Long-Term Monitoring and Reporting Plan for Sediment Remediation in Ward Cove

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September 2001

Doc. No.: 8600B0W.001 1903 0901 LJ14

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Acronyms and Abbreviations

AOC	area of concern
CoC	chemical of concern
EPA	U.S. Environmental Protection Agency
KPC	Ketchikan Pulp Company
MANOVA	multivariate analysis of variance
MLLW	mean lower low water
RAO	remedial action objective
RI/FS	remedial investigation and feasibility study
ROD	Record of Decision

Long-Term Monitoring and Reporting Plan for Sediment Remediation in Ward Cove

Introduction

This long-term monitoring and reporting plan for the Ward Cove area of concern (AOC) has been prepared for Ketchikan Pulp Company (KPC), the prior owner of the KPC facility. The long-term monitoring and reporting plan addresses the 80-acre AOC in the Marine Operable Unit, which is located in Ward Cove, Ketchikan, Alaska (Figure 1).

The unique physical and chemical characteristics of Ward Cove sediments and related risks were critical considerations in the selection of remedial measures. The natural degradation products of pulp mill by-product (i.e., ammonia, 4-methylphenol, and sulfide) are the likely source of sediment toxicity in Ward Cove. These degradation products are themselves non-persistent, and are readily oxidized in the environment. Pulp by-products were discharged historically by the pulp mill and accumulated over time in the adjacent sediments. Affected sediments contain pulp residue and wood debris, have high water and organic content, and are black in appearance. Concentrations of persistent chemicals that are toxic or that have the potential to bioaccumulate (e.g., mercury or polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans) were low and did not pose a risk to human health or wildlife (Exponent 1999). A risk to benthic infauna was predicted; however, a benthic community was present, with characteristics consistent with those documented for organic-rich areas. The cessation of pulping activities in May 1997 (i.e., complete control of effluent from the pulping process), the nature of the chemicals of concern (CoCs), and the potential for natural recovery were all considered during remedy selection.

Remedial action within the sediment AOC was performed between October 2000 and February 2001. Three general categories of remedial action were specified for the Ward Cove AOC in the U.S. Environmental Protection Agency's (EPA) Record of Decision (ROD) (U.S. EPA 2000): thin capping (estimated at 27 acres maximum), mounding (estimated at 1 acre minimum), and natural recovery (approximately 52 acres). Thin capping with 6–12 in. of clean sand was successfully implemented at all locations, including the 1 acre originally designated for mounding. Approximately 27 acres were thin capped. The remaining 52 acres will be subject to monitored natural recovery. Dredging was performed adjacent to the main dock and near the barge access area to address access issues and future use of the docking area. Details of sediment remediation efforts are described in the *Remedial Action Work Plan—Ward Cove Sediment Remediation* (Foster Wheeler 2000), the *Final Construction Report—Ward Cove Sediment Remediation* (Foster Wheeler 2001a), and the *Final Water Quality Monitoring Report—Ward Cove Sediment Remediation* (Foster Wheeler 2001b). The remedial

