DRAFT CARTY LAKE PREDESIGN SAMPLING AND ANALYSIS PLAN

FORMER PACIFIC WOOD TREATING CO. SITE

Prepared for
PORT OF RIDGEFIELD
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ACRONYMS AND ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
ASTM	American Society for Testing and Materials
bml	below mudline
CFR	Code of Federal Regulations
cm	centimeter(s)
COC	chain of custody
CUL	cleanup level
DGPS	differential global positioning system
dioxin TEQ	dioxin toxicity equivalent
dioxins	chlorinated dibenzo-p-dioxins and dibenzofurans
DMMP	Dredged Material Management Program
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
HDOH	Hawai'i Department of Health
ISM	incremental sampling methodology
ITRC	Interstate Technology & Regulatory Council
LRIS	Lake River Industrial Site
MFA	Maul Foster & Alongi, Inc.
MTCA	Model Toxics Control Act
µg/kg	micrograms per kilogram
ng/kg	nanograms per kilogram
PCP	pentachlorophenol
Port	Port of Ridgefield
PSAP	predesign sampling and analysis plan
PSEP	Puget Sound Estuary Program
PWT	Pacific Wood Treating Company
QA	quality assurance
QC	quality control
RDS	relative standard deviation
RI/FS	former PWT site remedial investigation and feasibility study
RNWR	Ridgefield National Wildlife Refuge
SMS	sediment management standards
SRM	standard reference material
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UWBZ	upper water-bearing zone
WAC	Washington Administrative Code

1 INTRODUCTION

On behalf of the Port of Ridgefield (Port), Maul Foster & Alongi, Inc. (MFA) has prepared this predesign sampling and analysis plan (PSAP) to describe the approach and methods used to collect data that will assist in the design of remedial actions to be conducted in Carty Lake in the Ridgefield National Wildlife Refuge (RNWR). Carty Lake is located north of the former Pacific Wood Treating Company (PWT) site in Ridgefield, Washington (see Figure 1-1). PWT operated a wood-treating facility from 1963 to 1993 at the Port's Lake River Industrial Site (LRIS); historical operations resulted in sediment contamination in Carty Lake. This document has been prepared under the authority of Agreed Order No. 01TCPSR-3119 between the Port and the Washington State Department of Ecology (Ecology) to satisfy the requirements of the Model Toxics Control Act (MTCA) and sediment management standards (SMS), and addresses the substantive requirements of Washington Administrative Code (WAC) 173-340, 350, and 360 (MTCA) and WAC 173-204 (SMS).

This PSAP describes environmental field sampling and laboratory analytical activities necessary to design the remedy of contaminated sediment in Carty Lake. The proposed remedy includes dredging and disposal of contaminated sediment and enhancing natural recovery of low-level residual contamination. Carty Lake sediment characterization, cleanup level (CUL) development, and remedial alternatives evaluation are detailed in the former PWT site remedial investigation and feasibility study (RI/FS) (MFA, forthcoming). This PSAP provides information regarding the field sampling objectives, sample location and frequency, equipment and procedures to be used during the sampling, sample handling and analysis, quality assurance (QA) protocols, and reporting requirements.

This PSAP is generally consistent with current Puget Sound Estuary Program (PSEP) and U.S. Environmental Protection Agency (USEPA) protocols for sampling and analysis (PSEP, 1986, 1997a,b; USEPA, 1993) and standard USEPA methods based on USEPA test methods for evaluating solid waste, physical/chemical methods (also known as SW-846) requirements, as amended (USEPA, 1986). PSAP contents are consistent with guidance provided in Ecology's Sediment Source Control Standards User Manual, Sediment Sampling and Analysis Plan Appendix (Ecology, 2008).

1.1 Background

The approximately 40-acre LRIS is located within the Ridgefield city limits at 111 West Division Street, Ridgefield, Washington (see Figure 1-2). The LRIS is the former location of the PWT facility; former operations involved pressure-treating wood products with oil-based treatment solutions and water-based mixtures. Constituents released to environmental media included pentachlorophenol (PCP), copper, chromium, arsenic, zinc, and chlorinated dibenzo-p-dioxins and dibenzofurans (collectively referred to as dioxins) (MFA, forthcoming). The LRIS is bounded on the north by the RNWR, which includes Carty Lake; on the west by Lake River; on the east by the Burlington Northern Santa Fe Railroad tracks, which separate the LRIS from residential areas; and on the south by a Port-owned public boat launch. The boat launch property adjoins the privately owned

McCuddy's marina that contains residences, including houseboats. The RNWR is also located on the west side of Lake River, across from the LRIS.

The RI/FS (MFA, forthcoming) identifies hazardous substances, characterizes nature and extent, identifies potential sources and exposure pathways, develops CULs, and evaluates possible remedial actions in Carty Lake. Hazardous substances detected in sediment and exceeding applicable screening criteria include dioxins, metals (arsenic and chromium), and PCP. Significantly elevated dioxin concentrations in Carty Lake occur in the southern portion of the lake, in the same area in which arsenic, chromium, and PCP exceed screening criteria. Therefore, cleanup actions directed at dioxins are expected to remediate the other chemicals.

The preferred remedy identified in the RI/FS (MFA, forthcoming) involves dredging Carty Lake sediment and placing clean sand to enhance natural recovery in areas of residual and low-level contamination. Following are components of the preferred remedy:

- Removal of sediment above remediation levels, which are based on dioxin congener CULs protective of ecological receptors.
- Disposal of dredged material as nonhazardous material waste at a Subtitle D landfill facility.
- Placement of sand to enhance the natural recovery of sediments in areas of residual contamination, i.e., enhanced natural recovery (ENR).
- Long-term monitoring to verify ongoing effectiveness of recovery of contaminated sediment by natural attenuation.
- Institutional controls to protect human receptors; advisories on fish consumption would be included as institutional controls.

2 INVESTIGATION OBJECTIVES

This PSAP identifies the chemical and physical sediment characterization required to design the Carty Lake cleanup action. The primary investigation objectives are:

- Delineation of the dredge (horizontal and vertical extent) and ENR areas
- Characterization of sediment physical parameters to evaluate sediment retrieval, handling, and disposal methods
- Collection of remedial action confirmation samples

These objectives are discussed further below.

2.1 Dredge and ENR Prism Delineation

The nature and extent of hazardous substances inCarty Lake are generally well understood (MFA, forthcoming). Screening criteria (and CULs, where applicable) for contaminants of concern are shown in Table 2-1. Significantly elevated dioxin concentrations are largely limited to the southern portion of the lake at locations LRIS-CL-01, -02, and -04, although elevated (i.e., higher than the CUL of 5 nanograms per kilogram [ng/kg]) dioxin toxicity equivalent (dioxin TEQ) concentrations occur at multiple locations. Dioxin concentrations decrease substantially within the top 1 to 2 feet of the mudline. Metals (arsenic and chromium) and PCP exceed screening criteria only in the southern portion of the lake. All other constituents are below screening criteria, with the exception of di-n-octyl phthalate, which was not detected but had a reporting limit that exceeded screening criteria at one location (see Figure 2-1).

To evaluate remedial options, a variety of scenarios were presented in the RI/FS (MFA, forthcoming). The dredge prism scenarios were evaluated in terms of technical feasibility, cost, and anticipated postremedial surface-weighted average concentrations. The preferred alternative presented in the RI/FS involved removing approximately 5,650 cubic yards of sediment with dioxins above CULs protective of ecological receptors, and approximately 2,700 cubic yards of sand would be placed in a 6- to 12-inch-thick layer over dredged areas and the resulting residuals (ENR layer).

The evaluation presented in the RI/FS relied on previously collected discrete surface and subsurface sediment samples. In consultation with Ecology and USFWS, it was determined that additional discrete surface sediment sampling may not define contaminant extent as effectively as the incremental sampling methodology (ISM) (Alaska Department of Environmental Conservation [ADEC], 2009; Hawai'i Department of Health [HDOH], 2009; Interstate Technology & Regulatory Council [ITRC], 2012). ISM characterizes the average concentration of contaminants in a predefined area termed the decision unit. Samples (called increments) are collected from multiple locations within a decision unit under evaluation; the decision unit is the area and depth of sediment to be represented by the sampling process. The increments are combined into one sample (called an increment composite sample in this PSAP) and analyzed to obtain a representative average contaminant concentration for the entire decision unit. Replicates can be collected to define variability due to sampling error or spatial heterogeneity; it is recommended that replicate samples be collected in the decision unit with the highest anticipated contamination (assumed to also have highest variability) (HDOH, 2011). ISM obtains data that are more representative of average concentrations than data from discrete or composite samples, and is particularly appropriate when the receptors of concern (e.g., fish) are expected to be exposed to larger areas rather than discrete locations.

Additional data collection is warranted to further delineate the spatial distribution of hazardous substances in sediment. The additional data obtained are not anticipated to change the general understanding of the nature and extent of contaminants in Carty Lake. The characterization will inform the dredge and ENR footprint, and may support either a larger or smaller footprint than was presented in the RI/FS. The final dredge and ENR remedy area will also consider dredging logistics, feasibility, and lakebed characteristics, and will be developed in consultation with Ecology and USFWS.

Data collected during the predesign sampling effort will also be used to confirm that the remedy will meet remedial action objectives such that confirmation samples will not be required during or upon completion of the remedial action.

2.2 Sediment Physical Characterization

Sediment physical properties within the anticipated dredge prism will inform the design of the remedy and the remedial cost estimates. These properties will be used to evaluate slope stability, hydrodynamics, sediment transfer, dredge production rates, volumes, and handling requirements. In addition to geotechnical laboratory analysis, a pilot study will be conducted, using the sediment obtained during this sampling event, to evaluate how the material behaves during the dredging, handling, and disposal processes.

The sediment physical properties not only inform the handling requirements and dredging methods for sediment, but also provide a better understanding of hydrodynamics and sediment transfer information. A full understanding of all of these elements is valuable, as the behavior of the sediment during dredge operations may impact the ease of removal and the volume of dredged material, as well as the length of time it takes to reach the design grades. These conditions will affect not only the rate of production, but also the final effectiveness of the removal action. In addition, the hydrodynamic information, when paired with the chemical analysis, will help to inform development of the dredge prism and its extent.

The pilot study will include physical manipulation of the sediment in order to simulate excavation and handling methods. The general behavior of the sediment during each test will be recorded. These pilot study tests are intended to show how the sediment will react to handling, stacking, drying, and amending, among other characteristics that can be observed and recorded.

3 SITE CONDITIONS

Carty Lake environmental conditions are summarized below and are detailed in the RI/FS (MFA, forthcoming).

3.1 Hydrodynamics

Carty Lake is a 52-acre ponded wetland located in the RNWR Carty Unit. During the rainy season, Gee Creek and Carty Lake can be hydraulically connected at the lake's northern end. During most of the year, Carty Lake has no outlet. Water levels range from 3 to 10 feet, varying seasonally, and are generally higher during winter and spring and lower during summer and fall. Water fluctuations are generally muted relative to Lake River, with increases and decreases occurring more gradually because there is no direct connection with the Columbia River.

Hydrodynamics and grain size distribution (see Figure 3-1) indicate that Carty Lake features a low-energy, depositional environment. Percent fines in Carty Lake are relatively uniform and high,

generally over 75 percent fines. Carty Lake's hydraulic exchange with other surface water bodies is limited to high water events. Since human access to Carty Lake is limited and boat access is restricted, anthropogenic high-velocity events are not expected. In summary, Carty Lake is a low-dynamic environment in which fine-grain surface sediments are prevalent and uniformly distributed.

