absence of a discrete free product layer or sheen was re-checked using a clear, polyethylene or PVC bailer. A broken and irregular petroleum-like sheen was observed in bailers retrieved from Tidewater wells AR-7, AR-12, MW-7, and MW-8. Although measurable PSH was not detected with the interface probe, well AR-1 had an approximately 0.01 foot thickness observed in a bailer. As described in Section 5.1.3, small fragments of sorbent material with PSH were observed in the water purged from CPL monitor well MW-3. No other CPL monitor well had any indication of PSH or a sheen.

### 5.2.2 Groundwater Levels and Gradients

To prepare the Site-wide groundwater elevation map, groundwater elevations were calculated by subtracting depth-to-groundwater measurements from the recently resurveyed TOC elevations. The measurements and the computed groundwater elevations for the CPL and Tidewater monitor wells for this sampling event are listed in Table 4. The Site-wide groundwater elevation map for June 28, 2010 is provided as Figure 9A.

The groundwater gradient in the Tidewater fuel release area is relatively flat, with the highest elevation in upgradient well AR-11. As demonstrated by the groundwater flow lines drawn on the map, the overall direction of groundwater flow is to the southeast toward the Snake River. Two separate groundwater flow lines were drawn on Figure 9A to illustrate that the magnitude of the hydraulic gradient varies with distance from the river. On June 28, 2010, the hydraulic gradient in the upland portion of the Site was approximately 0.0006 foot per foot whereas, down by the river, the hydraulic gradient was approximately 0.009 foot per foot. Thus, the hydraulic gradient in the upland portion of the Site is approximately one order of magnitude lower than the hydraulic gradient close to the river. The groundwater flow direction and hydraulic gradients are consistent with those shown on the previous two Site-wide maps produced for 2007 and 2008 (Section 2.6).

Groundwater levels measured on June 28, 2010 were the highest recorded during sampling events conducted since 2000. The previous high groundwater elevation was 343.63 feet NGVD in MW-12. According to the U.S. Army Corps of Engineers records for McNary Dam[2], the pool elevation of Lake Wallula on June 28, 2010 was 338.56 feet NGVD. The maximum and average pool elevations in June 2010 were 339.28 and 338.61 feet NGVD, respectively. These elevations are near the upper end of the normal pool range of 335 to 340 feet NGVD. Because the lake serves as the base level for groundwater discharge, elevated lake levels could have contributed to the higher than usual groundwater levels in the monitor wells.

During previous sampling events, groundwater elevations in two CPL monitor wells have been anomalous when compared to other wells nearby. The groundwater elevation in MW-8 has routinely been two to three feet higher than expected, while the elevation in MW-14 has routinely been has been up to three feet lower than expected. As shown on Figure 9A, resurveying appears to have resolved these issues.

### 5.2.3 Groundwater Quality

Groundwater samples were collected from most CPL and Tidewater monitor wells on June 28-30, 2010. A few wells were not sampled, for the reasons described below. All of the samples were shipped to TestAmerica Laboratories in Tacoma, Washington for analysis of the Site

[2] http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?k=id:MCN+record://MCN/HF//IR-MONTH/DRXZZAZD/+psy:+psm:+psd:+pey:+pem:+ped:+pk:forebay+elevation+mcnary)

COCs, and additional parameters to evaluate ORP conditions and the status of natural attenuation at the Site. Sampling and analytical methods used were those described in the SAP and QAPP (Appendices A and B in the *RI/FS Work Plan*).

All groundwater samples were collected using Grundfos Redi-Flo 2 submersible pumps and low-flow sampling techniques. These sampling techniques were used for the first time in 2010; prior to this event, sampling was conducted using disposable bailers at each CPL and Tidewater well location. New, clean disposable tubing was used for well purging and sample collection at each well location, and the sampling equipment was decontaminated between wells. The wells were purged and sampled in order from lowest to highest groundwater COC concentrations, based on the most recent data available.

Prior to sample collection, each monitor well was purged until water quality parameters stabilized. Depending on the height of the water column, the pump intake was set between 2.78 and 5.56 feet below the water table in the sampled CPL wells. Sampling personnel monitored the depth to groundwater and the following water quality parameters during purging: pH, specific conductance, temperature, color/clarity, ORP, and DO. These data are recorded on the field sampling forms provided in Appendix D. Analytical results from the June 2010 RI sampling event are summarized in Tables 4 and 5. Data for Site COCs (BTEX, TPH, and ethanol) are provided in Table 4. The results for other parameters are given in Table 5. Complete laboratory reports and Data Usability Summary Reports are provided in Appendix E.

***CPL Wells:***

Groundwater samples were collected from nine of the 12 CPL monitor wells and recovery well RW-1 on June 29 and 30, 2010. Monitor wells MW-1, MW-3 and MW-13 were not sampled for the following reasons:

- Monitor well MW-1 had 0.3 foot of water above the gravel in the well screen, but it was not enough to collect a sample;
- Even though over 200 gallons of water were removed from the monitor well MW-3 during the prior week, the water purged from the well on June 24, 2010 still contained remnants of the disintegrated absorbent sock, traces of free product, and very strong hydrocarbon sheen; and
- MW-13 is screened only in the vadose zone, so the bottom of this well is above the water table, and the well is consistently dry.

A duplicate sample from CPL monitor well MW-12 was submitted in order to verify the reliability and repeatability of the laboratory tests. This duplicate sample was given a fictitious name, MW-22, and was submitted along with the other samples for laboratory analysis. The analytical results for the duplicate sample were nearly identical to the results for MW-12. Triple the normal volume of water was collected from CPL well MW-7 for matrix spike and matrix spike duplicate (MS/MSD) analyses. URS also submitted an equipment rinse sample for analysis. The rinse sample was collected by running laboratory-supplied deionized water along the interface probe and collecting the runoff in laboratory-supplied sample bottles. Upon receipt of the analytical results, the laboratory report was reviewed in accordance with the QAPP to ensure that the data met the project acceptance criteria.

The Site COC analytical results for June 2010 from the CPL monitor wells are summarized as follows:

- Toluene, ethylbenzene, xylenes, ethanol, and NWTPH-Gx were not detected above the laboratory reporting limits in all samples;

- Benzene was detected above laboratory reporting limits only at MW-12 at a concentration of 1.1 µg/L. This concentration is below the MTCA Method A cleanup criterion of 5 µg/L;

- Diesel-range hydrocarbons (NWTPH-Dx) were detected above laboratory reporting limits in samples from monitor wells MW-2, MW-11, MW-12 and MW-14 at concentrations ranging from 160 µg/L in MW-14 to 3,600 µg/L in MW-2. The samples from MW-2, MW-11 and MW-12 had results that were above the MTCA Method A cleanup level of 500 µg/L; and

- Heavy oil-range hydrocarbons (NWTPH-Rx) were detected above laboratory reporting limits in three samples from monitor wells MW-2, MW-11 and MW-12 at concentrations ranging from 450 µg/L in MW-11 to 3,300 µg/L in MW-2. The samples from MW-2 and MW-12 had results that were above the MTCA Method A cleanup level of 500 µg/L.

Updated concentration trends for CPL wells with detected BTEX or TPH concentrations are provided in Appendix F.

Additional geochemical parameters were analyzed to demonstrate that active biodegradation and other natural attenuation processes are continuing across the Site. The following geochemical parameters were analyzed during the sampling event in June 2010: DO, ferrous iron, nitrate, sulfate, manganese, methane, and alkalinity. The data for these additional geochemical parameters are summarized in Table 5.

***Tidewater Wells:***

Groundwater samples were collected from eleven Tidewater monitor wells on June 28 and 29, 2010. Seven wells were not sampled for the reasons indicated below:

- Wells AR-1, AR-7, MW-7, and MW-8 were not sampled due to the presence of an observable petroleum hydrocarbon sheen.

- Well AR-2 apparently has been removed as part of site modification and construction.

- Well AR-3 has an obstruction in the well casing above the groundwater elevation.

- AR-12 had insufficient depth of saturated zone.

One field duplicate sample was collected from AR-4 (labeled MW-11), and one MS/MSD sample was collected from AR-8 for the June 2010 RI. Trip blanks were included with coolers containing samples for BTEX analysis. Results from field data quality control are presented in Appendix D.

As discussed previously, field measurements indicated suppressed DO and ORP in the groundwater samples collected from former free product wells AR-4 and AR-8. These wells also exhibited changes is water quality parameters signification different from upgradient well AR-11, and downgradient wells outside the former free product plume. Wells AR-4 and AR-8 had the highest concentrations of ferrous iron, manganese, and alkalinity with corresponding lowest concentrations of nitrate and sulfate. These parameters are indicative of natural biodegradation processes active within the former plume area and ongoing in areas with elevated dissolved phase petroleum hydrocarbons. Methane was detected in well AR-4 where concentrations of petroleum hydrocarbons in groundwater concentrations are the highest, suggesting even greater biologic activity in this area.

Figure 11A shows the wells monitored at the Tidewater fuel release site. Table 4 presents a list of the Pasco fuel site monitor wells, pertinent observations, and a tally of wells that were field screened and/or sampled during the June 2010 RI investigation. Groundwater concentrations of petroleum hydrocarbons were only detected in wells AR-4 and AR-8, with a relatively low total xylenes detection below water quality criteria in well AR-6. Only well AR-4 resulted in groundwater concentrations above the MTCA Method A criteria for the petroleum hydrocarbon constituents of benzene, toluene, ethylbenzene, and total xylenes.

The analytical results indicate that all laboratory quality control requirements were met for the analyses performed. For both the fuel volatiles (BTEX) and petroleum hydrocarbon (TPH-Gx and TPH-Dx) analyses, laboratory performance criteria for calibration, precision (as measured by laboratory duplicate samples), and accuracy (as measured by spike and surrogate recovery and laboratory control sample analysis) were met.

The trip blank contained no detectable analytes. The relative percent difference (RPD) for the field duplicate sample collected at Tidewater well MW-1 was within acceptable limits.

Key results from the June 2010 sampling event are summarized below:

- Of the original 20 Tidewater monitor wells, 13 were sampled. One well was been removed, two obstructed or dry, and four had an observed PSH sheen.

- Two of the 13 sampled wells contained measurable concentrations of gasoline-range petroleum hydrocarbons (i.e., TPH-Gx); TPH-Gx concentrations at AR-4 and MW-8 were detected at 21,000 µg/L and 3,300 µg/L, respectively. TPH-Gx was not detected in any other wells for the June 2010 RI.

- Two of the 13 sampled wells contained measurable concentrations of diesel-range petroleum hydrocarbons (i.e., TPH-Dx); TPH-Dx concentrations exceeded the MTCA Method A cleanup level in both AR-4 and AR-8 at 5,300 µg/L and 2,000 µg/L, respectively.

- Benzene was detected in two wells corresponding to the elevated TPH-G detections in these same wells. The highest benzene concentrations were observed at AR-4 at 380 µg/L. Benzene was detected below the MTCA Method A cleanup level in AR-8 (2.0 µg/L).

- Toluene and ethylbenzene were detected in both AR-4 and AR-8, but only well AR-4 toluene concentration exceeded clean up levels; all other detections were below MTCA Method A cleanup levels.

- Total xylenes was detected in three wells for the June 2010 sampling event. Total xylene concentrations exceeded the MTCA Method A cleanup level only in well AR-4 at 4,400 µg/L. Total xylenes were detected in AR-8 and AR-6, but do not exceed the MTCA Method A cleanup levels.

- TPH-Gx, TPH-Dx, or BTEX constituents were not detected in any of the downgradient monitor wells (MW-2, MW-3, MW-4, and MW-5).

- The distribution of groundwater concentrations suggest relatively localized petroleum hydrocarbons dissolved in groundwater, likely as a result of remedial actions and removal of in-situ PSH.

- Field and water quality parameters have confirmed the natural attenuation of residual PSH.

## 5.3 Evaluation of Site Conditions

### 5.3.1 CPL Monitor Wells

Dissolved-phase concentrations at the Site remained generally below MTCA Method A cleanup levels at most CPL well locations. BTEX and gasoline range-hydrocarbons were below the

Method A cleanup levels in groundwater from all of the sampled CPL monitor wells. Ethanol has not been detected in groundwater above the laboratory reporting limit since monitoring for this parameter began; therefore, the ethanol released in April 2008 does not appear to have impacted groundwater at the Site. Diesel- and heavy oil-range hydrocarbons were not detected in the samples obtained from the four downgradient monitor wells closest to the Snake River/Lake Wallula (MW-6, MW-7, MW-8, and MW-10). Exceedances of the Method A cleanup levels are limited to diesel- and heavy oil-range TPH in three wells in the tank farm, two of which also had exceedances in several previous sampling events.

