Sediment Investigation Sampling and Analysis Plan Loon Lake Loon Lake, Washington

Prepared for Washington Department of Natural Resources

April 9, 2008
17453-00

HARTCROWSER

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1.0 INTRODUCTION

Loon Lake is an approximately 1,100-acre lake located in Stevens County in northeastern Washington State (Figure 1). Known for its water clarity, Loon Lake early on became a recreation and vacation destination for Spokane and other eastern Washington residents. Currently, the lake provides habitat for many aquatic and water-dependent species, as well as providing recreational opportunities for people. Historically, the northeastern shore of the lake was the location of a succession of sawmills and ice production plants operating in the area from the late 1800s to the mid-1900s. Served by the railroad line, the old town site was also located in this area of the lake and the current Town of Loon Lake developed around the sawmills. The railroad was also an integral part of the sawmill and the ice plant operations. Both the sawmills and the town site were plagued by fires several times in their history.

In recent years, area residents have perceived large quantities of organic muddy debris accumulating on the bottom of the lake, affecting its water clarity. Some residents suspect that the debris is from accumulations of sawdust and sawmill debris related to the former sawmill and ice plant operations. However, other direct or indirect organic and nutrient inputs to the lake (e.g., surface water runoff, agriculture, and historical septic tank leachate) may also have contributed to sediment impacts (DNR 2007). In addition, over the last 5 years, lake levels have been receding due to drought conditions, resulting in decreased water levels, expanding shorelines, and beaching of floating docks. The purpose of this Sampling and Analysis Plan (SAP) is to document a sampling and analysis program that will provide information to adequately characterize the nature and extent of historically deposited wood waste, if present, and to assess whether former saw mill operations and waste disposal practices have adversely impacted sediment characteristics, including chemical quality.

This SAP has been produced pursuant to the Washington State Department of Natural Resources (DNR) Contract Number AE-177.

2.0 SITE BACKGROUND

This section provides information regarding the historical background of the sawmill and ice plant operations on the lake, and the historical and current conditions of the site. Most of the references mentioned in these sections were obtained from historical documents provided by DNR and from the Loon Lake Sediment Study—Phase I Report prepared by DNR in October 2007.

Loon Lake is approximately 2,382 feet in elevation with an average depth of 46 feet and a maximum depth of 100 feet. The lake has several unnamed intermittent streams as inflow and one outlet on the northwest corner of the lake (Figure 2). As a result, the lake has no continuous inflow of new water and stratifies during the dry months when inflow is minimal. During years of normal precipitation, the lake receives large groundwater inputs from the regional aquifer to reach full pool level. It has been noted that Loon Lake and Deer Lake, approximately 3 miles northeast of Loon Lake, are hydraulically connected. Outflow from the lake, as well as infiltration to its deep-water aquifer, form the headwaters of the Colville River.

Developments around the lake are mostly residential and resorts, and the lake is primarily used for recreational activities including boating, fishing, and birding. The area of the former Town of Lake Side is now the Morgan Park subdivision, a private beach community surrounded by other residential communities. This area of the lake tends to be the shallowest with possible wetlands fronting the shoreline.

2.1 Historical Setting

Sawmill Operations

European settlement around Loon Lake began in the mid- to late1800s, after completion of the Government Land Office (GLO) survey of the northern lake shore in 1855. At the time, the government required the land to be surveyed by the GLO prior to settlement.

The survey showed the town sites of Lake Side and Loon Lake Park located along the northeastern shore of the lake (Figure 2). Lake Side was platted in 1890 and Loon Lake Park was platted in 1891. While Loon Lake Park was the location of the Spokane Falls and Northern Railway Railroad Depot, Lake Side was commonly referred to as "slabtown" for the numerous sawmills located within the former town site. Eventually, Loon Lake Park was simply referred to as Loon Lake.

The first sawmills on record that were located on or near the former town site of Lake Side are the Holland-Horr, Gherke Brothers, Dart, and Curtiss and Potts Sawmills. In addition, the Holland-Horr Sheep Creek Mill was reportedly 3 miles west of Loon Lake. The Dart Sawmill was constructed in 1890 on Lot 10 of the Town of Lake Side and was destroyed by fire in 1896. In 1900, the Curtiss and Potts Sawmill, operated by the Loon Lake Lumber Company, was constructed in the same site as the former Dart Sawmill. This sawmill floated lumber from the cutting operations in the Deer Creek area (northeast of the town) on a tramway to the sawmill located in the shoreline of the lake. The Holland-Horr Lumber Company acquired this sawmill later that same year. Although the Horr Brothers owned lots 3, 4, 5, 6, and 8 of the original Lake Side plat, the sawmill is believed to have remained on Lot 10. A large fire in 1911 destroyed the "lower mill" and although the sawmill and yards were spared, the Holland-Horr Sawmill remained idle until 1913 when its Spokane door and sash operations were moved to Loon Lake and the mill was overhauled. By 1926, the Holland-Horr Sawmill was no longer listed as an active business in local city street directories and is assumed to have closed.

The Gherke Mill operated from 1890 to 1916 on Lot 1 of the former Lake Side town site, approximately ¼ mile north of the Holland-Horr Sawmill. The mill reportedly manufactured fruit boxes and was believed to be related to the Arcadia Orchards Company, also operating in Loon Lake. According to historical records, this mill was dismantled in 1926 and moved to Entiat, Washington.

Sometime in the mid-1920s, the Loon Lake Lumber Mill started operations in Loon Lake. The precise location of the mill, its relation to the Holland-Horr Sawmill, and when it ceased operations are unknown. However, it is known that this mill also operated on the northeastern shore of the lake.

By 1943, Alvin Luhr bought portions of Lots 10 and 11 where the former sawmills were located. After returning from World War II, Mr. Luhr decommissioned and sold parts of the former mills and subdivided the lots into the Luhrs Addition to Loon Lake.

Ice Production

Because of the quality of the water in Loon Lake, ice production became a profitable business in the area. Ice houses were located around the lake including the northeastern shoreline where the sawmills and the towns were located. The Great Northern Railroad Company reportedly operated the ice block collection and storage venture in the northeastern lakeshore between 1905 and 1916. The railroad shipped the ice for use in its cold storage facilities

located in Spokane County. Other firms continued ice production until the mid-1950s when electric refrigeration became widespread. Sawdust from the nearby mills was reportedly used to insulate ice during storage and shipping up until the time the mills ceased operation in the mid-1930s.

Sawdust and Wood Waste

For the sawmills and the ice production businesses along the lakeshore, the sawmill sawdust became a usable commodity. Based on historical photographs and other documents, it is known that the sawmills typically burned sawdust, wood debris by-products, or waste in "hog fuel burners" to provide power for mill operations. In addition, it is documented that sawdust was used as insulation for ice transport and storage. Based on this information, it is thought that much of the sawdust generated in the sawmills may have been used rather than disposed of as a waste.

Lake Levels

Lake levels have decreased steadily since its recorded history as a result of a combination of man-made controls and drought. The first records of the lake level were from 1889 when a local rancher decided to cut a channel leading from the north end of the lake, lowering the lake level approximately 3 feet. This started what would be a lengthy controversy regarding the water level in Loon Lake. By 1893, the same rancher wanted to cut the channel deeper to lower the lake level even further but a local Federal Circuit Court judge granted the Spokane and Northern Railroad Company an injunction against this action. By 1911, the Arcadia Orchard Company cut an irrigation canal in the northwest corner of the lake lowering the lake substantially. Prior to Arcadia's channel construction, the lake level was reported as 2,386.2 feet above mean sea level (or 2,385.67 feet ordinary high water) and the shoreline fronting the Town of Lake Side was reportedly wetlands. This lowering by Arcadia had a significant impact on sawmill operations since extra effort was required to transport the logs from the water to the sawmills. After an agreement between the Loon Lake Park Company and Arcadia, the lake level was set at 2,383.19 feet above mean sea level (3 feet lower). In 1936, the commissioner of Public Lands established the elevation of ordinary high water at 2,380.7 feet (an additional 2.5 feet lower). By 1950, Steven's County Superior Court established the maximum lake level at 2,381.25 feet, which raised the lake level by about half a foot and required a control structure to be installed at the lake's outlet. This created another controversy in 1973 when the Washington State Supreme Court ruled that since in 1950 only a maximum level had been established and not a minimum, this made the lake unavailable for additional water appropriations.