During installation of monitoring wells in and near Carty Lake, a potential confining layer composed of clay that would restrict movement of water was identified. Clay was present upland near Carty Lake between approximately 5.6 and 9.0 feet below ground surface, and was most prominent in Carty Lake sediments from the surface to approximately 2.5 feet below ground surface. Based on lithology and head potential, the upper water-bearing zone (UWBZ) does not discharge to Carty Lake, and it is unlikely that Carty Lake significantly discharges to the UWBZ in the lake's southern portion (MFA, forthcoming).

In the future, USFWS may consider the feasibility of reconnecting Carty Lake either to the Columbia River via Gee Creek or to Lake River through a constructed channel. Of the two options, the Gee Creek connection likely would be most feasible in terms of construction and access for salmonids such as cutthroat trout and coho salmon. The resulting hydrology of the lake could vary considerably, depending on the option selected; however, some changes to the fish, wildlife, and vegetation communities would be expected and implementation would need to consider the potential for contaminant impacts to fish and the potential for contaminant migration.

3.2 Environmental Conditions

Dioxin TEQs are most elevated in surface sediment in the southern portion of the Lake (LRIS-CL-01, -02, and -04 at concentrations of 140 ng/kg, 1,400 ng/kg, and 300 ng/kg, respectively) and decrease substantially within approximately 100 feet (LRIS-CL-03 at 24 ng/kg) and 300 feet (LRIS-CL-05 at 1.8 ng/kg). Dioxin TEQs in the surface sediment in the rest of the lake are generally consistent and range between 15 ng/kg and 32 ng/kg, with the following two exceptions: one low-level concentration of 1.8 ng/kg (LRIS-CL-13) and one somewhat higher concentration of 54 ng/kg (LRIS-CL-09). The vertical extent of dioxin impacts is limited; dioxin TEQs in samples collected at 1 to 2 feet below mudline (bml) are generally between 1 and 5 ng/kg, except at the most highly impacted location, LRIS-CL-02, where the 1- to 2-foot-bml sample was 130 ng/kg and the extent is defined at 2 to 3 feet bml at 2.5 ng/kg.

Metal exceedances (arsenic and chromium) of screening criteria occur at LRIS-CL-02. Arsenic was above criteria in the surface sample and marginally above in the 1- to 2-foot-bml sample. Chromium exceeded only in surface. Metals in other samples were below screening criteria.

PCP exceeded bioaccumulation screening criteria protective of ecological receptors (310 micrograms per kilogram [µg/kg]) and human fish consumption (250 µg/kg) in surface sediment at LRIS-CL-02 but was below the Avocet (2011) benthic criterion of 1200 µg/kg. At nearby sample locations, concentrations were below bioaccumulation screening criteria, bounding the lateral extent of impacts. PCP decreased substantially with depth at LRIS-CL-02, indicating that vertical extent is bounded.

In summary, dioxins are the most widespread contaminant in Carty Lake sediment, and other contaminants exceeding screening criteria occur only where dioxins are most elevated (see Figure 2-1). Remedial actions directed at reducing dioxins will therefore reduce other contaminant concentrations above applicable screening criteria (MFA, forthcoming). The spatial distribution of impacts is consistent with the conceptual model that shows that the source of impacts is historical discharge and/or surface soil erosion from the upland LRIS to the southern portion of Carty Lake.

4 DATA GENERATION AND ACQUISITION

4.1 Sample Program Design

The sample program design for refining dioxins, metals (arsenic and chromium), and PCP extent in sediment and for evaluating sediment physical characteristics is described below. A summary of data needs, sampling methods, and the analytical program is provided in Table 4-1. Figure 4-1 shows proposed increment and discrete sample stations. Table 4-2 summarizes the sampling method and analytical program by sample station.

4.1.1 Surface Sediment

Surface sediment will be characterized using ISM. The spatial distribution of contaminants is shown in Figure 2-1. Contaminant extent will be refined by collection of samples from five decision units (see Figure 4-1).

Decision units were constructed based on an understanding of contaminant distributions (ADEC, 2009; HDOH, 2009; ITRC, 2012) and Carty Lake bathymetry, which is associated with variable surface sediment and vegetation conditions, as determined during a site visit conducted with USFWS on May 7, 2013. Five decision units were generated. Three decision units were placed in low-elevation, inundated "in-water" areas that feature low-density vegetation (i.e., reed canary grass). Two decision units were selected for the higher-elevation, densely vegetated "island" area; this area features a dense surface (approximately 3 centimeters [cm]) reed canary grass mat and less-saturated sediments.[1] See the aerial photograph included as Appendix A for an overview of approximate locations of the in-water (blue boundary) and island (orange boundary) areas.

See Figure 4-1 for decision unit locations. The borders of decision unit 1 (in-water) enclose the two southern discrete sample locations known to have significantly elevated dioxins; the area to the south and east of decision unit 1 is targeted for remedial action. Decisions units 2 and 4 (both in-water) "step out" from decision unit 1 to the former berm that marks the northernmost boundary of ISM decision units. The berm likely restricted historical transport of sediment and sediment-bound chemicals; this is supported by the low concentrations observed at LRIS-CL-05, approximately 150 feet north of the berm (see Figure 2-1). In addition, a southern and a northern decision unit (3 and

[1] Note that the island area likely is inundated during high water events; however, sediment (and chemical) transport among lower in-water areas is likely to be more frequent than between the in-water and island areas.

5, respectively) were selected for the island area. Decision unit 3 is directly adjacent to historical sample location LRIS-CL-04, which is known to have elevated dioxin concentrations. The area to the east of decision unit 3 is therefore selected for remedial action.

Decision unit sizes account for potential ecological exposure areas. Decision units are smaller (<0.3 acre) than typical foraging ranges of most mobile receptors (e.g., fish and piscivorous birds), thus subsampling a decision unit to estimate exposure concentrations is unnecessary. For example, should future reconnection with the Columbia River allow access by juvenile salmon, foraging ranges for these fish likely will be larger than individual decision units, and exposure could be estimated by evaluating concentrations in multiple decision units.

As determined in consultation with Ecology and USFWS, ten surface (0 to 10 cm) increment samples will be collected at each decision unit to characterize the extent of contamination (see Figure 4-1 and Table 4-2). Thirty increments or more are generally recommended for ISM sampling; however, ISM sampling schemes have largely been developed for soil, which can be significantly more heterogeneous than sediment (HDOH, 2009; ITRC, 2012). As discussed in Section 3.1, Carty Lake is a low-energy environment with uniform surface sediment predominantly composed of fines, indicating that particles in the area are distributed more uniformly as compared to typical soils. Selection of separate decision units for the in-water and island areas also further limits sediment heterogeneity in each unit. In addition, the decision units are small (<0.3 acre); thus the absolute distance between increments in each decision unit is low and does not differ strongly from a 30-increment sampling scheme. This is illustrated using an HDOH (2011) equation developed to calculate appropriate increment spacing based on decision unit area and number of increments:

$$\text{Spacing} = \{\text{decision unit area} / [(\text{number of increments})^{1/2} - 1]^2\}^{1/2}$$

When applying the largest decision unit area (approximately 10,000 square feet) and ten increments, 46 feet is recommended between increments. For 30 increments, spacing of 22 feet is recommended. The difference between increment spacing for the ten- versus 30-increment sampling scheme is therefore less than 25 feet in the largest decision unit. Sediment heterogeneity is not expected to be significant at a less-than-25-foot scale, indicating that ten increments provide sufficient spatial coverage for the defined decision units.

Increment locations were selected based on a stratified random approach using a triangular grid (using ArcGIS 10 and Visual Sample Plan 6). Using a systematic random grid, as opposed to a simple random sampling approach, reduces the probability of missing areas with significantly elevated concentrations; the maximum distance between increments is approximately 40 feet in the larger decision units (i.e., decision units 3, 4, and 5). This distance is less than the home range of typical mobile receptors that may be present at Carty Lake and juvenile salmonids that could be present in the future (i.e., if Carty Lake is reconnected to the Columbia River). Increment spacing is therefore expected to reflect sediment concentrations at a scale appropriate to typical mobile ecological receptors.

Triplicates will be collected at decision unit 1; this decision unit is anticipated to have the highest contamination and therefore the most variability across replicates (HDOH, 2011). Triplicate sampling at decision unit 1 will therefore provide a conservative measure of ISM variability at other

areas of the site. Three sets of ten locations each ("A," "B," and "C") are assigned for collection of three composite increment samples "A," "B," and "C."

All ISM samples will be analyzed for dioxins, arsenic, chromium, PCP, and total organic carbon.

4.1.2 Subsurface Sediment

Impacts to Carty Lake occur predominantly in surface sediment (see Section 3.2). However, additional discrete subsurface sediment samples will be collected to refine vertical extent. Discrete sampling is preferred to ISM sampling in this case because of logistical constraints associated with collecting subsurface samples in Carty Lake. Two 1- to 2-foot below mudline samples will be collected in each decision unit (see Figure 4-1). Samples will be analyzed in tiered fashion. The samples closest to the historical source area and elevated contamination (LRIS-CL-16 and -17, located in decision unit 1) are designated as Tier I and will be analyzed upon collection. In addition, two 2- to 3-foot samples will be collected at LRIS-CL-16 and -17; these Tier II samples will be analyzed only if concentrations in the 1- to 2-foot layer (Tier I samples) exceed screening criteria (see Table 4-2). If any chemicals exceed screening criteria in decision units 2 through 5, then the associated subsurface samples located in the decision unit will be analyzed for those chemical(s) (see Table 4-2).

4.1.3 Physical Sediment Characterization

Physical data will be collected during predesign sampling to inform design, dredging methodology, and dredge material handling, and to aid in the refinement of the dredge prism. Samples will be collected at four locations for physical characterization (see Figure 4-1 and Table 4-2).

Locations were selected to represent a cross section of substrate type in the anticipated dredge area, including sediment with varying percent fines. The distribution of percent fines is shown in Figure 3-1.

Samples will be obtained using manually advanced Shelby tubes to preserve in situ conditions to the extent possible. Three-foot samples will be collected and analyzed at four locations, with an allowable minimum recovery of 2 feet to meet volume requirements for lab tests. Each sample will be analyzed for bulk density, grain size distribution, permeability, and Atterberg limits.

An additional quantity of sediment will be collected at each subsurface sediment sample location for a series of pilot tests to evaluate how the material behaves during the dredging, handling, and disposal processes. The pilot tests include (but are not limited to) dewatering, settlement time, slump, and general handling. These tests will be performed as a constructability assessment and will consist of analyzing the workability of the sediment to inform construction procedures. Tests will include:

- Drying tests—measuring the time that it takes for the sediment to dry out enough to be transported and measuring the moisture contents at which the sediment will pass a paint filter test. Drying time will be assessed with and without coagulants at various moisture contents.

- Settling tests—dropping sediment through a water column and monitoring the time that it takes to fall out.
- Workability—assessment of the saturated material's ability to accumulate in stacks on the ground, to evaluate natural compressive dewatering of the sediment and the apparent slump/spread as it comes out of the water.

In addition, the behavior of both the saturated and the dried material will be observed and recorded throughout multiple manual handling processes (i.e., buckets, shovels and mixing).

4.2 Sampling Methods

Sampling methods, including navigation to sample stations and sediment retrieval, are described below.

4.2.1 Positioning

A differential global positioning system (DGPS) will be used to locate the sampling position for each proposed incremental sample station shown on Figure 4-1. Coordinates of stations are summarized in Table 4-3. Sample locations will be located to submeter accuracy. Horizontal coordinates will be referenced to the Washington South State Plane HARN (NAD83). The DGPS will be used to record the location of each sample station that has been field adjusted.