Detected concentrations of diesel-range and heavy oil-range hydrocarbons in 2010 represent an increase from the 2008 sampling event. The apparent increase in TPH in the CPL wells with detectable concentrations in June 2010 may be attributable to one or more of the following factors: the change in analytical laboratories; the change in sampling technique (from bailing to low-flow sampling); and a consequence of high groundwater levels. The higher than usual groundwater levels may have caused PSH residue to be washed from the well casing and filter pack. With only one sampling event thus far, it is not possible to determine how much the laboratory change affected the results. Because only the less volatile diesel- and heavy oil-range TPH concentrations increased, it is unlikely that the change to low-flow techniques cause the increase.

In conjunction with the ORP field data collected, the additional geochemical parameters indicate slightly reducing conditions in the affected CPL monitor wells, MW-2 and MW-12. Geochemical data collected from Tidewater's upgradient monitor well MW-1 indicate higher DO concentrations than in the affected CPL monitor wells MW-2 and MW-12. The lower DO concentrations at MW-2 and MW-12 may be attributed to the biological degradation of hydrocarbon constituents. The other geochemical parameters did not yield conclusive results.

Because the aquifer beneath the Site consists of permeable sand and gravel, the hydraulic gradient is relatively flat. The short distance between well pairs MW-2 and RW-1 (28 feet), and MW-11 and MW-7 (108 feet), and absence of COCs in the downgradient wells, demonstrate that the TPH constituents that remain in groundwater in the tank area are confined within a short distance from the affected wells. CPL monitor wells MW-6, MW-7, MW-8, and MW-10 are located between the tanks and the shoreline. These monitor wells are downgradient of the wells with the highest COC concentrations (MW-2, MW-11, and MW-12), and will detect plume migration, if it occurs. Based upon the information documented in this report, and summarized above, URS and CPL conclude that the groundwater plume in the tank area is stable or shrinking, and the existing network of wells is adequate to continue to monitor the natural attenuation of COCs in groundwater in the central tank area.

### 5.3.2 Tidewater Monitor Wells

Field parameters for pH, specific conductance, and temperature were relatively consistent across the Site. The DO was highest in upgradient well AR-11, with lower but still relatively high DO concentrations in downgradient monitor wells outside the former plume area. Wells AR-4 and AR-8 showed both suppressed DO concentrations and negative ORP values.

The initial RI event delineated thedistribution of petroleum hydrocarbons in the groundwater system beneath the Tidewater release site as of June 2010. Monitoring data collected to date confirm that the remedial actions have effectively removed the free product plume with localized residual PSH in groundwater, and mitigated plume expansion and migration above MCLs at the Site. The July 2010 RI sampling was performed to document spatial and temporal variations in dissolved-phase fuel hydrocarbon concentrations throughout the Site since the previous sampling events. Historical BTEX and TPH analytical results are presented in Appendix B.

Time series plots of historical petroleum concentrations for wells AR-4, AR-5, AR-6, and AR-8 are provided for discussion and shown in Figures 12 and 13. The groundwater hydrograph for well AR-10 is also shown for comparison to groundwater levels for the Site. For interior wells AR-4 and AR-5, Figure 12 shows decreasing groundwater concentrations in response to remedial actions and natural attenuation processes. The higher concentrations at AR-4 are considered localized because of the response and groundwater concentrations observed in AR-5 (located immediately downgradient of AR-4). Though petroleum concentrations in AR-4 have not decreased significantly since 2008, field and water quality parameters indicate active natural attenuation processes at this location without increased downgradient concentrations (localized and not migrating).

Wells AR-6 and AR-8 historically had free product, with free product level removed, and decreased groundwater concentrations in response to remedial activities (Figure 13). Post-remedial groundwater concentrations have decreased to below MTCA Method A concentrations for BTEX.

The groundwater elevations have increased, with the highest groundwater levels observed during the June 2010 monitoring event. As groundwater elevation increases, residual PSH, if present above the lower groundwater level, is expected to be dissolved and can potentially result in higher concentrations and larger plume size. This process may be occurring at well AR-4, where historical measurements have indicated localized residual PSH in the formation resulting in higher groundwater concentrations. However, natural attenuation processes appear active and significant to sufficiently maintain and reduce groundwater concentrations in response to these groundwater fluctuations. Long-range groundwater fluctuations are expected to result in continued soil "flushing" with natural attention processes sufficient to address groundwater concentrations.

A comparison of the historical monitoring results demonstrates that concentrations of dissolved-phase fuel hydrocarbons have decreased in lateral extent concentration. The June 2010 analytical data provide support that the plume continues to contract due to Site conditions that facilitate natural attenuation and biological degradation.

### 5.3.3 Conclusions

In summary, concentrations of petroleum products in groundwater from CPL monitor wells have remained relatively consistent and are below Ecology's MTCA Method A cleanup levels with the exception of diesel-range and heavy oil-range TPH at MW-2, MW-11, and MW-12, which show an overall declining trend. Monitor wells downgradient from the CPL tanks do not have detectable concentrations of petroleum constituents. Thus, it is concluded that the dissolved hydrocarbon plume resulting from historical CPL releases is not migrating, and continues to shrink in size.

Primary conclusions for the Tidewater fuel release area from the June 2010 RI sampling event are presented below:

- Petroleum hydrocarbons have been sufficiently removed and addressed at the Site.
- Residual dissolved-phase petroleum hydrocarbons are present in localized portions of the former free product plume area beneath the Site. Highest fuel hydrocarbon concentrations were observed at wells AR-4 and AR-8. Field screening information suggests that elevated fuel hydrocarbon concentrations are present in the vicinity of AR-1, AR-7, MW-7, and MW-8.
- The lateral extent of the dissolved-phase plume has continued to decrease since the remedial actions, as evidenced by non-detects or concentrations of fuel hydrocarbons below regulatory limits in monitor wells immediately within and downgradient of the former free product area.
- Measured concentrations of DO, ORP, nitrate, dissolved iron, dissolved manganese, sulfate, alkalinity, and methane, as well as decreased lateral extent and concentration of petroleum hydrocarbons in the groundwater suggest that biodegradation processes are occurring at the Tidewater fuel release site, and are contributing to the observed reduction in fuel hydrocarbon concentrations observed over much of the Site. Biodegradation and associated natural attenuation processes are expected to continue, resulting in continued decreased PSH and BTEX concentrations.

## 5.4 Potential Data Gaps

Attempts to remove sediment from the bottoms of CPL wells MW-2, MW-4, and MW-7 were partially successful (i.e., it was not possible to expose the full 20 feet of screen). Based on the camera survey, the exposed screen length after redevelopment was approximately 12 feet in MW-2, 18 feet in MW-4, and 19 feet in MW-7. However, despite the record high groundwater levels, the saturated screen length was much lower. Based on measurements from the June 2010 sampling event, the actual height of the water column before purging and sampling was 6.01 feet in MW-2, 8.96 feet in MW-4, and 11.33 feet in MW-7. Therefore, URS and CPL conclude that these wells are suitably constructed for continued use as groundwater sampling locations.

An issue could be raised with RW-1, which was constructed with 34 feet of screen. At the time of sampling in June 2010, the saturated screen length was approximately 22 feet. To address the potential impact of the long screen on COC concentrations, the submersible pump intake was set at 4.6 feet below the water table. This shallow withdrawal depth, coupled with use of the low-flow sampling technique in a highly permeable aquifer, minimized mixing with deeper, potentially unaffected, groundwater in the well. Given the precautions taken, URS and CPL believe that the COC analytical results for the sample from RW-1 are representative of groundwater from the upper few feet of the aquifer.

Two CPL monitor wells, MW-1 and MW-3, currently are not capable of yielding representative groundwater samples. MW-1 was deemed unsalvageable during maintenance activities in June 2010. The long-term presence and disintegration of the PSH-saturated absorbent sock in MW-3 have probably irreparably compromised this well. PSH absorbed on the sock has likely been smeared along the inside of the well screen as the sock moved up and down with fluctuating groundwater levels. If Ecology requires MW-1 and/or MW-3 to be replaced, new wells will be at the proposed locations shown on Figure 14. (The proposed location of the replacement well downgradient of MW-3 may need to be adjusted slightly to avoid the Salt Lake Pipelines.) Both proposed locations are adjacent to the access road down to the river, and would serve as downgradient monitoring points between the tanks and the river. As described in the *RI/FS Work Plan*, soil samples would be collected during well installation for the purpose of soil characterization. These wells would be installed as a supplemental step in the RI process.

The existing CPL monitor well MW-1 will be plugged and abandoned due to its location in the center of a gravel roadway. It is also proposed that groundwater samples will no longer be collected from CPL monitor well MW-3; this well could be retained, however, as a water level measuring point.

Two Tidewater monitor wells, AR-2 and AR-3, have been removed and obstructed, respectively. These wells are located near existing monitor wells. Additional monitor wells are located cross-gradient and downgradient of these locations. The current distribution and location of monitor wells is sufficient to cover these areas, and do not suggest a need for replacement. The status of these monitor locations shall be addressed as part of the Site-wide monitoring network recommendations.

## 5.5 Potential Impacts to Surface Water

An important consideration for this Site is whether surface water resources are potentially impacted by the presence of COCs in soil and groundwater. Existing information indicate that the nature and current extent of groundwater and soil contamination at the Site do not pose a threat to surface water, shore sediments or sensitive ecological receptors. Site-wide concentrations of COCs are generally close to or below MTCA Method A cleanup levels, in particular at perimeter locations for the 2000 Tidewater gasoline release, and between the CPL tanks and shoreline. Thus, prior remediation efforts have effectively addressed most impacts to groundwater and soil near the source. Even with current detections, the characteristically low groundwater gradients at the Site indicate that the transport of COCs would occur very slowly. There is no evidence to indicate that COCs from prior releases are currently migrating to or reaching the shoreline.

# 6.0 December 2010 Sampling Event

In a letter dated October 28, 2010, Ecology requested another sampling event (Appendix A). Upon further discussion, all parties agreed that field work for the sampling event would occur before the end of 2010. Results from the December 2010 sampling event were provided to Ecology in an *Addendum to the Preliminary RI Report*, dated February 28, 2011.

## 6.1 Results from December 2010 Sampling Event

The additional sampling event was conducted December 14-16, 2010. Procedures used to gauge and sample the Site monitor wells, and preserve, ship and analyze the groundwater samples, were as described in the Ecology-approved *RI/FS Work Plan*.

### 6.1.1 Groundwater Levels and Gradients

Groundwater levels in all accessible CPL and Tidewater monitor wells were measured on December 14, 2010. URS and CH2M HILL also measured the total well depth and, if present, the thickness of PSH. The presence/absence of a discrete free product layer or sheen was re-checked using a clear, polyethylene or PVC bailer. Small fragments of sorbent material with PSH were again observed in the water purged from CPL monitor well MW-3. No other CPL monitor well had any indication of PSH or a sheen. Tidewater wells AR-1 and AR-7 contained a broken sheen that was observed in the water as the well was purged. No other Tidewater wells contained a petroleum sheen.

The measurements and the computed groundwater elevations for the CPL and Tidewater monitor wells for the December 2010 sampling event are listed in Table 4. The most recent groundwater elevations have been added to the hydrographs in Figure 8, which illustrate that groundwater elevations across the Site were approximately 0.4 to 0.5 foot lower in December than in June. The Site-wide groundwater elevation contour map for December 2010 is provided as Figure 9B.

As has been observed previously, the groundwater gradient in the Tidewater fuel release area is relatively flat, with the highest elevation in upgradient well AR-11. The overall direction of groundwater flow is to the southeast toward the Snake River. Two separate groundwater flow lines were drawn on Figure 9B to illustrate that the magnitude of the hydraulic gradient varies with distance from the river. On December 14, 2010, the hydraulic gradient in the upland portion of the Site was approximately 0.0001 foot per foot whereas, closer the river, the hydraulic gradient was approximately 0.009 foot per foot. Due to the uniformly lower groundwater elevations, these gradients are similar in magnitude to those calculated from the June 2010 data. The hydraulic gradient in the upland portion of the Site remains approximately one to two orders of magnitude lower than the gradient close to the river. The groundwater flow direction and hydraulic gradients are consistent with those shown on the previous three Site-wide maps for 2007, 2008, and 2010.

According to the U.S. Army Corps of Engineers records for McNary Dam, the pool elevation of Lake Wallula on December 14, 2010 was 338.62 feet NGVD[3]. The maximum and average pool elevations in December 2010 were 339.35 and 338.19 feet NGVD, respectively. These elevations are near the upper end of the normal pool range of 335 to 340 feet NGVD. The lake elevation, which serves as the base level for groundwater discharge, was slightly lower than in June 2010. This condition contributed to lower groundwater elevations in the monitor wells.

