Public Review Draft
Sampling and Analysis Plan
Remedial Investigation/Feasibility Study
and Interim Action
Cap Sante Marine Lease Area
Anacortes, Washington

April 2, 2007

Prepared for

Port of Anacortes
Anacortes, WA

LANDAU
ASSOCIATES
130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

This sampling and analysis plan (SAP) describes the procedures for conducting field activities during the remedial investigation (RI) at the Cap Sante Marine site (Site) located in Anacortes, Washington. This SAP is an appendix to the Cap Sante Marine RI/FS work plan. The primary objective of this plan is to provide sampling methodology consistent with accepted procedures such that the data collected will be adequate for use in characterizing site conditions. The plan was prepared consistent with the requirements of WAC 173-340-820, the Sediment Management Standards program [SMS; WAC 173-204; Washington State Department of Ecology (Ecology) 1995], and the Sediment Sampling and Analysis Plan Appendix (Ecology 2003). This SAP provides field, sampling, and analytical procedures to be used during the RI.

2.0 FIELD INVESTIGATION PROCEDURES

Field investigations during the RI will consist primarily of the following:

- Collecting surface sediment samples for chemical analysis and bioassay testing
- Drilling of soil borings and collecting soil samples and a groundwater sample for chemical analysis to characterize Site soil and groundwater
- Installation of shallow and deep monitoring wells.
- Collection of groundwater samples for chemical analysis
- Performing a tidal study and slug testing (if conditions merit) to monitor groundwater levels and to determine groundwater flow direction.

This section describes the field procedures to be employed during the RI.

2.1 SEDIMENT INVESTIGATION

The initial Site investigation will be performed to determine the range of total petroleum hydrocarbon (TPH) concentrations offshore of the Site and to determine sediment toxicity-based soil and groundwater cleanup criteria as described in Section 3.1.1 of the work plan. Twelve surface (0 to 10 cm) sediment samples (SED-1 through SED-12) will be collected from the locations shown on Figure 4 of the work plan. Sediment Sampling will follow Puget Sound Estuary Program (PSEP) protocols.

2.1.1 SAMPLE COLLECTION METHODS

Surface sediment samples will be collected directly from intertidal areas or by using a grab-type sampler where sediments are submerged. Sample locations will be determined using Global Positioning System or by hand measuring from known landmarks using scaled maps.

2.1.1.1 Offshore Sediment

Grab samplers deployed from a work vessel will be used to collect surface sediments from open water areas or subtidal areas that are not accessible by foot. The general procedure for collecting grab sediment samples is as follows:

1. Make field notes and logbook entries, as necessary, throughout the sampling process to ensure thorough and accurate recordkeeping.
2. Maneuver the sampling vessel to the proposed sampling location using the project-specified positioning procedures.

3. Open the sampler and slide the locking pin into place.

4. Signal the winch operator to lift the sampler.

5. Guide the sampler overboard until it is clear of the vessel and remove the locking pin.

6. Lower the sampler through the water column to the bottom, on station at approximately 1.0 ft/sec.

7. Record the location and note the angle of the cable relative to the boat when sampler reaches bottom.

8. Signal the winch operator to begin retrieving the sampler and raise it at approximately 1.0 ft/sec.

9. Guide the sampler on board the vessel and place it on the work table on the deck; use care to avoid jostling that might disturb the integrity of the sample.

10. Examine the sample for the following sediment acceptance criteria:
    - Sampler jaw is closed
    - The sample does not contain foreign objects
    - The sampler is not overfilled so that the sediment surface presses against the top of the sampler
    - No leakage has occurred, as indicated by overlying water on the sediment surface
    - No sample disturbance has occurred, as indicated by limited turbidity in the overlying water
    - No winnowing has occurred, as indicated by a relatively flat undisturbed surface
    - A penetration depth of at least 11 cm has been achieved.

    If sample acceptance criteria are not achieved, the sample will be rejected and the location re-sampled. If unable to obtain a sample that meets the appropriate acceptance criteria within 50 ft of the proposed location, the sample will be relocated as determined by the Project Manager or Task Manager, as appropriate.

11. Siphon off any standing water from the surface of the sediment using a hose primed with Site water. Care should be taken to not disturb the integrity of the sediment surface.

12. Visually classify sediment. Record sediment descriptions on the field forms.

13. Collect the upper 10 cm of sediment from the sampler using a stainless-steel spoon or equivalent. Take care not to include any material that has been in contact with any interior sampler surface. Place sediment into an appropriate-sized stainless-steel homogenization bowl.

14. Thoroughly rinse the interior of the sampler until all loose sediment has been washed off.

15. Repeat the sampling process (if necessary) until sufficient volume is obtained to satisfy the sampling requirements for each location. Collect successive grab samples within a radius of 3 miles of the initial sampling location.
16. Homogenize the bulk sediment until the sediment appears uniform in color and texture. For toxicity testing, a pore water sample will be obtained (following homogenization) to determine salinity.
17. Distribute the homogenized sediment to appropriate sample containers according to the specified project requirements and ensure that sample labels are completely filled out and affixed to the containers.
18. Clean the exterior of all sample containers and store them in a cooled ice chest away from the immediate work area on board the boat.
19. Thoroughly decontaminate the sampler.
20. Ensure that sediment descriptions and supporting logbook entries are complete.
21. Proceed to the next proposed sampling location.

2.1.1.2 Intertidal Sediment

Along the intertidal bank area inaccessible by vessels, samples may be collected by hand using stainless-steel utensils. To collect the sample, field representatives will walk along the intertidal bank area to locate the sampling locations. Samples will be collected where significant sediment deposits are located. Sediment will be collected directly from the shoreline using a decontaminated stainless-steel spoon. Upon retrieval of all sediment for the composite, the samples will be processed as described in steps 15 through 20 described above.

2.1.1.3 Bioassay Sampling

At each of the surface sampling locations shown on Figure 4 of the work plan, additional volume will be collected and archived for toxicity tests (bioassays). The required wet sediment volume for the bioassays is 5 liters (Table A-1). Under SMS regulations, the interpretation of bioassay data requires the collection and analysis of clean reference sediment, similar in physical characteristics to the test sediments. One to two reference samples will also be collected from Samish Bay for use in the bioassays. These samples will be analyzed for chemical parameters during the first phase of sample analysis, with toxicity testing (bioassays) to be conducted in parallel with the test samples as described above.

2.1.1.4 Sediment Sample Handling

Sediment samples obtained for chemical analyses and laboratory bioassays will be placed in appropriate certified-clean, wide-mouth polyethylene or glass jars with Teflon lids and a certified cleaning certificate (summarized in Table A-1). Pre-cleaned sample containers are typically provided by the analytical laboratories. All sample containers will be filled leaving 0.5 inch of headspace to prevent the jars from breaking during storage. Each jar will be sealed, affixed with a completed label, and stored under appropriate conditions.

Sample labels will be pre-made for each jar. Each sample label will contain the project number, sample identification, preservation, analyses, date and time of collection, and initials of the person(s) preparing the sample. A completed sample label will be affixed to each sample container.