4.2.2 Surface Sediment Sampling

Surface sediment samples will be collected from decision units in the in-water and island areas to account for varying sediment and vegetation conditions in each area as identified during a site visit conducted with USFWS on May 7, 2013 (see Section 4.1.1). Depending on water depth during the sampling event, locations will be accessed through a combination of small vessel and/or wading. A 1.5-inch-diameter, thin-walled, stainless steel sediment sampling tube will be used to retrieve cylindrical–shaped increments from all decision units. Pilot testing of this method at Carty Lake found that 1.5-inch-diameter increments (that are 10 cm in length, which generally represents the biologically active zone) provide the overall mass required by the analytical laboratory for each decision unit. The sampling tubes will be manually advanced to a depth greater than 10 cm. The sampling tube will be withdrawn and the increment extruded, using a plunger, onto a clean work surface. The increment will be measured, trimmed to 10 cm, weighed, and placed into the laboratory-supplied sampling container.

If increment recovery is poor at certain locations, the increment will be discarded and resampled within a few feet of the original location. In cases where less than 10 cm of representative sediment is recovered (e.g., the non-biologically-active clay layer found in some saturated decision units may be less than 10 cm below the mudline in some cases), the representative (upper) sediment component will be retained and additional increment mass will be obtained from a second increment collected in the same approximate location. Each increment will be weighed in the field to ensure similar contribution of each increment to the increment composite sample. Approximately 150 grams of sediment per increment (± approximately 20 percent) will be collected, for a total of

approximately 1.5 kilograms per decision unit. In addition, reed canary grass mats covering island sediment will be removed before sampling. This effort will ensure that excessive organic matter is not included in sediment collected and ensure substrate consistency between sample increments; sediment mats are approximately 3 cm thick. Island sediment sample locations will be accessed on foot.

Each 10-cm increment will be placed in a decision unit-dedicated jar with a properly decontaminated stainless steel spoon or by hand, using a clean nitrile glove. Effort will be made to selectively sample finer substrate material of approximately 2 millimeters and less (i.e., sand and finer). Purposefully excluding larger substrates and distinct sediment layers will improve the probability that a consistent, uniform sample from each increment location will be incorporated, resulting in a representative average concentration.

Retrieving samples in areas where the lake bottom includes debris or where excessive organic matter obstructs in-water sediment (e.g., underwater reed canary grass) may require multiple deployments. If after the third deployment of the sampler an adequate sample volume is not retrieved or it is highly impractical to attempt sampling because of obstruction, sampling coordinates of the unsuccessfully sampled location may be field adjusted (i.e., within approximately 2 to 5 feet of the original sample location). Any field-adjusted location will remain in the assigned decision unit and the location recorded by the DGPS unit.

4.2.3 Subsurface Sediment Sampling

Discrete subsurface sediment sampling will be conducted using a stainless-steel hand auger. For proposed sample locations, see Figure 4-1. Locations may be accessed by a small boat or by wading. If present, reed canary grass mats covering sediment will be removed before sampling.

Two 8-ounce jars will be filled at sample locations for each 1- to 2-foot sample. One 8-ounce jar will be submitted for analysis. The other sample container will be submitted to the laboratory for archiving. In decision unit 1, two 2- to 3-foot samples will be collected. Two 8-ounce jars will be filled for each sample and will be submitted to the laboratory for archiving.

If after three deployments an adequate sample volume is not retrieved or if it is highly impractical to attempt sampling because of obstruction, sampling coordinates of the unsuccessfully sampled location may be field adjusted (i.e., within approximately 5 feet of the original sample location).

Remaining material from the top zero to 3 feet of the sample will be collected, with the hand auger, in a 5-gallon bucket. The material will be used to perform pilot tests for drying, handling, and other material behaviors.

4.2.4 Shelby Tube Sampling

Sediment sampling for physical parameters will be conducted by manually advancing Shelby tubes through the lake substrate. The Shelby tube sampling method allows for retrieval of a relatively undisturbed (i.e., in situ) sample. Shelby tube sampling procedures will be performed in conformance with American Society for Testing and Materials (ASTM) D 1587.

For proposed sample locations, see Figure 4-1. Locations may be accessed by a small boat or by walking/wading. A 3-inch-by-36-inch, thin-walled Shelby tube will be secured to pole extensions and advanced through the sediment a minimum of 2, but preferably 3, feet. The sample will be retrieved and inspected to ensure that a minimum of 2 feet of sediment is contained in the sampler. Depending on the grain size of the sediment, it may be necessary to repeat this process because of loss of sediment.

If after three deployments an adequate sample volume is not retrieved or if it is highly impractical to attempt sampling because of obstruction, sampling coordinates of the unsuccessfully sampled location may be field adjusted (i.e., within approximately 5 feet of the original sample location).

Once the Shelby tube sample is collected, each end will be wiped clean of loose sediment cuttings (if applicable) and the sample length will be measured. The sample length should be at least 75 percent of the drive depth. The sample will be sealed at each end in a fashion that provides proper confinement and will be stored upright for transportation to the laboratory.

4.3 Decontamination Procedures

Nondisposable sampling equipment that comes in direct contact with the sample (e.g., scoops, bowls) will be decontaminated before use at each sample location, according to the following procedure:

- Rinse with distilled water.
- Wash with scrub brush and Alconox™ soap.
- Rinse with distilled water.
- Rinse with methanol.
- Rinse with distilled water.

4.3.1 Sediment Sampler

Sample equipment will be decontaminated before use at each sample location according to the following procedure:

- Rinse with site (lake) water.
- Wash with scrub brush and Alconox™ soap.
- Rinse with distilled water.

4.3.2 Shelby Tube Sampling

New single-use Shelby tubes will be clean and free of all surface irregularities, debris, and/or deleterious sediment before sampling. The exterior of each Shelby tube will be rinsed with site water after sampling. If the Shelby tube contacts visibly contaminated sediment, its exterior will be thoroughly washed with Alconox™ soap and then rinsed with site water before the sample is readied for transport to the laboratory.

4.4 Management of Investigation-Derived Waste

Decontamination fluids will be collected and consolidated into Washington State Department of Transportation–approved 55 gallon drum for off-site disposal at a permitted disposal facility. Personal protective equipment will be disposed of in a sanitary landfill.

4.5 Sample Documentation

Accurate recordkeeping will be maintained throughout the course of the field sampling effort. A field notebook will be prepared documenting the weather, field staff, sampling methodology and equipment, sampling procedures, chain-of-custody (COC) data, and observations made during the course of the work. COC forms will be prepared at the time of sampling and will be maintained throughout the sample handling and testing process. Field notes and photographs will be maintained during sampling. The following information will be included:

- Name(s) of the person(s) collecting and logging in the samples
- Field staff
- A record of site health and safety meetings and updates
- Weather conditions
- The sample location as recorded by the DGPS
- Date and time of collection of each sample
- Sample methodology
- Penetration depth and sample length or percent recovery
- Photographs with sample location ID
- Gross characteristics of the sample, such as organic matter, biota, debris, and sheen
- Physical soil description of each sample, consistent with the Unified Soil Classification System (includes soil type, density/consistency of soil, color)
- Description of material selectively removed from the sample before filling of containers for chemical analysis (e.g., gravel, wood debris)
- Any deviation from the Ecology-approved PSAP

4.6 Sample Custody

Samples collected will be traceable from sample collection through laboratory and data analysis. Samples are in custody if they are in the custodian's view, stored in a secure place, or placed in a container secured with custody seals. A COC record will be signed by each person who has custody of the samples and will accompany the samples at all times. Copies of the COC will be included in laboratory reports and data validation memoranda.

The form will include the following information:

- Site name
- Field staff name
- Collection date and time for each sample
- Sampling station identification
- Number of sample containers shipped
- Requested analysis

The original COC form will be transported to the laboratory with the samples. Upon receipt of the samples at the laboratory, the samples will be inventoried and compared with the documentation on the COC. The laboratory will document the samples' progress through the laboratory analytical process.

4.7 Sample Containers, Preservation, and Shipping

Each sample will have an adhesive plastic or waterproof paper label affixed to the container and will be labeled at the time of collection. Samples will be uniquely identified with a sample identification that, at a minimum, specifies sample number, sample location, sample date/time, and type of sample. Sample container, preservations, and holding-time requirements are summarized in Table 4-4.

4.7.1 Sample Containers for Chemical Analysis

The laboratory will supply sample containers, sample coolers, and packing materials for the sampling event. The laboratory will maintain documentation certifying the cleanliness of containers provided. Individual sample containers will be placed in a sealed plastic bag along with COCs. Glass jars will be packed to prevent breakage and will be separated in the shipping container by a shock-absorbent material, such as bubble wrap. Ice in sealed plastic bags will be placed in the cooler to maintain a temperature of approximately 4 degrees Celsius.

When the cooler is full, a temperature blank will be placed in each cooler. Coolers will be taped and then sealed with two COC seals. The temperature blanks are prepared by the laboratory, using analyte-free (reagent) water. Temperature blanks are used by the laboratory to record the temperature of each cooler used to transport samples from the field to the laboratory. The laboratory will verify that the temperature blank measurement is 4 (±2) degrees Celsius. Sample containers identified for archiving will be frozen at -18 degrees Celsius to achieve holding times as specified in Table 4-4.

Coolers will be transported to the laboratory by courier or overnight shipping service. Packing and shipping procedures consistent with U.S. Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24 will be followed.

4.7.2 Sample Containers for Physical Analysis

Shelby tubes will be submitted to the geotechnical laboratory for physical properties analysis. The tubes shall conform to the standards in ASTM D 1587. The tubes will be sealed and packed with spacers if necessary to provide acceptable transport. The tubes will be protected to the degree possible against vibration, shock, bumping, rolling, and shock, as well as from extreme heat or cold.

Dewatering and handling-behavior bench testing of sediment will be conducted at the POR LRIS. Upon completion of testing, the sample sediment will be returned to the site and combined with the investigation-derived waste drums for disposal.

5 LABORATORY MEASUREMENTS AND PROCEDURES

5.1 Laboratory Test Methods and Reporting Limits

Chemical and physical testing will be conducted at the Ecology-accredited Apex Laboratories of Tigard, OR, and at GeoDesign, Inc. of Portland, OR, respectively. Analytes, analytical methods, and detection limits are summarized in Table 5-1. Samples will be maintained according to the appropriate holding times and temperatures for each analysis.

MFA will submit samples representing each decision unit for chemical ISM analysis. Each decision unit will have equal mass collected from its 10 increments (approximately 150 grams wet weight per increment). As discussed above, the approximately equal mass collected from each increment will be field consolidated to generate a sample of at least 1.5 kilograms (wet weight) representative of each decision unit.

The laboratory will air dry each decision unit sample at room temperature. The entire volume of each sample will be chopped and sieved to facilitate obtaining a representative subsample and improving analyte extraction efficiency. The sample will be sieved using an ASTM No. 10 (2 millimeter) sieve.

Once the sample is dried and sieved, the laboratory will perform the "1-dimensional slabcake" subsampling procedure to sub-aliquot sample volume to be used for analysis. The slabcake procedure involves spreading the sample at a consistent depth in a line, using 20 or more passes and using a square scoop to cut across the line as needed to create an aliquot for each analysis.

Each sub-aliquot will be placed in its own, single sample container consistent with the volume and preservation requirements indicated in Table 4-4. The final mass of the sample must be sufficient to run the requested analyses and attain the requested reporting limit. Please note that sufficient sample volume must be composited by the laboratory to create a laboratory duplicate sample and matrix spike and matrix spike duplicate, where applicable.

The remaining volume of the composite samples will be archived at the laboratory at -18 degrees Celsius.