### 6.1.2 Groundwater Quality

Groundwater samples were collected from CPL and Tidewater monitor wells on December 14-16, 2010. The same wells sampled in June 2010 were sampled in December. In addition, groundwater samples were collected in December from Tidewater wells MW-7 and MW-8; these two wells were not sampled in June due to the presence of a broken sheen observed during purging. All groundwater samples were shipped to TestAmerica Laboratories, Inc. in Tacoma, Washington for analysis of the Site COCs, and additional parameters to evaluate ORP conditions and the status of natural attenuation at the Site.

The analytical results for Site COCs are provided in Table 4. Water quality parameters monitored during purging are summarized in Table 5, along with ORP and natural attenuation parameters.

***CPL Wells:***

Groundwater samples were collected December 14-16, 2010 from nine of the 12 CPL monitor wells and recovery well RW-1. The submersible pump intake was set between approximately 2.36 and 5.32 feet below the water table in these wells. Consistent with the June 2010 sampling event, monitor wells MW-1, MW-3, and MW-13 were not sampled for the following reasons:

- MW-1 was dry, and was filled with road gravel to within 1.3 feet of the top of the well screen;
- Water purged from MW-3 in December still contained remnants of the disintegrated absorbent sock (removed in June 2010), traces of free product, and very strong hydrocarbon sheen; and
- MW-13 is screened only in the vadose zone, so the bottom of this well is above the water table.

Field duplicate and MS/MSD samples were collected from MW-12; the duplicate sample was labeled MW-22. The analytical results for the duplicate sample were nearly identical to the

[3] (http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?k=id:MCN+record://MCN/HF//IR-MONTH/DRXZZAZD/+psy:+psm:+psd:+pey:+pem:+ped:+pk:forebay+elevation+mcnary)

results for MW-12. An equipment rinse sample was also submitted for analysis under the fictitious name RW-02. Upon receipt of the analytical results, the laboratory report was reviewed in accordance with the QAPP in the *RI/FS Work Plan* to ensure that the data met the project acceptance criteria.

COC concentrations in groundwater CPL monitor wells for the December 2010 sampling event are summarized in Table 4 and depicted on Figure 10B. The Site COC analytical results for December 2010 from the CPL monitor wells are summarized as follows:

- BTEX, ethanol, and NWTPH-Gx were not detected above the laboratory reporting limits in any groundwater sample. Except for benzene, this is consistent with the June 2010 results. In June, benzene was detected in the sample from MW-12 at a concentration of 1.1 µg/L.

- Diesel-range hydrocarbons (NWTPH-Dx) were detected above laboratory reporting limits in samples from monitor wells MW-2, MW-11, and MW-12. Reported concentrations ranged from 200 µg/L in MW-11 to 3,100 µg/L in MW-2. Only two results (MW-2 and MW-12 Duplicate [MW-22]) were above the MTCA Method A cleanup level of 500 µg/L. Compared to the June 2010 data, fewer wells had diesel-range hydrocarbon detections, and the December concentrations were lower at all locations.

- Heavy oil-range hydrocarbons (NWTPH-Rx) were detected above laboratory reporting limits in samples from monitor wells MW-2 and MW-12, at concentrations ranging from 430 µg/L in MW-12 to 2,400 µg/L in MW-2. The MW-2 and MW-12 Duplicate (MW-22) samples had results that were above the MTCA Method A cleanup level of 500 µg/L. As with the diesel-range hydrocarbons, fewer wells had diesel-range hydrocarbon detections in December 2010 compared to June 2010, and the December concentrations were lower at all locations.

The laboratory report narrative indicated that all detected diesel- and heavy oil-range hydrocarbons contained a fingerprint that could be associated with a mineral or transformer oil, or with biogenic interference. The laboratory analyst and URS QA Officer reviewed the chromatograms from the June and December 2010 sampling events and concluded that the fingerprint from each event did not differ significantly. Since mineral oil and transformer oil were not stored or released at the Pasco Terminal, the biogenic fingerprint is assumed to be the result of natural attenuation processes.

The following geochemical parameters were analyzed during the December 2010 sampling event: DO, ferrous iron, nitrate, sulfate, manganese, methane, and alkalinity. The analytical results for these parameters (Table 5) continue to demonstrate that active biodegradation is occurring across the Site.

***Tidewater Wells:***

Groundwater samples were collected from 15 of the 20 Tidewater monitor wells from December 14-16, 2010. Wells MW-7 and MW-8, which were not sampled in June 2010 due to the presence of a broken sheen, were sampled in December 2010 since no observable sheen was observed. Five wells were not sampled for the December 2010 event for reasons indicated below:

- AR-1 and AR-7 were not sampled due to the presence of a petroleum hydrocarbon sheen observed during purging;
- Well AR-12 was dry; and
- Wells AR-2 apparently has been removed and AR-3 has an obstruction within the well preventing sampling.

A field duplicate sample was collected from AR-8 (labeled FD-1), and one MS/MSD sample was collected from MW-3 for the December 2010 sampling event. Field duplicate results are included in Table 4. Trip blanks were included within each cooler containing samples for BTEX analysis.

Field parameter results for the December 2010 sampling event are presented in Table 5. As with the June 2010 event, low DO and negative ORP results were observed in the former free product wells AR-4 and AR-8. Additional field parameters for these wells suggest that biodegradation processes are occurring within the former plume area. A relatively low DO result and a negative ORP were also observed in monitor well MW-8. Field parameters for these three wells varied from the upgradient wells and other wells located outside of the former free product plume, which have historically shown higher DO and positive ORP readings.

Groundwater samples were submitted to TestAmerica Laboratories, Inc. in Tacoma, Washington for analysis. Analytical results indicate that all laboratory quality control requirements were met for the analyses performed. The RPD for the field duplicate sample collected from AR-8 was within acceptable limits. No BTEX constituents were detected in submitted trip blanks.

Analytical results for the December 2010 sampling event are provided in Table 4 and shown on Figure 11B for each Tidewater well, as summarized below:

- Toluene, total xylenes, and TPH-Gx were detected in well MW-7, but at concentrations below MTCA Method A cleanup levels. A broken sheen had been observed in MW-7 in June 2010 during the sampling event.
- Total xylenes, TPH-Gx, and TPH-Dx exceeded MTCA Method A cleanup levels in MW-8. Benzene, toluene, and ethylbenzene were detected below MTCA cleanup

levels. A broken sheen had been observed in MW-8 in June 2010 during the sampling event.

- AR-4 continues to contain the highest petroleum concentrations of the Tidewater wells. Benzene, toluene, and total xylenes exceeded MTCA Method A cleanup levels. Ethylbenzene was detected below the MTCA cleanup level of 700 µg/L. TPH-Gx and TPH-Dx exceeded their respective MTCA cleanup levels at 17,000 µg/L and 2,900 µg/L, respectively. December 2010 concentrations for AR-4 are slightly lower than the June 2010 sampling results.

- AR-5 concentration of TPH-Dx (730 µg/L) exceeded the MTCA cleanup level of 500 µg/L. TPH-Gx (260 µg/L) was detected below the MTCA cleanup level for the December 2010 sampling event. No petroleum constituents were detected above laboratory detection limits for the June 2010 sampling event for AR-5.

- Total xylenes (8.6 µg/L) and TPH-Gx (81 µg/L) were detected in AR-6 at concentrations below MTCA cleanup levels. No other constituents were detected. Only total xylenes (2.4 µg/L) was detected in AR-6 for the June 2010 event.

- All BTEX constituents were detected in AR-8, but below their respective MTCA cleanup levels. TPH-Gx and TPH-Dx were detected at concentrations exceeding MTCA Method A cleanup levels. TPH-Gx increased from 2,000 µg/L in the June 2010 event to 3,700 µg/L in December 2010. TPH-Dx decreased from 3,300 µg/L in June 2010 to 1,500 µg/L for the December 2010 event.

- No COCs were detected in any other Tidewater wells for the December 2010 sampling event.

## 6.2 Evaluation and Conclusions

Groundwater investigation results from the December 2010 sampling event were generally consistent with those of the June 2010 event. Although Site-wide groundwater levels were uniformly lower in December, there was little to no change in the magnitude or direction of groundwater flow. The hydraulic gradient near the river was the same during both events (0.009 foot per foot). However, the hydraulic gradient in the upland portion of the Site was slightly lower in December (0.0001 foot per foot) than in June (0.0006 foot per foot).

***CPL Wells:***

At CPL well locations, diesel- and heavy oil-range hydrocarbons are the only COCs that remain above MTCA Method A cleanup levels. Concentrations of these COCs in groundwater decreased in December at all locations where they were detected in June. At MW-11 in December, the NWTPH-Dx concentration decreased to below the Method A cleanup level. The

NWTPH-Rx concentrations at MW-11 and MW-14 in December were not detected. Prior to the June 2010 sampling event, reported concentrations of these COCs had been below the Method A cleanup levels at MW-11 and MW-14 since July 2006.

Diesel- and/or heavy oil-range concentrations exceed MTCA Method A cleanup levels at only two CPL well locations within the tank farm. At MW-12, the concentration of diesel-range hydrocarbons was slightly above the cleanup level in the duplicate sample (520 µg/L), but was below the cleanup level in the original sample (490 µg/L). Heavy oil-range hydrocarbon concentrations were below the cleanup level in both samples from MW-12. As has been the case for the previous six sampling events, the highest diesel-and heavy oil-range hydrocarbon concentrations occurred at MW-2. Despite the elevated concentrations at this location, neither COC was detected in groundwater from RW-1, which is located 28 feet downgradient from MW-2.

In summary, there is no evidence that the low levels of dissolved hydrocarbons in groundwater beneath the CPL tank area are migrating. Low hydraulic gradients and non-detects in downgradient wells, coupled with the apparent biogenic fingerprint for the diesel- and heavy oil-range hydrocarbons in the few remaining affected wells, lead CPL and URS to conclude that biodegradation and other natural attenuation processes are active at the Site.

***Tidewater Wells:***

Field parameters remained consistent across the Site, except in wells containing elevated concentrations of petroleum hydrocarbons. Wells AR-4, AR-8, and MW-8 showed suppressed DO and negative ORP readings that indicate natural biodegradation processes are occurring.

Updated time series plots illustrating historical petroleum concentrations are provided for interior wells AR-4 and AR-5 (Figure 12), and for plume perimeter wells AR-6 and AR-8 (Figure 13). The updated hydrograph for AR-10 is included for comparison of groundwater levels at the Site (Figure 8).

Overall, petroleum concentrations for the December 2010 sampling event are fairly similar to concentrations from the June 2010 event. Wells AR-5 and AR-6 had slightly higher petroleum concentrations than in June 2010. Petroleum concentrations decreased slightly in AR-4. As with the June 2010 event, petroleum constituents were not detected in upgradient or downgradient wells for the Tidewater release site.

Wells MW-7 and MW-8 historically have not been sampled due to the presence of an observable sheen, but were located within the active remediation area. The results from these wells suggest that while petroleum hydrocarbons may still be present in these areas, they have been highly remediated and undergoing continued degradation due to natural attenuation.

The results of the December 2010 sampling event continue to support the conclusions drawn for the Tidewater release area after completion of the June 2010 sampling event (Section 5.3.3):

- Liquid phase petroleum hydrocarbons have been sufficiently removed and addressed at the Site based on analytical data from the June 2010 and December 2010 sampling events. No petroleum hydrocarbons were observed in downgradient wells for the Tidewater Site for both June 2010 and December 2010 sampling events.

- Residual dissolved-phase petroleum hydrocarbons still remain on-site within localized areas of the former free product plume. These areas include AR-1, AR-4, AR-7, and AR-8.

- The lateral extent of the dissolved-phase plume has continued to decrease since active remedial actions were discontinued.

- Measured concentrations of field parameters and analytical results of geochemical constituents, as well as the decreased lateral extent and concentration of petroleum hydrocarbons in sampled wells suggest that biodegradation processes are continuing at the Tidewater release site. Biodegradation and associated natural attenuation processes have contributed to the observed reduction in petroleum concentrations. These processes are expected to continue, resulting in continued decreases in petroleum concentrations.

# 7.0 Feasibility Study

Two of the objectives of the *RI/FS Work Plan* were to evaluate the current and potential future risk to human health and the environment, and to identify appropriate remedies to address remaining contamination at the Pasco Site. These two objectives are addressed in this section, which concludes with the selection of the preferred cleanup action alternative.

The FS identifies the objectives for remedial action, and compares a focused number of practicable cleanup alternatives consistent with MTCA requirements. The cleanup alternatives considered will protect human health and the environment, achieve the cleanup standards, comply with applicable or relevant and appropriate requirements (ARARs), comply with applicable state and federal laws, and provide for monitoring of compliance [WAC 173-340-360(2)(a)]. Preference is given to permanent solutions (as defined in WAC 173-340-173-200) to the maximum extent practicable. Potential alternatives were screened using a disproportionate cost analysis (cost/benefit analysis), following the procedure described in WAC 173-340-360(3)(e)(ii), that compared the most practicable permanent solution to other practicable remedies based on the following criteria: protectiveness, permanence, management of short-term risks, long-term effectiveness, technical and administrative implementability, cost, and consideration of public concerns.