Immediately after the sample jars are filled with sediment and properly labeled and dated, they will be placed in the appropriate coolers with a sufficient number of ice packs to keep them cold until transport and delivery to the laboratories. Sample holding time will be relative to the time and date recorded for each sample.

2.1.1.5 Sediment Sample Documentation

Information to be collected for sediment samples includes bottom depth, sampler penetration depth, and information on sediment characteristics (e.g., sediment type, color, and odor). After surface sample collection, the following information will be recorded in field logbooks for the sediment samples:

- Date, time, and name of person logging sample
- Weather conditions
- Equipment used for sampling
- Sampling location number
- Confirmed location coordinates and tide elevation
- Project designation
- Physical description of sediment
- Vertical distribution of visible contamination
- Description of layering
- Description of sediment [American Society for Testing and Material (ASTM) D 2488-84]:
    - Lithology

  - Sorting
  - Color
  - Structure
  - Relative density or consistency
  - Relative moisture content
- Documentation of any unusual observations, such as noticeable sandblast grit, paint chips, or hydrocarbon sheens.

Any deviations or additions to this SAP will be documented in the field report(s) prepared upon completion of field activities.

2.1.2 FIELD GRAIN SIZE WET SIEVING

Field grain size wet sieving may be required for determining the appropriate reference sediments. This process separates the sediment sample into size fractions greater than 62.5 micrometers (pm) (i.e., sand and gravel) and less than 62.5 pm (i.e., silt and clay) for classification of sand and silt/clay fractions. This process helps determine appropriate reference stations with similar grain size fractions (by volume) during field operations. This procedure requires a 62.5-pm sieve, a funnel with a diameter slightly greater than that of the sieve frame, a 100-ml graduated cylinder, a squirt bottle, a supply of distilled water, and a bowl for collecting rinse water. Procedures for field grain size sieving are as follows:

- Place a 62.5-pm (4-phi or 0.0025-inch mesh or #230 mesh size) sieve in a funnel with a bowl underneath.
- Moisten the sieve using a light spray of distilled water.
- Place exactly 50 ml of sample in the 100-ml graduated cylinder, add 20 to 30 ml of distilled water, and stir to fluidize the sample.
- Pour the sample into the sieve and thoroughly rinse any residue from the 100-ml graduated cylinder and stir into the sieve.
- Wash the sediment onto the sieve with distilled water using a water pique or squirt bottle having low water pressure.
- Continue wet sieving until only clear water passes through the sieve. Take care to ensure that the rinsate does not exceed approximately 950 ml. This is accomplished by sieving an appropriate sample quantity (i.e., a sample volume that is not too large) and by efficient use of rinse water. Both of these techniques may require experimentation before routine wet sieving is started. Upon completion of sieving, carefully return the contents (i.e., sand and gravel fraction) of the sieve to the 100-ml graduated cylinder.

- Tap the graduated cylinder gently to settle the solid material.
- Read the volume of solid material from the scale on the side of the graduated cylinder and record the value. The fraction of sample with grain size greater than 62.5 pm is the ratio of the volume of material retained in the sieve to the original volume (50 ml).

2.1.3 REFERENCE SAMPLE COLLECTION FOR TOXICITY TESTING

Toxicity testing requires that appropriate reference sediment be collected and tested with Site sediments. Concurrent tests on reference sediment are conducted to control possible sediment grain size effects on bioassay organisms. Bioassays will be conducted using reference sediment samples with grain size and total organic carbon (TOC) concentrations that are similar to the Site sediment samples used for toxicity testing. The reference samples will be collected from an area where no known chemical contamination is present. However, chemical testing will also be conducted on the reference sediment samples to confirm that chemical contamination is not present. Reference sample(s) may be collected from Samish Bay or another appropriate location.

2.1.4 CHEMICAL ANALYSES

Sediment samples will be analyzed for petroleum hydrocarbon fractions using volatile petroleum hydrocarbons (VPH), extractable petroleum hydrocarbons (EPH), and NWTPH-Dx methodologies. Samples subject to bioassay testing will also be analyzed for TOC and grain size. Sample preparation, cleanup, and analytical methods will be in accordance with Ecology protocols (Ecology 1997) for the VPH, EPH, and NWTPH-Dx analyses and PSEP protocols (PSEP 1997a, 1997b, 1997c) for the TOC analysis. Grain size determination will use the Plumb (1981) method. All analytical testing and reporting will be conducted in accordance with the specified method, the QA/QC requirements described in this work plan, and, for sediments, PSEP guidelines (PSEP 1997d). Analytical methods and reporting limits goals for the analysis of each constituent are summarized in Table A-2.

2.1.5 TOXICITY TESTING

Initially, toxicity testing will be conducted on the shoreline sediment sample (SED-1, SED-2, or SED-3) containing the highest concentration of TPH. Other sediment samples with significant TPH concentrations that are considered to be associated with historical upland releases of petroleum hydrocarbons may also be submitted for bioassay testing. If the sediment sample passes the bioassay, the concentrations of TPH in sediment will be considered protective of benthic organisms and no further toxicity testing will be performed. If the sediment sample fails the bioassay, additional bioassay testing will be performed on archived sediment samples representative of the range of TPH at the site as determined from the 12 sediment sampling locations. Additional toxicity testing will be identified and completed in consultation with Ecology.

The purpose of the sediment toxicity testing is to evaluate the degree and nature of potential surface sediment toxicity to marine organisms resulting from historical activities and releases to the marine area surrounding the site. The tests are designed to provide data regarding the acute and chronic effects of sediments on both benthic and epibenthic organisms from the perspective of mortality, growth, and reproduction. The tests are also intended to provide data for evaluation of chemical (i.e., SMS) versus non-persistent, natural, compound-related (e.g., ammonia, sulfides) toxic effects. The evaluation framework and decision criteria will follow the SMS procedures. Toxicity test results will be interpreted against the SMS criteria.

Three sediment toxicity tests (bioassay) will be conducted on the samples:

- Acute 10-day amphipod mortality (*Rhepoxynius abronis, Eohaustoris estuaries,Ampelisca abdita*)
- Acute larval mortality/abnormality (*Strongylocentrotus purpuratus, Strongylocentrotus droebachiensis* or *Dendraster excentricus*)
- Chronic 20-day juvenile polychaete growth rate (*Neanthes arenoceodentata*).

Toxicity testing will be in compliance with the procedures and QA/QC performance standards described in PSEP (1995) as revised by subsequent agency-approved updates and as described in sub-appendix D of the Sampling and Analysis Plan Appendix (Ecology 2003). The biological laboratory SOPs will be provided once a lab is selected.

All samples for toxicity testing will be stored in coolers at approximately 4°C until transported to the laboratories. Chain-of-custody (COC) procedures (see Section 2.8) will be followed throughout laboratory sample handling.