5.2 Laboratory Instrumentation

The laboratory shall maintain an inventory of instruments and equipment, and the frequency of maintenance will be based on the manufacturers' recommendations and/or previous experience with the equipment. Laboratory QA and quality control (QC) will be maintained through the use of standard USEPA methods, based on USEPA test methods for evaluating solid waste, physical/chemical method (also known as SW-846) requirements, as amended (USEPA, 1986).

Laboratory QC procedures, where applicable, include initial and continuing instrument calibrations, standard reference materials (SRMs), laboratory control samples, laboratory replicates, matrix spikes, surrogate spikes, and method blanks. Table 5-1 presents the data quality objectives of solid phase testing for precision, accuracy, and completeness, while Table 5-2 summarizes general laboratory QA/QC procedures. The laboratory will also meet QA/QC requirements specified in the 2010 Dredged Material Management Program (DMMP) clarification paper (Hoffman and Fox, 2010). If the laboratory does not meet QA/QC acceptance limits, particularly if estimated maximum potential concentration qualifiers are anticipated, MFA will be contacted and corrective actions consistent with DMMP requirements will be conducted (Hoffman and Fox, 2010).

5.3 Evaluation of ISM Replicates

Field QC sampling will include the collection of triplicate samples. The relative standard deviation (RSD) of the analytical results for triplicate samples will be calculated to measure data precision. The RSD is calculated using the following equation:

$$RSD\% = \frac{100\% \text{ X Standard Deviation}}{\text{Average}}$$

Lower RSD values are desirable, as the lower the RSD, the greater confidence there is that the average approximates a normal distribution and that the average contaminant concentrations are adequately representative of the decision units (HDOH, 2009). It is assumed that data normally distributed have an RSD of 30 percent or less (ADEC, 2009). Acceptability of the calculated RSD percent will be evaluated in the context of such considerations as analytical results at or near the method reporting limit. Analytical results at or near the method reporting limit may exhibit a greater level of variability and, therefore, an elevated RSD (ADEC, 2009).

5.4 Field Duplicate

One field duplicate (LRIS-CL-17-DUP) will be collected for the discrete 1- to 2-foot subsurface sample. The field duplicate will be prepared by dividing aliquots of a homogenized sample into two distinct samples for laboratory analysis. The field duplicate result will be evaluated during data quality review.

5.5 Standard Reference Material

One SRM sample, SRM 1944, will be analyzed. The SRM sample is matrix-specific with known concentrations of dioxins, and has been certified by the National Institute of Standards and Technology or an equivalent provider. The SRM will be assessed by comparing laboratory results to the certified performance criteria. The results will be evaluated during data quality review.

5.6 Equipment Rinsate Blank

One equipment rinsate blank will be collected per sampling day from reusable equipment coming into direct contact with sediment samples, i.e., bowls and spoons. An equipment rinsate blank will be collected by pouring laboratory-supplied distilled water over or through decontaminated (clean) sampling equipment used in the collection of sediment samples and subsequently collected in prepared sampling containers. Rinsate blanks will be submitted for analysis of dioxins, arsenic, chromium, and PCP. The rinsate blanks will be shipped with the associated field samples. The rinsate blank results will be evaluated during data quality review.

5.7 Data Reduction, Validation, and Reporting

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subject to further review by MFA or a third party.

The laboratory data produced will be independently reviewed by MFA for data quality. Dioxin data will be reported consistent with the attached Dioxin and Furan Analysis, Data Validation, and TEQ Calculation Rules memorandum (see Appendix B). The data review will include an assessment of laboratory performance criteria and will be consistent with the USEPA national functional guidelines (USEPA, 2004, 2008). Results of the data review will be provided as a memorandum to be included with the data report and lab results sheets. Ecology will be notified before development of the data review memorandum if laboratory results indicate any significant data quality issues. Consistent with WAC 173-340-840(5) and Ecology Toxics Cleanup Program Policy 840 (Data Submittal Requirements), data will be submitted simultaneously in both written and electronic formats.

6 REPORTING

A data report will be prepared and submitted to Ecology within 30 days of receipt and review of the validated analytical data. The data report will include a brief summary of data collection procedures (noting, in particular, deviations from the PSAP); sample locations; summary of field notes; analytical results; a data validation memorandum; and an evaluation of the results. Data will be submitted to Ecology's EIM data system at the same time the final report is submitted.

Data interpretation will focus on the average chemical concentrations in decision units compared to screening criteria and CULs, and on the variability associated with the average concentration. The results of the predesign sampling will be used to support the remedial design effort, including delineation of the extent of the dredge and ENR area. The final dredge and ENR area delineation will consider dredging logistics, feasibility, and lakebed characteristics, and will be developed in consultation with Ecology and USFWS.

LIMITATIONS

The services undertaken in completing this plan were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This plan is solely for the use and information of our client unless otherwise noted. Any reliance on this plan by a third party is at such party's sole risk.

Opinions and recommendations contained in this plan apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this plan.

REFERENCES

ADEC. 2009. Draft guidance on multi increment soil sampling. Division of Spill Prevention and Response, Contaminated Sites Program. Alaska Department of Environmental Conservation. March.

Avocet. 2011. Development of benthic SQVs for freshwater sediments in Washington, Oregon, and Idaho. Prepared for Washington State Department of Ecology. Avocet Consulting. November.

DEQ. 2007. Guidance for assessing bioaccumulative chemicals of concern in sediment. Oregon Department of Environmental Quality, Portland, Oregon. April.

Ecology. 2008. Sediment source control standards user manual. Sediment sampling and analysis plan appendix. Ecology Publication No. 03-09-043. Washington State Department of Ecology Sediment Management Unit. Revised February 2008.

HDOH. 2009. Interim final technical guidance manual for the implementation of the Hawai'i State Contingency Plan. Office of Hazard Evaluation and Emergency Response. Hawai'i Department of Health. November 12.

HDOH. 2011. Technical guidance manual notes: decision unit and multi-increment* sample investigations. Office of Hazard Evaluation and Emergency Response. Hawai'i Department of Health. March.

Hoffman, E., and D. Fox. 2010. Polychlorinated dioxins and furans (PCDD/F): revisions to the supplemental quality assurance project plan (SQAPP). U.S. Environmental Protection Agency. November.

ITRC. 2012. Technical and regulatory guidance: incremental sampling methodology. The Interstate Technology & Regulatory Council Incremental Sampling Methodology Team. February.

MFA. Forthcoming. Former PWT site remedial investigation and feasibility study. Prepared for the Port of Ridgefield. Maul Foster & Alongi, Inc., Vancouver, Washington.

PSEP. 1986. Recommended protocols for measuring conventional sediment variables in Puget Sound. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Puget Sound Estuary Program.

PSEP. 1997a. Recommended guidelines for measuring organic compounds in Puget Sound sediment and tissue samples. Prepared for the U.S. Environmental Protection Agency, Region 10, and the Puget Sound Water Quality Authority. Puget Sound Estuary Program.

PSEP. 1997b. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Prepared for the U.S. Environmental Protection Agency, Region 10, and the Puget Sound Water Quality Authority. Puget Sound Estuary Program.

USEPA. 1986. Test methods for the evaluation of solid waste: physical/chemical methods. 3rd ed. EPA SW-846. U.S. Environmental Protection Agency.

USEPA. 1993. Test methods for evaluating solid waste, physical/chemical methods. 3rd ed., update 4B. EPA SW-846. U.S. Environmental Protection Agency. August.

USEPA. 2004. USEPA Contract Laboratory Program, national functional guidelines for inorganics data review. EPA 540/R-94/013. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. October.

USEPA. 2008. USEPA contract laboratory program, national functional guidelines for organics data review. EPA 540/R-08/01. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. June.

TABLES

Table 2-1
Cleanup and Screening Criteria
Carty Lake
Ridgefield, Washington

Chemical	Cleanup Level[a]	Screening Level[b]
Dioxins (ng/kg)		
Human Health		
TEQ	5.0E+00	NV
Ecological Receptors		
2,3,7,8-TCDD	3.3E+00	NV
1,2,3,7,8-PeCDD	9.8E+01	NV
1,2,3,4,7,8-HxCDD	2.0E+02	NV
1,2,3,6,7,8-HxCDD	1.2E+03	NV
1,2,3,7,8,9-HxCDD	1.2E+03	NV
1,2,3,4,6,7,8-HpCDD	3.1E+05	NV
OCDD	1.0E+07	NV
2,3,7,8-TCDF	8.6E+01	NV
1,2,3,7,8-PeCDF	5.5E+02	NV
2,3,4,7,8-PeCDF	6.5E+00	NV
1,2,3,4,7,8-HxCDF	9.8E+02	NV
1,2,3,6,7,8-HxCDF	9.8E+02	NV
1,2,3,7,8,9-HxCDF	9.8E+02	NV
2,3,4,6,7,8-HxCDF	9.8E+02	NV
1,2,3,4,6,7,8-HpCDF	2.5E+05	NV
1,2,3,4,7,8,9-HpCDF	2.5E+05	NV
OCDF	1.0E+07	NV
Metals (mg/kg)		
Arsenic	NA	14[c]
Chromium	NA	72[c]
Phenols (µg/kg)		
Pentachlorophenol	NA	250[d]

NOTES:

mg/kg = milligrams per kilogram.

µg/kg = micrograms per kilogram.

NA = not applicable.

ng/kg = nanograms per kilogram.

NV = no value.

TEQ = toxicity equivalent.

[a]Cleanup levels developed and described in MFA (forthcoming). The TEQ cleanup level was derived for protection of human health; congener-specific levels are protective of ecological receptors and represent selected remediation levels.

[b]Lowest available screening level developed and described in MFA (forthcoming).

[c]Avocet benthic criteria (2011).

[d]DEQ human fish consumption bioaccumulation screening criteria (2007).

Table 4-1
Summary of Data Needs
Carty Lake
Ridgefield, Washington

Data Need	Data Collection	Sample Type and Interval	Field Measurements	Laboratory Parameters
Sediment Chemical Analysis				
Refine lateral extent of chemicals in sediment and the distribution of total organic carbon.	Eckman Grab/ Push-Core Sampler	10 ISM increments per decision unit, 0 to 10 centimeters	Visual observation and GPS	Dioxins, arsenic, chromium, pentachlorophenol, and total organic carbon
Refine vertical extent of chemicals in sediment and the total organic carbon content.	Push-Core Sampler	10 ISM increments per decision unit, 1-foot intervals in subsurface	Visual observation and GPS	Dioxins, arsenic, chromium, pentachlorophenol, and total organic carbon
Sediment Physical Properties				
Estimate loading/handling performance, quantify potential loss of fines through overflow related to loading, and predict the ability to handle and stabilize sediment prior to transport.	Shelby Tube	Undisturbed, 0 to 3 feet	Visual observation and GPS	Grain size distribution
Refine production rate prediction by estimating sediment resistance to cutting. Predict amending requirements. Optimize dredging methods. Refine quantity estimates.	Shelby Tube	Undisturbed, 0 to 3 feet	Visual observation and GPS	Bulk density, unit weight, and moisture content
Measurement of the fluid flow through sediments or the volumetric flux of fluid through a porous medium. Will inform processes for post dredge handling (e.g., drying, amending) as well as the ability to cut the soil.	Shelby Tube	Undisturbed, 0 to 3 feet	Visual observation and GPS	Permeability
Indicates the range of water content over which the portion of fine soil behaves in a plastic manner. The upper limit (liquid limit) gives the water content at which the soil will flow. Will inform drying requirements for transportation and disposal.	Shelby Tube	Undisturbed, 0 to 3 feet	Visual observation and GPS	Atterberg Limits
Physical manipulation of soil to estimate drying time, ability to stack and farm, turbidity, appropriate amendments, and other behavioral attributes.	Make visual field observations; collect in bulk quantities, using any collection method available.	Disturbed	Visual-Manual Tests for Estimating Soil Properties	None

NOTE:
GPS = global positioning system.
ISM = incremental sampling methodology.