## 7.1 Streamlined Risk Evaluation

A traditional baseline risk assessment has not been performed for the Pasco Site because most impacts from the historical releases have already been addressed through the interim remedial activities completed to date (Table 2, and Sections 3.0 and 4.0). There is no obvious or immediate threat of exposure to petroleum hydrocarbons that would adversely impact human health or the environment, and there are no physical hazards associated with the COCs. In addition, there is little potential for current or future exposure to the COCs in groundwater or soils. Therefore, this section focuses on the low concentrations of COCs that remain in groundwater and the overlying soil column.

COCs for the Site are BTEX, NWTPH-Gx, NWTPH-Dx, and NWTPH-Rx. Ethanol is an additional COC for the CPL monitor wells. These COCs were selected based on the nature of the historical releases, and the results of previous investigations and groundwater sampling events conducted by CPL and Tidewater. Concentrations of COCs from the RI were compared to MTCA Method A cleanup levels to evaluate whether the risk to groundwater, soil, surface water, or near-shore sediments is sufficient to require remedial action and, if so, which remedy or remedies would be appropriate to achieve the cleanup levels(s).

As described in Sections 5.0 and 6.0, COC concentrations in recent groundwater samples from most CPL and Tidewater monitor wells are below MTCA Method A cleanup criteria. Only a few wells remain where COC concentrations are above the cleanup levels. COC concentrations in groundwater from the four monitor wells closest to the river (CPL wells MW-6, MW-7, MW-8, and MW-10) have been below MTCA Method A cleanup criteria since 2006 (earlier at some of these wells), and have been non-detect for the last four sampling events. Potential impacts to surface water and near-shore sediments of the Snake River, which resulted from the historical releases in the tank area of the Site, were addressed through prior remedial activities (Sections 3.0 and 4.0).

The relative toxicity of each COC is indicated by the magnitude of the MTCA Method A cleanup level. Very conservative exposure assumptions were utilized in the development of the MTCA Method A cleanup levels. Current COC concentrations in groundwater from all monitor wells sampled in 2010 are summarized in Table 4. The maximum COC concentrations reported in 2010, and the corresponding Method A cleanup levels, are listed here:

| *COC* | *MTCA Method A Cleanup Level (µg/L)* | *2010 Maximum Concentration (µg/L)* | *Monitor Well* | *Date Sampled* |
|---|---|---|---|---|
| Benzene | 5 | 380 | T-AR-4 | 6/29/2010 |
| Toluene | 1000 | 1900 | T-AR-4 | 6/29/2010 |
| Ethylbenzene | 700 | 270 | T-AR-4 | 6/29/2010 |
| Xylenes (total) | 1000 | 4400 | T-AR-4 | 6/29/2010 |
| NWTPH-Gx | 1000/800 [A] | 21000 | T-AR-4 | 6/29/2010 |
| NWTPH-Dx | 500 | 5300 | T-AR-4 | 6/29/2010 |
| NWTPH-Rx [B] | 500 | 3300 | C-MW-2 | 6/30/2010 |
| Ethanol | N/A | <10000 | Not detected in any CPL well | |

[A] The lower value applies if benzene is detected in the sample.
[B] The heavy oil fraction of NWTPH is reported as NWTPH-Rx.

### 7.1.1 Exposure Pathways

Historical releases of petroleum hydrocarbons from tanks and pipelines have resulted in soil and/or groundwater contamination in limited areas of the Site. The sources, nature, and extent of affected environmental media at the Site are summarized in Sections 3.0 through 6.0. Potentially affected media include groundwater, soil, surface water, sediment, and air. Based on the findings of the June and December 2010 remedial investigation, and data from prior historical investigations and monitoring, groundwater, and possibly soil in the vicinity of the original releases, are the only affected media.

Potential exposure pathways for COCs in groundwater and soil at the Site include groundwater ingestion, migration and discharge of potentially affected groundwater to surface water and/or near-shore sediments, direct contact with affected soil or groundwater, and leaching of COCs from soil to groundwater. Inhalation risk from soil particulates is not an issue since surface soils are not impacted by COCs from the historical releases. Human and ecological receptors at the Pasco Terminal would not be exposed via air pathways because surface soils are not affected, there are no buildings located in the affected areas, and the depth to groundwater in areas having dissolved COCs is approximately 70-80 feet bgs. For these reasons, further assessment of the soil-to-air exposure or groundwater-to-air pathways is not warranted.

Groundwater ingestion is currently an incomplete exposure pathway because there are no water supply wells on-site. A water supply well was formerly located close to the office building in the northeast part of the Site. Records indicate that this well was decommissioned and sealed in 1993 (Table 2). Potable water is now supplied by the City of Pasco. The existing monitor wells on-site are not equipped with pumps, and do not supply water for drinking or other consumptive use.

Most documented releases, and all of the larger releases (Table 1), occurred from tanks or pipelines located in the upland area, at least 500 feet from the shoreline. A few small releases have occurred at the barge dock, but impacts to surface gravel, riprap, or surface water were addressed at the time of each release. Periodic inspections have not identified a sheen on surface water attributable to groundwater seepage since the 1986 release of Jet A from a buried pipeline near the shoreline (Section 2.2). Based upon the evidence to date, hydrocarbon products released from the tank area of the Pasco Terminal have not reached the near-shore sediments or surface water. Furthermore, the low hydraulic gradients measured at the Site are not conducive to rapid transport of COCs in groundwater, as demonstrated by historical monitoring results. Therefore, there is no need for the FS to address near-shore sediments or surface water. Moreover, as stated in Section 7.1, COC concentrations in downgradient areas are close to or below MTCA Method A cleanup levels, and none of the COCs has been detected in the downgradient wells closest to the Snake River since 2007.

### 7.1.2 Human Health Risk Assessment

Potential human receptors at the Pasco Terminal are limited to on-site workers. The historical release areas are not accessible to visitors, because the Site is surrounded by a security fence, which prevents access by unauthorized visitors or trespassers. Electric gates can only be opened by a security guard or a remote opener issued to users by CPL.

Potential exposure to on-site workers via direct contact with COCs adsorbed on the soil is unlikely because the COCs are not present near the ground surface. Surface soils in the vicinity of the historical releases were excavated and replaced with backfill. Hydrocarbons that were not recovered or contained in the excavated soil would have migrated vertically down through the thick vadose zone soil column, with little horizontal movement.

Isolated pockets of PSH have been identified in locations where historical releases were of sufficient volume to reach the water table. However, remedial activities were conducted by CPL and Tidewater between 1989 and 2003 to address the PSH and dissolved COCs (Sections 3.0 and 4.0). Thus, the potential for exposure to COCs would be limited to those isolated areas where residual hydrocarbons moved down through the soils, or where PSH was previously in contact with the water table. Based on the findings of the 2010 remedial investigation, only residual petroleum hydrocarbons in pore space and low concentrations of COCs remain at a few monitor well locations. Based upon the significant depth, potential on-site worker exposure to PSH and residual pore space hydrocarbons is unlikely.

Direct contact with groundwater containing COCs is unlikely because affected groundwater is present in only a few upland areas of the Site, and the water table in those areas is more than 70 feet bgs. Personnel who periodically sample the on-site monitor wells wear protective gloves and take other safety precautions to prevent direct contact with the groundwater.

One of AO's primary goals is the protection of surface water resources. The State of Washington has established water quality standards for the protection of surface water, and assigned use designations to each water body. Use designations for the Lower Snake River (Water Resource Inventory Area #33) are listed as [WAC 173-201A-Table 602]:

- Aquatic Life Use [173-201A-200(1)]: Spawning/Rearing (salmonid)
- Recreation Use [173-201A-200(2)]: Primary Contact
- Water Supply Uses [173-201A-200(3)]: Domestic, Industrial, Agricultural, and Stock
- Miscellaneous Uses [173-201A-200(4)]: Wildlife Habitat, Harvesting, Commerce/Navigation, and Aesthetics

As a receiving water body, the Snake River must be protected against discharge of groundwater that contains COCs in concentrations that would have an adverse impact on surface water quality.

### 7.1.3 Ecological Risk Assessment

There are no known ecological receptors in the upland portions of the Site where historical releases have occurred. The Site is an active storage terminal for petroleum products, and is not attractive to local wildlife due to constant disturbances caused by ongoing industrial activity, lack of surface water, and scarcity of foraging habitat. Potential exposure to groundwater beneath the upland part of the Site is considered to be an incomplete pathway for ecological receptors due to the great depth to groundwater (70-80 feet bgs). Because petroleum hydrocarbon-affected surface soils were excavated at the time of the historical releases, potential exposure to affected soil is also considered an incomplete pathway. Therefore, further terrestrial ecological risk assessment is not warranted per WAC 173-340-7492(2)(b) and (c)(ii), At this time, CPL plans to continue using the Site as a products storage terminal; thus, conditions will not change in the foreseeable future.

The Snake River (Lake Wallula) is the only surface water present at the Site. As described in Sections 7.1.1 and 7.1.2, the river provides aquatic habitat, and is used for recreation and water supply. Ecological receptors could only be exposed to COC-impacted water at the groundwater-surface water interface, which occurs at the shoreline. As presented in Section 5.3.1, there is no evidence that the low concentrations of dissolved COCs remaining in groundwater beneath the tank area (and farther back) are currently migrating to the Snake River. At MW-06, which is the monitor well closest to the shoreline, COCs have been below MTCA Method A cleanup levels since monitoring began in 1990, and have not been detected since 2005. Therefore, the groundwater-to-surface water and groundwater-to-sediment pathways do not appear to pose an unacceptable risk, and further ecological risk assessment is not warranted.

## 7.2 Remedial Action Objectives and Cleanup Criteria

The remedial action objective for groundwater is to prevent the potential migration of COCs in groundwater beyond the Pasco Site boundary at the shoreline of the Snake River at concentrations exceeding MTCA Method A cleanup levels. A remedial action objective was not developed for on-site soil because potential soil ingestion/direct contact/inhalation exposure pathways would be adequately addressed through OSHA worker protection standards and the remedial action objective for groundwater. The potential for future groundwater impacts from the release of COCs adsorbed on soil will be addressed through the performance monitoring program (Section 8.0). If COCs in groundwater remain below MTCA Method A cleanup levels, it can be presumed that the residual COC concentrations in soil are protective of groundwater, i.e., will not leach out of the soil to groundwater at a rate that will cause the groundwater cleanup levels to be exceeded. Similarly, remedial action objectives for the protection of human health or ecological receptors for COCs in surface water or near-shore sediments were not developed, because COCs from the historical releases in the tank area could only reach these media via migration of affected groundwater. Thus, the remedial action objectives for surface water and sediments also are addressed through the remedial action objective for groundwater.

There are two general types of cleanup criteria:

1. Risk-based cleanup criteria developed from human health and ecological risk equations using acceptable risk levels, and conservative default or Site-specific factors; and

2. ARARs.

MTCA Method A cleanup levels fall into the category of risk-based cleanup criteria. ARARs are "applicable" or "relevant and appropriate" federal state, and local environmental requirements. Applicable requirements include cleanup standards and other substantive requirements, criteria, or limitations promulgated under federal or state laws that apply to hazardous substances and removal actions at the Site. Relevant and appropriate requirements are not legally applicable to the Site, but may be suitable for use because they address issues or problems sufficiently similar to those present at the Site.

The results of the RI (Sections 5.0 and 6.0) and risk evaluation (Section 7.1) indicate that the only potentially significant source of risk at the Site is from the discharge of COC-affected groundwater to the Snake River. The discussion of ARARs and proposed cleanup criteria, therefore, focuses on groundwater as the only medium of concern at the Site. ARARs and proposed cleanup criteria for groundwater are discussed below and summarized in Table 6.

### 7.2.1 Scope and Purpose of Remedial Action

The primary goal of remedial action is to protect human health and the environment by preventing or minimizing the potential release of a hazardous substance, and by reducing the potential for direct contact and transport of contaminants to the environment. Prior remedial activities conducted by CPL and Tidewater have reduced the concentrations of COCs in soil and groundwater near the historical release areas. Based on the findings of the RI, COCs concentrations in groundwater are above MTCA Method A criteria in only a few limited areas. More significantly, the COCs do not appear to be migrating, and time-series data show overall declining trends in COC concentrations. Therefore, the remedial action objective for this FS is to remove or decontaminate the COCs in groundwater in the few areas where these COCs are still present above MTCA Method A cleanup levels. There is no separate remedial action objective for soil, because the potential transfer of COCs from soil to ground water will be addressed through the remedial objective for groundwater.