2.1.5.1 Amphipod Bioassay

Short-term, adverse effects of potentially contaminated sediment will be evaluated by measuring survival in adult amphipods *Eohaustaurius estuaris*. Amphipods will be exposed to the CSM site sediment and reference sediment for a 10-day period.

In the acute amphipod bioassay, short-term, adverse effects of potentially contaminated sediment will be evaluated by measuring survival in adult phoxocephalid amphipods (e.g., *Rhepoxynius abronius*, *Ampelisca abdita*). Amphipods will be exposed to the site sediment and reference sediment for a 10-day period.

All amphipods used (either *Rhepoxynius abronius*, *Ampelisca abdita*) will be from natural populations and collected just prior to the tests. Experience with *Rhepoxynius abronius* exposed to sediments of varying grain size distributions has confirmed its sensitivity to sediment exhibiting high percentages of fine-grained sediments, particularly those with more than 60 percent fines. *Ampelisca abdita* and *Eohaustorius estuaries* do not exhibit this sensitivity. If grain size analysis indicates sediment grain size is more than 70 percent, *Ampelisca abdita* or *Eohaustorius* estuaries will be tested. Testing procedures will generally follow those described in PSEP (1995) protocols.

There will be five replicate tests per sediment sample. In addition to the control and reference samples required by PSEP, an ammonia-positive control test will be conducted. The purpose of conducting an ammonia-positive control test is to determine the toxicity of ammonia to the test organisms being used in this study. Quality control samples and procedures for the amphipod bioassay are discussed in more detail in the Quality Assurance Project Plan (QAPP) provided in Appendix B of the work plan.

2.1.5.2 Chronic Juvenile Polychaete Bioassay

The chronic juvenile polychaete sublethal bioassay is used to characterize the toxicity of potentially contaminated marine sediments based on the growth of juvenile polychaete worm growth (*Neanthes arenaceodendata*). Parameters measured after a sediment exposure duration of 20 days are survival and growth. The test will be performed according to the procedures and QA/QC performance standards described in PSEP (1995). Quality control samples and procedures for the chronic juvenile polychaete sublethal bioassay are discussed in more detail in the QAPP provided in Appendix B of this work plan.

2.1.5.3 Larval Development Bioassay

The larval development bioassay is primarily an indicator of the relative toxicity among different samples because larvae normally reside in the water column and are not intimately associated with sediments. In general, any one of five larval species can be used for this test. Selection of an appropriate test species is dependent on the seasonal availability of adult organisms that can produce viable gametes. Ecology has limited the test organism selection to those that are sensitive to petroleum hydrocarbon-contaminated sediments (i.e., echinoderm) However, experience with past larval tests indicates that, of the allowable echinoderm, larvae of the sanddollar *Dendraster excenticus* provide the most consistent and reliable results. Consequently, for this project, the laboratory will select the best available echinoderm larvae (e.g., *Strongylocentrotus purpuratus, Strongylocentrotus droebachiensis* or *Dendraster excentricus*) during the week preceding delivery of the initial sediment samples. Three endpoints are measured in larvae after a 48-hour exposure period: mortality, abnormal development, and combined mortality/abnormality. Test protocols and QA/QC performance standards will be in accordance with PSEP (1995). The purpose of conducting an ammonia-positive control test is to determine the toxicity of ammonia to the test organisms being used in this study. Quality control samples and procedures for the larval development bioassay are discussed in more detail in the QAPP provided in Appendix B of the work plan.

2.2 SOIL INVESTIGATION

Soil borings will be used to characterize site lithology, to collect soil samples for chemical analyses, and for installation of groundwater monitoring wells. Soil borehole drilling and soil sample collection methods and laboratory analyses to be used during the RI investigation are described below. The soil investigation will be initiated following completion of the sediment investigation. This will allow TPH cleanup levels protective of sediment to be developed for the soil prior to collecting and analyzing soil samples. The soil investigation will consist of collecting soil samples from twelve borings (SB-1 through SB-12) at the approximate locations shown on Figure 5 of the work plan.

2.2.1 SOIL BORINGS

Boreholes for collecting soil samples and one groundwater sample (see Section 2.2.3) will be drilled using a truck-mounted Geoprobe® direct-push drilling rig. The direct-push borings will be advanced to the water table [approximately 4 to 5.5 ft below ground surface (BGS)]. Borings will be accomplished by a licensed driller in the state of Washington and will be monitored and recorded by a Landau Associates' field representative. Soil will be described in accordance with the Unified Soil Classification System. Prior to initiation of drilling, or any other invasive subsurface activity, the locations of each proposed exploration will be checked in the field to locate aboveground utilities or physical limitations that would prevent drilling at the proposed location. In addition, a public utility locate service will be contacted to locate underground utilities at the perimeter of the site and a private utility locate service will be contacted to clear explorations for underground utilities. The final location for each borehole will be based on the findings of the field check.

Before and between drilling of each boring and at completion of the project, downhole drilling equipment will be cleaned using a high-pressure hot water or steam washer as described in Section 2.9.

2.2.2 SOIL SAMPLE COLLECTION METHODS

Continuous soil samples will be collected from each boring using a closed-piston sampling device with a 24-inch long, 1.5-inch inside-diameter (ID) core sampler. The sampler will be advanced to the top of the sample interval with the piston in a locked position. The piston tip will then be loosened and the sampler will be advanced over the desired depth interval, thereby coring the soil inside the sampler’s disposable, single-use liner. The sampler will then be withdrawn to retrieve the liner and soil sample. The liner will be cut to remove the soil sample. A new liner will be placed in the core sampler and this process will be repeated until all desired soil samples have been obtained. Between locations, the core sampler, including the piston tip and rods, will be decontaminated as described in the Equipment Decontamination section below.

After the liner is cut, the soil type will be evaluated by the Landau Associates’ field representative and recorded on a Log of Exploration form. The soil column retained in the sample liner will be field-screened for evidence of impact. Field-screening will be conducted by visually inspecting the soil for staining and other evidence of environmental impact, and monitoring soil vapors for volatile organic compounds (VOCs) using a portable photoionization detector (PID). Soil samples collected for analysis of gasoline-range petroleum hydrocarbons by Method NWTPH-Dx and for analysis of VOCs will be collected in accordance with EPA Method 5035A. Soil samples to be submitted for chemical analysis of constituents other than VOCs and gasoline-range petroleum hydrocarbons will be placed into decontaminated stainless-steel bowls and homogenized using a decontaminated stainless-steel spoon.

At each boring location, a sample of the surface soil (0 to 0.5 ft BGS) will be collected and submitted for laboratory analysis. Additionally, if soil conditions at any of the twelve borings indicate a zone of potential contamination based on the field screening (e.g., debris, presence of oil or sheen, odors, and/or discoloration), a sample will be collected from that zone and submitted for laboratory analysis and a third sample will be collected from a depth below the zone of potential contamination where no evidence of contamination is present. If no evidence of potential contamination is observed at a boring, a soil sample will be collected from the 1 to 2 ft depth and from the capillary fringe, in addition to the surface soil sample, and submitted for laboratory analysis.