Table 4-2
Sampling Design
Carty Lake
Ridgefield, Washington

Location					Chemical Parameters		Physical Parameters			
Sample Location	Decision Unit	Sample Type	Depth	Number of Increments	Chemicals[a]	TOC	Unit Weight	Grain Size	Atterberg Limits	Permeability
LRIS-CL-DU1A	1	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-DU1B	1	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-DU1C	1	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-16	1	Discrete	0-1 ft	NA	NA	NA	Tier I	Tier I	Tier I	Tier I
			1-2 ft	NA	Tier I	Tier I				
			2-3 ft	NA	Tier II	Tier II				
LRIS-CL-17	1	Discrete	1-2 ft	NA	Tier I	Tier I	NA	NA	NA	NA
			2-3 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-17-DUP	1	Discrete	1-2 ft	NA	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-DU2	2	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-18	2	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-19	2	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-DU3	3	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-20	3	Discrete	0-1 ft	NA	NA	NA	Tier I	Tier I	Tier I	Tier I
			1-2 ft	NA	Tier II	Tier II				
			2-3 ft	NA	NA	NA				
LRIS-CL-21	3	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA

Table 4-2
Sampling Design
Carty Lake
Ridgefield, Washington

Location					Chemical Parameters		Physical Parameters			
Sample Location	Decision Unit	Sample Type	Depth	Number of Increments	Chemicals[a]	TOC	Unit Weight	Grain Size	Atterberg Limits	Permeability
LRIS-CL-DU4	4	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-22	4	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-23	4	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-DU5	5	ISM	0-10 cm	10	Tier I	Tier I	NA	NA	NA	NA
LRIS-CL-24	5	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-25	5	Discrete	1-2 ft	NA	Tier II	Tier II	NA	NA	NA	NA
LRIS-CL-26	NA	Discrete	0-3 ft	NA	NA	NA	Tier I	Tier I	Tier I	Tier I
LRIS-CL-27	NA	Discrete	0-3 ft	NA	NA	NA	Tier I	Tier I	Tier I	Tier I

NOTES:

cm = centimeter.

ft = feet.

ISM = incremental sampling methodology.

NA = not applicable.

TOC = total organic carbon.

[a]Includes dioxins, arsenic, chromium, and pentachlorophenol.

Table 4-3
Sample Station Coordinates
Carty Lake
Ridgefield, Washington

Station ID	Surface Sample	Subsurface Sample(s)	X Coordinate	Y Coordinate
LRIS-CL-DU1A-1	ISM	NA	1066525.7398	186370.6299
LRIS-CL-DU1A-2	ISM	NA	1066550.0359	186370.6299
LRIS-CL-DU1A-3	ISM	NA	1066574.3319	186370.6299
LRIS-CL-DU1A-4	ISM	NA	1066513.5918	186391.6709
LRIS-CL-DU1A-5	ISM	NA	1066537.8879	186391.6709
LRIS-CL-DU1A-6	ISM	NA	1066562.1839	186391.6709
LRIS-CL-DU1A-7	ISM	NA	1066586.4800	186391.6709
LRIS-CL-DU1A-8	ISM	NA	1066501.4438	186412.7120
LRIS-CL-DU1A-9	ISM	NA	1066525.7398	186412.7120
LRIS-CL-DU1A-10	ISM	NA	1066550.0359	186412.7120
LRIS-CL-DU1B-1	ISM	NA	1066534.4001	186412.7120
LRIS-CL-DU1B-2	ISM	NA	1066558.6961	186370.6299
LRIS-CL-DU1B-3	ISM	NA	1066546.5481	186391.6709
LRIS-CL-DU1B-4	ISM	NA	1066558.6961	186412.7120
LRIS-CL-DU1B-5	ISM	NA	1066510.1040	186412.7120
LRIS-CL-DU1B-6	ISM	NA	1066570.8442	186391.6709
LRIS-CL-DU1B-7	ISM	NA	1066534.4001	186370.6299
LRIS-CL-DU1B-8	ISM	NA	1066522.2520	186391.6709
LRIS-CL-DU1B-9	ISM	NA	1066582.9922	186370.6299
LRIS-CL-DU1B-10	ISM	NA	1066595.1402	186391.6709
LRIS-CL-DU1C-1	ISM	NA	1066530.0700	186378.1299
LRIS-CL-DU1C-2	ISM	NA	1066554.3660	186420.2120
LRIS-CL-DU1C-3	ISM	NA	1066530.0700	186420.2120
LRIS-CL-DU1C-4	ISM	NA	1066554.3660	186378.1299
LRIS-CL-DU1C-5	ISM	NA	1066578.6621	186378.1299
LRIS-CL-DU1C-6	ISM	NA	1066566.5140	186399.1709
LRIS-CL-DU1C-7	ISM	NA	1066505.7739	186420.2120
LRIS-CL-DU1C-8	ISM	NA	1066590.8101	186399.1709
LRIS-CL-DU1C-9	ISM	NA	1066517.9219	186399.1709
LRIS-CL-DU1C-10	ISM	NA	1066542.2180	186399.1709
LRIS-CL-DU2-1	ISM	NA	1066499.1084	186446.3422
LRIS-CL-DU2-2	ISM	NA	1066524.0216	186446.3422
LRIS-CL-DU2-3	ISM	NA	1066548.9349	186446.3422
LRIS-CL-DU2-4	ISM	NA	1066511.5650	186467.9177
LRIS-CL-DU2-5	ISM	NA	1066536.4783	186467.9177
LRIS-CL-DU2-6	ISM	NA	1066499.1084	186489.4932
LRIS-CL-DU2-7	ISM	NA	1066524.0216	186489.4932
LRIS-CL-DU2-8	ISM	NA	1066486.6518	186511.0687
LRIS-CL-DU2-9	ISM	NA	1066511.5650	186511.0687
LRIS-CL-DU2-10	ISM	NA	1066536.4783	186511.0687

Table 4-3
Sample Station Coordinates
Carty Lake
Ridgefield, Washington

Station ID	Surface Sample	Subsurface Sample(s)	X Coordinate	Y Coordinate
LRIS-CL-DU3-1	ISM	NA	1066590.3600	186419.7180
LRIS-CL-DU3-2	ISM	NA	1066575.9775	186444.6291
LRIS-CL-DU3-3	ISM	NA	1066604.7424	186444.6291
LRIS-CL-DU3-4	ISM	NA	1066561.5951	186469.5402
LRIS-CL-DU3-5	ISM	NA	1066590.3600	186469.5402
LRIS-CL-DU3-6	ISM	NA	1066575.9775	186494.4513
LRIS-CL-DU3-7	ISM	NA	1066604.7424	186494.4513
LRIS-CL-DU3-8	ISM	NA	1066561.5951	186519.3624
LRIS-CL-DU3-9	ISM	NA	1066590.3600	186519.3624
LRIS-CL-DU3-10	ISM	NA	1066619.1248	186519.3624
LRIS-CL-DU4-1	ISM	NA	1066499.2418	186533.1591
LRIS-CL-DU4-2	ISM	NA	1066483.9470	186559.6506
LRIS-CL-DU4-3	ISM	NA	1066514.5367	186559.6506
LRIS-CL-DU4-4	ISM	NA	1066468.6521	186586.1421
LRIS-CL-DU4-5	ISM	NA	1066499.2418	186586.1421
LRIS-CL-DU4-6	ISM	NA	1066529.8316	186586.1421
LRIS-CL-DU4-7	ISM	NA	1066453.3572	186612.6337
LRIS-CL-DU4-8	ISM	NA	1066483.9470	186612.6337
LRIS-CL-DU4-9	ISM	NA	1066514.5367	186612.6337
LRIS-CL-DU4-10	ISM	NA	1066545.1265	186612.6337
LRIS-CL-DU5-1	ISM	NA	1066544.3022	186550.2190
LRIS-CL-DU5-2	ISM	NA	1066573.8593	186550.2190
LRIS-CL-DU5-3	ISM	NA	1066603.4164	186550.2190
LRIS-CL-DU5-4	ISM	NA	1066632.9734	186550.2190
LRIS-CL-DU5-5	ISM	NA	1066559.0808	186575.8162
LRIS-CL-DU5-6	ISM	NA	1066588.6378	186575.8162
LRIS-CL-DU5-7	ISM	NA	1066618.1949	186575.8162
LRIS-CL-DU5-8	ISM	NA	1066573.8593	186601.4133
LRIS-CL-DU5-9	ISM	NA	1066603.4164	186601.4133
LRIS-CL-DU5-10	ISM	NA	1066588.6378	186627.0105
LRIS-CL-16	NA	CP	1066538.0117	186380.4088
LRIS-CL-17	NA	C	1066563.1716	186413.2147
LRIS-CL-18	NA	C	1066526.0881	186436.5514
LRIS-CL-19	NA	C	1066524.1768	186509.2843
LRIS-CL-20	NA	CP	1066584.5385	186447.2883
LRIS-CL-21	NA	C	1066582.4892	186509.5134
LRIS-CL-22	NA	C	1066489.7251	186559.4786
LRIS-CL-23	NA	C	1066515.9023	186604.3920
LRIS-CL-24	NA	C	1066568.9299	186557.1106
LRIS-CL-25	NA	C	1066585.3849	186604.4163

Table 4-3
Sample Station Coordinates
Carty Lake
Ridgefield, Washington

Station ID	Surface Sample	Subsurface Sample(s)	X Coordinate	Y Coordinate
LRIS-CL-26	NA	P	1066596.2202	186338.5163
LRIS-CL-27	NA	P	1066636.3487	186431.1207

NOTES:

Coordinates based on Washington South State Plane HARN (NAD83).

C = discrete chemical data collection.

CP = discrete chemical and physical data collection.

ISM = incremental sampling methodology.

NA = not applicable.

P = discrete physical data collection.

Table 4-4
Sample Size Requirements, Holding Times, and Preservation
Carty Lake
Ridgefield, Washington

Parameter	Sample Size	Container Size and Type	Hold Time for Analysis	Preservation
Dioxins	30-40 g	40 ml VOA	30 days	4°C
			1 year	-18°C
Arsenic	5-10 g	40 ml VOA	6 months	4°C
			2 years	-18°C
Chromium	30-40 g	40 ml VOA	6 months	4°C
			2 years	-18°C
Pentachlorophenol	30-40 g	40 ml VOA	14 days/40 days post extraction	4°C
			1 year/40 days post extraction	-18°C
Total organic carbon	1 g	40 ml VOA	14 days	4°C
			6 months	-18°C

NOTES:

°C = degrees Celsius.

g = grams.

ml = milliliter.

VOA = volatile organic analysis.