### 7.2.2 Applicable or Relevant and Appropriate Requirements

Numerous federal, state, and local laws, and their implementing regulations, were reviewed to identify ARARs that could potentially apply as cleanup levels (CULs) for the Pasco Site. ARARs may be used to (1) evaluate the extent of Site cleanup needed; (2) identify and evaluate cleanup action alternatives; and (3) guide the implementation and operation of the preferred alternative. Chemical-specific ARARs are usually human health or ecological risk-based numerical values that define acceptable exposure levels, and which may also serve as the basis for establishing remediation goals. The values are derived from published tables or by methodologies that, when applied to site-specific conditions, result in the establishment of numerical cleanup levels. Location-specific ARARs are restrictions placed on the concentration of hazardous substances based on the location of the site. Action-specific ARARs are usually requirements or limitations relating to particular actions taken or technologies used at a site. If a chemical has more than one ARAR requirement, the more stringent requirement applies. The following discussion considers only those ARARs that pertain to conditions at the Pasco Site, i.e., standards equal to or lower than the MTCA Method A cleanup levels used in the Site risk evaluation.

COCs contained in groundwater beneath the Site may potentially discharge to the Snake River. Therefore, State of Washington surface water quality standards for toxic chemicals [WAC 173-201A-240(5) and (6)] apply to the Site. The surface water quality standards are chemical-specific ARARs that are based on U.S. EPA Quality Criteria for Water (1986, as revised). Human health-based water quality criteria are contained in 40 CFR 131.36 (National Toxics Rule), and include consideration of excess human health cancer risk of less than or equal to one in one million. National drinking water standards are also applicable because the river is protected as a potential source of public water supply.

Table 6 summarizes the key ARARs for the COCs detected at the Site. The ARARs are identified by a statutory or regulatory citation, followed by a brief description of the ARAR, and whether it is applicable (i.e., relevant and appropriate), and the applicable concentrations, if available. For comparison, the MTCA Method A cleanup levels are also listed in Table 6. Potential key ARARs for the Site include the following chemical-specific standards:

- Federal Safe Drinking Water Act: National Primary Drinking Water Standards, Maximum Contaminant Levels (MCLs) [40 CFR 141.61] and Maximum Contaminant Level Goals [40 CFR 141.50];
- Washington State Drinking Water Act and Regulations [WAC 246-290-310(4)]: MCLs;
- Federal Water Pollution Control Act (Clean Water Act): Water Quality Standards authorized by sections 303(c) and 304(a)(1) [40 CFR 131 36];
- Washington State Water Pollution Control Act and Washington State Water Resources Act of 1971 [WAC 173-201A-240(5)]; and
- National Recommended Water Quality Criteria, accessed online June 23, 2011 at http://water.epa.gov/scitech/swguidance/standards/current/index.cfm.

### 7.3 MTCA Cleanup Standards

One of the requirements of the MTCA cleanup regulation [WAC 173-340] is to establish cleanup standards for individual sites. The two primary components of the cleanup standards are (1) cleanup levels, and (2) point of compliance (POC). Both must be established for a site. A cleanup level represents the concentration at which a particular hazardous substance does not threaten human health or the environment. The goal is to address all substances that are present in site media at concentrations exceeding a cleanup level. POCs are designated at on-site locations where cleanup levels are to be met. All cleanup actions conducted under MTCA must comply with legally applicable state and federal requirements, criteria, or limitations that are relevant and appropriate.

### 7.3.1 MTCA Cleanup Levels Development

The purpose of this section is to present cleanup levels for the Pasco Site in accordance with the MTCA requirements. The cleanup levels were developed considering the existing Site conditions, known exposure pathways, and anticipated receptors for the current Site activities and nearby land uses. The MTCA cleanup levels are provided to assist in the evaluation and comparison of cleanup alternatives, and to guide the selection of a recommended remedial alternative. Cleanup levels for the Site were developed following the guidance in WAC 173-340-700 through -760, and review of the ARARs for the Site.

### 7.3.2 Cleanup Levels

Results of the RI indicate that petroleum hydrocarbons, such as gasoline- and diesel- range organics (reported as NWTPH-Gx, NWTPH-Dx, and NWTPH-Rx) and fuel chemical constituents (BTEX), are the COCs found in groundwater from the historical petroleum releases. As stated in Section 7.1, ethanol is an additional COC for the CPL monitor wells. Groundwater has been impacted from historical releases resulting in dissolved phase petroleum hydrocarbons and PSH in groundwater. Interim remedial measures, which have included source removal of soil and PSH, have resulted in decreasing groundwater concentrations over time. Based on these results, groundwater is the identified environmental medium of interest for the cleanup standards and cleanup levels.

The historical releases have resulted in localized degradation of groundwater quality within the unconfined groundwater beneath the Site. The downgradient extent of the localized plume has been delineated, and ongoing post-interim remedial action monitoring has documented continued reduction of COC concentrations and a shrinking plume. The primary beneficial use of the groundwater beneath the Site is as a drinking water source. Access to the groundwater beneath the Site is limited by institutional controls, including ownership, fencing, and current land use as a fuel products storage and distribution facility. The groundwater depth is below terrestrial animal or plant interaction, and the lateral extent of the plume is confined within the facility boundaries. Based on these Site considerations, there is no present and imminent threat to human health and the environment.

Establishing cleanup levels for Site groundwater requires consideration of current and potential future beneficial uses of groundwater. A final groundwater cleanup level should result in protection of groundwater addressed within the context of potential domestic groundwater use. Therefore, MTCA Method A cleanup levels for groundwater, as listed in Table 720-1 of WAC

173-340-900 for the COCs, are proposed for groundwater at the Site. Concentrations have been reported above these cleanup levels in groundwater from a few monitor wells during the most recent monitoring event. These groundwater monitoring results indicate that remedial alternatives should be considered to further mitigate groundwater COC concentrations.

### 7.3.3 Points of Compliance

The groundwater POC is the point or points where the groundwater cleanup level must be obtained for a site to be in compliance with the cleanup standards. The results of the RI were used to develop the following POCs in groundwater at the Site.

The standard POC for groundwater is established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest depth which could potentially be affected by the site. For the Pasco Site, the standard POC is the unconfined groundwater located in the sand and gravel deposits beneath the facility. Many of the existing groundwater monitor wells are located in the areas of degraded groundwater, and provide an adequate assessment of the groundwater and COCs at the POC.

## 7.4 Remedial Action Technologies and Development of Alternatives

The NWTC Pasco Terminal has undergone several aggressive, interim remedial actions, resulting in the effective removal of the vast majority of petroleum hydrocarbons released. Given the extent and success of past interim remedial actions, the Site is considered an appropriate candidate for use of natural attenuation as a last stage cleanup action alternative leading to final closure. The following is a focused discussion and screening of remedial technologies, which takes into account the interim remedial measures that have already been implemented successfully at the Site.

### 7.4.1 Identification and Screening of Remedial Action Alternatives

Key factors influencing development of applicable and appropriate remedial alternatives include Site hydrogeology, the nature and distribution of the contamination, and consideration of the Site status as an operational bulk fuel terminal. The following Site conditions, discussed in Sections 2.0 and 5.0, were considered in developing applicable and appropriate remedial alternatives:

- The significant age of the releases, and interim remedial activities undertaken when they occurred;
- Current distribution of petroleum hydrocarbons and limited areal extent within the Site boundaries;
- Pre-existing institutional controls that prevent routes of exposure to human and environmental receptors;

- Relatively homogeneous subsurface conditions;
- The great depth to groundwater from the ground surface (70-80 feet);
- Low groundwater gradients; and
- Distance to the Snake River from the areas of impacted groundwater.

Several remedial technologies were screened according to the criteria specified in WAC 173-340-350(8)(b). The remedial technologies retained through the screening were used to develop three cleanup action alternatives using one or more of the remedial technologies. These cleanup action alternatives were evaluated on the basis of the requirements and the criteria in WAC 173-340-360.

General cleanup actions represent a group of actions or a broad category of responses that are designed to yield a permanent and significant reduction in the toxicity, mobility, volume, or likely contact with contaminants. General cleanup actions typically are media-specific and may include treatment, containment, removal, or any combination of these technologies. In addition, institutional controls can be implemented on location-specific or site-wide basis to manage or prevent unauthorized access to contaminated areas. The following general cleanup actions are considered for addressing contaminated groundwater at the Site:

- Institutional Controls
- Engineering Controls
- Treatment

These general cleanup actions were used to organize and screen remedial technologies. The screening process is based on criteria from WAC 173-340-350(8)(b). Some remedial technologies were eliminated from further consideration based on the screening criteria. The retained remedial technologies were evaluated based on the minimum requirements for cleanup actions [WAC 173-340-360(2)(a)]:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal law
- Costs are clearly disproportionate to benefits
- Provide for compliance monitoring

The evaluation is discussed in the following sections applicable to general cleanup actions.

#### 7.4.1.1 Source Containment and Institutional Controls

***Containment***

Interim remedial actions, including PSH/groundwater pumping, vapor extraction, and air sparge, have been conducted at the Site to address the historical releases (Sections 3.0 and 4.0). Application of the best available technologies have resulted in containment of the contaminated groundwater through removal of PSH, reduction in the concentration of COCs in soil and groundwater, and groundwater plume contraction, thereby avoiding lateral and vertical expansion of the groundwater plume. The interim remedial actions were discontinued after significant decreases in treatment mass removal and asymptotic extraction levels were observed. Source containment is considered completed as part of the source removal accomplished through the interim remedial actions. Based on the latest monitoring results, application of additional containment and controls would not significantly enhance the current containment accomplished at the Site.

***Institutional Controls***

An institutional control is an administrative action taken to limit exposure to hazardous substances, including land use restrictions; environmental monitoring requirements; site access and security measures; or deed restrictions and advisories to notify current and prospective future users about potential contamination concerns. Institutional controls cannot be used as a substitute for cleanup actions that would otherwise be technically possible [WAC 73-340-440(2)]. However, institutional controls are required if (1) cleanup action results in residual concentrations that exceed Method A or Method B cleanup levels, (2) conditional POCs have been established, or (3) Ecology makes a determination that such controls are required [WAC 173-340-440(1)].

Common controls include fencing or other physical barriers that restrict site access, signage, and zoning, as well as deed notices that place limitations on land use. Environmental monitoring is used to ensure that potential risks to human health and the environment are controlled while the remedy is being implemented. Institutional controls are readily implemented, and their cost can be significantly lower relative to other technologies. This mechanism can be especially effective at sites where there is limited exposure potential. Institutional controls are last on MTCA's priority list of preferred remedial measures.

Institutional controls are already in place at the Site, including physical barriers to access. CPL also adheres to a strict Permit-To-Work policy, which requires issuance of a Safe Work Permit whenever work is performed. Each Safe Work Permit would describe the specific tasks to be performed, and safety precautions to be taken. CPL employees and subcontractors who perform work in or around excavations, including excavation of hydrocarbon-affected soils, are trained in the hazards associated with this work.

#### 7.4.1.2 Groundwater Technologies

The application of groundwater treatment technologies at the Site would limit contaminated groundwater plume extent, rather than address source contamination. However given the residual nature of the groundwater contamination in localized areas of the Site, some technologies might provide enhancements, and result in further reduction in plume concentrations.

***Pump and Treat***

All treatment technologies in this category require pumping and subsequent treatment of recovered groundwater. Free product and groundwater pumping, and vapor enhanced groundwater extraction, were implemented to their full extent as part of interim remedial actions. Pumping tests conducted in 1989 during previous CPL investigations and remedial activities (Section 3.1) indicate that successful implementation of a pump and treat system at the Site would be adversely affected by the high transmissivity of the sand and gravel aquifer, and large volume of groundwater that would need to be withdrawn to provide any substantial groundwater capture. CH2M HILL also evaluated these technologies to address the Tidewater release in 2000, but considered pump and treat to be infeasible due to the high groundwater production rates required, and associated disposal issues. Moreover, the large volumes of groundwater removed would require treatment beyond the capabilities of the existing wastewater treatment system at the Site. Additionally, this approach would not be expected to improve cleanup or decrease the restoration time frame. Therefore, pump and treat technologies are screened from further consideration.

***In-Situ Groundwater Treatment Technologies***

Several in-situ groundwater treatment technologies have already been implemented to their full effectiveness at the Site. Groundwater and in-well air sparging were implemented and found effective during the interim remedial actions. These activities were discontinued after the applications became ineffective for further removal of residual petroleum hydrocarbons. Based on the results of the implemented technology, use of these treatment technologies are screened from further consideration.

An in-situ groundwater treatment technology that is retained for further consideration is enhanced biological remediation. This technology would involve the injection of nutrients and/or oxygen into groundwater, thereby enhancing aerobic bioremediation of the remaining petroleum hydrocarbons. Although enhanced biological remediation has been successfully used to treat petroleum hydrocarbons in groundwater, the treatment basically would involve increased disturbance to the groundwater system and potential addition of chemicals not present in groundwater. Nutrients are already available in the groundwater as petroleum hydrocarbons (carbon source) and elevated levels of nitrate from agricultural activities upgradient of the Site (Section 2.5 and Table 5).