Lake water level has been dropping naturally over the past 5 years due to drought conditions in the Colville Drainage Basin.

Water Quality

Loon Lake is a deep, dimictic lake (water mixes twice a year) with relatively good surface water quality. The lake thermally stratifies from around June through October, with warm surface waters (~20 °C) above a depth of around 25 feet and cool, dense bottom waters (~8 °C) below a depth around 40 feet. Total phosphorus levels (~10 µg-P/L) and chlorophyll levels (<2 µg/L) are low and water transparency is high (~Secchi depth ~20 to 25 feet). Based on nutrient levels, phytoplankton levels, and water clarity, the lake is classified as oligotrophic.

The lake exhibits hypoxia (dissolved oxygen levels below ~5 mg/L) in bottom waters after the onset of thermal stratification. For example, data from 1971 showed that waters at a depth of 50 feet had 2.5 mg/L of dissolved oxygen in late July and 1.5 mg/L of dissolved oxygen on mid-September. Summer oxygen data from the late 1990s showed hypoxic bottom waters below a depth of around 40 feet. Because of bottom-water hypoxia, a characteristic of eutrophic lakes, Loon Lake is generally classified as oligo-mesotrophic.

Historical data suggest that bottom-water anoxia leads to the release of nutrients from deep, anaerobic sediments, and a stimulation of phytoplankton activity upon overturn in the fall when these nutrients mix into the photic zone. Anoxia is also likely impacting biota by not providing well oxygenated cold water refuge for fish and zooplankton during the summer. It is unclear why the lake has such good surface water quality but poor bottom water quality. This could be a legacy of historical nutrient pollution to the lake, and the resulting build-up of organic matter in deep sediments over decades.

Nutrient Inputs and Sewage Treatment

From the early 1900s, the shoreline of the lake was used as a vacation destination. In 1894, Ewan and Johanah Morgan constructed the first resort along the shores of the new Town of Loon Lake Park. This park was turned into Morgan Park, after the 1960s. From the 1960s on, the number of residences along the shore increased rapidly.

Water quality studies (Ecology 1973 and 1980) indicated that eutrophication (decreased dissolved oxygen levels and increased nutrient levels) of Loon Lake was being accelerated by the introduction of nutrients (nitrogen and phosphorus) to the lake, possibly the result of seepage from private on-site

sewage disposal systems surrounding the lake. In addition, the arrival of fruit orchards into the area in the 1910s with a subsequent increase in agricultural fertilizer runoff into the lake also altered the lake's chemistry. As a result of increased nutrient loading, concentrations of algae increased subsequently reducing water clarity. In addition, aquatic vegetation and noxious weeds became established in the lake. As vegetation dies back in the fall and sinks to the lake bottom and decays, it forms an organic rich "muck" and nutrients bound up in the vegetation are released and recycled through the water column.

The Loon Lake sewer district was established in 1981 to install sewer facilities to protect water quality of the lake. Between 1983 and 1986, a septic tank pumping program was installed to serve a majority of residences around the lake and, in 1986, the district sewage treatment system began operation (Esvelt 1998). The treatment plant and area for land application of treated effluent are located slightly less than a mile northeast of Loon Lake. The amount of effluent applied to the spray field between April and October typically ranges from 189,000 to 220,000 gallons per day. Based on facility monitoring reports between 1991 and 1994, total nitrogen concentrations of the final effluent ranged from 5 to 40 mg/L with an average of 19 mg/L. While there is a monitoring well network about the effluent spray field, it is not adequate to determine groundwater flow direction; however, groundwater flow is assumed to be to the southwest toward Loon Lake. Soil hydraulic conductivity is estimated to be 500 ft/day (Ecology 1995). A private sewer system (septic) still serves the Granite Point area on the southeast portion of Loon Lake.

2.2 Natural Resources and Ecological Receptors

Natural Resources

Loon Lake supports an active recreational fishing resource. Resident fish species include bass, bluegill, crappie, perch, sunfish, tench, rainbow trout, and kokanee. The rainbow trout, and kokanee populations are regularly supplemented by stocking with hatchery raised fish.

Loon Lake provides high quality habitat to over 60 species of resident and nesting birds as well as a wide range of migratory birds. Two species, the bald eagle and red-necked grebe, are listed on the Wildlife Heritage Point list as having breeding occurances (nests). Active red-necked grebe nesting sites have been documented on the west side of the lake. In addition, six nesting platforms have been installed between approximately mid April to mid September in a wetland area by the inlet in the northeast part of the lake near the former sawmill locations.

Three wetland areas abut the west side of Loon Lake: McVay Meadow (160 acres), Anderson Meadow (70 acres), and Pearson Meadow (80 acres) wetlands. In addition, there is a 12-acre wetland area in the northeast inlet of the lake (Lamb 2004; Stevens County Critical Area Ordinance, RCW 13.10.025(4)). While these areas have been classified as Category 1 and 2 wetlands, formal wetlands delineations have not been performed. In addition to providing habitat for birds and other animals, the beneficial functions of wetland areas include filtering of waters flowing into the lake from forested upland areas and absorption of winter and spring runoff with subsequent release of water to the lake during the summer dry period.

Aquatic Plants cover approximately 3 percent of the lake surface and 18 percent of the lake bottom. Aquatic plants are an integral part of the lake ecology. When aquatic plants are not extremely dense or widespread, they provide a good balance of habitat for both fish and the invertebrates that fish feed upon. Emergent plants include watershield, sedge, white waterlily, and yellow waterlily. Submerged plants include pondweed, water milfoil, waterweed, and quillwort. Eurasian milfoil is a recent invasive species and control measures have been implemented. Excessive growth of aquatic plants may indicate intrusion of nonnative species or eutrophication caused by excess nutrients from the surrounding watershed.

Ecological Receptors

The primary ecological receptors of concern in Loon Lake are the benthic communities on the lake bottom (crayfish, amphipods, worms, etc.). Secondary receptors would be fish that feed on the benthic organisms as well as birds that feed on both aquatic insects and fish. Potential impacts to these receptors could result from organic debris deposited in the lake over time, excess nutrient loading , wood degradation products, and secondary effects, such as production of sulfide and ammonia, due to oxygen depletion from decaying wood or vegetation.

3.0 PROJECT OBJECTIVES AND APPROACH

3.1 Project Objectives

The overall project objective for the Loon Lake sediment investigation is to assess whether there are sediment impacts from historical sawmill operations adjacent to the lake. The current approach assumes that evidence of sawmill activity is likely to be at some depth below the sediment surface due to the

length of time since the mills stopped operating. Specific tasks to achieve the overall project objective include:

- Collect, analyze, and characterize sediment from areas adjacent to former sawmills located on the northeast part of the lake to determine whether wood waste is present in sediment;
  - If wood waste is present, determine the nature, depth, thickness, and areal extent of sawdust, bark, and logs; and
- Assess whether historically deposited wood waste has impacted the chemical, physical, or biological characteristics of the lake sediments.

If sediment has been impacted by historical wood waste deposition, an assessment of restoration potential and remedial options will be evaluated by DNR in a follow-on phase.

3.2 Project Approach

The following approach will be used to attain the project objectives listed above:

- Perform sediment coring to:
  - Visually identify the presence and location of sawdust and/or other wood waste within the sediment column;
  - Visually determine the thickness of the wood waste layer, if present; and
  - Visually determine the depth of the biologically active zone and any anoxic layer in the sediment.

- Analyze selected conventional parameters (i.e., total organic carbon [TOC]), total volatile solids [TVS], total nitrogen, phosphorus, sulfide, biological oxygen demand [BOD], grain size, and density separation with microscopic examination) to assess whether sediment conditions (organic-rich material) in the upper 4 to 12 inches are the result of wood waste or decaying vegetation.

- Compare chemical concentrations and analyte ratios (TOC/Total Nitrogen) from areas containing wood waste and reference areas unimpacted by wood waste to assess whether there are chemical differences in the upper, biologically active zone that can distinguish wood waste from peat and decayed vegetation. Selected samples from sediment wood waste layers will also be analyzed to establish chemical "signatures" indicative of wood waste. It is expected that the TOC/Total Nitrogen ratio would be higher for wood waste than for decayed vegetation since wood waste contains little nitrogen.