Table 5-1
Sampling Parameters, Analytical Methods, and Data Quality Objectives
Carty Lake
Ridgefield, Washington

	Analytical Method	Units	PQL	Level of Detection*	Precision	Laboratory Control Sample Accuracy	Labeled Standard/ Surrogate Accuracy	Completeness
Chemical Parameters								
2,3,7,8-TCDF	USEPA 1613B	ng/kg	0.5	0.10	NA	75-158% R	24-169% R	100%
2,3,7,8-TCDD	USEPA 1613B	ng/kg	0.5	0.10	NA	67-158% R	25-164% R	100%
1,2,3,7,8-PeCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	80-134% R	24-185% R	100%
2,3,4,7,8-PeCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	68-160% R	21-178% R	100%
1,2,3,7,8-PeCDD	USEPA 1613B	ng/kg	2.5	0.50	NA	70-142% R	25-181% R	100%
1,2,3,4,7,8-HxCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	72-134% R	26-152% R	100%
1,2,3,6,7,8-HxCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	84-130% R	26-123% R	100%
2,3,4,6,7,8-HxCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	70-156% R	28-136% R	100%
1,2,3,7,8,9-HxCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	78-130% R	29-147% R	100%
1,2,3,4,7,8-HxCDD	USEPA 1613B	ng/kg	2.5	0.50	NA	70-164% R	32-141% R	100%
1,2,3,6,7,8-HxCDD	USEPA 1613B	ng/kg	2.5	0.50	NA	76-134% R	28-130% R	100%
1,2,3,7,8,9-HxCDD	USEPA 1613B	ng/kg	2.5	0.50	NA	64-162% R	NA	100%
1,2,3,4,6,7,8-HpCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	82-122% R	28-143% R	100%
1,2,3,4,7,8,9-HpCDF	USEPA 1613B	ng/kg	2.5	0.50	NA	78-138% R	26-138% R	100%
1,2,3,4,6,7,8-HpCDD	USEPA 1613B	ng/kg	2.5	0.50	NA	70-140% R	23-140% R	100%
OCDF	USEPA 1613B	ng/kg	5.0	1.00	NA	63-170% R	NA	100%
OCDD	USEPA 1613B	ng/kg	5.0	1.00	NA	78-144% R	17-157% R	100%
Arsenic	USEPA 6010	mg/kg	2.0	0.5	+/- 20% RPD	80-120% R	NA	90%
Chromium	USEPA 6010	mg/kg	2.0	1	+/- 20% RPD	80-120% R	NA	90%
Pentachlorophenol	USEPA 8270	µg/kg	250.0	125	+/- 20% RPD	25-25% R	40-125% R	90%

Table 5-1
Sampling Parameters, Analytical Methods, and Data Quality Objectives
Carty Lake
Ridgefield, Washington

	Analytical Method	Units	PQL	Level of Detection*	Precision	Laboratory Control Sample Accuracy	Labeled Standard/ Surrogate Accuracy	Completeness
Physical Parameters								
Atterberg Limits	ASTM D-4318	NA	NA	NA	NA	NA	NA	90%
Grain size	ASTM D-422 with hydrometer	percent	1	0.1	NA	NA	NA	90%
Total solids	PSEP, 1986	percent	0.1	0.1	+/- 20% RPD	NA	NA	90%
Total organic carbon	COE 9060	mg/kg	0.1	0.1	+/- 20% RPD	75-125% R	NA	90%
Permeability	COE EM 1110-2-1906	m^2	0.1	0.1	NA	NA	NA	90%
Unit Weight/Moisture Content	ASTM D-2216	percent	0.1	0.1	+/- 20% RPD	NA	NA	90%

NOTES:

ASTM = American Society for Testing and Materials.

COE = U.S. Army Corps of Engineers.

m^2 = square meter.

mg/kg = milligrams per kilogram (parts per million).

µg/kg = micrograms per kilogram.

NA = not applicable.

ng/kg = nanograms per kilogram (parts per trillion).

PQL = practical quantitation limit.

PSEP = Puget Sound Estuary Program.

R = recovery.

RPD = relative percent difference.

USEPA = U.S. Environmental Protection Agency.

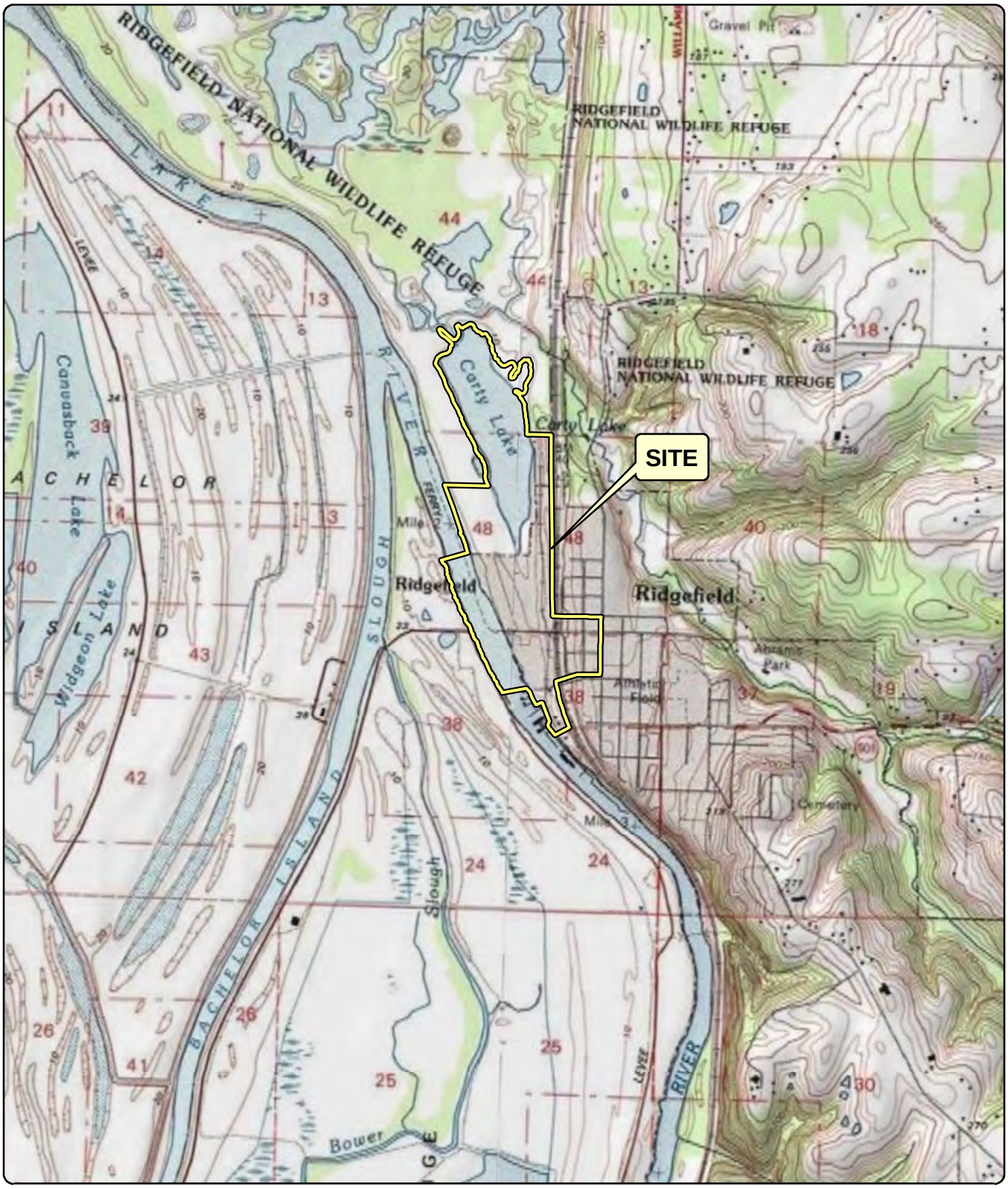
*Level of detection for Method 1613B is based on likely estimated detection limits from Vista Analytical Laboratory. Estimated detection limits may change, depending on matrix conditions and laboratory discretion.

Table 5-2
Analytical Methods and Quality Control Requirements
Carty Lake
Ridgefield, Washington

Analysis Type	Initial Calibration	Ongoing Calibration	Labeled Analogs	Surrogate Spikes	Duplicates	Matrix Spikes/Matrix Spike Duplicates	LCS/OPR	Method Blanks	Sediment Reference Material	Equipment Rinsate Blank	Field Duplicate
Dioxins	As required by USEPA Method 1613B	Every 12 hours	Every sample	Every sample	NA	NA	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per day of sampling	1
Arsenic	As required by USEPA Method 6010	As required by USEPA Method 6020	NA	NA	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	NA	1 per day of sampling	1
Chromium	As required by USEPA Method 6010	As required by USEPA Method 6020	NA	NA	1 per 20 samples	1 per 10 samples	1 per 20 samples	1 per 20 samples	NA	1 per day of sampling	1
Pentachlorophenol	As required by USEPA Method 8270	As required by USEPA Method 8270	NA	Every sample	NA	1 per 10 samples	1 per 20 samples	1 per 20 samples	NA	1 per day of sampling	1
Total organic carbon	PSEP 1997 SM 5310B Mod CCV daily or each batch	1 per 10 samples	NA	NA	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per 20 samples	1 per day of sampling	1

NOTES:
LCS = laboratory control sample.
NA = not applicable.
OPR = ongoing precision and recovery sample (used for dioxin analysis).
PSEP = Puget Sound Estuary Program.
USEPA = U.S. Environmental Protection Agency.

FIGURES



Source: Topographic Quadrangle obtained from ArcGIS Online Services/NGS-USGS TOPO/US Geological Survey (1999)
7.5-minute topographic quadrangle: Ridgefield
Address: Lake River Industrial Site
111 W. Division Street, Ridgefield, WA 98642
Section: 24 Township: 4N Range: 1W Of Willamette Meridian

Legend

Former Pacific Wood Treating Site

Figure 1-1
Site Location

Former PWT Site
Ridgefield, Washington

0 1,000 2,000
Feet

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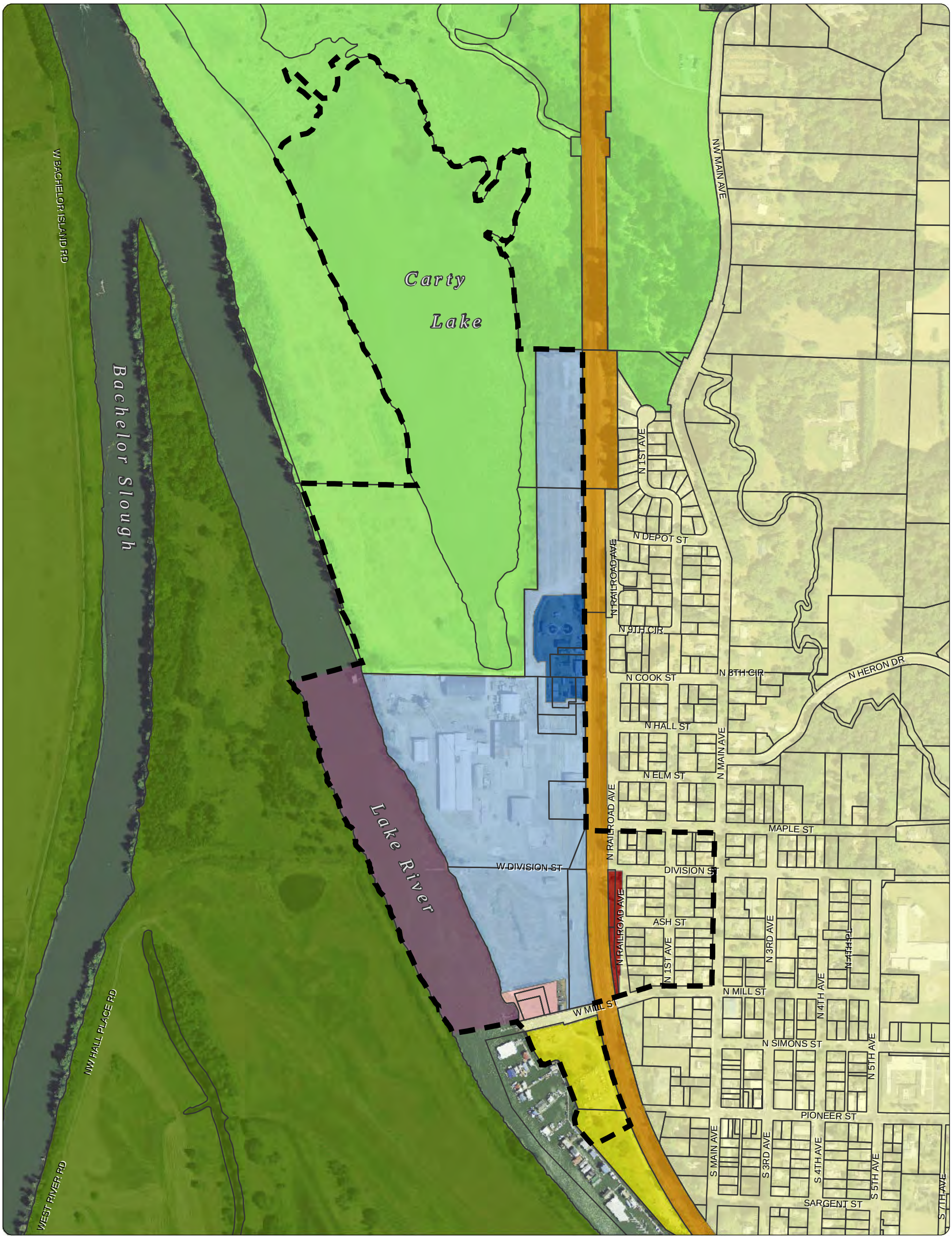

Source: Aerial photograph obtained from Clark County (2007).