One option might include the application of an oxygen-releasing compound to enhance the natural aerobic biological process and further reduce the groundwater concentrations. However, existing monitor wells appear to be providing sufficient diffusion of atmospheric oxygen through bioventing. The groundwater DO levels are depressed in the areas of higher contamination, likely in response to biological demand, however DO levels rebound in wells just downgradient of these areas. Therefore the application of this technology is retained, but is considered to have a limited and localized effectiveness under current conditions.

***Monitored Natural Attenuation***

A large body of literature has been generated to demonstrate the technical viability and applicability of monitored natural attenuation (MNA) at a number of petroleum hydrocarbon sites nationwide. In recognition of this option, Ecology has issued Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation (July 2005). This document describes criteria to be considered when determining the applicability of this technology. Specifically, MNA is best used to address residual groundwater contamination (1) after other, more active, remedial actions have removed the majority of the contamination, (2) in conjunction with other active cleanup action components, or (3) as follow-up to active cleanup alternatives that have already been implemented. Therefore, the application of this technology is retained for further evaluation.

***Bioventing***

Bioventing is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. While contamination in the capillary fringe and saturated zone are unaffected, fluctuations in groundwater can expose residual contamination within the unsaturated zone accessible to this type of technology. This method is similar to vapor extraction; however, contamination is removed primarily through biodegradation rather than volatilization.

Vapor extraction was previously implemented at the Site, and was considered a more effective and aggressive technology than bioventing. Under changes in atmospheric pressure conditions, passive bioventing is possible and has been implemented at the Site. Vented caps on monitor wells and vapor extraction wells allow atmospheric oxygen to enter the formation in response to differential pressures between the surface and subsurface. Active bioventing would be considered as an "enhancement" to the presently occurring passive action. Full implementation may require additional wells in the areas of impacted groundwater. The application of this technology is retained for further evaluation under the alternatives.

### 7.4.2 Description of Alternatives

The technologies that were retained for further consideration were combined into cleanup alternatives and carried forward for more detailed evaluation consistent with MTCA requirements for identifying and evaluating cleanup actions [WAC 173-340-360]. Three cleanup action alternatives were evaluated using MTCA criteria.

- **Alternative 1 – Institutional Controls and Monitored Natural Attenuation**

  This alternative would mean that the Site would continue to be managed under current conditions with existing wells for passive bioventing, routine monitoring, and maintenance of a groundwater monitoring network. The alternative includes existing institutional controls, such as physical barriers to site access, signage, and limitations on land use. The primary mechanism of remedial action would be continued natural attenuation processes that have been demonstrated to exist at the Site, and which have provided significant remedial progress since discontinuation of active remedial activities in December 2002. Progress assessment toward the cleanup standards would be accomplished through a performance monitoring program.

- **Alternative 2 – Enhanced Biological Remediation, Institutional Controls, and Monitored Natural Attenuation**

  This alternative would involve the introduction of oxygen-releasing compounds into existing monitor wells to provide additional DO within the impacted groundwater areas of the Site. DO concentrations measured within the groundwater plume are suppressed, indicating that biological oxygen demand exceeds that being provided through the passive bioventing. Providing additional oxygen through an oxygen-releasing compound could further drive the biodegradation process and, potentially, over a greater depth of the saturated zone. However, current conditions show significant DO rebound in downgradient wells. This suggests that enhanced biological remediation through oxygen-releasing compounds would have limited beneficial effect under the low hydraulic gradient conditions at the Site and may not necessarily have a significant impact on the site wide restoration time frame.

- **Alternative 3 – Enhanced Bioventing, Institutional Controls, and Monitored Natural Attenuation**

  This alternative would include the operation of a blower system to provide additional bioventing capacity to the existing passive system. For some locations, this likely would require additional wells for reasonable implementation, though without assurance of increased effectiveness over existing passive venting, especially considering that soil vapor extraction has already been implemented as part of the interim remedial activities. This active remediation would also require installation and regular maintenance of one or more blower systems.

## 7.5 Evaluation of Alternatives

### 7.5.1 Evaluation Criteria

WAC 173-340-360 establishes minimum requirements and procedures for selecting cleanup actions. The alternatives considered here in detail meet the threshold requirements for cleanup actions, as stated in WAC 173-340-360(2), including:

- Protect human health and the environment;
- Comply with cleanup standards;
- Comply with applicable state and federal law; and
- Provide for compliance monitoring.

Other requirements used in the selection of a preferred alternative, as stated in WAC 173 340-360(2)(b), are:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration time frame; and
- Consider public concerns.

The following sections discuss these evaluation criteria and their application in the selection of a preferred alternative.

**Use of Permanent Solutions to the Maximum Extent Practicable**

The alternatives were evaluated for use of permanent solutions to the maximum extent possible based on the disproportionate cost analysis described in WAC 173-340-360(3)(e). The evaluated alternatives were ranked from most to least permanent, and the most practicable permanent solution was selected as the baseline. The criteria used to rank the evaluated alternatives in terms of permanence comply with WAC 173-340-360(3)(f), and include:

***Protectiveness*** of human health and the environment, including reduction of risk, time required to reduce risk, and risks resulting from implementation of the alternative.

***Permanence*** of reduction in toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying hazardous substances, the reduction of hazardous substance releases and sources, the degree of irreversibility of the treatment, and the characteristics and quantity of treatment residuals generated.

***Cost*** to implement the alternative, including cost of construction, net present value of long-term costs, developed at a conceptual level for the alternatives.

***Effectiveness over the long term*** includes the certainty that the alternative will be successful; its reliability during cleanup; the magnitude of residual risk with the alternative in place; and the effectiveness of controls required to manage treatment residues or remaining wastes.

***Management of short-term risks*** addresses the risk to human health and the environment during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

***Technical and administrative implementability*** considers whether the alternative is technically possible; whether off-site facilities, services, and materials are available; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; integration with existing facility operations; and other current or potential remedial actions.

***Consideration of public concerns*** addresses the extent to which the alternative addresses any concerns the community may have regarding the alternative. This includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

**Reasonable Restoration Time Frame**

The determination of whether each alternative provides for a reasonable restoration time frame was made according to the factors described in WAC 173-340-360(4)(b), including:

- Potential risks posed by the site to human health and the environment;
- Practicability of achieving a shorter restoration time frame;
- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
- Availability of alternative water supplies;

- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the site;
- Toxicity of the hazardous substances at the site; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

The FS considered these restoration time frame factors as part of the evaluation of the cleanup action alternatives.

### 7.5.2 Cleanup Alternatives Comparison

The following is a discussion of each of the proposed cleanup action alternatives with respect to the threshold criteria, disproportionate cost analysis, and reasonableness time frame. All three proposed alternatives will result in a permanent, irreversible reduction in the toxicity, volume, and sources from the historical releases. Therefore, the disproportional cost analysis focuses on the comparative costs and benefits of each alternative.

There is no evidence of imminent or unacceptable risk posed by current conditions at the Site to human health and the environment. The lateral extent of impacted groundwater has been delineated, and monitoring has shown that COC concentrations within the shrinking groundwater plumes are decreasing. At the few wells where COCs are still above MTCA Method A cleanup levels, the remaining dissolved COC concentrations would not pose a risk to beneficial use downgradient, i.e., at the Snake River. Existing institutional controls will continue to prevent contact with hazardous substances on-site. Moreover, continued use of the Site as an operating fuel terminal precludes potential conflicts with future uses of the Site.

Public participation and consideration of public concerns are an integral part of the Site cleanup process under MTCA. A draft of this RI/FS report will be issued for public comment, and the comments will be considered prior to finalizing this report. A similar process will occur for the draft Cleanup Action Plan (to be prepared by Ecology), prior to selection of the final cleanup action, as specified in WAC 173-340-380.

**Alternative 1 – Institutional Controls and Monitored Natural Attenuation**

**Threshold Criteria**

- ***Protects human health and the environment*** – Existing containment, through successful source removal and institutional controls, prevents exposure to Site contaminants and migration of COCs outside Site boundaries.

- ***Complies with cleanup standards and ARARs*** – Current groundwater concentrations exceed Method A cleanup levels at the point of compliance. However, groundwater monitoring has demonstrated that natural attenuation is responsible for ongoing decreases in groundwater concentrations to levels below Method A cleanup levels in downgradient wells.

- ***Provides for compliance monitoring*** – The existing groundwater monitoring network was used to evaluate the effectiveness of interim remedial actions. A modified network, with fewer wells, would be considered adequate for this alternative.

**Disproportionate Cost Analysis**

- ***Protectiveness*** – This alternative does not reduce any existing risk to human health or the environment; conversely, its implementation does not incur additional on-site or off-Site risks. The time required until cleanup is achieved by this alternative is considered to be five to ten years, based on historical reductions in groundwater concentrations and biodegradation rates at other petroleum hydrocarbon release sites.

- ***Cost*** – This alternative incurs no additional costs beyond the continuation of routine monitoring, maintenance of institutional controls, and maintenance of the existing monitor well network.

- ***Effectiveness over the long term*** – Natural biodegradation processes are well documented to be capable of producing significant decreases in groundwater concentrations, in a relatively short time, at petroleum hydrocarbon release sites, particularly in response to increased DO provided through passive bioventing.

- ***Management of short-term risks*** – This alternative does not incur short-term risks associated with construction or implementation.

- ***Technical and administrative implementability*** – This alternative is demonstrated to be technically and administratively implementable, as this alternative represents a continuation of existing practices.

**Reasonable Restoration Time Frame**

This alternative relies on natural processes that occur gradually to achieve cleanup. The restoration time frame is unknown; however, in downgradient former free product wells, MTCA Method A cleanup levels have been achieved within four years after completion and cessation of interim remedial actions. The relatively low groundwater gradient across the Site reduces the cleanup time frame for this alternative. It is anticipated that continued biodegradation will further reduce groundwater concentrations, potentially reaching cleanup levels for all COCs in a five- to ten-year time frame, based on historical monitoring results.

**Alternative 2 – Enhanced Biological Remediation, Institutional Controls, and Monitored Natural Attenuation**

**Threshold Criteria**

- ***Protects human health and the environment*** – Alternative 2 includes all the protections discussed in Alternative 1.

- ***Complies with cleanup standards and ARARs*** – This alternative represents a similar ability to comply with the cleanup standards as Alternative 1. Some additional benefits due to enhanced biological degradation within localized areas may be possible.

- ***Provides for compliance monitoring*** – Alternative 2 has the same provisions for compliance monitoring as Alternative 1.

**Disproportionate Cost Analysis**

- ***Protectiveness*** – Alternative 2 would provide the same protectiveness as Alternative 1. However, the application of enhanced bioremediation techniques at a few well locations may provide localized benefits, though the overall time required for Site-wide cleanup may not be reduced.

- ***Cost*** – Compared to Alternative 1, this alternative would incur additional cost related to providing materials and labor for the injection of oxygen-releasing compounds, in addition to the continuation of routine monitoring, maintenance of institutional controls, and maintenance of the existing monitor well network.

- ***Effectiveness over the long term*** – The certainty of success with Alternative 2 is not considered any different than that for Alternative 1. Therefore, because the same biodegradation processes are involved, this alternative would provide the same long-term effectiveness as Alternative 1 for Site-wide cleanup.

- ***Management of short-term risks*** – The alternative incurs some short-term risks associated with construction or implementation. Such risks include the potential for injury to workers during injection of an oxygen-releasing compound, and introduction of a foreign substance into groundwater, the outcome of which is currently unknown.

- ***Technical and administrative implementability*** – This alternative has been demonstrated to be technically and administratively implementable at similar petroleum release sites, and represents a minor modification of existing practices.

**Reasonable Restoration Time Frame**

The Enhanced Bioremediation Alternative relies primarily on the same natural processes to achieve cleanup as Alternative 1. However, in localized areas, the lack of DO may limit the rate of natural biodegradation. The injection of an oxygen-releasing compound into the groundwater system at wells where COCs remain above MTCA Method A cleanup levels could help reduce COC concentrations within a limited area, but given that current conditions show significant DO rebound in downgradient wells, the cleanup time would otherwise be similar to Alternative 1 (five to ten years).

**Alternative 3 – Enhanced Bioventing, Institutional Controls, and Monitored Natural Attenuation**

**Threshold Criteria**

- ***Protects human health and the environment*** – Alternative 3 includes all the protections discussed in Alternative 1.
- ***Complies with cleanup standards and ARARs*** – This alternative represents the similar ability to comply with the cleanup standards as Alternative 1. Some additional benefits due to enhanced bioventing within localized areas may be possible.
- ***Provides for compliance monitoring*** – Alternative 3 has the same provisions for compliance monitoring as Alternative 1. However, this alternative would require installation of additional wells, and monitoring as part of ongoing operations of the enhanced bioventing action.