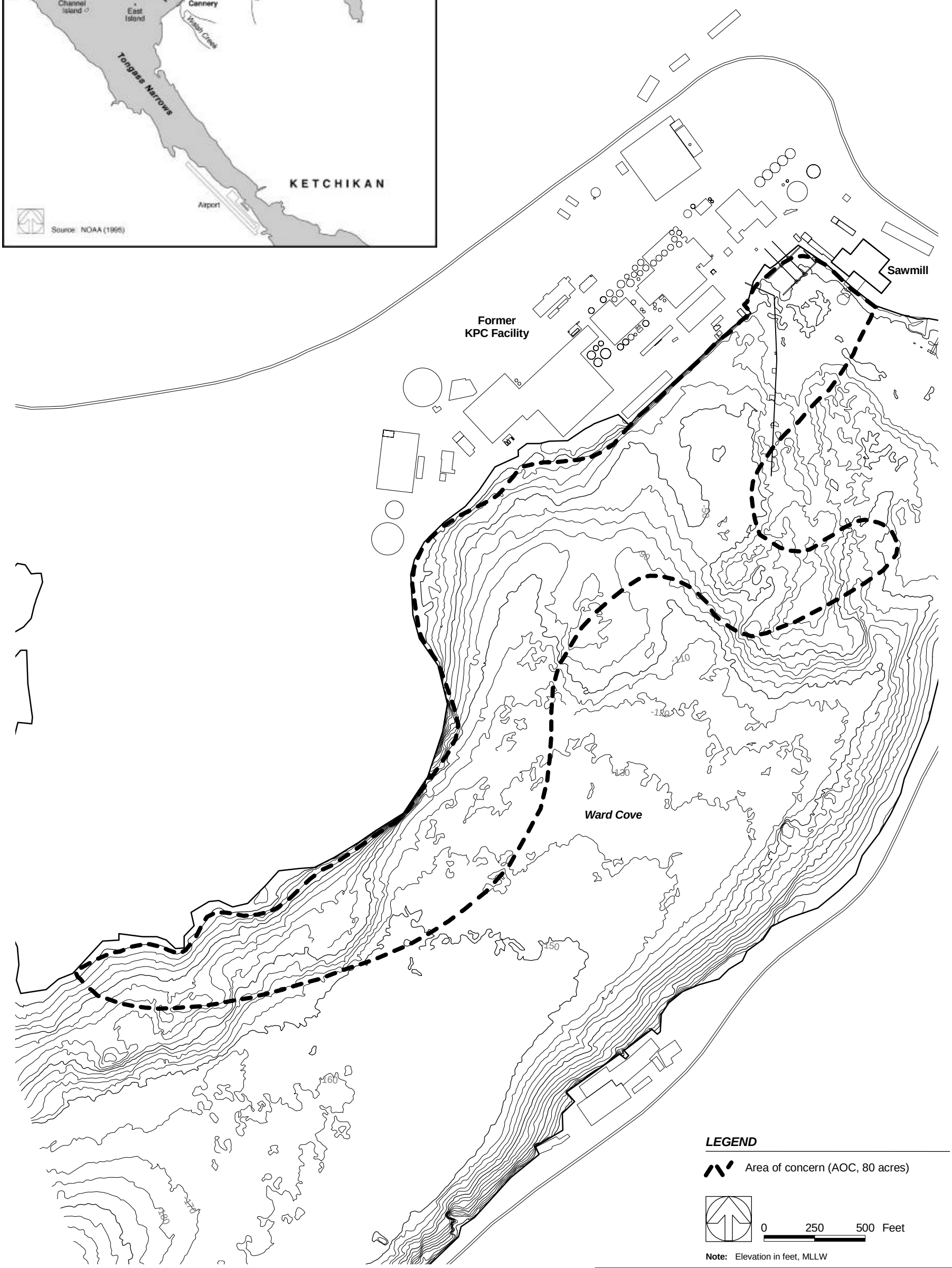

Figure 1. Ward Cove area of concern

investigation and feasibility study (RI/FS),[1] conducted as part of the detailed technical studies for Ward Cove, was completed in 1999 (Exponent 1999). Early stages of the project (through the RI/FS) were performed in compliance with a 1995 Consent Decree between EPA and KPC. Later activities (remedial action, long-term monitoring) are conducted in compliance with a 2000 Consent Decree between EPA, KPC, and Gateway Forest Products (No. A00-225CV (JKS)).

This document presents the monitoring objectives, an overview of the monitoring approach, the monitoring program design, and a discussion of the methods to be used for data analysis and interpretation. In addition, a field sampling plan, a quality assurance project plan, standard operating procedures, example field forms, and a health and safety plan are provided as appendices.