- Bioassay toxicity testing will be conducted to assess whether sediment quality has been impacted by wood waste. Samples for bioassay analysis will be collected from the upper 10 cm or the biologically active zone (BAZ), whichever is greater, taking care to avoid anoxic sediment below the redox potential discontinuity (RPD) horizon unless there is evidence that biological activity occurs beneath the RPD. The BAZ or the top 10 cm were selected to be consistent with Washington State Sediment Management Standards (SMS) procedures for determining if sediments have been impacted.
  - Bioassays will be based on midge (chironomid) larvae 20-day growth, midge larvae 10-day survival, amphipod (hyalella) 10-day survival, and Microtox testing using a 100 percent pore water extract; and
  - Bioassay test results will be compared to reference samples collected from areas where sawmill impacts are not expected. Reference samples will be collected from areas with both highly enriched organic sediment and less organic enriched sediment. In both cases, grain size will be matched to sediment samples selected for biossay testing. Individual biological test failures will be identified as SQS or CSL failures depending on the extent of exceedances. Individual sample locations will also be identified as SQS or CSL, based on two SQS failures or one CSL failure as described in the Washington State Sediment Management Standards (WAC 173-204).

- If sediment impacts are identified based on bioassay testing results, an evaluation will be performed to assess whether potential remedial actions would require habitat mitigation. A formal wetlands delineation may be required at this time to determine if remedial actions would affect critical areas.

4.0 PROJECT TEAM AND RESPONSIBILITIES

Key staff members for this task order are listed below with their professional levels and project functions.

- Rick Moore, LHG, Principal in Charge and Technical Oversight;
- Roger McGinnis, PhD, Project Management and Environmental Chemistry;
- Sonia Fernandez, LG, Sr. Project Geologist and Sediment Specialist;
- Celina Abercrombie, Project Biologist and Wetlands Specialist;
- Anne Conrad, Sr. Staff Chemist/Environmental Scientist;
- Greg Both, Sr. Associate Technical Editor; and
- Kit Malmfeldt, Staff Database Administrator.

Subcontractors will include:

- EnviroIssues, Public meeting support;
- Management of Environmental Resources (MER; Nancy Musgrove), Technical support;
- Dr. Marc Beutel, Limnologist/Lake Management;
- Gravity Environmental, Sediment sampling and coring support;
- Analytical Resources, Inc. (ARI), Chemical analysis testing laboratory; and
- Northwest Aquatic Sciences, Bioassay testing laboratory.

5.0 SAMPLING PROGRAM

5.1 Sampling Approach

Samples will initially be collected using a piston coring device from locations in the vicinity of the former sawmill areas to determine the depth and areal extent of wood waste.

Samples will also be collected from reference locations within Loon Lake to compare sediment physical and chemical characteristics and, for bioassay toxicity testing, for statistical comparison of organism survival and growth. Reference samples will be collected from locations that exhibit similar sediment characteristics (grain size, organic content, vegetation, presence of peat beds, etc.) as samples collected from wood waste impacted areas. Reference samples will also be collected from areas with less organic enriched sediment.

It is anticipated that approximately 20 cores will be collected to a depth of about 4 to 6 feet beneath the sediment surface. Final depths of each core will depend on the depth to wood waste and the nature of the sediment substrate. Cores will be visually examined to determine the presence, depth, and thickness of wood waste and the thickness of the BAZ. A qualitative assessment of species abundance in the BAZ will also be performed. The BAZ will be determined by visual examination of sediment to cores to identify the redox discontinuity interface. In addition, sediment will be examined to determine the depth of sediment organism feeding voids. It is anticipated that chemical analysis will be performed on sediment from the BAZ at locations where wood waste is encountered. Chemical analysis will also be performed on a selected number of samples collected between the BAZ and the wood waste layer.

Piston core samples are expected to provide sufficient volume for chemical analysis; however, a power vanVeen grab sampler will be used to collect surface samples from selected locations for bioassay and collocated chemical analyses.

5.2 Sampling Locations

Sediment samples will be collected from 20 locations along the shoreline of the former town sites where the sawmills were formerly located. The final location of these samples will be adjusted in the field based on observations on wood waste accumulations noted during the investigation. Additional cores may be advanced, if needed, to help determine the extent of the wood waste accumulation area. The proposed sample locations are shown on Figure 3. Based on field evaluation of the presence or absence of sawdust or other wood waste, sampling locations may be modified in the field to determine the location and extent of wood waste.

Since bioassays must be run with reference sediments that are well matched to the test sediments for grain size and other sediment conventional parameters such as TOC, reference locations will be selected meeting these criteria. Reference samples will also be collected from areas with less organic enriched sediment. In addition, the reference sample will be collected toward the end of the field event to account for any differences in these criteria throughout the sampling area. Potential reference sample locations are presented on Figure 4.

5.3 Sampling Positioning

Once the vessel is at the sampling location, a 2- or 3-point anchor system will be deployed to maintain position throughout sample acquisition.

A differential global positioning system (DGPS) will be used aboard the sampling vessel in conjunction with visual triangulation methods for location positioning. The DGPS receiver will be placed above the block on the sampling device deployment boom to accurately record the sampling location position. Once the sampler has been deployed, the actual position will be recorded when the sampler is on the bottom and the deployment cable is in a vertical position. Horizontal coordinates will be referenced to latitude and longitude.

5.4 Water Depth Measurement

Water depths will be measured directly by lead line and sonar. The measurements also serve as a check on location positioning, as the actual water depth at the location coordinates should generally match the depths from bathymetric charts at those locations.

6.0 SAMPLE COLLECTION

Field sediment sampling is planned for August or September 2008 when lake stratification is expected. This time frame will allow a qualitative assessment of the lake's benthic community when maximum impacts from wood waste or decaying vegetation would be expected. The sampling protocol used for the collection of sediment can affect its performance during biological testing. Samples for bioassay analysis will be collected from the upper 10 cm or the BAZ, whichever is greater, taking care to avoid anoxic sediment below the RPD horizon unless there is evidence that biological activity occurs beneath the RPD. The BAZ or the top 10 cm were selected to be consistent with Washington State Sediment Management Standard procedures for determining if sediments have been impacted. Selected samples from sediment wood waste layers will also be analyzed to establish chemical "signatures" indicative of wood waste.

Wet sieving will be performed in the field to obtain a good grain size match between site and reference test sediment. Wet sieving will be performed with a 63-micron (No. 230) sieve and a graduated cylinder to estimate the fine and coarse fraction of the sediments according to the following procedure:

- Place 100 mL of sediment in the sieve and wash thoroughly until the water runs clear.
- Wash the volume of sand and gravel remaining in the sieve into the 100 mL graduated cylinder.
- The remaining volume represents the coarse fraction; the fines content is determined by subtracting this number from 100.

6.1 Sampling Equipment and Methods

Piston Cores

Piston cores (4- to 6-inch-diameter) will be collected from locations in the vicinity of the former sawmill areas and from potential reference locations. Samples will be collected to a depth of up to 8 feet. Cores will be collected using clear Lexan or polycarbonate liners so that they can be examined and evaluated in the field. Cores will be visually examined to determine:

- Presence and depth to sawdust or other wood waste, if present;
- Thickness of the wood waste layer, if present;
- Depth to the sediment anoxic layer; and
- Presence and relative abundance of benthic organisms.

Most lake sediments are anticipated to be very fine-grained and "mucky," which can make core recovery and sample retention difficult. A piston coring device was selected because piston cores can be collected to a deeper depth than hand cores, sample recovery is generally higher than that for hand cores, and there is generally less sample disturbance compared to hand-collected cores. Piston cores are also very effective at retaining high water content samples.

Pneumatic vanVeen Power Grab

A power vanVeen grab sampler will be used to collect surface samples at locations selected for bioassay testing. Power grab samples will be used to obtain sufficient sediment volume to conduct both bioassay analyses and chemical analyses. Approximately 10 surface grab samples would be collected from locations delineated by core samples for chemical analysis and toxicity testing to assess whether there were any differences between locations with wood waste and reference areas in the upper BAZ. Samples will be collected from the BAZ or the upper 10 cm, whichever is greater.