2.2.3 DIRECT PUSH GROUNDWATER SAMPLE COLLECTION

One groundwater sample will be collected from boring SB-01. The sample will be collected using a groundwater sampler consisting of a 4-ft long, wire-wrapped, stainless-steel screen (0.010-inch slot size) with a retractable protective steel sheath. The groundwater sampler will be advanced to the sample depth and the protective sheath will be retracted to expose the stainless-steel screen to the formation. Groundwater will be sampled using disposable polyethylene tubing and a peristaltic pump. Low-flow purging will be performed for 10 minutes or until purge water is clear. During purging, pH, conductivity, and temperature will be measured using a flow-through cell. The groundwater sample will be submitted to the laboratory for analysis as described in Section 2.4.5. Sufficient volume will be collected to perform all analyses identified in Section 2.4.5, except dissolved metals, using an aliquot of sample where the particulates were not allowed to settle and also using an aliquot where the particulates were allowed to settle.

2.2.4 SOIL SAMPLE LABORATORY ANALYSES

Soil Samples submitted for analysis will be analyzed for the chemicals of potential concern (COPCs) identified in Section 2.4.2 of this work plan, which consist of gasoline-range, diesel-range, and heavy oil range petroleum hydrocarbons; carcinogenic polycyclic aromatic hydrocarbons (cPAHs); napthalenes (naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene); benzene, toluene, ethylbenzene, and xylenes (BTEX); methyl tert-butyl ether (MTBE); 1,2-dibromoethane (EDB); 1,2-dichlorethane (EDC); n-Hexane, and lead. Soil samples submitted for laboratory analysis from soil boring SB-07, located near the former waste oil tank, will be analyzed for the COPCs, as well as, total chromium, hexavalent chromium, copper, zinc and polychlorinated biphenyls (PCBs). An acid/silica gel cleanup will be applied to all soil samples analyzed for diesel-range and heavy oil-range petroleum hydrocarbons.

If necessary for development of TPH cleanup levels that are protective of sediment, 10 soil samples will be collected from the vadose zone at borings where petroleum hydrocarbon contamination is observed. The vadose zone samples will be analyzed for TPH fractions using

EPH and VPH methodologies. Analytical methods and reporting limits goals for the analysis of each constituent are summarized in Table A-1.

2.3 GROUNDWATER INVESTIGATION

The groundwater investigation will consist of installing shallow groundwater monitoring wells and one deep groundwater monitoring well, collecting groundwater samples from each well and from one soil boring for chemical analyses, and measuring groundwater elevations in the monitoring wells to estimate the groundwater flow direction. This section provides procedures for constructing, developing and monitoring groundwater levels and groundwater quality.

2.3.1 MONITORING WELL INSTALLATION

Four new monitoring wells will be installed within the shallow (upper) aquifer and one new monitoring well will be installed in the deep (lower) aquifer (the shallow and deep aquifers are described in Section 2.4.1 of this work plan). The proposed locations of the new monitoring wells are shown on Figure 5 of the work plan. Monitoring wells will be constructed by a licensed drilling contractor in the state of Washington using the hollow-stem auger method, in accordance with the *Minimum Standards for Construction and Maintenance of Wells* (WAC 173-160; Ecology 2006). Oversight of drilling and well installation activities will be performed by an environmental professional familiar with environmental sampling and construction of resource protection wells. Prior to any drilling activities, an underground utility locate will be conducted by both private and public utility locating services at planned drilling locations.

During drilling, continuous soil samples will be collected at each well location to classify soil lithology in accordance with the Unified Soil Classification System (USCS). The soil samples will be obtained using a 3-inch diameter split-spoon sampler. A record of the soil and groundwater conditions observed during drilling will be recorded on a log of exploration form. The boring log will also show soil types; evidence of contamination, if indicated through visual observation; and other pertinent information. At each monitoring well location, soil samples will be submitted for laboratory analysis using the depth interval selection process described in Section 2.2.2.

The well names and the identification numbers assigned by Ecology will be marked on the well identification tags supplied by Ecology and will be attached to each well casing following well installation.

Shallow Monitoring Well Installation

Shallow monitoring wells will be installed within the dredged fill material that extends below ground surface about 9 ft. This fill unit overlies a thin silty, clay aquitard unit that ranges from about 3 to 6 ft thick. The shallow monitoring well boreholes will be advanced using a hollow-stem auger rig and will be terminated at the top of the confining unit, or will extend no more than 1 ft into the confining unit. Care will be taken to not drill through the aquitard unit when installing the shallow wells. Shallow monitoring wells will be screened in the upper water-bearing zone. The bottom of the screen will be near the top of the confining unit. The screened interval (approximately 5 to 10 ft) will extend upward across the water table to approximately 3.5 ft BGS. Shallow Monitoring wells will be constructed using flush-threaded 2-inch diameter Schedule 40 polyvinyl chloride (PVC) casing with PVC machine-slotted screens (0.010-inch). A filter pack will be installed around the screen, extending from the bottom of the end cap to 1.5 ft above the screen. Filter pack material consisting of commercially prepared, pre-sized, pre-washed No. 20-40 Colorado silica sand will be carefully poured down the annulus between the well casing and the auger flights as the auger is slowly withdrawn. During placement of the filter pack, the distribution and depth of the filter pack and sand will be monitored with a weighted tape. Once the well is installed, the total depth of the well will be verified by lowering a weighted tape to the bottom of the well casing. The annular space above the filter pack will be filled with at least 1 ft of bentonite grout or chips.

Deep Monitoring Well Installation

The deep monitoring well will be installed within the silty fine sand unit underlying the silty clay aquitard. The borehole will be advanced using the hollow-stem auger drilling and telescoping methods, as described below:

- The boring will be advanced from the ground surface to the silt and clay aquitard using a 10.25-inch inside-diameter auger. Within the upper dredged fill material unit, soil samples will be collected continuously to avoid penetration of the 3 to 6 ft thick aquitard unit.

- Once the boring is drilled approximately 1 ft into the aquitard, a temporary steel casing will be installed. A grout seal will be installed in the annulus between the steel casing and the soil as the auger is withdrawn. Sufficient time will be allowed for the grout to set, to completely seal off the upper transmissive unit.

- Once the grout is set, a 4.25-inch inside diameter auger will be used to drill within the steel casing through the aquitard and to the total depth of the boring (approximately 10 to 15 ft below the base of the confining unit with a total depth expected to range between about 30 to 45 ft BGS).