Monitoring Objectives

Remedial action objectives (RAOs) provide a general description of what the cleanup action will accomplish and represent EPA's goals for addressing risk at the site. The long-term success of the sediment remedy (or response action) for Ward Cove will be assessed by monitoring measurement endpoints that directly relate to RAOs. EPA identified RAOs in the ROD (U.S. EPA 2000) on the basis of the ecological evaluation, as follows. To eliminate or minimize the ecological risks associated with the toxicity of Ward Cove sediment to benthic organisms, the response action is intended to:

- Reduce toxicity of surface sediments
- Enhance recolonization of surface sediment to support a healthy marine benthic infauna community with multiple taxonomic groups.

The monitoring program described in this document is designed to evaluate progress made in achieving sediment RAOs following completion of remedial activities in Ward Cove.

The primary objectives of the Ward Cove monitoring program are to:

- Compare sediment toxicity in thin capped and natural recovery areas in the AOC with sediment toxicity in reference areas located elsewhere in the cove
- Compare the characteristics of benthic communities in thin capped and natural recovery areas in the AOC with the characteristics of communities in reference areas located elsewhere in the cove

[1] The complete name of the report is *Ward Cove Sediment Remediation Project, Detailed Technical Studies Report, Remedial Investigation and Feasibility Study* (two volumes).

- Evaluate temporal trends in sediment toxicity in the thin capped and natural recovery areas of the AOC
- Evaluate temporal trends in the characteristics of benthic macroinvertebrate communities found in the thin capped and natural recovery areas of the AOC
- Evaluate chemical concentrations and their relationship to sediment toxicity and benthic community structure.

The information collected to satisfy the objectives described above will be used to provide an assessment of how sediment toxicity and benthic communities in thin capped and natural recovery areas are changing over time, as well as how similar the evolving communities are to those of reference areas at various points in time. This information will be used to determine the degree to which sediment recovery is occurring, as well as when it is projected to be complete.

Overview of Monitoring Approach

The monitoring program will evaluate three major indicators of sediment quality: 1) sediment chemistry, 2) sediment toxicity, 3) and benthic macroinvertebrate communities. These indicators will be evaluated on sediment samples representing the surface (i.e., 0–10 cm horizon) of sediments. Sediment chemistry and toxicity were assessed during the RI/FS and therefore these monitoring components can be compared to pre-remedial conditions as well as to reference areas. Temporal trends in sediment chemistry, sediment toxicity, and benthic infauna will be evaluated from multiple monitoring events. Analytical methods for chemistry and toxicity testing will be the same as those used in the RI/FS (Exponent 1999). Benthic infauna measurements will be compared only to reference area conditions.

The specific components of sediment quality used for the Ward Cove monitoring program are as follows:

- **Sediment Chemistry—**Each surface sediment sample (0–10 cm horizon) will be analyzed for ammonia and 4-methylphenol. These analytes were identified as CoCs in the RI/FS and ROD and will assist in the interpretation of sediment toxicity data. Sediments will also be analyzed for grain size distribution, organic content, and total solids, because those three variables can influence the composition of benthic communities.
- **Sediment Toxicity—**The potential toxicity of each surface sediment sample (0–10 cm horizon) will be evaluated using the 10-day amphipod test based on *Rhepoxynius abronius*. This test is commonly used to evaluate sediment toxicity on the west coast of the United

States (Becker et al. 1990; Swartz et al. 1982; Williams et al. 1986; Chapman et al. 1987) and has standardized and well-established test protocols (PSEP 1995). In addition, this test was used to characterize sediment toxicity in Ward Cove in the RI/FS, and test responses were found to be potentially related to sediment concentrations of ammonia and/or 4-methylphenol. Because *R. abronius* has been documented to be sensitive to chemical toxicity and because it is a free-burrowing organism that is directly exposed to sediment contaminants, it will provide an environmentally conservative assessment of the changes in sediment toxicity that will occur following remedial activities in Ward Cove. The response of *R. abronius* relative to the four toxicity tests conducted in Ward Cove is described in greater detail in the RI/FS (Exponent 1999) (e.g., two of the four tests demonstrated no adverse effects throughout the study area).