**Disproportionate Cost Analysis**

- ***Protectiveness*** – Alternative 3 would provide the same degree of protectiveness as Alternative 1. The application of enhanced bioventing may provide increased response and degradation of groundwater concentrations at a few well locations. However the time required until cleanup is achieved across the entire Site is not considered to be significantly reduced.
- ***Cost*** – Compared to Alternative 1, this alternative would incur costs related to installation of additional bioventing wells, installation and operation of the piping, pumps, and blowers an enhanced bioventing system would require, and additional monitoring and maintenance related to wells and flow controls. This would be in addition to routine monitoring, maintenance of institutional controls, and maintenance of the existing monitor well network.

- ***Effectiveness over the long term*** – Because the same biodegradation processes are involved, Alternative 3 would provide the same long-term effectiveness as Alternative 1.

- ***Management of short-term risks*** – This alternative does include short-term risks associated drilling and installation of new bioventing wells, including installation of associated mechanical and electrical equipment at an operating bulk fuel terminal. The drilling of wells near active tanks and piping include a high level of risk for potential damage to existing infrastructure, and potential for additional releases if piping is compromised.

- ***Technical and administrative implementability*** – This alternative is demonstrated to be technically and administratively implementable, as bioventing (and a similar technology, air sparging) has been used previously at the Site as an interim remedial measure.

**Reasonable Restoration Time Frame**

The Enhanced Bioventing Alternative relies primarily on the same natural processes to achieve cleanup as Alternative 1. However, the presence of residual petroleum hydrocarbons within the unsaturated zone in some areas may present a continuing source of COCs that prevents the groundwater cleanup levels from being achieved over a reasonable time frame. By installing additional bioventing wells, this alternative may enhance the biodegradation process through the introduction of atmospheric oxygen into the subsurface. Based on these considerations, a cleanup time frame of five to ten years is expected.

## 7.6 Recommended Remedial Action Alternative

Alternative 1 (Institutional Controls and Monitored Natural Attenuation), is the preferred cleanup action for the Site. Alternative 1 is recommended for the following reasons:

- It meets all threshold criteria;

- It has demonstrated reduction of toxicity, mobility, and volume of hazardous substances;

- Source removal has been addressed through interim remedial actions;

- The restoration time frame is consistent with other alternatives;

- It provides a factor of protection that is comparable to or better than other remedial alternatives; and

- It is readily implementable.

Alternative 1 has been employed at the Site since active, interim remediation was terminated in December 2002. Annual groundwater monitoring has demonstrated the ongoing effectiveness of this alternative in reducing COC concentrations. A performance monitoring program will be implemented to enable continued assessment of the MNA progress toward achieving the cleanup levels (Section 8.0). This alternative also allows for contingent application of Enhanced Bioremediation to one or more specific areas if the restoration time frame does not appear reasonable, for example, in the central area of the release with the highest current petroleum hydrocarbon concentrations in groundwater.

## 7.7 Remedial Action Schedule

The proposed cleanup remedy, MNA, is an ongoing process that is not dependent on an arbitrary start date. The RI has documented that natural attenuation is occurring, and has been successful in lowering COC concentrations in groundwater beneath the Site. If approved by Ecology, the PLPs will continue to implement the proposed MNA remedy until COC concentrations in groundwater have declined to or below the MTCA Method A cleanup levels. Progress toward achieving the cleanup levels will be monitored periodically. The monitoring frequency and end-point(s) of the proposed cleanup remedy are defined in the Performance Monitoring Plan provided in Section 8.0.

# 8.0 Performance Monitoring Plan

Monitored natural attenuation (MNA) is the proposed remedy for cleanup of the remaining constituents of concern (COCs) in groundwater at the NWTC Pasco Terminal (Site). This section describes the Performance Monitoring Plan (PMP) the Potentially Liable Parties (PLPs) will follow until the monitoring results demonstrate that the COC concentrations are below the required cleanup levels described in Section 7.0, and the Site has achieved closure. To develop the PMP, URS Corporation (URS) and CH2M HILL utilized Washington Department of Ecology's (Ecology's) *Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation* (Ecology, July 2005).

## 8.1 Performance Monitoring Objectives

The goal of the performance monitoring program is to monitor the effectiveness of natural attenuation as the selected cleanup action for the Site. The objectives of the PMP are to:

- Document groundwater flow patterns, including changes that might adversely impact effectiveness of the natural attenuation remedy;
- Identify the wells to be sampled and analyses to be performed to demonstrate compliance with the cleanup standards;
- Establish a monitoring frequency that ensures that human health and the environment continue to be protected during performance monitoring period; and
- Provide periodic reports to demonstrate progress toward achieving Site closure.

The performance monitoring program will be conducted jointly by Chevron Pipe Line Company (CPL) and Tidewater Terminal Company (Tidewater). Field activities performed on behalf of CPL and Tidewater will be conducted in accordance with the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) presented in Appendices G and H, respectively. Together, use of the SAP and QAPP are intended to promote:

- Consistent field procedures;
- Collection of representative samples;
- Proper calibration of field equipment to obtain accurate field measurements;
- Minimization of cross-contamination and the introduction of artificial contaminants;
- Accurate documentation of field observations, sampling procedures, and decontamination procedures;

- Consistent laboratory analytical procedures; and
- Collection of data that are accurate and defensible, and are of adequate technical quality to meet the data quality objectives for the Site.

## 8.2 Monitor Well Network

The proposed performance monitoring network consists of a subset of the existing monitor wells at the Site. Proposed performance monitor wells are identified in Table 7, and are shown on Figure 14. Groundwater samples will be collected for chemical analysis from these wells during each performance monitoring event. The proposed performance monitoring network includes six Tidewater monitor wells and nine CPL monitor wells.

In the Tidewater release area, the proposed performance monitoring network includes one upgradient monitoring location (AR-11), three sentinel wells (MW-4, MW-5, and MW-8), and two interior plume source area well (AR-4 and AR-8). It is anticipated that as results indicate improvement in well AR-4, the interior wells may be alternated between AR-4 and AR-1. MW-8 is in an area of former free product but located up- and cross-gradient, with significant reductions in dissolved phase petroleum hydrocarbons. In response to improvements in the groundwater concentrations in well MW-8, this location may be replaced by MW-7, as the plume contracts. The other existing Tidewater wells will be retained for passive bioventing (Section7.4.1.2), and may also be used as part of final compliance monitoring for closure.

All usable CPL monitor wells are included in the performance monitoring network except RW-1, which is a large diameter well. The following CPL wells will not be sampled during the performance monitoring period: MW-01 (obstructed), MW-03 (unable to yield a representative groundwater sample), and MW-13 (screen terminates above the water table).

The standard point of compliance (POC), as defined by WAC 173-340-720(8)(b), is established throughout the Site from the uppermost level of the saturated zone extending vertically to the lowest depth which could potentially be affected by the Site. The proposed CPL and Tidewater monitor well networks are considered adequate for identifying and addressing the standard POC and assessing compliance with cleanup levels. As previously discussed in Section 7.2, the primary point of exposure is the point at which groundwater discharges to surface water in the Snake River.

## 8.3 Field Measurements

The performance monitoring program will include the measurement of the depth to water and total well depth in all available CPL and Tidewater monitor wells on the Site. The total well depth will be used to assess whether sediment is accumulating in the well. The depth to water measurements will be used to construct a potentiometric surface map for each sampling event.

Low-flow sampling techniques will be used to collect groundwater samples from the performance monitor wells. During purging and prior to sampling, field water quality parameters will be measured to determine when water removed from a well is representative of in-situ groundwater conditions. The field parameters to be measured include temperature, pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. Groundwater samples will not be collected from monitor wells that have measureable phase-separated hydrocarbon (PSH). Prior to groundwater sampling, a disposable translucent bailer will be used to confirm the presence or absence of PSH in each performance monitor well that measurements or prior history indicate might have PSH.

## 8.4 Analytical Parameters

COCs for the performance monitoring program are benzene, toluene, ethylbenzene, total xylenes (BTEX), gasoline range-hydrocarbons (NWTPH-Gx), diesel range-hydrocarbons (NWTPH-Dx), and heavy oil-range hydrocarbons (NWTPH-Rx). Ethanol is an additional COC for the CPL monitor wells only, because the April 2008 ethanol release occurred approximately 200 feet downgradient from the closest Tidewater well. Table G-2 in the SAP lists the analytical parameters, methods, and estimated number of groundwater samples to be collected during the performance monitoring period. Analytical methods and data quality objectives are described in the QAPP (Appendix H). All groundwater samples will be analyzed by an Ecology-accredited laboratory.

Geochemical indicator parameters will also be analyzed on some groundwater samples to demonstrate that active biodegradation is continuing. Only the samples from wells that had detected COCs during the previous sampling event will be analyzed for the geochemical indicator parameters. The geochemical indicator parameters will include ferrous iron and manganese. Ferrous iron will be measured in the field due to its short holding time of 48 hours. These geochemical indicator parameters will be used in conjunction with DO and pH values collected at the end of well purging to evaluate ORP conditions and the status of natural attenuation at the Site.

## 8.5 Sampling Frequency

COC concentrations in groundwater samples collected in 2006 through 2010 from most CPL and Tidewater monitor wells were below Model Toxics Control Act (MTCA) Method A cleanup criteria. Residual dissolved-phase petroleum hydrocarbons still remain on-site within two localized areas previously containing PSH. However, PSH has been sufficiently removed and addressed at the Site based on the recent analytical data. In addition, no petroleum hydrocarbons have been observed in the four downgradient monitor wells closest to the river. Given the large amount of historical data (Appendix B), the overall declining trend in COC concentrations (Section 6.3), and because the low hydraulic gradients measured at the Site are not conducive to rapid transport of COCs in groundwater, one year of semiannual performance monitoring is proposed for the Site, followed by annual performance monitoring until the cleanup levels have been achieved.

After compliance with cleanup levels has been demonstrated in the performance monitoring network, two additional semiannual sampling events will be conducted to confirm that groundwater concentrations in all wells have met the cleanup levels under high- and low-level groundwater conditions. All existing Tidewater and CPL monitor wells will be sampled during the two confirmation sampling events.

## 8.6 Reporting

Results of the annual performance monitoring program will be compiled into a summary report that will be submitted every two years. In addition to the summary report, the water level and analytical data will be submitted online in a format compatible with Ecology's Environmental Information Management System.

The performance monitoring summary report will provide a brief evaluation of the progress of natural attenuation toward achieving the cleanup levels, including whether the dissolved-phase plume is stable, shrinking, or moving in an unexpected direction; impacts (if any) to downgradient receptors; and verification that COC concentrations in sentinel wells remain below cleanup levels.

The summary report will also include documentation of the following items for the last two sampling events:

- Changes, if any, to the performance monitor well network (Section 8.2);
- Tabulated water level measurements, elevations, and analytical results for the last two sampling events;
- Potentiometric surface maps and hydraulic gradient calculations;
- Field sampling records; and
- Laboratory analytical reports.

## 8.7 Amendment of Performance Monitoring Plan

In the event that changes in Site conditions require modification of the performance monitoring plan, including changes to the monitor well network, any proposed modifications will be submitted to Ecology for approval prior to implementation.

# 9.0 References

Anderson, Dan, 2010. Personal communication with Annette Brewster (URS Corporation), March 4, 2010.

Bretz, J H., 1928. *Alternative hypotheses for Channeled Scabland I, II.* Journal of Geology, v. 36, p. 193-223, 312-341.

Briggs, Philip R., 1992. Chevron U.S.A. letter to Carl Nuechterlein, Washington Department of Ecology, April 16, 1992.

Cushing, C.E., 1994. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. PNL-6415, Rev. 6. Pacific Northwest National Laboratory. Richland, Washington. July 1994.

Delaney, C.D, K.A. Lindsey, and S.P. Reidel, 1991. *Geology and Hydrology of the Hanford Site: A Standardized Text for use in Westinghouse Hanford Company Documents and Reports*. WHC-SD-ER-TI-003. Westinghouse Hanford Company. Richland, Washington.

Federal Water Quality Standards under the Clean Water Act (40 CFR 131)

Fenneman, Nevin M., 1931. *Physiography of Western United States*, McGraw-Hill, Inc. (New York, London), p. 534.

Flint, R.F., 1938. *Origin of the Cheney-Palouse Scabland Tract*, Washington: Bull. Geol. Soc. America, v. 49, p. 461-524.

Frazier, Brandon, 2010. United States Army Corps of Engineers, Columbia Basin Water Management Division, Personal Communication, September 15, 2010.