The deep monitoring well will be screened over a 5 to 10-ft interval in the lower water-bearing zone. The well screen will be placed at a depth that will allow proper installation of the filter pack as described below. The deep monitoring well will be constructed using flush-threaded 2-inch diameter Schedule 40 PVC casing with a PVC machine-slotted screen (0.010-inch). A filter pack will be installed around the screen, extending from the bottom of the end cap to the base of the confining unit with at least 2 ft of filter pack extending above the well screen. Filter pack material consisting of commercially prepared, pre-sized, pre-washed No. 20-40 Colorado silica sand will be carefully poured down the annulus between the well casing and the auger flights as the auger is slowly withdrawn. During placement of the filter pack, the distribution and depth of the filter pack and sand will be monitored with a weighted tape. Once the well is installed, the total depth of the well will be verified by lowering a weighted tape to the bottom of the well casing. The annular space above the filter pack will be filled with a high solids bentonite grout mixture to about 2 ft BGS. The remaining annular space will be filled with concrete as described for the shallow zone monitoring wells.

2.3.2 MONITORING WELL DEVELOPMENT

The monitoring wells will be developed after construction to remove formation material from the well borehole and the filter pack prior to groundwater level measurement and sampling. Development will be achieved by repeatedly surging the well with a surge block and purging up to 10, but no less than 5, well casing volumes. During development, the purged groundwater will be monitored for the following field parameters:

- pH
- Conductivity
- Temperature
- Turbidity.

The wells will be developed until the turbidity of the purged groundwater decreases to 5 Nephelometric turbidity units (NTUs), if practicable. If the well dewaters during the initial surging and purging effort, one final well casing volume will be removed after the well has fully recharged, if practicable. Well development activities will be recorded on a Well Development form.

2.3.3 MONITORING WELL SURVEYING

The location of each well will be surveyed using differential global positioning system (DGPS) equipment to facilitate accurate placement of these features on project figures and drawings, as well for submittal to Ecology. Surveying will be accomplished after completion of the well installations.

Monitoring well reference elevations will be surveyed by a professional licensed surveyor to the nearest 0.01 ft for use in evaluating groundwater and lithologic unit elevations. Both the top of monitoring well casing elevation and ground surface elevation adjacent to the monitoring well will be obtained. This information will be used to develop groundwater elevation contour maps, which are crucial in evaluating the groundwater flow direction and gradient.

2.4 GROUNDWATER MONITORING

Groundwater monitoring consists of obtaining water level measurements for calculation of groundwater elevations and estimation of groundwater flow directions, determining tidal influence on site groundwater, and collecting groundwater samples from each of the monitoring wells for chemical analysis. The scope and procedures for conducting these activities are described below.

2.4.1 72-HOUR TIDAL STUDY

Water levels in monitoring wells will be recorded using a combination of pressure transducers with internal dataloggers and an electronic water level indicator. The data collection will include continuous (every 15 minutes) transducer-based water level measurements in wells and in the marina. The datalogger will be programmed to automatically convert pressure changes to water levels. If possible, a vented transducer will be used that internally corrects for fluctuations in atmospheric pressure.

Procedures for conducting the 72-hour tidal study are summarized below:

1. At each monitoring well, a pressure transducer will be lowered into the well and securely fastened to the top of the well casing for the duration of the monitoring period. A transducer will also be lowered into Cap Sante Waterway from a secured location.

2. The transducers will be set to record the height of the water column above the transducer at 15-minute intervals.

3. Pressure transducers will be rated to a minimum 15 pounds per square inch range capable of measuring a water level change of 23 ft with a resolution of 0.01 ft.

4. Depth to water will also be measured from the top of the well casing to the nearest 0.01 ft with a manual electronic water level indicator. Depth-to-water level will be manually measured a minimum of four times during the monitoring period.

5. At the end of the monitoring period, the pressure transducers will be removed and the water level data will be uploaded to a computer.

Similar procedures will be used to monitor surface water levels in the marina.

2.4.2 HYDRAULIC CONDUCTIVITY DETERMINATION

The groundwater hydraulic conductivity at the Site will be estimated using slug tests. Slug tests will be performed in all monitoring wells to identify the range of hydraulic conductivities present in the vicinity of the former USTs. Slug tests can be performed prior to or following the 72-hour tidal study. The tests will be performed at a low tidal stage to minimize the interference of tidal fluctuations on the aquifer and the determination of the hydraulic conductivities.

Slug tests will be performed using a PVC slug rod, a down-hole pressure transducer as described above, and a water level indicator in general accordance with ASTM D 4044-96 (1999). The general procedure for conducting the slug tests in monitoring wells is summarized below:

1. At each monitoring well, the static depth of groundwater will be measured prior to placing the pressure transducer near the bottom of the well.

2. After stabilization of the groundwater level (from the displacement of the transducer), the slug rod will be lowered into the well until it is submerged in the water column.

3. The recovery of the perturbed water level will be monitored until it has returned to within 95 percent of the initial head indicated by the transducer prior to the introduction of the slug rod.

4. Once the water level has re-equilibrated, the slug rod will be quickly removed from the water column and the groundwater level will be monitored for recovery.

*5. After the water level has recovered to within tolerance (95 percent), depth to groundwater will be manually measured again and the transducer will be removed and the well secured.

The slug test response data will be analyzed using the Bouwer and Rice method (Bouwer and Rice 1976, Bouwer 1989).

2.4.3 WATER LEVEL MEASUREMENTS

Water level measurements will be obtained at each monitoring well prior to purging and sample collection. Water levels will also be measured in Cap Sante Waterway during each sampling event. All water levels will be measured using an electronic water level indicator and will be recorded to the nearest 0.01 ft. Measurements will be taken from the top of the well casing. Water levels in Cap Sante Waterway will be measured from a surveyed point at the edge of a stationary dock or piling.

2.4.4 MONITORING WELL GROUNDWATER SAMPLE COLLECTION

The initial groundwater samples will be collected at least 2 days after well development. Samples from the shallow wells will be collected within 1 hour before and 1 after a low tide so that samples collected will be of water discharging from the site that is minimally influenced by the tide. Collection of groundwater samples will be completed at each monitoring well using the following procedures:

- Immediately following removal of each well monument cover, the well head will be observed for damage, leakage, and staining. Additionally, immediately following removal of the well head cap, any odors will be recorded and the condition of the well opening will be observed. Any damage, leakage, or staining to the well head or well opening will be recorded.

- Prior to sampling, each well will be purged using a pump that is attached to dedicated purge and sample collection tubing (types of pumps used may vary depending on purge volume and depth and include a centrifugal pump, a peristaltic pump, and an electric submersible pump). Purging will begin with a small pumping rate. The rate will be adjusted upward slowly to minimize drawdown (with a target drawdown of less than 0.33 ft) during purging. Purging will continue until at least three casing volumes of water have been removed and specific conductance and temperature have stabilized or until the well goes dry. The purge volume will be calculated based on the following formula:

  $$1 \text{ casing volume (gallons)} = \pi r^2 h \times 7.48 \text{ gal/ft}^3$$

  where: π = 3.14
  r = radius of well casing in ft
  h = height of water column from the bottom of the well, in feet.

- Field parameters, including pH, temperature, conductivity, dissolved oxygen, and turbidity, will be continuously monitored during purging using a flow cell. Purging of the well will be considered to be complete when all field parameters become stable for three successive readings. The successive readings should be within +/- 0.1 pH units for pH, +/- 3% for conductivity, and +/- 10% for dissolved oxygen and turbidity.