- **Benthic Communities—**The characteristics of benthic communities in various parts of Ward Cove will be evaluated directly by collecting and enumerating the organisms found in surface sediment samples (0–10 cm horizon) collected from the site. Benthic communities are commonly used to assess sediment quality because these organisms are relatively stationary and live in close association with bottom sediment (U.S. EPA 1990). The communities in Ward Cove will be sampled using standardized methods and analyzed using a variety of common techniques to ensure that the data are quantitative in nature and that results are analyzed in an objective manner.

Sampling of the AOC at Ward Cove will occur every third year in July after completion of the remedial activities (i.e., 2004, 2007, and 2010) until RAOs are achieved, as determined by EPA. If RAOs are not achieved by Year 10 (2010), EPA anticipates that those localized areas that have not recovered will continue to be monitored through Year 20 (2020) at reduced frequency, consistent with the long-term monitoring and reporting plan. Long-term monitoring issues are discussed in Section 11.2 of EPA's ROD, and in Response to Comments 30 and 54 in the ROD. Although seasonal variations in benthic macroinvertebrate communities have not been characterized in Ward Cove, past studies in the deeper parts of Puget Sound (Lie 1968) suggest that both numbers of individuals per sample and variability among stations are lowest during the late winter and highest during the late summer. This pattern is likely related to the recruitment cycles of many species. PSEP (1987) concluded that late winter may be the optimal time to sample benthic communities in Puget Sound, when population estimates are less variable. However, because low oxygen conditions may be found in some deeper waters of Ward Cove during late summer, it is preferable to sample benthic communities in July (i.e., prior to the onset of the oxygen depletion) so that the characteristics of the communities will not be affected by potential low oxygen levels. Although community characteristics may be more variable in July than later in the year, they will not be confounded by the potential depletion of oxygen.

There are no unacceptable human health or wildlife risks associated with the sediment AOC; risks to benthos are the driver for the selected remedy and the long-term monitoring. A three-year delay between remedy implementation and sampling was selected to allow initial recolonization of the benthos following thin capping. For the natural recovery areas, modeling and an assessment of case studies (Exponent 1999, Section 9) indicated that recovery of benthic macroinvertebrate communities is expected to occur within 10 years but may take as long as 20 years (as estimated from the conditions in 1996 and 1997). Initial sampling in 2004 allows for both recolonization of the thin capped area and natural recovery in selected portions of the AOC. Increments of three years allow progress to be assessed over the time scale where recolonization is typically effective.

The details of the design of the monitoring program are presented in the following section.

Monitoring Program Design

The design of the benthic monitoring program for Ward Cove builds on different categories of benthic strata, which are based on water depth and on the kind of remedial action taken. Multiple sampling stations will be evaluated within each benthic stratum to estimate average (or mean) conditions in the stratum and to provide a measure of within-stratum variability so that statistical analyses can be conducted. The mean values of monitoring variables (e.g., chemical concentrations, sediment toxicity responses, and benthic community characteristics) within each stratum will then be compared statistically on both a temporal and spatial basis. The temporal evaluations will involve comparisons of monitoring variables for each benthic stratum among different sampling periods, whereas the spatial comparisons will involve comparisons of monitoring variables between each thin capped or natural recovery area with conditions in the corresponding reference area during the same sampling period.

An additional kind of quantitative comparison will be made for the sediment toxicity responses, in which results at four representative stations (Stations 8, 9, 13, and 38) will be compared with results obtained in 1995–1996 for the RI/FS. These four stations were selected because the 1995–1996 data at these locations showed exceedances of site-specific sediment quality values for CoCs and exceedances of the sediment quality standard for the *Rhepoxynius abronius* toxicity test. The four monitoring stations will be positioned at the same locations used for the RI/FS in 1995–1996. Similar comparisons will not be made for benthic community variables because benthic communities were not evaluated in the RI/FS. The details of the various monitoring components are described below.