The pneumatic power grab is a 0.1-square-meter surface grab sampler that is used to collect large volume surface sediment samples. A pneumatic ram closes the grab around debris and substrate that otherwise may make conventional vanVeen grabs impractical. The absence of hydraulic fluid reduces the likelihood of sample contamination. During processing the ram swings away from the grab and the doors are removed, allowing unobstructed access to the sample for photos and visual characterization.

6.2 Sample Acceptance Criteria

Piston Cores

Sediment cores will be collected at each location identified in Table 1 using a piston coring device. The corer will use Lexan or polycarbonate liners tubing 4 inches in diameter. The corer will be lowered to the bottom, where the unit will be driven into the substrate. The core will be driven to its maximum length or to refusal. Acceptance criteria for a sediment core sample are as follows:

- The core penetrated to, and retained material to, desired project depth or refusal.

- Recovery was at least 75 percent of the length of core penetration. If 75 percent recovery is not possible due to compression of soft bottom material, sediment sampling intervals will be corrected for compression during processing.

- Cored material does not extend out the top of the core tube or contact any part of the sampling apparatus at the top of the core tube.

- Sediment was retained in the bottom of the corer.

- There are no obstructions in the cored material that might have blocked the subsequent entry of sediment into the core tube and resulted in incomplete core collection.

If core rejections require the core sample to be relocated, three additional attempts will be made within a radius of 25 feet of the target location.

Power vanVeen Grab Sampler

Sediment samples collected with the power grab sampler will be carefully inspected to ensure that the following acceptability criteria are satisfied:

- The sampler is not over-filled with sample so that the sediment surface is pressed against the top of the sampler.

- Overlying water is present (indicating minimal leakage).

- The overlying water is not excessively turbid (indicating minimal sample disturbance).

- The sediment surface within the grab is relatively level (indicating minimal disturbance or winnowing).

- The desired penetration depth is achieved (e.g., several centimeters more than the targeted sample depth).

If sediment acceptance criteria are not achieved, the sample will be rejected and the location resampled. If the sample has been rejected due to overfilling, the sampler may be modified (e.g., remove weights) or the "drop" speed may be lowered. If, following any sampler modifications and resampling, the field crew is still unable to obtain a sample that meets the appropriate acceptance criteria, the sample will be relocated within 25 feet of the proposed location. Additional failures will result in the sample being relocated to another position as determined by the Project Manager or Task Manager, as appropriate. If rejection is due to debris, the depth, location, and type of debris, if known, will be recorded on the field log.

6.3 Equipment Decontamination Procedures

Sampling equipment and sampling utensils will be thoroughly cleaned prior to use according to the following procedure:

- The grab sampler and sampling spoons/tools will be initially rinsed with lake water to dislodge remaining sediments. If sediment remains, the equipment will be brushed and rinsed again with lake water; and

- After rinsing with lake water, non-disposable sampling utensils and mixing bowls will then be decontaminated using an Alconox wash with deionized water rinse.

Since dedicated liners will be used during piston coring, decontamination procedures will not be necessary.

Acid or solvent washes will not be used in the field or sample processing because the use of acids and organic solvents on a congested sampling vessel deck may pose a safety hazard to the crew and because sediment chemical contamination is not expected. In addition, disposal and spillage of acids or solvents during field activities may pose an environmental concern. All hand work will be conducted with disposable nitrile gloves, which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between samples to prevent cross contamination.

6.4 Sediment Processing

Once the piston core samples are collected and the initial inspection and evaluations are completed, the core will be processed onshore at a location to be determined. Samples collected with the pneumatic power grab will be processed onboard the vessel.

In general, and regardless of collection methods, sediment descriptions will be documented on the sediment sampling log form for the following parameters as appropriate and present:

- Sample recovery (depth in feet of penetration and sample compaction);
- Physical soil description in accordance with the Unified Soil Classification System (ASTM D 2488; including soil type, density/consistency of soil, and color);
- Odor (e.g., hydrogen sulfide, petroleum, etc.);
- Vegetation;

- Debris including sawdust, bark, or other wood debris;
- Biological activity (e.g., detritus, shells, tubes, bioturbation, and live or dead organisms);
- Presence and depth of the RPD layer;
- Presence of oil sheen; and
- Any other distinguishing characteristics or features.

Piston Core Samples

Core samples will be temporarily stored in capped liner tubes pending a field determination of which samples will be submitted for analysis. Samples may be temporarily archived in coolers or refrigerators pending selection of intervals to be submitted for analysis. It is anticipated that samples for bioassay and chemical analyses will be collected from the upper 10 cm or the BAZ. Chemical analysis will also be performed on a selected number of samples collected between the BAZ and the wood waste layer. In addition, a few samples collected from the wood waste layer may be analyzed for conventional chemical parameters to determine organic carbon/nitrogen ratios of wood waste to distinguish it from organic-rich sediment derived from decaying vegetation.

The steps for processing piston core samples that meet acceptance criteria listed above are provided below.

- Clean the sediment core liner and photograph the core. Document the depth and thickness of wood waste, if present. Observe any gradations of texture or color. Document the thickness of the BAZ and provide a qualitative description of the species abundance in the BAZ.

- Extrude sample material from sample core tube onto a stainless steel tray using a vibrating core extruder or piston.

- Due to the potential for volatilization, total sulfides samples will be collected first. Using a clean, stainless steel spatula or spoon, fill a pre-labeled 2-ounce glass container preserved with zinc acetate from an unexposed inner portion (no contact with any work surface or equipment) of the sample core. The jar will be capped and shaken vigorously to completely expose the sediment to the zinc acetate.

- Using a clean spoon, place the sample material from the core into a cleaned stainless steel bowl or HDPE bucket and homogenize the sample within the bucket using a stainless steel spoon or powered paddle.

- Fill the remaining sample containers with sample as full as possible to eliminate air space in sample.

- Screw cap on the container and tighten.

Power vanVeen Grab Samples

Power vanVeen grab samples will be used to obtain sufficient sediment volume from the BAZ or the upper 10 cm, whichever is greater, to conduct bioassay analyses and collocated chemical analyses to assess whether there have been biological impacts to sediment.

Power vanVeen grab sediment samples that meet the acceptance criteria described above will be processed in the following manner:

- Water overlying sediment in the sampler will be decanted or siphoned off using a peristaltic pump, taking care to avoid sample disturbance.

- The depth of the sediment from the top of the sampler will be measured and the condition of the sediment surface such as biological activity or vegetation will be documented prior to sampling.

- The sediment will be visually classified using ASTM D 2488 and the description recorded on the Sediment Sampling Form.

- Sediment from the top 10 cm or the BAZ will be collected from the sampler using a stainless steel spoon or other disposable sampling tool, taking care to exclude material in contact with the sampler.

- The collected sediment will be placed in a stainless steel bowl and thoroughly homogenized with the spoon or sampling tool until the sample is uniform in color and texture. Note that samples for sulfide analysis will be removed immediately prior to mixing (sulfides could volatize during mixing). The sample (approximately 50 grams) will be immediately placed into a pre-cleaned 4-ounce glass jar containing 8 ml of 2N zinc acetate. The jar will be capped and shaken vigorously to completely expose the sediment to the zinc acetate.

- Labeled sample jars will be temporarily stored in an insulated cooler with ice away from the immediate work area.

6.5 Sample Containers and Labels

Sample container requirements vary according to analyte and sample matrix. Pre-cleaned sample containers will be obtained from the analytical laboratory. Sample containers shall be cleaned following the requirements described in Specifications and Guidance for Contaminant-Free Sample Containers (EPA 1992, OSWER Directive 92.0-05a). Required sample containers, preservatives, and holding times are summarized in Table 2.

6.6 Field Documentation

Field notes will be maintained during sampling and processing operations. The following will be included in the field notes:

- Names of the field sampling crew, including vessel operator and person(s) collecting and logging the samples;
- Weather conditions;
- GPS coordinates of each sampling location;
- Mudline elevation of each sampling location;
- Date and time of collection of each sample;
- The sample location;
- Descriptions of cores; and
- Any deviation from the approved SAP.