GeoEngineers Incorporated, 1987. Report of Geotechnical Services, East Pasco Fuel Terminal, Pasco, Washington, For Chevron U.S.A., Inc., June 22, 1987.

http://tapestry.usgs.gov/physiogr/physio.html

http://www.commerce.wa.gov/DesktopModules/CTEDNews/CTEDNewsView.aspx?tabID=0&ItemID=246&mid=840

http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?k=id:MCN+record://MCN/HF//IR-MONTH/DRXZZAZD/+psy:+psm:+psd:+pey:+pem:+ped:+pk:forebay+elevation+mcnary; McNary Dam & Lake Wallula on Columbia River; viewed on September 15, 2010.

http://www.nww.usace.army.mil/html/pub/pi/navigation/mcnary.htm

Hunt, C. B., 1974. *Natural Regions of the United States and Canada*. San Francisco: W. H. Freeman and Co., p. 725.

Lasmanis, Raymond, 1991. *The Geology of Washington: Rocks and Minerals*, v. 66, no.4, p. 262-277.

Lewis, J.D., 1983. Internal Chevron Pipe Line Company Memorandum to J.J. Patry, June 3, 1983.

Lindsey, Kevin A., and Gaylord, David R.,1990. *Lithofacies and Sedimentology of the Miocene-Pliocene Ringold Formation, Hanford Study, South Central Washington*. Northwest Science. v. 64, no. 3, 1990, pgs 165-180.

Lindsey, Kevin A., Law, Al G., Fecht, Karl R., Reidel, S.P.,1994. *Abstract: Stratigraphic and Sedimentologic Controls on Groundwater Flow in Late Neogene Sediments at the Hanford Site, South-Central Washington*. AAPG Search and Discovery Article #90986©1994. AAPG Annual Convention, Denver, Colorado, June 12-15, 1994.

National Primary Drinking Water Standards (40 CFR 141)

Neitzel, D.A., ed., 2005. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. PNNL-6415, Rev 17, Pacific Northwest National Laboratory, Richland, Washington. September 2005.

Opperman, Hal, 2003. *A Birder's Guide to Washington*, American Birding Association, p. 650.

Patry, J.J., August 16, 1983. Memorandum to J.D. Lewis, Hydrogeologic Review of Pasco, Washington.

Puls, R.W., and M.J. Barcelona, 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. United States Environmental Protection Agency guidance document EPA/540/S-95/504, dated April 1996.

Reidel, S.P., Fecht, K.R., and Lindsey, K.A., 1992. *Post-Columbia River Basalt Structure And Stratigraphy of South-Central Washington*. Geol. Soc. America Abstracts with Programs, v. 24, no. 5, p. 78.

Rittenhouse-Zeman & Associates, Inc. 1993. Summary of Remedial Operations, East Pasco Terminal, October 29, 1993.

Schramke, J.A., Glantz, C.S., and Holdren, G.R., 1994. *Hanford Site Environmental Setting Data Developed for the Unit Risk Factor Methodology in Support of the Programmatic*

*Environmental Impact Statement PEIS*. PNL-9801. Pacific Northwest National Laboratory. Richland, Washington. May 1994.

Swanson, D.A., and Wright, T.L., 1978. *Field Guide to Field Trip between Pasco and Pullman, Washington, Emphasizing Stratigraphy, Vent Areas and Intra-Canyon Flows of the Yakima Basalts*, in Proceedings, Geological Society of America, Cordilleran Section meeting, Pullman.

U.S. Environmental Protection Agency (EPA), 1987 (as revised). *Quality Criteria for Water 1986*, EPA 440/5-86-001 (The Gold Book), Washington, D.C., May 1987.

U.S. EPA, 1993. *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*, Publication 9360.0-32, Washington, D.C., August 1993.

U.S. EPA, 2011. *National Recommended Water Quality Criteria for Water*, Office of Water, Office of Science and Technology, Washington, D.C., accessed online June 23, 2011 at http://water.epa.gov/scitech/swguidance/standards/current/index.cfm.

URS Corporation, 2009. 2007-2008 Groundwater Monitoring Report, NWTC Pasco Terminal. June 3. 2009.

Walters, Kenneth L. and Gralier, Maurice J., 1960. *Geology and Ground Water Resources of the Columbia Basin Project Area, Washington, Volume I*. Water Supply Bulletin 8: U. S. Geological Survey and State of Washington Department of Conservation, 34 p.

Washington Model Toxics Control Act Cleanup Regulation, 2007. Washington Administrative Code (WAC) 173-340, Washington State Department of Ecology, Toxics Cleanup Program, Publication No. 94-06, November 2007.

Washington State Department of Ecology, 2005. *Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation.* Toxics Cleanup Program. Publication No. 05-09-091, July 2005.

Washington Water Quality Standards for Surface Waters, last updated May 11, 2011. WAC 173-201A.

Whitehead, R.L., 1994, *Ground Water Atlas of the United States Segment 7 – Idaho, Oregon, Washington*. U.S. Geological Survey – Hydrologic Investigations Atlas 730-H, p. H21.

***Additional References for CPL Investigations and Remedial Activities (not cited in the RI/FS Report):***

Environmental Emergency Services Company, 1984. Groundwater Quality Survey, Chevron Pipe Line Company, Pasco, Washington Terminal, January 12, 1984.

Rittenhouse-Zeman & Associates, Inc. (RZA), 1987. Groundwater Monitoring Data and Free-Phase Petroleum Hydrocarbon Recovery Recommendations, September 14, 1987.

Rittenhouse-Zeman & Associates, Inc., 1988a. Free-Phase Petroleum Hydrocarbon Recovery Operations Status and Updated Recommendations, January 25, 1988.

Rittenhouse-Zeman & Associates, Inc., 1988b. Status Report for May 10 to 31, 1988, June 1, 1988.

Rittenhouse-Zeman & Associates, Inc., 1989a. Analytical Chemistry Results for Groundwater Discharge to Unlined Pond, February 17, 1989.

Rittenhouse-Zeman & Associates, Inc., 1989c. Continued Subsurface Hydrocarbon Exploration and Free-Phase Petroleum Hydrocarbon Recovery System Installation, May 19, 1989.

Rittenhouse-Zeman & Associates, Inc., 1989d. Bioventing System, for Chevron U.S.A., Inc., November 29, 1989

Rittenhouse-Zeman & Associates, Inc., 1990a, Quarterly Status Report, April 30, 1990.

Rittenhouse-Zeman & Associates, Inc., 1990b, Quarterly Status Report, September 17, 1990.

Rittenhouse-Zeman & Associates, Inc., 1990c, Quarterly Status Report and Monitoring Well Sampling Results, December 6, 1990.

Rittenhouse-Zeman & Associates, Inc., 1991a, Quarterly Status Report and Monitoring Well Sampling Results, March 1, 1991.

Rittenhouse-Zeman & Associates, Inc., 1991b, Quarterly Status Report and Monitoring Well Sampling Results, June 7, 1991.

Rittenhouse-Zeman & Associates, Inc., 1991c, Quarterly Status Report and Monitoring Well Sampling Results, September 9, 1991.

Rittenhouse-Zeman & Associates, Inc., 1993a, Status Report, March 11, 1993.

Rittenhouse-Zeman & Associates, Inc., 1993b, Quarterly Operation and Maintenance Report, May 20, 1993.

Rittenhouse-Zeman & Associates, Inc., 1993c, Quarterly Operation and Maintenance Report, September 3, 1993.

Rittenhouse-Zeman & Associates, Inc., 1993d, Summary of Remedial Operations, October 29, 1993.

Rittenhouse-Zeman & Associates, Inc., 1994, Quarterly Operation and Maintenance Report, January 17, 1994.

Olympus Environmental, Inc., 1998. Ground Water Monitoring and Remediation System Inspection, Pasco Pipeline Terminal, October 12, 1998.

Olympus Environmental, Inc., 1999a. Ground Water Monitoring and Remediation System Inspection, Pasco Pipeline Terminal, January 8, 1999, revised January 13, 1999.

Olympus Environmental, Inc., 1999b. Ground Water Monitoring and Remediation System Inspection, Pasco Pipeline Terminal, April 12, 1999.

Olympus Environmental, Inc., 1999c. Ground Water Monitoring and Remediation System Inspection, Pasco Pipeline Terminal, July 9, 1999.

Maxim Technologies Inc., 1999. Groundwater Sampling/VES Inspection, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, December 9, 1999.

Maxim Technologies Inc., 2000a. Progress Toward Site Closure, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, July 10, 2000.

Maxim Technologies Inc., 2000b. Second Quarter 2000 Groundwater Monitoring Results, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, July 11, 2000.

Maxim Technologies Inc., 2000c. Progress Toward Site Closure, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, July 14, 2000.

Maxim Technologies Inc., 2000d. Summary of Site Conditions and Petroleum Release History, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, October 10, 2000.

Maxim Technologies Inc., 2000e. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, October 27, 2000.

Maxim Technologies Inc., 2001a. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, February 6, 2001.

Maxim Technologies Inc., 2001b. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, March 27, 2001.

Maxim Technologies Inc., 2001c. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, April 3, 2001.

Maxim Technologies Inc., 2001d. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, April 30, 2001.

Maxim Technologies Inc., 2001e. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, November 16, 2001.

Maxim Technologies Inc., 2001f. Groundwater Sampling, Pasco Bulk Terminal, 3000 Sacajawea Road, Pasco, Washington, December 13, 2001.

***Additional References for Tidewater Investigations and Remedial Activities:***

**August 15, 2000** – Status Report #1: Status of Site Investigation and Proposed Interim Fuel recovery Measures: Tidewater Pipeline Release – Pasco, WA

**September 1, 2000** -- Status Report #2: Tidewater Pipeline Fuel Release – Pasco, WA

**October 11, 2000** – Tidewater Pipeline Release July 21, 2000: Status Letter Report for Emergency Response Remedial Systems

**October 30, 2000** – Status Report #3: Tidewater Pipeline Fuel Release – Pasco, WA

**December 20, 2000** – Emergency Response Subsurface Site Investigation Report (prepared by TCM Northwest, Inc.)

**January 30, 2001** – Status Report #4: Tidewater Pipeline Fuel Release – Pasco, WA

**April 26, 2001** – Status Report #5 (August 2000 – February 2001): Tidewater Pipeline Fuel Release – Pasco, WA

**September 2001 --** Construction, System Start-up and Operations Report

**October 2001** – Tidewater Remedial Action – Groundwater Sampling and Analysis Report

**February 2002** – Remediation Progress Summary and November 2001 Groundwater Sampling Results – Tidewater Barge Lines, Pasco Fuel Release Site

**June 2002** – Remediation Progress Summary and April 2002 Groundwater Sampling Results – Tidewater Barge Lines, Pasco Fuel Release Site

**October 2002** – Remediation Progress Summary and July 2002 Groundwater Sampling Results – Tidewater Barge Lines, Pasco Fuel Release Site

**January 2003** – Remediation Progress Summary and November 2002 Groundwater Sampling Results – Tidewater Barge Lines, Pasco Fuel Release Site

**May 2003** – Remediation Progress Summary and February 2003 Groundwater Sampling Results – Tidewater Barge Lines, Pasco Fuel Release Site

**June 2003** – Ecology Status Meeting and Presentation titled "Pasco Fuel Release: Site Review, Cleanup Status and Path Forward"

**July 2003** – June 2003 Groundwater Sampling Results, Tidewater Barge Lines, Pasco Fuel Release Site

**February 2004** – Rounds 3 and 4 Post-Remediation Sampling Results, Tidewater Barge Lines, Pasco Fuel Release Site

**June 2005** - Tidewater Remediation System Decommissioning and Performance Monitoring Plan, Tidewater Barge Lines, Pasco Fuel Release Site

**May 16, 2006** - Supplemental Groundwater Sampling, Tidewater Barge Lines, Pasco Fuel Release Site

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**APPENDIX B**
**HISTORICAL DATA**

**CPL MONITOR WELLS**

**TIDEWATER MONITOR WELLS**

URS

CH2MHILL

# APPENDIX C
# PHOTOGRAPHIC LOG

**APPENDIX D**
**FIELD SAMPLING RECORDS**

URS CH2MHILL

# CPL MONITOR WELLS

# JUNE 2010 SAMPLING EVENT

**CPL MONITOR WELLS**

**DECEMBER 2010 SAMPLING EVENT**

**TIDEWATER MONITOR WELLS**

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URS CH2MHILL

# CPL MONITOR WELLS

# DECEMBER 2010 SAMPLING EVENT

**TIDEWATER MONITOR WELLS**

**JUNE 2010 SAMPLING EVENT**

**TIDEWATER MONITOR WELLS**

**DECEMBER 2010 SAMPLING EVENT**

## APPENDIX F
## CONCENTRATION TRENDS

**APPENDIX G**
**SAMPLING AND ANALYSIS PLAN**

**APPENDIX H**
**QUALITY ASSURANCE PROJECT PLAN**