Qualitative observations of benthic community characteristics will be made to assess whether the evolving communities are following the classical patterns of colonization and recovery for disturbed benthic habitats described in the RI/FS (Exponent 1999). Those patterns include initial colonization by “pioneering” species, subsequent modification of physical/chemical characteristics, and final colonization by deeper dwelling “equilibrium” species (Rhoads et al. 1977, 1978; Pearson and Rosenberg 1978; Rhoads and Boyer 1982). Quantitative methods are discussed below.

Sampling Strategy for Benthic Monitoring

The characteristics of benthic communities can be influenced by water depth and sediment character. Therefore, the AOC is subdivided as follows:

- **Water depth (4 strata):** Water depth strata are defined as very shallow areas (<20 ft water depth at mean lower low water [MLLW]), shallow areas (20–70 ft MLLW), moderately deep areas (70–120 ft MLLW), and deep areas (>120 ft MLLW).
- **Remedial action (2 strata):** Remedial action strata are defined as either thin capped areas or natural recovery areas.

The shallow, natural recovery stratum is further subdivided into an area with thick organic deposits (>5 ft) adjacent to the former pulp mill and an area with more limited organic deposits along the north shore near the mouth of the cove. A delineation of the area with thick organic deposits is provided in the RI/FS (Exponent 1999, Figure 10-5). The toxicity and benthic infauna data associated with each of these strata classifications will be evaluated following the initial monitoring event to determine if there are patterns in benthic infauna or toxicity that suggest that the water depth, remedial method, or organic thickness are relevant to data interpretation. If not, strata classifications may be eliminated or redefined for future sampling events.

An overview of the sampling strata for benthic monitoring is presented in Table 1.

Because the characteristics of benthic macroinvertebrate communities are strongly influenced by sediment character and water depth, it is essential that the reference stations selected for use in Ward Cove be similar to the remediated areas with respect to both of those variables. They should therefore be located in areas of similar depth and slope and should not differ substantially with respect to various sediment characteristics such as grain size distribution, total organic carbon content, and presence/absence of debris (e.g., bark). The reference areas should also be relatively free from sediment contamination, although they should be representative of any generalized background condition found throughout an area. The extensive amount of sediment information collected during the RI/FS studies in 1996 and 1997 provide a sufficient amount of information with which reference areas can be identified with a reasonable amount of confidence.

Reference areas are located in Ward Cove but outside the AOC at depths that correspond to the shallow (20–70 ft MLLW) and moderate (70–120 ft MLLW) strata used for the AOC. Reference areas are also located away from other potential sources of contaminants. The long-term monitoring reference stations are positioned in the vicinity of 1995–1996 stations that showed no exceedances of the lowest site-specific sediment quality values for CoCs and no exceedances of the lowest sediment quality values for toxicity tests (see Sections 7 and 8 of the RI/FS). The shallow reference area, Station Cluster 96, will be located near Station 26 and the moderate reference area,

Table 1. Overview of sampling strata

Stratum ID	Depth Category (ft MLLW)	Remediation Category	Benthic Stations	Bioassay Stations (laboratory replicates)
1	Very shallow (<20)	Thin capping	5, 66, 67, 68, 69	5 (1), 66 (1), 67 (1), 68 (1), 69 (1)
2a	Shallow (20–70)	Thin capping	9, 72, 73, 74	9 (5), 72 (1), 73 (1), 74 (1)
2b	Shallow (20–70)	Natural recovery (thick organic deposits)	38, 70, 71, 75, 76, 77, 78	38 (5), 70 (1), 71 (1), 75 (1), 76 (1), 77 (1), 78 (1)
2c	Shallow (20–70)	Natural recovery (thin organic deposits)	47, 89, 90, 91, 92	47 (1), 89 (1), 90 (1) 91 (1), 92 (1)
3a	Moderate (70–120)	Thin capping	8, 48, 83, 84, 93, 94	8 (5), 48 (1), 83 (1), 84 (1), 93 (1), 94 (1)
3b	Moderate (70–120)	Natural recovery	6, 79, 80, 81, 82	6 (1), 79 (1), 80 (1), 81 (1), 82 (1)
4	Deep (>120)	Natural recovery	13, 85, 86, 87, 88	13 (5), 85 (1), 86 (1), 87 (1), 88 (1)
5a	Shallow (20–70)	Reference	96 (5 field replicates)	96 (5 field replicates, 1 laboratory replicate each)
5b	Moderate (70–120)	Reference	95 (5 field replicates)	95 (5 field replicates, 1 laboratory replicate each)