6.7 Excess Sediment Disposal

Any remaining excess sediment will be returned to the location from which it was collected.

7.0 SAMPLE HANDLING PROCEDURES

7.1 Sample Preservation and Holding Times

Chemical and Physical Analyses

Samples will be preserved according to the requirements of the specific analytical methods to be employed, and all samples will be extracted and analyzed within method-specified holding times. Required sample containers, preservatives, and holding times are summarized in Table 2.

Bioassay Analyses

All sediment samples for potential bioassays will be stored in the dark at 4° C. Sample containers will be filled as full as practical to minimize headspace. All bioassay analyses will commence as soon as possible after collection of sediment samples, i.e., bioassay testing will not depend on chemical testing results.

7.2 Chain of Custody and Shipping Procedures

Chain of Custody Procedures

Chain of custody forms will be used to document the collection, custody, and transfer of samples from their initial collection location to the laboratory, and their ultimate use and disposal. Entries for each sample will be made on the custody form immediately after each sample is collected.

Sample custody procedures will be followed to provide a documented record that can be used to follow possession and handling of a sample from collection through analysis. A sample is considered to be in custody if it meets at least one of the following conditions:

- The sample is in someone's physical possession or view;
- The sample is secured to prevent tampering (i.e., custody seals); and/or
- The sample is locked or secured in an area restricted to authorized personnel.

A chain of custody form will be completed in the field as samples are packaged. At a minimum, the information on the custody form shall include the sample number, date and time of sample collection, sampler, analyses, and number of containers. Two copies of the custody form will be placed in the cooler prior to sealing for delivery to the laboratory with the respective samples. The other copy will be retained and placed in the project files after review by the Project Chemist. Custody seals will be placed on each cooler or package containing samples so the package cannot be opened without breaking the seals.

Sample Shipping Procedures

After sample containers have been filled, they will be packed on ice in coolers. Samples for chemical analysis will be transferred to Analytical Resources, Inc. in Tukwila, Washington. Samples for bioassay toxicity analysis will be shipped to Northwest Aquatic Sciences in Newport, Oregon. Chain of custody procedures

will commence in the field and will track delivery of the samples to the analytical laboratories. Specific procedures are as follows:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24;
- Individual sample containers will be packed to prevent breakage;
- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler, and the Hart Crowser office name and address) to enable positive identification;
- A sealed envelope containing custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler;
- Signed and dated custody seals will be placed on all coolers prior to shipping;
- Samples will either be shipped by overnight courier or will be hand delivered to the laboratory by Hart Crowser personnel; and
- Upon transfer of sample possession to the testing laboratories, the custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the shipping container custody seal will be broken and the laboratory sample-receiving custodian will compare samples to information on the chain of custody form and record the condition of the samples received.

8.0 LABORATORY ANALYTICAL METHODS

Samples will be analyzed according to EPA methods as described in Update III to Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846 (EPA 1986), Methods for Chemical Analysis of Water and Wastes (EPA 1983), and the Puget Sound Estuary Program Protocols (PSEP 1986 and updates), as referenced in Ecology's Sediment Sampling and Analysis Plan Appendix (SAPA; Ecology 2003).

8.1 Physical and Chemical Analysis

Sediment samples will be analyzed for the parameters described below. In all cases, to avoid potential problems and to leave open the option for retesting, sediments or extracts will be archived under proper storage conditions until the chemistry data are deemed acceptable.

Physical Parameters

Analysis of total solids will follow the PSEP (1986) method. Solids results will be used to correct sediment sample results to a dry weight basis.

Samples will be analyzed to evaluate appropriate reference sediment locations and test organisms for bioassay toxicity analyses, if required. Particle size will be determined by ASTM Method D 422. The fine-grained fraction will be classified by phi size using hydrometer analysis. Hydrogen peroxide will not be used in preparations for grain size analysis.

A semiquantitative estimation of the amount of wood waste in samples will be determined using the approached originally developed for the Gray's Harbor sediment wood waste investigation. The method is summarized as follows:

- Air dry a sediment sample;
- Slurry a weighed amount of sediment with trichloroethylene. Wood debris and vegetation will float on the trichloroethylene while sediment will sink;
- Filter the trichloroethylene and floating debris;
- Air dry the debris collected on the filter and weigh;
- View the dry debris under a microscope to estimate the percentage of wood waste compared to plant vegetation; and
- If desired, perform a total volatile solids analysis on the collected debris.

Chemical Analysis

Laboratory testing of sediment samples will include the following:

- Total Organic Carbon (TOC) using EPA Method 9060;

- Total phosphorous using Method 4500 of Standard Methods for the Examination of Water and Wastewater (SM);

- Biological oxygen demand (BOD) using the procedure described in the PSEP protocols;

- Total Kljeldahl nitrogen (TKN) using the PSEP modification of EPA Method 351.2;

- Total nitrite and nitrate using by EPA Method 353.2;

- Total volatile solids (TVS) using the procedure described in the PSEP Protocols; and

- Total sulfides using the modification of EPA Method 9060 procedure described in the PSEP Protocols.

The standard analytes listed in the Washington State Sediment Management Standards (SMS) (Chapter 173-204 WAC) will not be analyzed because, except for phenols, these compounds are generally not associated with wood or wood waste. It is likely that decayed vegetation would also produce phenols.

8.2 Bioassay Analysis

General Biological Testing Procedures

The following freshwater bioassays will be performed:

- **Midge.** A 20-day sediment chronic toxicity test that assesses growth of the midge *Chironomus dilutus* and a 10-day sediment acute toxicity test that assesses mortality.

- **Amphipod.** A 10-day sediment acute toxicity test that assesses mortality of the amphipod *Hyalella azteca.*

- **Microtox 100 Percent Sediment Pore Water Extract Test.** A 15-minute acute toxicity test that assesses decreased bioluminescence of the bacteria *Vibrio fischeri* (strain NRRL B-11177) exposed to a pH, dissolved oxygen, and salinity-adjusted 100 percent pore water extract of the freshwater sediment sample. For more information of freshwater marine Microtox® 100 percent sediment pore water extract toxicity assessment, see Subappendix C of Ecology's Sediment Sampling and Analysis (SAPA) Appendix (Ecology 2003).

Standard protocols for each of these tests are established both by American Society for Testing and Materials (ASTM 1998) and EPA (EPA 2000). Either protocol may be used for the freshwater bioassays. Adherence to the protocol performance standards aids in interpreting bioassay responses by limiting effects from factors other than sediment toxicity due to the contaminants of interest.

9.0 QUALITY ASSURANCE AND QUALITY CONTROL REQUIREMENTS

9.1 Chemical and Physical Analyses

The quality of analytical data generated is controlled by the frequency and type of internal QC checks developed for analysis type. The quality of laboratory measurements will be assessed by reviewing results for analysis of method blanks, matrix spikes, duplicate samples, laboratory control samples, surrogate compound recoveries, etc., as specified in the analytical methods to be used.

Laboratories must meet requirements specified in Ecology's SAPA (Ecology 2003). The following general procedures will be followed for all laboratory analyses:

- Laboratory blank measurements at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix;

- Matrix spike (MS) and matrix spike duplicate (MSD) analysis to assess accuracy and precision at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix; and

- Laboratory control sample analysis to assess accuracy in the absence of any matrix effect at a minimum frequency of 5 percent or one per batch of 20 samples or fewer for each matrix.

Specific in-house laboratory-derived control limits will be used to assess data quality.

9.2 Bioassay Analyses

This section contains the specific QA/QC requirements for solid phase biological testing. The parameters covered include:

- Negative Control and Reference Sediment;
- Quality Control Limits for the Negative Control Treatment;
- Quality Control Limits for the Reference Treatment;
- Positive Control; and
- Water Quality Monitoring.

General procedures are given first, followed by specific performance standards for each bioassay. These standards aid in interpreting the bioassay responses because they control for environmental effects that may produce confounding factors not associated with the toxicity of the contaminants of interest.

Negative Controls

Negative control sediments are used in bioassays to check laboratory performance. Negative control sediments are clean sediments in which the test organism normally lives (or are cultured) and which are expected to produce low mortality. Negative control reliability must be demonstrated.