- Purge data will be recorded on a Groundwater Sample Collection form including purge volume; time of commencement and termination of purging; any observations regarding color, turbidity, or other factors that may have been important in evaluation of sample quality; and field measurements of pH, specific conductance, temperature, dissolved oxygen, and turbidity.

- Following the stabilization of field parameters, the flow cell will be disconnected and groundwater samples will be collected. Sample data will be recorded on a Groundwater Sample Collection form, including sample number and time collected; the observed physical characteristics of the sample (e.g., color, turbidity, etc.); and field parameters (pH, specific conductance, temperature, and turbidity).

- Four replicate field measurements of temperature, pH, specific conductance, dissolved oxygen, and turbidity will be obtained using the following procedures:

  - A 250-mL plastic beaker will be rinsed with deionized water followed by sample water.

  - The electrodes and temperature compensation probe will be rinsed with deionized water followed by sample water.

  - The beaker will be filled with sample water; the probes will be placed in the beaker until the readings are stabilized. Temperature, pH, specific conductance, dissolved oxygen, and turbidity measurements will be recorded on the Groundwater Sample Collection form.

  - The above step will be repeated to collect remaining replicates.

- Any problems or significant observations will be noted in the "comments" section of the Groundwater Sample Collection form.

- Groundwater samples will be collected into the appropriate sample containers using a peristaltic pump. To prevent degassing during sampling for VOCs and gasoline-range petroleum hydrocarbons, a pumping rate will be maintained below about 100 ml/min. The VOC and gasoline-range petroleum hydrocarbons containers will be filled completely so that no head space remains. Samples will be chilled to 4°C immediately after collecting the sample. Clean gloves will be worn when collecting each sample.

- Groundwater for dissolved metals analyses will be collected last and field filtered through a 0.45 micron, in-line disposable filter. Dissolved metal samples will be preserved, as specified in Table A-1. A note will be made on the sample label, sample collection form, and COC to indicate the sample has been field filtered and preserved, including the type of preservative used.

2.4.5 GROUNDWATER SAMPLE LABORATORY ANALYSES

Groundwater samples collected from the monitoring wells and soil boring SB-01 will be analyzed for the COPCs identified in Section 2.4.2 of this work plan, which consist of gasoline-range, diesel-range, and heavy oil-range petroleum hydrocarbons, PAHs, BTEX, MTBE, EDB, EDC, n-hexane, and lead. Both total and dissolved lead will be analyzed for in each groundwater sample. For turbid groundwater samples, the dissolved lead results will likely be used to characterize Site groundwater. For non-turbid groundwater samples, total lead results will likely be used to characterize Site groundwater. However, the use of total or dissolved metal results for characterizing Site groundwater will be determined in consultation with Ecology.

During the first groundwater monitoring event, each groundwater sample, including the direct-push groundwater sample, will also be analyzed for total dissolved solids (TDS), salinity, and chloride to support demonstration that groundwater at the Site should not be classified as potable. Also, during the first groundwater monitoring event, each groundwater sample, including the direct-push groundwater sample, will be analyzed for parameters that can be used to evaluate the feasibility of natural attenuation as a cleanup option. These parameters include nitrate, dissolved manganese, sulfate, and methane. Other parameters used to evaluate natural attenuation will be measured in the field. These parameters are described in Section 2.4.6.

Analyzing samples collected during subsequent groundwater monitoring events for the constituents that are not considered COPCs will be evaluated in consultation with Ecology. For all analyses except dissolved metals, any suspended material in the sample will be allowed to settle and the sample will not be agitated prior to analysis of the supernatant. For the dissolved metal analyses, the samples will be filtered in the field to remove any suspended material. For the single direct-push groundwater sample, sufficient volume will be collected to perform all analyses using an aliquot of sample where the particulates were not allowed to settle and using an aliquot where the particulates were allowed to settle. An acid/silica gel cleanup will be applied to all groundwater samples analyzed for diesel-range and heavy oil-range petroleum hydrocarbons.

Methods and reporting limit goals for the analysis of each of the above constituents are summarized in Table A-2.

2.4.6 FIELD PARAMETERS

Field parameters, including pH, temperature, conductivity, dissolved oxygen, turbidity, and oxidation reduction potential (Redox) will be measured at each well using a flow-through cell. Ferrous iron will also be measured using a field test kit. Each parameter will be measured during all four groundwater monitoring events, except for the possibility of ferrous iron. Elimination of ferrous iron during future groundwater monitoring events will be determined in consultation with Ecology.

2.5 QUALITY ASSURANCE AND QUALITY CONTROL

Analytical samples collected during the RI will follow QA/QC procedures and standards outlined in the Quality Assurance Project Plan (QAPP; Appendix B of this work plan). Field QA/QC includes the collection of quality control samples, including blind field duplicate samples, matrix spike and matrix spike duplicate samples, and equipment rinsate blanks. Each of these quality control samples will be collected at the rate of 1 in every 20 samples collected for each sample media type with the following exception. Equipment rinsate blanks will be collected at a rate of one per sampling event (i.e., any continuous sampling period not interrupted by more than 2 working days). The procedures for collection of the quality control samples are provided in the QAPP (Appendix B of this work plan).

2.6 SAMPLE CONTAINERS, PRESERVATION, AND STORAGE

Soil and groundwater samples submitted to the analytical laboratory for analysis will be collected in the appropriate sample container provided by the analytical laboratory. The samples will be preserved by cooling to a temperature of 4°C and as required by the analytical method. Maximum holding and extraction times until analysis is performed will be strictly adhered to by field personnel and the analytical laboratory. Sample containers, preservatives, and holding times for each chemical analysis are presented in Table A-1.

2.7 SAMPLE TRANSPORTATION AND HANDLING

The transportation and handling of groundwater samples will be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to release of samples. Samples will be logged on a COC form and will be kept in coolers on ice until delivery to the analytical laboratory. The COC will accompany each shipment of samples to the laboratory.

2.8 SAMPLE CUSTODY

The primary objective of sample custody is to create an accurate, written record that can be used to trace the possession and handling of samples so that their quality and integrity can be maintained from collection until completion of all required analyses. Adequate sample custody will be achieved by means of approved field and analytical documentation. Such documentation includes the COC record that is initially completed by the sampler and is, thereafter, signed by those individuals who accept custody of the sample. A sample is in custody if at least one of the following is true:

- It is in someone's physical possession.
- It is in someone's view.
- It is secured in a locked container or otherwise sealed so that tampering will be evident.
- It is kept in a secured area, restricted to authorized personnel only.

Sample control and COC in the field and during transportation to the laboratory will be conducted in general conformance with the procedures described below:

- As few people as possible will handle samples.
- Sample containers will be obtained new or pre-cleaned from the laboratory performing the analyses.
- The sample collector will be personally responsible for the completion of the COC record and the care and custody of samples collected until they are transferred to another person or dispatched properly under COC rules.
- The cooler in which the samples are shipped will be accompanied by the COC record identifying its contents. The original record and laboratory copy will accompany the shipment (sealed inside the shipping container). The other copy will be forwarded to Landau Associates along with sample collection forms.
- Coolers will be sealed with strapping tape and custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information will be entered in the "remarks" section of the COC record and traffic report.