Notes:
1. BNSF = Burlington Northern Sante Fe
2. LRIS = Lake River Industrial Site
3. Port = Port of Ridgefield
4. RNWR = Ridgefield National Wildlife Refuge
5. WWTP = Wastewater treatment plant

Legend

Pacific Wood Treating Site

Clark County Tax Lots (2010)

Area Designations

LRIS
- Port-Owned
- City of Ridgefield WWTP

Port-Owned
- Railroad Avenue Property
- Marina Property

Upland Off-Property
- Residential; Low-Density
- McCuddy's Marina Property

Other
- RNWR-Carty Unit
- RNWR-River S Unit
- BNSF Railroad Property
- Lake River

Figure 1-2
Site Vicinity

Former PWT Site
Ridgefield, Washington

0 250 500
Feet

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LRIS-CL-15	TEQ
0-10 cm	**25**

LRIS-CL-14	TEQ
0-10 cm	**26**

LRIS-CL-13	TEQ
0-10 cm	1.9

LRIS-CL-12	TEQ
0-10 cm	**20**

LRIS-CL-11	TEQ
0-10 cm	**27**

LRIS-CL-09	TEQ
0-10 cm	**54**

LRIS-CL-10	TEQ
0-10 cm	**15**

LRIS-CL-07	TEQ
0-10 cm	**32**
1-2 ft	0.65

LRIS-CL-08	TEQ
0-10 cm	**27**

LRIS-CL-06	TEQ
0-10 cm	**22**
1-2 ft	0.31

LRIS-CL-04	TEQ
0-10 cm	**300***
1-2 ft	2.1

LRIS-CL-05	TEQ
0-10 cm	1.8
1-2 ft	0.74

LRIS-CL-03	TEQ
0-10 cm	**24**
1-2 ft	1.1

LRIS-CL-01	TEQ
0-10 cm	**140***
1-2 ft	**5.5**

LRIS-CL-02	TEQ	DNOP	PCP	As	Cr
0-10 cm	**1,400***	31 J	**880**	**48**	**86**
1-2 ft	**130***	**87 U**	**270 J**	**15**	34
2-3 ft	2.5	NV	NV	NV	NV

Source: Aerial photograph obtained from ESRI, Inc. ArcGIS Online/Bing Maps.

Legend

- Sediment Sample Location
- Cell Boundaries

Figure 2-1
Carty Lake Exceedances in Surface and Subsurface Sediment

Former PWT Site
Ridgefield, Washington

Notes:
1. **Bold** value exceeds screening criteria
2. TEQ = Toxicity Equivalent
3. * Indicates dioxin congener exceedance of ecological screening criteria. Values are available in Table 2-1.
4. U = Non-detection
5. J = Estimated value
6. DNOP = Di-n-octyl phthalate
7. PCP = Pentachlorophenol
8. As = Arsenic
9. Cr = Chromium
10. TEQ measured in ng/kg (nanograms per kilogram) DNOP and PCP in ug/kg (micrograms per kilogram) As and Cr in mg/kg (milligrams per kilogram)

0 150 300
Feet

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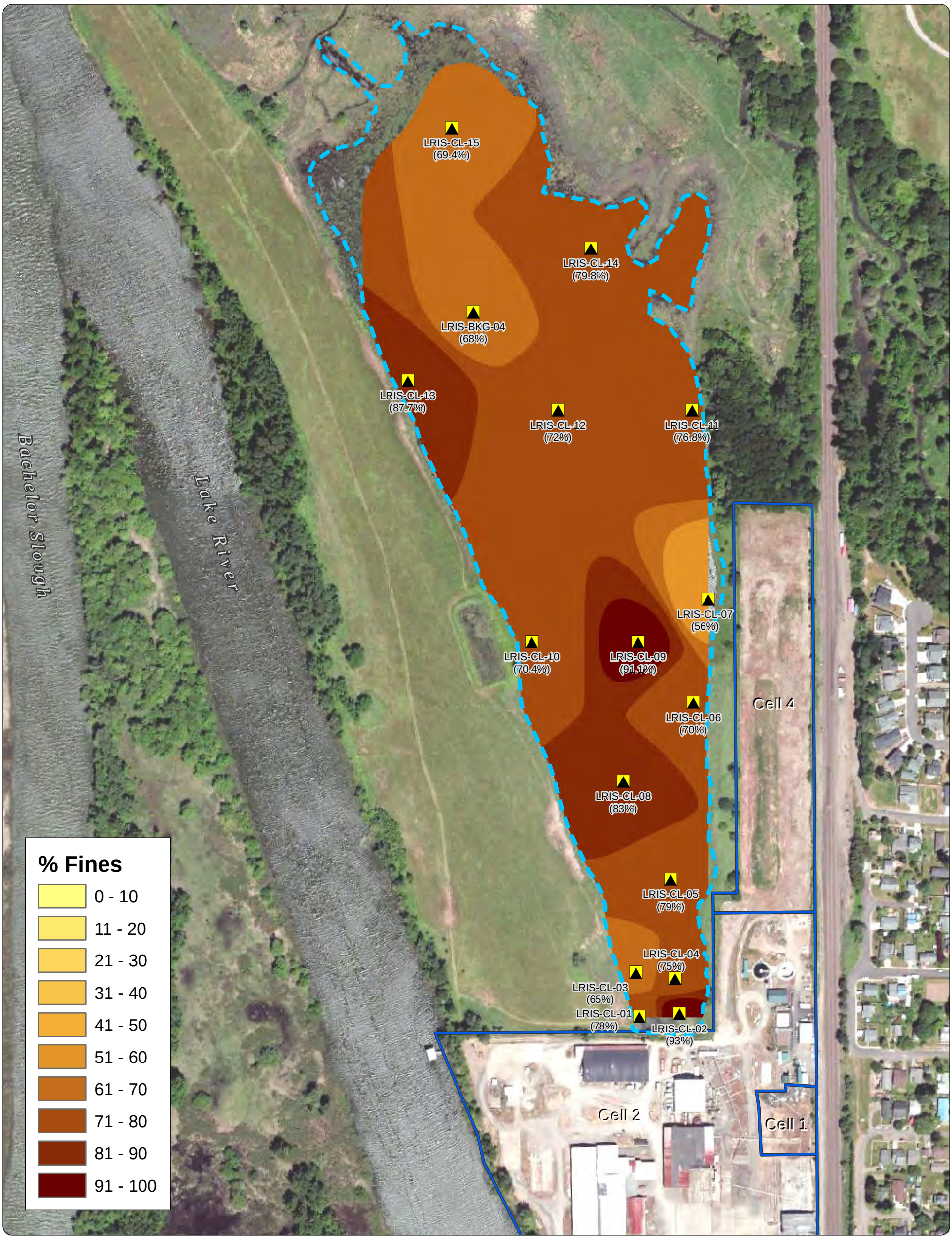

Source: Aerial photograph obtained from ESRI, Inc. ArcGIS Online/Bing Maps.

Notes:
1. Percent fines is percent of clay and silt.
2. Percent fines sampling depth is 0-10 cm.
3. Contours created using ArcGIS 10 Spatial Analyst inverse distance weighted (IDW) interpolation method.
4. IDW parameters: Power of 6, 12 Points

Legend

- Sediment Sample Location
- Carty Lake
- Cell Boundaries

Figure 3-1
Carty Lake Percent Fines

Former PWT Site
Ridgefield, Washington

0 150 300
Feet

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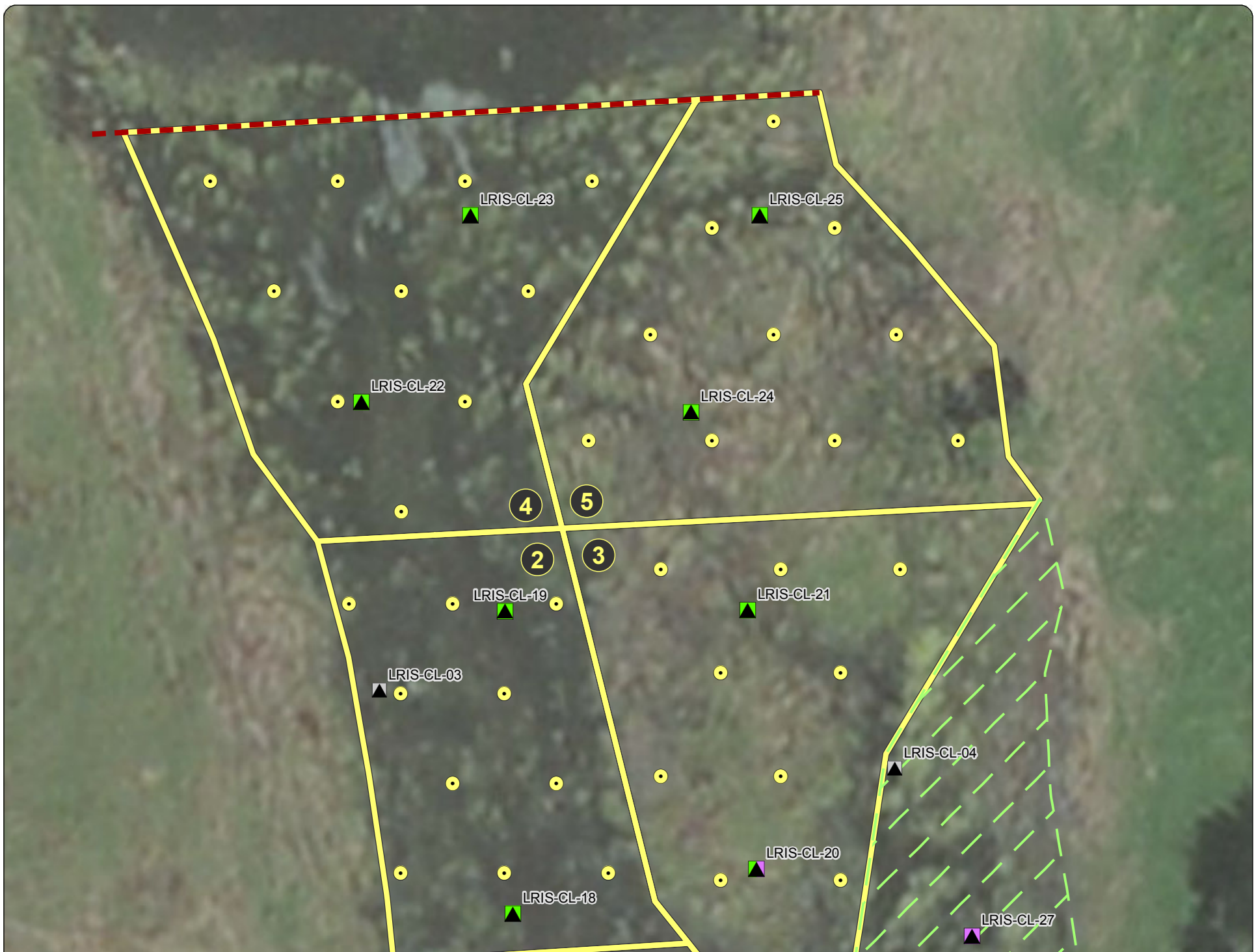

Source: Aerial photograph obtained from ESRI, Inc. ArcGIS Online (2010).