Reference Sediment

Agency regulations prescribe the use of bioassay reference sediments for test comparison and interpretations that closely match the grain size characteristics of the test site sediments. The reference sediment provides a point of comparison for evaluating the potential effects of the test sediment. Samples from reference locations will be analyzed for the same suite of chemicals as samples from areas containing wood waste, as little information is available about sediment chemical quality in the lake.

All bioassays have performance standards for reference sediments. Failure to meet these standards may result in the requirement to retest.

Replication

Eight laboratory replicates of test sediments, reference sediments, and negative controls will be run for each bioassay (per ASTM and EPA guidance).

Positive Controls

A positive control (sometimes called the reference toxicant test) will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism and provide an indication of the sensitivity of the particular organisms used in a bioassay. Positive controls are generally performed on spiked fresh water and compared with historical laboratory reference toxicity test results to confirm that organism responses are within control limits established by the testing laboratory. Control charts will be constructed to show performance variability (organism sensitivity) over time.

Water Quality Monitoring

Water quality monitoring of the overlying water will be conducted for the bioassays. Measurements of temperature, pH, conductivity, hardness, alkalinity, sulfide, and ammonia in overlying water will be conducted on Day 0 and Day 10 of the amphipod and sediment larval tests. Temperature and dissolved oxygen measurements will obtained on Days 1 through 9 of the bioassay testing. Monitoring will be conducted for all test and reference sediments and negative controls. Parameter measurements must be within the limits specified for each bioassay. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

Midge 20-day Growth Bioassay

The 20-day growth test has a performance standard of 0.6 mg minimum mean wet weight or a 0.48 mg mean ash-free dry weight per individual (per EPA). (Ash-free dry weights are regarded as a more accurate weight.) The reference performance standard is 80 percent of the final negative control growth weight.

Midge 10-day Survival Bioassay

This bioassay measures the survival of the midge *Chironomus* dilutus after a 10-day exposure to the test sediment. The control has a performance standard of 30 percent absolute mean mortality. The reference performance standard is 30 percent absolute mean mortality.

Amphipod 10-day Survival Bioassay

This bioassay measures the survival of the amphipod *Hyalella azteca* after a 10-day exposure to the test sediment. The control has a performance standard of 20 percent absolute mean mortality. The reference sediment performance standard is 25 percent absolute mean mortality.

Microtox Bioassay

The Microtox test is a 15-minute acute toxicity test that assesses decreased bioluminescence of the bacteria *Vibrio fischeri* (strain NRRL B-11177) exposed to a pH, dissolved oxygen, and salinity-adjusted 100 percent pore water extract of the freshwater sediment sample. The control final mean light output has a performance standard of greater than or equal to 72 percent of the control initial mean light output. If control criteria are not met, reference output may used for comparison with test sediment light output.

The reference final mean light output has a performance standard of greater than or equal to 80 percent of the control final mean light output.

It should be noted that, if sediment extracts are cloudy or turbid, measured light output may be reduced since light is scattered and does not reach the detector. In this event, a potion of the extract will be filtered using a 0.45 micron filter and retested.

9.4 Data Quality Assurance Review

A project chemist at Hart Crowser will perform an independent data quality review of the chemical analytical results provided by ARI. This report will assess

the adequacy of the reported detection limits in achieving the project screening levels for sediment; the precision, accuracy, representativeness, and completeness of the data; and the usability of the analytical data for project objectives. Exceedances of analytical control limits will be summarized and evaluated.

A data evaluation review will be performed on all results using QC summary sheet results provided by the laboratory for each data package. The data evaluation review is based on the Quality Control Requirements previously described and follows the format of the EPA National Functional Guidelines for Organic (EPA 1999) and Inorganic (EPA 2004) Data Review modified to include specific criteria of individual analytical methods. The following is an outline of the data evaluation review format:

- Verify sample numbers and analyses match the chain of custody request;
- Verify sample preservation and holding times;
- Verify that laboratory blanks were performed at the proper frequency and that no analytes were present in the blanks;
- Verify field and laboratory duplicates, matrix spikes, and laboratory control samples were run at the proper frequency and that control limits were met; and
- Verify required detection limits have been achieved.

Data qualifier flags, beyond any applied by the laboratory, will be added to sample results that fall outside the QC acceptance criteria. An explanation of data qualifiers to be applied during the review is provided below:

U. The compound was analyzed for but was not detected. The associated numerical value is the sample reporting limit.

J. The associated numerical value is an estimated quantity because QC criteria were slightly exceeded or because reported concentrations were less than the practical quantitation limit (lowest calibration standard).

UJ. The compound was analyzed for, but not detected. The associated numerical value is an estimated reporting limit because QC criteria were not met.

R. Data are not usable because of significant exceedance of QC criteria. The analyte may or may not be present; resampling and/or re-analysis are necessary for verification.

10.0 DATA ANALYSIS AND REPORTING

10.1 Data Analysis

Sediment Chemistry and Physical Parameters

Sediment chemistry results from potentially impacted and reference locations will be compared to one another to determine whether there are significant differences.

Bioassay Analysis

Data analysis will consist of endpoint comparisons to controls and reference on an absolute percentage basis as well as statistical comparison to reference. Individual biological test failures will be identified as SQS or CSL failures depending on the extent of exceedances. Individual sample locations will also be identified as SQS or CSL based on two SQS failures or one CSL failure as described in the Washington State Sediment Management Standards (Chapter 173-204 WAC).

Bioassay test results will be evaluated to determine whether there are statistically significant differences between test and reference samples, and the magnitude of the difference will be quantified. Both control and reference samples must meet performance criteria, for the results of the comparison to reference to be accepted. Reference samples not meeting performance criteria will result in comparison of test results to control samples, as a surrogate for the reference comparison.

Bioassay Interpretive Criteria

The response of bioassay organisms exposed to discrete test sediment in a site investigation will be statistically compared to the response of these organisms in reference treatments (or default to control treatments if the reference sediment does not meet specified performance standards). This will determine whether in-place sediment at a site under investigation poses an unacceptable risk to ecological receptors.

Biological test interpretation in the Pacific Northwest relies on two levels of observed response in the test organisms. These are known as "one-hit" or "two-hit" failures. The bioassay-specific guidelines for each of these response categories are listed below. In general, a one-hit failure is a marked response in any one biological test. A two-hit failure is a lower intensity of response. It must be identified in two or more biological tests for the test sediment to potentially cause adverse impacts to ecological receptors at a contaminated site.

One-Hit Failure. When any one biological test shows a test sediment response relative to reference sediment that exceeds the bioassay-specific response guidelines and is statistically different from the reference, the in-place sediments are considered to potentially cause adverse impacts to ecological receptors at a contaminated site. The acceptable methods for determining statistical significance are in Chapter 173-204 WAC.

Two-Hit Failure. When any two biological tests show test sediment responses, which are less than the bioassay-specific guidelines for a one-hit failure but show a lower level effect and are statistically different from the reference sediment, the in-place sediments are considered to potentially cause adverse impacts to ecological receptors at a contaminated site.

Midge 20-day Growth Bioassay. For the midge 20-day growth test, a mean reduction in biomass greater than 40 percent and statistical significance is considered a hit. If either or both endpoints fail the guideline, the test is considered a hit.

Midge 10-day Survival Bioassay. For the midge 10-day mortality test, a mean mortality in the test sediment of 20 percent over reference and statistically different from reference (alpha = 0.05) is a hit. If the endpoint fails the guideline, the test is considered a hit.

Amphipod 10-day Survival Bioassay. For the amphipod bioassay, mean test mortality greater than 15 percent over the mean reference response, and statistically different from the reference (alpha = 0.05), is considered a hit.

Microtox. Statistical calculations are performed using a standard t-test by comparing control with test site data. No gamma correction is required. Statistically significant differences with $\alpha = 0.05$ AND the following relative differences are indications of test failure or test "hit." Test mean output (Tmean) less than 90 percent of Control/Reference mean output (Cmean/Tmean) AND statistically significantly different ($\alpha = 0.05$) from Control/Reference mean output indicates a SQS "hit." Test mean output less than 75 percent of

Control/Reference mean output AND statistically significantly different (α= 0.05) from Control/Reference mean output indicates a CSL "hit."