When samples are transferred, the individuals relinquishing and receiving the samples will sign the COC form and record the date and time of transfer. The sample collector will sign the form in the first signature space. Each person taking custody will observe whether the shipping container is correctly sealed and in the same condition as noted by the previous custodian (if applicable); deviations will be noted on the appropriate section of the COC record.

A designated sample custodian at the laboratory will accept custody of the shipped samples, verify the integrity of the custody seals, and certify that the sample identification numbers match those on the COC record. The custodian will then enter sample identification number data into a bound logbook, which is arranged by a project code and station number. If containers arrive with broken custody seals, the laboratory will note this on the COC record and will immediately notify the sampler and Landau Associates.

2.9 EQUIPMENT DECONTAMINATION

The decontamination procedures described below are to be used by field personnel to clean drilling, sampling, and related field equipment. Deviation from these procedures must be documented in field records.

2.9.1 WATER LEVEL INDICATOR

The tape from the water level indicator will be rinsed with drinking water between each well measurement, and washed with alconox soap if petroleum product or sheen is encountered.

2.9.2 SAMPLING EQUIPMENT

All sampling equipment used (e.g., stainless-steel bowls, stainless-steel spoons, soil split-spoon samplers, etc.) will be cleaned using a three-step process, as follows:

1. Scrub surfaces of equipment that would be in contact with the sample with brushes using an Alconox solution
2. Rinse and scrub equipment with clean tap water.
3. Rinse equipment a final time with deionized water to remove tap water impurities.

Decontamination of the reusable sampling devices will occur between collection of each sample.

2.9.3 HEAVY EQUIPMENT

Heavy equipment (e.g., the drilling rigs and drilling equipment that is used downhole, or that contacts material and equipment going downhole) will be cleansed by a hot water, high pressure wash before each use and at completion of the project. Potable tap water will be used as the cleansing agent.

2.10 RESIDUAL WASTE MANAGEMENT

Soil cuttings generated during boring advancement will be temporarily stored onsite in 55-gal drums. Disposal methods for soil stored in 55-gal drums will be determined based on the analytical results for the soil.

Water generated during well development, purging, and decontamination, will be temporarily stored onsite in 55-gal drums or 5-gal buckets secured with a lid. Disposal methods for groundwater stored in drums and/or buckets will be determined based on the analytical results for the groundwater samples.

Excess sediment generated during sediment sampling will be returned to the water at the station where it was collected.

3.0 REFERENCES

ASTM. 1999. *Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers, (Method D 4044-096), Standards on Determining Subsurface Hydraulic Properties and Ground Water Modeling*. Second Edition, pp. 19-21. American Society for Testing and Materials.

Bouwer, H. 1989. *Slug Test – An Update*. Ground Water 27:15-20.

Bouwer, H. and M.R. Rice. 1976. *A Slug Test Determining the Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells*. Water Resources Research. 12:423-428.

Ecology. 2006. *Minimum Standards for Construction and Maintenance of Wells* (Chapter 173-160 WAC). Washington State Department of Ecology. Update November.

Ecology. 2003. *Sediment Sampling and Analysis Plan Appendix; Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC)*. April.

Ecology. 1997. *Analytical Methods for Petroleum Hydrocarbons.* Publication No. ECY 97-602. Washington State Department of Ecology. June.

Ecology. 1995. *Sediment Management Standards.* Chapter 173-204 WAC. Washington State Department of Ecology. Amended December.

EPA. 1986. *Test Methods for Evaluating Solid Waste*. EPA/SW-846, Third Edition, with 1990 updates. U.S. Environmental Protection Agency.

EPA. 1983. *Methods for Chemical Analysis of Water and Wastes*. Publication EPA-600/4-79-020. U.S. Environmental Protection Agency. March.

Ferris. 1951. Ferris, J.G. 1951. *Cyclic fluctuations of water level as a basis for determining aquifer transmissibility.* Intl. Assoc. Sci. Hydrology, Publ. 33. pp. 148-155.

Plumb, R.H., JR. 1981. *Procedure for Handling and Chemical Analysis of Sediment and Water Samples.* Technical Report EPA/CE-81-1. U.S. Environmental Protection Agency and U.S. Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

PSEP. 1997a. *Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound.* Prepared by U.S. Environmental Protection Agency, Region 10 for Puget Sound Estuary Program. April.

PSEP. 1997b. *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water Sediment and Tissue Samples.* Prepared by U.S. Environmental Protection Agency, Region 10 for Puget Sound Estuary Program. April.

PSEP. 1997c. *Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples.* Prepared by U.S. Environmental Protection Agency, Region 10 for Puget Sound Estuary Program. April.

PSEP. 1997d. *Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound.* Puget Sound Estuary Program. April.

PSEP. 1995. *Recommended Protocols for Conducting Laboratory Bioassays on Puget Sound Sediments.* Puget Sound Estuary Program.

TABLE A-1
SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIMES
CAP SANTE MARINE, ANACORTES, WA

Analyses	Sample Container	Preservation	Holding Time
Soil Samples			
NWTPH-G	2 - 40 ml vials	Methanol; Cool 4° C	7 days
NWTPH-Dx	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
VPH	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
EPH	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
VOCs	3-40 ml vial	Sodium bisulfate - 2 vials Methanol - 1 vial	7 days
PCBs	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
Metals (a)	1 - 4 oz wide mouth glass	Cool, 4°C	6 months
Chromium (total)	1 - 4 oz wide mouth glass	Cool, 4°C	28 days
PAHs	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
Groundwater Samples			
NWTPH-G	3 - 40 ml vial	HCl to pH <2; Cool 4°C	14 days
NWTPH-Dx	1 - 1 L amber glass	Cool, 4°C	7 days
VOCs	3 - 40 ml vial	HCl to pH <2; Cool 4°C	14 days
PAHs	2 - 1 L amber glass	Cool, 4°C	7 days
Total lead	1 - 1 L polyethelene	5 ml - HNO_3 (c); Cool 4°C	6 months
Dissolved lead and manganese (b)	1 - 1 L polyethelene	5 ml - HNO_3 (c); Cool 4°C	6 months
Hexavalent Chromium	1 - 500 ml polyethylene	Cool, 4°C	24 hours
TDS	1 - 1 L polyethelene	Cool, 4°C	7 days
Chloride	1 - 500 ml polyethylene	Cool, 4°C	28 days
Nitrate	1 - 500 ml polyethylene	Cool, 4°C	48 hours
Sulfate	1 - 500 ml polyethylene	Cool, 4°C	48 hours
Salinity	1 - 500 ml polyethylene	Cool, 4°C	28 days
Methane	3 - 40 ml vial	Cool, 4°C	7 days
Sediment Samples			
NWTPH-Dx	1 - 8 oz wide mouth glass	Cool, 4°C Freeze, -18°C	14 days 1 year
VPH	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
EPH	1 - 8 oz wide mouth glass	Cool, 4°C	14 days
TOC	1 - 8 oz wide mouth glass	Cool, 4°C Freeze, -18°C	28 days 6 months
Grain Size	1-16 oz wide mouth glass	Cool, 4°C	6 months
Bioassay	5L-HDPE bucket	Cool, 4°C	56 days

(a) Metals include total chromium, hexavalent chromium, copper, lead, and zinc.