Note: MLLW - mean lower low water

Station Cluster 95, will be located near Station 40. The exact locations of the stations within each reference area will target the appropriate water depths, and will be determined in the field by the field team leader. Samples from the very shallow (<20 ft MLLW) and deep (>120 ft MLLW) strata within the AOC will be compared against the shallow and moderate reference areas, respectively. The adequacy of these reference stations will be assessed after the first monitoring year.

Use of the shallow reference area for evaluation of the very shallow thin-capped area is consistent with the Washington State Department of Ecology's combined evaluation of benthic communities at all depths less than 150 ft (Ecology 1996). The only comparably shallow areas within Ward Cove are adjacent to the mouth of Ward Creek, where sediment grain size and salinity are unlikely to be comparable to those within the thin-capped area.

Station Locations and Replication

The distribution of sampling stations throughout the various benthic strata of the AOC in Ward Cove is presented in Figures 2a and 2b. In accordance with the ROD (U.S. EPA 2000, p. 74), long-term monitoring stations are not located within the sawmill

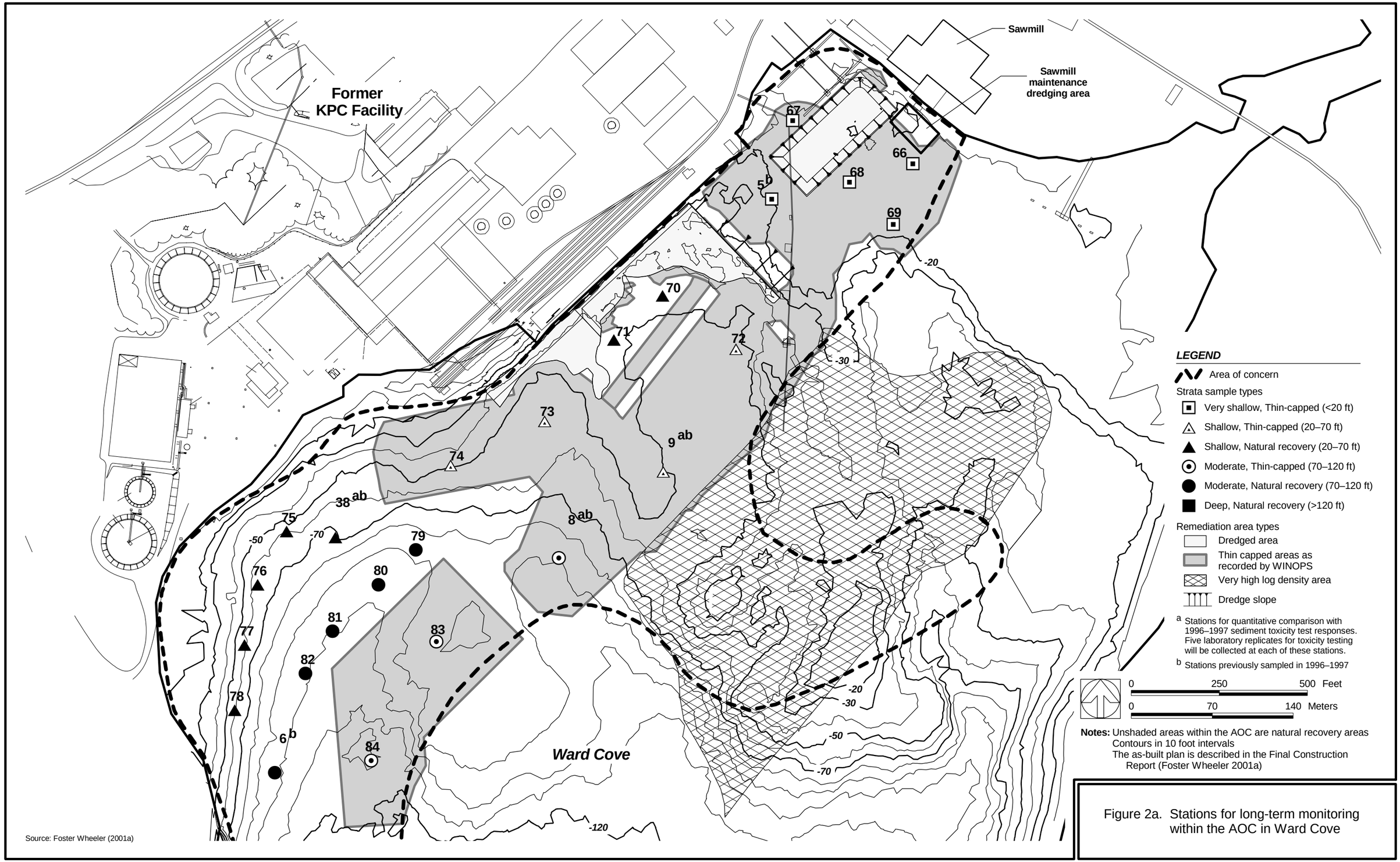

Figure 2a. Stations for long-term monitoring within the AOC in Ward Cove

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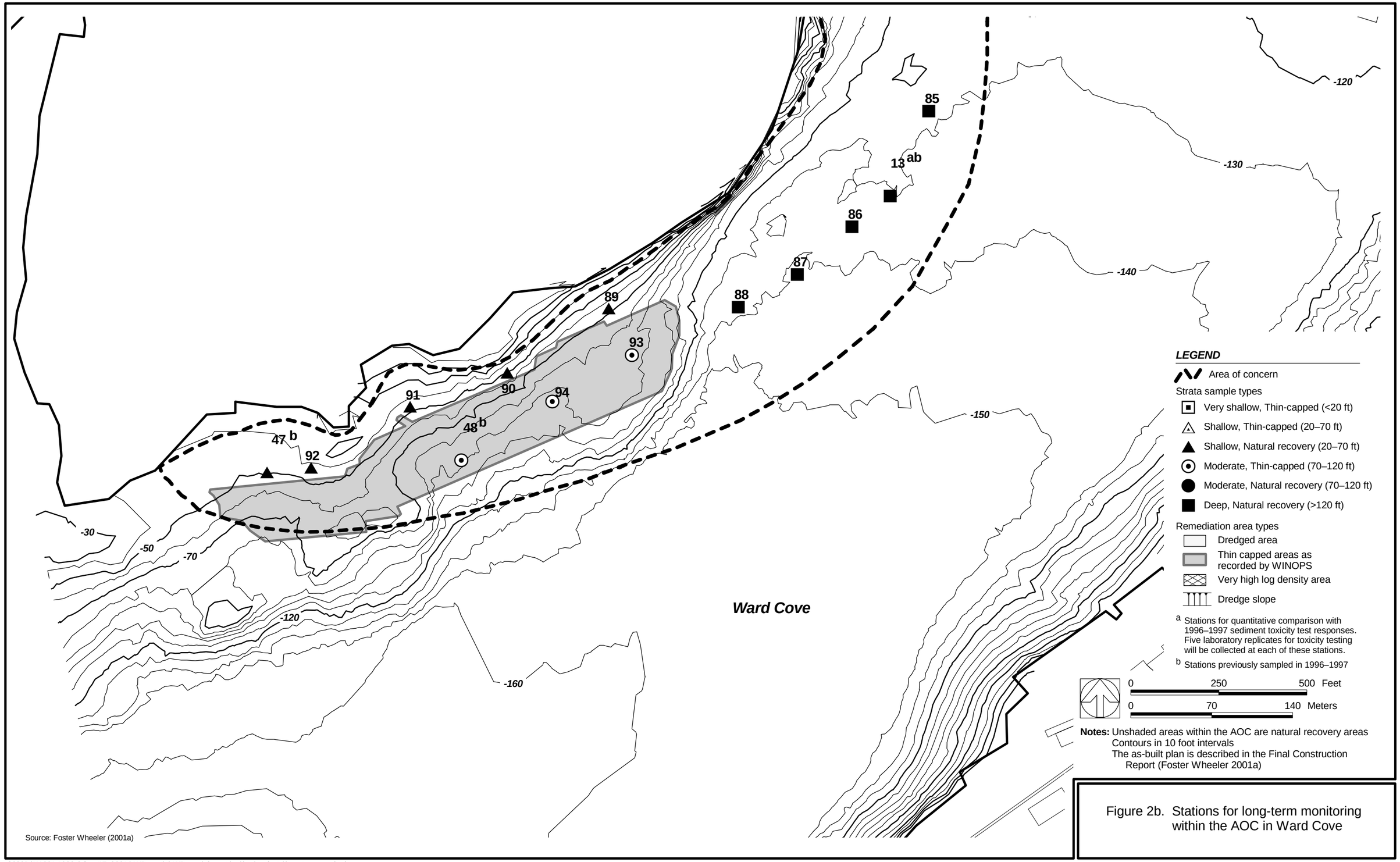