10.2 Reporting

Physical and Chemical Analysis Laboratory Reports

The laboratory data reports will consist of summary data packages that will allow independent data quality review of analytical results. Each laboratory data report will include the following:

- Case narrative identifying the laboratory analytical batch number, matrix and number of samples included, analyses performed and analytical methods used, and description of any problems or exceedance of QC criteria and corrective action taken. The laboratory manager or their designee must sign the narrative.

- Copy of chain of custody forms for all samples included in the analytical batch.

- Tabulated sample analytical results with units, data qualifiers, percent solids, sample weight or volume, dilution factor, laboratory batch and sample number, Hart Crowser sample number, and dates sampled, received, extracted, and analyzed all clearly specified.

- Blank summary results indicating samples associated with each blank.

- Matrix spike/matrix spike duplicates result summaries with calculated percent recovery and relative percent differences.

- Laboratory control sample results, when applicable, with calculated percent recovery.

- Hard copy and electronically formatted data deliverable results (CD or electronic e-mail deliverable) in SEDQUAL (now EIM) data format.

Bioassay Analysis Reports

A written report will be prepared by the biological laboratory documenting the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory bioassay analyses and QA/QC results (including control charts), reported both in hard copy and in Ecology's SEDQUAL (now EIM) data format. Raw data will be legible or typed.

- All protocols used during analyses, including explanation of any deviation from the Recommended Protocols and the approved sampling plan.

- The source of all bioassay testing organisms will be reported.

- Chain of custody procedures, including explanation of any deviation from the identified protocols.

- Location and availability of data, laboratory notebooks and chain of custody forms.

Reports to DNR

Hart Crowser will prepare a report summarizing sediment sampling procedures and laboratory testing results. The report will include a map with confirmed sediment sampling locations, tabulated analytical testing data with comparisons between site and reference locations, and laboratory analytical documentation.

At a minimum, the report will include the following sections

- Introduction/Purpose;
- Results of sediment chemistry and bioassay tests;
- Discussion and interpretation of results; and
- Conclusions and recommendations.

Sediment sampling analytical and bioassay data will also be submitted to DNR electronically in SEDQUAL (now EIM) data entry templates. In addition, it should be noted that if three or more locations exceed CSL criteria, the area will be listed on the 303d-impaired water body list as well as designated as an SMS/MTCA cleanup site.

11.0 REFERENCES

ASTM 1999. Standard Test Methods for Measuring the Toxicity of Sediment-associated Contaminants with Freshwater Invertebrates. E1706-95b, Annual Book of ASTM Standards, Vol. 11.05.

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Ecology 2003. Sediment Sampling and Analysis Appendix. Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-203 WAC). Ecology Publication No. 03-09-043. Revised April 2003.

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EPA 1986. Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846, 3rd Update.

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Esvelt 1998. Comprehensive Sewer Plan Update and Engineering Report. Prepared for Loon Lake Sewer District No. 4 by Esvelt Environmental Engineering. August 1998.

Lamb 2004. Integrated Aquatic Vegetation Management Plan. Prepared for Lake Management district of Loon Lake by David Lamb, Lake Management Specialist. March 2004.

PSEP 1986. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, WA.

PSEP 1997. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, WA.

J:\jobs\1745300\Loon Lake Final SAP.doc

Table 1 - Proposed Sample Location Coordinates

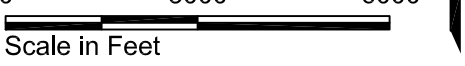
Sample ID	Northing	Easting
LL-01	1005858.094	2344406.105
LL-02	1005463.022	2344037.192
LL-03	1005725.392	2344833.552
LL-04	1005373.657	2344545.345
LL-05	1005041.944	2344196.142
LL-06	1004745.526	2344037.419
LL-07	1005358.634	2345107.405
LL-08	1005050.264	2344886.846
LL-09	1004659.424	2344597.308
LL-10	1004390.143	2344333.119
LL-11	1004148.462	2344249.487
LL-12	1004236.657	2344771.072
LL-13	1003898.193	2344581.416
LL-14	1003739.044	2345065.675
LL-15	1003475.986	2344688.006
LL-16	1003396.429	2345524.143
LL-17	1003353.024	2345134.63
LL-18	1003064.513	2346094.637
LL-19	1003017.046	2345686.201
LL-20	1002928.922	2345274.318
LLBG-01	1004927.993	2339458.068
LLBG-02	1003074.35	2340641.684
LLBG-03	1000488.237	2348055.708
LLBG-04	997353.9204	2348071.642
LLBG-05	996607.281	2348488.833

Coordinates are Washington State Plane South NAD 83

Table 2 - Sample Containers, Preservation, and Holding Times

Sample Type	Holding Time	Sample Size	Temperature	Container
Particle Size	6 Months	100-200g (75-150 ml)	4 degrees C	1L- Glass (combined)
Total Solids	14 Days	125g (100 ml)	4 degrees C	
Density separation	none	100 g	4 degrees C	
Total Volatile Solids	14 Days	125g (100 ml)	4 degrees C	
Total Organic Carbon	14 Days	125g (100 ml)	4 degrees C	
TKN	28 days	50 g	4 degrees C	
Nitrate + nitrite	28 days	50 g	4 degrees C	
Total Phosphorus	28 days	50 g	4 degrees C	
BOD	48 hours	50 g	4 degrees C	
Total Sulfides	7 Days	50g (40 ml)	5 mL 2 N zinc acetate 4 degrees C	125 ml-Glass or Polethylene
Bioassay	8 Weeks	3-1 L jars	4 degrees C	3 -1 L-Glass or 1 gal HDPE pail

Source: Base map prepared from Microsoft Streets and Trips 2005.



Loon Lake
Loon Lake, Washington

Vicinity Map

17453-00 3/08

HARTCROWSER

Figure
1

EAL 03/31/08 1745300-001.dwg

Colville Road

Cedar Street

Pine Street

Maple Street

Garden Spot Road

See Inset 1

Highway 292

Neil Road

Morgan Road

Evan Road

Mackinaw Avenue

Highway 395

North Shore Drive

North Shore Lane

Park Lane

State Road

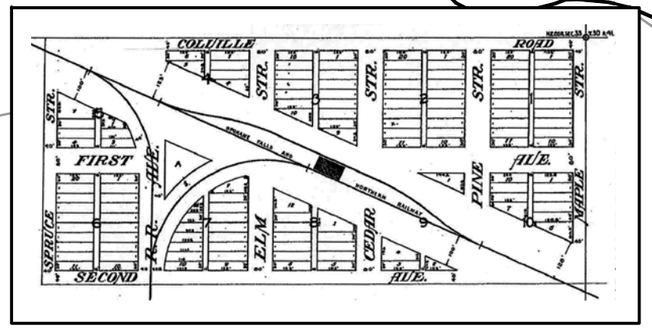
Loon Lake

Sunset Bay Road

Lynn Road

Sunset Drive

See Inset 2



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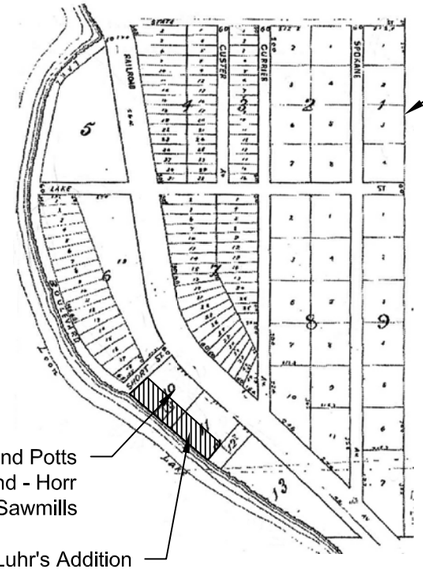