Note: Decision unit boundaries are approximate; the outermost boundaries are based on a recent site survey (2013).

Legend

Discrete Sub-Surface Sample Locations

- Incremental Sample (Replicate 1)
- Incremental Sample (Replicate 2)
- Incremental Sample (Replicate 3)
- Incremental Sample Location
- Former Berm (Approximate)
- Chemical
- Physical
- Chemical and Physical
- Historical Sediment Sample Location
- Decision Unit
- Remedial action area identified based on previous data collection activities

Figure 4-1
Proposed Sample Locations
Carty Lake

Former PWT Site
Ridgefield, Washington

0 20 40
Feet

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Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Fig4-1_Proposed Sample Locations Carty Lake.mxd
Print Date: 5/24/2013
Approved By: P. Wiescher
Produced By: jschane
Project: 9003.01.40

APPENDIX A

AERIAL PHOTOGRAPH

APPENDIX B

DIOXIN AND FURAN ANALYSIS, DATA VALIDATION, AND TEQ CALCULATION RULES

MEMORANDUM

To: File Date: September 28, 2012

From: Erik Naylor Project: 9003.01.40

RE: Dioxin and Furan Analysis, Data Validation, and TEQ Calculation Rules

The term dioxin is used to refer to a family of toxic chemicals that share a similar chemical structure and a common mechanism of toxic action. While there are 210 dioxin congeners, typically only the 17 most toxic congeners are reported by laboratories. The reported concentrations of the 17 dioxin congeners typically are validated to assess usability and then a toxicity equivalent concentration (TEQ) is calculated from the reported results to evaluate the toxicity of these compounds as a whole. The purpose of this memo is to provide an approach for dioxin data validation and TEQ calculation for the former Pacific Wood Treating site. Further, analytical method recommendations and requirements for laboratory deliverables are provided to enable consistent data validation and TEQ calculation using data from a variety of laboratories.

Critical to consistent data use is consistent use of terminology. Terms used in this memorandum are defined below.

- Method Detection Limit (MDL)—The minimum concentration of a compound that can be measured and reported with 99 percent confidence that the value is greater than zero according to the Washington State Department of Ecology's (Ecology), Model Toxics Control Act (MTCA) (Ecology, 2007).
- Estimated Detection Limit (EDL)—The sample- and analyte-specific EDL is an estimate made by the laboratory of the concentration of a given analyte that would have to be present to produce a signal with a peak height of at least 2.5 times the background noise signal level (U.S. Environmental Protection Agency [USEPA], 2005).
- Practical Quantitation Limit (PQL)—The lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using Ecology-approved methods (Ecology, 2007). This value is usually the lowest concentration used to calibrate the instrument after being adjusted for sample volume, sample extract volume, cleanups performed, and injection volume. PQLs should be no greater than 10 times the MDL (Ecology, 2007) and no greater than what is established by the USEPA in 40 Code of Federal Regulations (CFR) 136, 40 CFR 141-143, or 40 CFR 260-270.

- Estimated Maximum Potential Concentration (EMPC)—An EMPC is a value calculated for a reported analyte when the signal-to-noise ratio is at least 2.5:1 for both quantitation ions, but the ion abundance ratio criteria used for analyte confirmation are not met (USEPA, 2005). An EMPC value represents the maximum possible result of an analyte that could not be positively identified. The inability to positively identify the analyte could be a result of matrix interference, a coeluting compound, or low response.
- Toxic Equivalency Factor (TEF)—The factor by which each congener is multiplied in order to calculate its toxicity relative to 2,3,7,8-TCDD (Ecology, 2007). These values are summed to calculate the TEQ. TEFs depend on the endpoint being examined (i.e., birds, fish, mammals).
- TEQs—Concentrations of each congener are adjusted and summed to reflect their potency relative to 2,3,7,8-TCDD, one of the most toxic congeners. The TEQ is the sum of congener results multiplied by their specific TEF (Ecology, 2007).

ANALYTICAL METHODS

Dioxins are analyzed generally by USEPA Method 1613B or 8290, using a high-resolution gas chromatograph paired with a high-resolution mass spectrometer. A laboratory's PQL is usually the same for both methods. While the methods are very similar, Method 1613B is preferred, as it requires more rigorous quality assurance and quality control (QA/QC) through the use of six more internal standards than Method 8290. Because analytical technology and methodology have advanced rapidly since the methods were written, many laboratories combine elements of both methods to obtain the best results possible (Hoffman, E., and D. Fox 2010). Often the preparation and analyses are run using Method 1613B (for the additional QA/QC), while the calculations will be performed by Method 8290 (in order to obtain the sample- and analyte-specific EDLs). Method 1613B with calculated EDLs is the preferred method.

LABORATORY DELIVERABLES

It is important to work closely with the laboratory performing the dioxin analyses because different laboratories report data in different ways. The following items should be requested to ensure that the analytical report and electronic data deliverable (EDD) will contain all of the requisite information to validation the data and calculate TEQs:

- EDLs[1] and PQLs should be included in the final analytical report. EDLs, MDLs, and PQLs should all be included in the EDD.
- Results should be reported to the sample- and analyte-specific EDL. Results below the PQL but above the EDL will be qualified as estimates (J).

[1] Note that USEPA Method 1613B does not provide for the calculation of EDLs; therefore, the laboratory must use the calculation approach provided in Method 8290 to report the required limits.

- EMPC results should be reported at the EMPC value (EMPC values will be assigned a "U" qualifier [the analyte was not detected at or above the concentration qualified] at the time of validation).

TEQ concentrations will not be requested from the laboratory. If the laboratory provides TEQ concentrations, they will not be used because the data have not been validated TEQs should be calculated only after the data are validated.

VALIDATION

Dioxin data are validated much like other organic data, but there are a few issues that do not typically arise in other organic data sets. In addition to standard validation procedures (USEPA 2005), the following scenarios should be addressed in the fashion described below, consistent with other Ecology sites (Ecology and Environment and G. L. Glass, 2011):

- EMPC reported values should be assigned a U qualifier at the reported EMPC value.
- EMPC values that appear to be significantly elevated should be investigated further with the laboratory and may be assigned an R qualifier (unusable) when applicable.
- Non-detected results should be assigned a U qualifier and reported at the EDL value.

Further dioxin validation guidelines can be found in the National Functional Guidelines for Chlorinated Dibenzo-p-Dioxins (CDDs) and Chlorinated Dibenzofurans (CDFs) Data Review (USEPA 2005). Data must be validated before TEQs are calculated.

TEQS

To express the overall toxicity of the 17 reported dioxins, the concentration of each congener is adjusted based on its toxicity relative to the most toxic congener, 2,3,7,8-TCDD, and then all 17 are added together. The adjustment factors, the TEFs, are provided by the 2005 World Health Organization. TEQs are commonly calculated by one of the following two methods:

- Non-detected values (U) are set as one half of the EDL. Values that are detected, even as estimates (J), should be used at face value. Multiply congener values by their corresponding TEF and then sum all of the products.
- Non-detected values (U) are set as 0. Values that are detected, even as estimates (J), should be used at face value. Multiply congener values by their corresponding TEF and then sum all of the products.

These methods result in two different TEQ values that can be shown as TEQ (U=1/2) and TEQ (U=0). TEQs should not be calculated to more significant figures than the original data. The table below illustrates these methods:

Dioxin	Result (ng/kg)	TEC[1] (U=1/2) (ng/kg)	TEC[1] (U=0) (ng/kg)	TEF Mammals
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	44	44	44	0.0003
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3000 J	3000	3000	0.0003
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	41	41	41	0.01
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	510	510	510	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	2.9 U	1.45	0	0.01
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	6.9 U	3.45	0	0.1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	7.4	7.4	7.4	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	5.2 U	2.6	0	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	27	27	27	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.5 U	0.25	0	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	22	22	22	0.1
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	3.4 U	1.7	0	0.03
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	3.2 U	1.6	0	1
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	2.4	2.4	2.4	0.1
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	3 U	1.5	0	0.3
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	1.4 U	0.7	0	0.1
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.23 U	0.115	0	1
Total Heptachlorodibenzofuran (HpCDF)	99	99	99	--
Total Heptachlorodibenzo-p-dioxin (HpCDD)	1,100	1100	1100	--
Total Hexachlorodibenzofuran (HxCDF)	97 J	97	97	--
Total Hexachlorodibenzo-p-dioxin (HxCDD)	250	250	250	--
Total Pentachlorodibenzofuran (PeCDF)	44	44	44	--
Total Pentachlorodibenzo-p-dioxin (PeCDD)	32 J	32	32	--
Total Tetrachlorodibenzofuran (TCDF)	19	19	19	--
Total Tetrachlorodibenzo-p-dioxin (TCDD)	8.2	8.2	8.2	--
TEQ (U=1/2)	**15.2**	--	--	--
TEQ (U=0)	**12.3**	--	--	--

NOTES:
-- = no value.
ng/kg = nanograms per kilogram.
[1]TEC is analyte-specific TEF adjusted concentration.

The difference between TEQ (U=1/2) and TEQ (U=0) values gives data reviewers an idea of how much the EDL substitution affects the TEQ summation (Hoffman, E., and D. Fox 2010). While

MTCA does not specify using the TEQ (U=1/2) method, it is the method that has been historically used at the Port of Ridgefield and will continue to be used.

SUMMARY

- USEPA Method 1613B is recommended for dioxin analysis (with Method 8290 EDL calculations).
- The laboratory must report a PQL and EDL for each sample and each congener, and provide a PQL, EDL, and MDL for each sample and each congener in the EDD.
- Results should be reported to the sample- and analyte-specific EDL. Results below the PQL but above the EDL will be qualified as estimates (J).
- EMPC results should be reported at the EMPC value (EMPC values will be assigned a "U" qualifier at the time of validation). However, if the EMPC is significantly elevated, additional qualification may be appropriate.
- Non-detected results should be assigned a U qualifier and reported at the EDL value.
- Laboratory data must be validated before a TEQ is calculated.
- TEQs should be calculated as follows: non-detected values (U) are set as one half of the EDL. Values that are detected, even as estimates (J), should be used at face value. Multiply congener values by their corresponding TEF and then sum all of the products.

REFERENCES

Ecology. 2007. Model Toxics Control Act statute and regulation. Publication No. 94-06. Washington State Department of Ecology. November.

Ecology and Environment Inc. and Gregory L. Glass. 2011. Rayonier Mill off-property soil dioxin study. June.

Hoffman, E., and D. Fox. 2010. Polychlorinated dioxins and furans (PCDD/F): revisions to the supplemental quality assurance project plan (SQAPP). U.S. Environmental Protection Agency. November.

USEPA. 2005. USEPA contract laboratory program national functional guidelines for chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) data review. EPA 540-R-05-001. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. September.