(b) Dissolved metals samples must be filtered prior to preservation; therefore, samples will be filtered in the field.

TABLE A-2
SUMMARY OF SOIL, SEDIMENT, AND GROUNDWATER SAMPLE ANALYTICAL METHODS AND TARGET REPORTING LIMITS
CAP SANTE MARINE
ANACORTES, WASHINGTON

	Analytical	Target Reporting Limits (b)			
Analyte	Method (a)	Soil/Sediment		Groundwater	
Semivolatile Petroleum Hydrocarbons					
Diesel-Range Petroleum Hydrocarbons	NWTPH-Dx (c)	5	mg/kg	0.25	mg/L
Heavy Oil-Range Petroleum Hydrocarbons	NWTPH-Dx	10	mg/kg	0.5	mg/L
C_8-C_{10} Aliphatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{10}-C_{12} Aliphatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{12}-C_{16} Aliphatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{16}-C_{21} Aliphatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{21}-C_{34} Aliphatics	EPH (d)	2	mg/kg	0.04	mg/L
C_8-C_{10} Aromatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{10}-C_{12} Aromatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{12}-C_{16} Aromatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{16}-C_{21} Aromatics	EPH (d)	2	mg/kg	0.04	mg/L
C_{21}-C_{34} Aromatics	EPH (d)	2	mg/kg	0.04	mg/L
Volatile Petroleum Hydrocarbons					
Gasoline-Range Petroleum Hydrocarbons	NWTPH-Gx (e)	5	mg/kg	0.25	mg/l
C_5-C_6 Aliphatics	VPH (f)	5	mg/kg	--	
C_6-C_8 Aliphatics	VPH (f)	5	mg/kg	--	
C_8-C_{10} Aliphatics	VPH (f)	5	mg/kg	--	
C_{10}-C_{12} Aliphatics	VPH (f)	5	mg/kg	--	
C_5-C_6 Aromatics	VPH (f)	5	mg/kg	--	
C_6-C_8 Aromatics	VPH (f)	5	mg/kg	--	
C_8-C_{10} Aromatics	VPH (f)	5	mg/kg	--	
C_{10}-C_{12} Aromatics	VPH (f)	5	mg/kg	--	
PAHs					
Naphthalene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
1-Methylnaphthalene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
2-Methylnaphthalene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Benzo(a)anthracene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Chrysene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Benzo(b)fluoranthene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Benzo(k)fluoranthene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Benzo(a)pyrene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Indeno(1,2,3-cd)pyrene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Dibenz(a,h)anthracene	EPA Method 8270-SIM (g)	6.7	µg/kg	0.01	µg/L
Volatile Organic Compounds					
Benzene	EPA Method 8260	1.0	µg/kg	1	µg/L
Toluene	EPA Method 8260	1.0	µg/kg	1	µg/L
Ethylbenzene	EPA Method 8260	1.0	µg/kg	1	µg/L
Xylenes	EPA Method 8260	1.0	µg/kg	1	µg/L
n-Hexane	EPA Method 8260	1.0	µg/kg	1	µg/L
Methyl-t-butyl ether (MTBE)	EPA method 8260	1.0	µg/kg	1	µg/L
1,2-Dibromoethane (EDB)	EPA method 8260	1.0	µg/kg	1	µg/L
1,2-Dichloroethane (EDC)	EPA method 8260	1.0	µg/kg	1	µg/L

TABLE A-2
SUMMARY OF SOIL, SEDIMENT, AND GROUNDWATER SAMPLE ANALYTICAL METHODS AND TARGET REPORTING LIMITS
CAP SANTE MARINE
ANACORTES, WASHINGTON

Analyte	Analytical Method (a)	Target Reporting Limits (b) Soil/Sediment	Target Reporting Limits (b) Groundwater
Total Metals			
Lead	EPA Method 6010/6020 (j)	2 mg/kg	0.001 mg/L
Chromium (total)	EPA Method 6010	0.5 mg/kg	--
Copper	EPA Method 6010	0.2 mg/kg	--
Zinc	EPA Method 6010	0.6 mg/kg	--
Dissolved Metals			
Lead	EPA Method 6020	--	0.001 mg/L
Manganese	EPA Method 6020	--	0.0005 mg/L
PCBs			
PCB Aroclors	EPA Method 8082	33 µg/kg	--
Conventionals			
Chloride	EPA Method 325.2 (h)	--	1 mg/L
TOC	EPA Method 9060	0.1% dry weight	--
Grain size	Plumb (1981) (i)	1% dry weight	--
Total Dissolved Solids	Method 160.1	--	10 mg/L
Sulfate	EPA Method 300.0	--	2.0 mg/L
Salinity	Standard Method 2520	--	0.1 g/kg
Nitrate	EPA Method 353.2	--	0.01 mg/L
Methane	RSK 175	--	1 µg/L

(a) Analytical methods are from SW-845 (EPA 1986) and upddates, unless otherwise noted.

(b) Reporting limits goals are based on current laboratory data and may be modified during the investigation process as methodology is refined. Laboratory reporting will be based on the lowest standard on the calibration curve. Instances may arise where high sample concentrations, nonhomogeneity of samples, or matrix interferences preclude achieving the desired reporting limits.

(c) Method NWTPH-DX as described in *Analytical Methods for Petroleum Hydrocarbons* , Washington State Department of Ecology, Publication ECY97-602, June 1997.

(d) Extractable Petroleum Hydrocarbons as described in *Analytical Methods for Petroleum Hydrocarbons* , Washington State Department of Ecology, Publication ECY97-602, June 1997,

(e) NWTPH-Gx Method as described in *Analytical Methods for Petroleum Hydrocarbons* , Washington State Department of Ecology, Publication ECY97-602, June 1997.

(f) Volatile Petroleum Hydrocarbons as described in *Analytical Methods for Petroleum Hydrocarbons* , Washington State Department of Ecology, Publication ECY97-602, June 1997,

(g) PAHs in groundwater will be analyzed using EPA Method 8270-SIM LIV.

(h) EPA method 325.2 as described in *Methods for Chemical Analysis of Water and Wastes* , EPA, Publication EPA-600/4-79-020, March 1983.

(i) Plumb (1981) - EPA/U.S. Army Corps of Engineers Technical report EPA/CE-81-1.

(j) Method 6010 will be used for the analysis of lead in soil and method 6020 will be used for the analysis of lead in groundwater.