Inset 2

0 600 1200

Scale in Feet

N

Loon Lake
Loon Lake, Washington

Historical Features Map

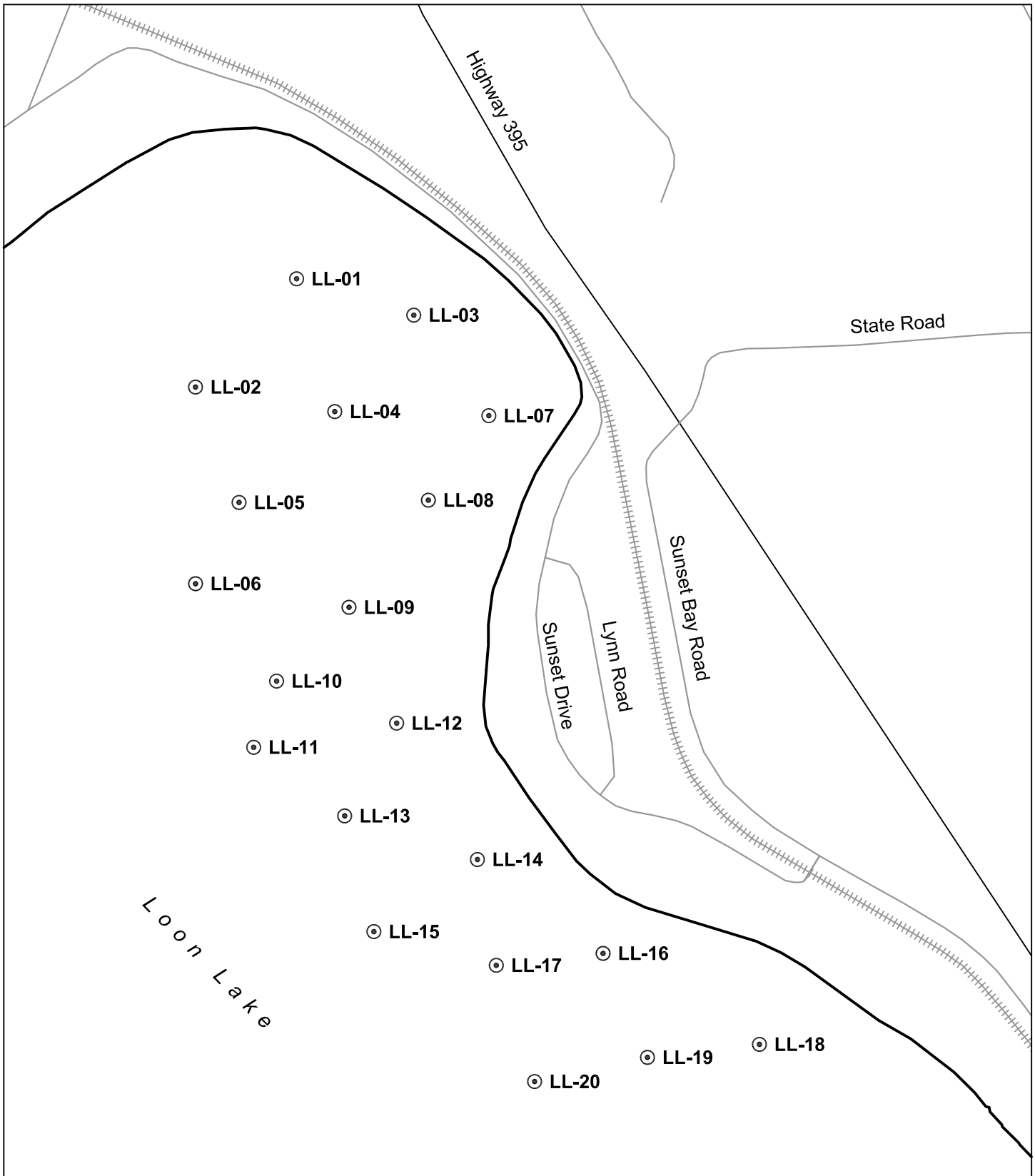
17453-00 3/08

HARTCROWSER

Figure
2

Source: Base map prepared from drawings provided by DNR 2008.

EAL 03/31/08 1745300-002.dwg



Loon Lake
Loon Lake, Washington

Sediment Sample Location Plan

17453-00 3/08

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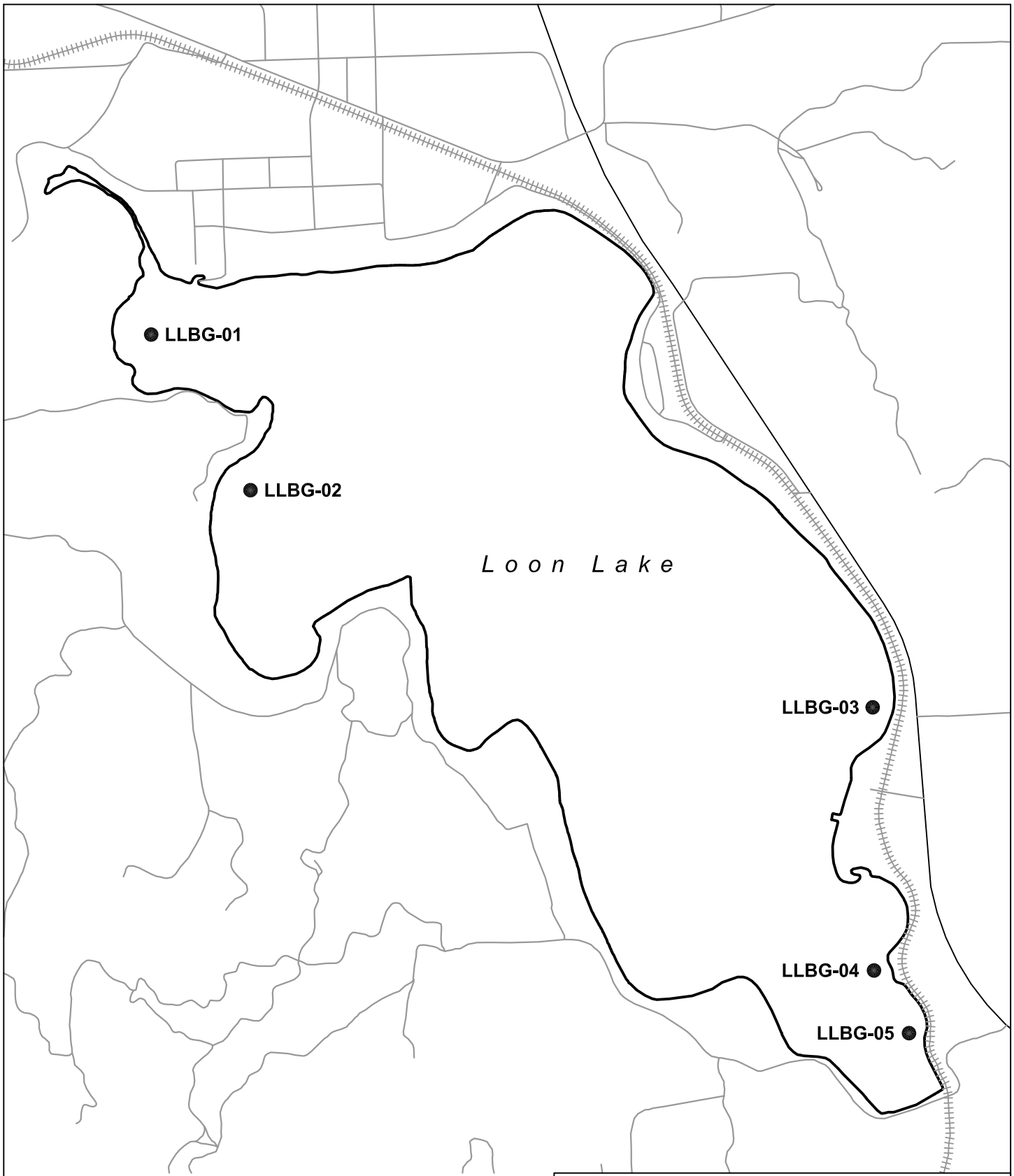
Figure
3

EAL 03/31/08 1745300-003.dwg



Source: Base map prepared from drawings provided by DNR 2008.

LLBG-03 ● Potential Reference Sediment Sample Location

0 1600 3200

Scale in Feet

N

Loon Lake
Loon Lake, Washington

Reference Sediment Sample Location Plan

17453-00 3/08

HARTCROWSER

Figure
4

EAL 03/31/08 1745300-004.dwg