Figure 2b. Stations for long-term monitoring within the AOC in Ward Cove

maintenance dredging area or the very-high density areas of sunken logs. Reference locations are shown in Figure 3. As discussed previously, multiple stations will be located in each kind of benthic stratum. However, single samples will be collected at each station within the AOC and at the reference areas, instead of replicate samples (as was done in the RI/FS). In this manner, a greater number of stations can be distributed throughout each stratum, so that the characteristics of benthic assemblages and sediment toxicity results can be adequately evaluated on the scale of the stratum rather than on the scale of individual stations. The use of replicates that are spatially distributed throughout a stratum is consistent with the approach used by the Puget Sound Ambient Monitoring Program (Llansó et al. 1998a,b), by the National Oceanic and Atmospheric Administration's National Benthic Surveillance Project (NOAA 1993), and by EPA's Environmental Monitoring and Assessment Program.

An exception to the replication scheme described above will be made for the subset of four stations selected for the comparison of sediment toxicity results for the monitoring program with results obtained in 1995–1996 in the RI/FS (i.e., Stations 8, 9, 13, and 38). Each of those stations will be positioned at the location sampled in 1995–1996, and number of replicate toxicity tests evaluated at each of those stations will be the same as the number evaluated during the earlier studies (i.e., five). In that manner, results can be compared among time periods using the same level of replication.

Field Sampling Methods

Sediment samples will be collected in a manner consistent with the methods used in 1995–1996 in the RI/FS. Briefly, sediment at each station will be collected using a 0.06-m^2 stainless steel van Veen grab sampler. For chemical and toxicity analyses at each station, the top 10 cm of sediment in one or more grab samples will be transferred to a stainless steel bowl and homogenized until uniform in texture and color. Subsamples will then be transferred to appropriate containers and shipped to the laboratories for chemical analysis and sediment toxicity evaluations.

Sediments collected for benthic community analysis will be sieved sequentially using mesh sizes of 1.0 and 0.5 mm. However, initial laboratory taxonomic analyses will be conducted only on the organisms retained on the 1.0-mm screen, whereas organisms retained on the 0.5-mm screen will be archived for potential future analysis. Analysis of archived samples may be conducted if benthic recovery appears to be slower than expected. Because the 0.5-mm mesh screen will capture smaller organisms than the 1.0-mm mesh screen, the former samples can be used to evaluate whether adults of smaller species or juveniles of any species are present in areas where relatively small numbers of organisms larger than 1.0 mm are found. Retained material will be transferred to appropriate containers, fixed with formalin, and transferred to the laboratory for taxonomic analysis.

A detailed description of all field sampling methods is presented in the field sampling plan (Appendix A).

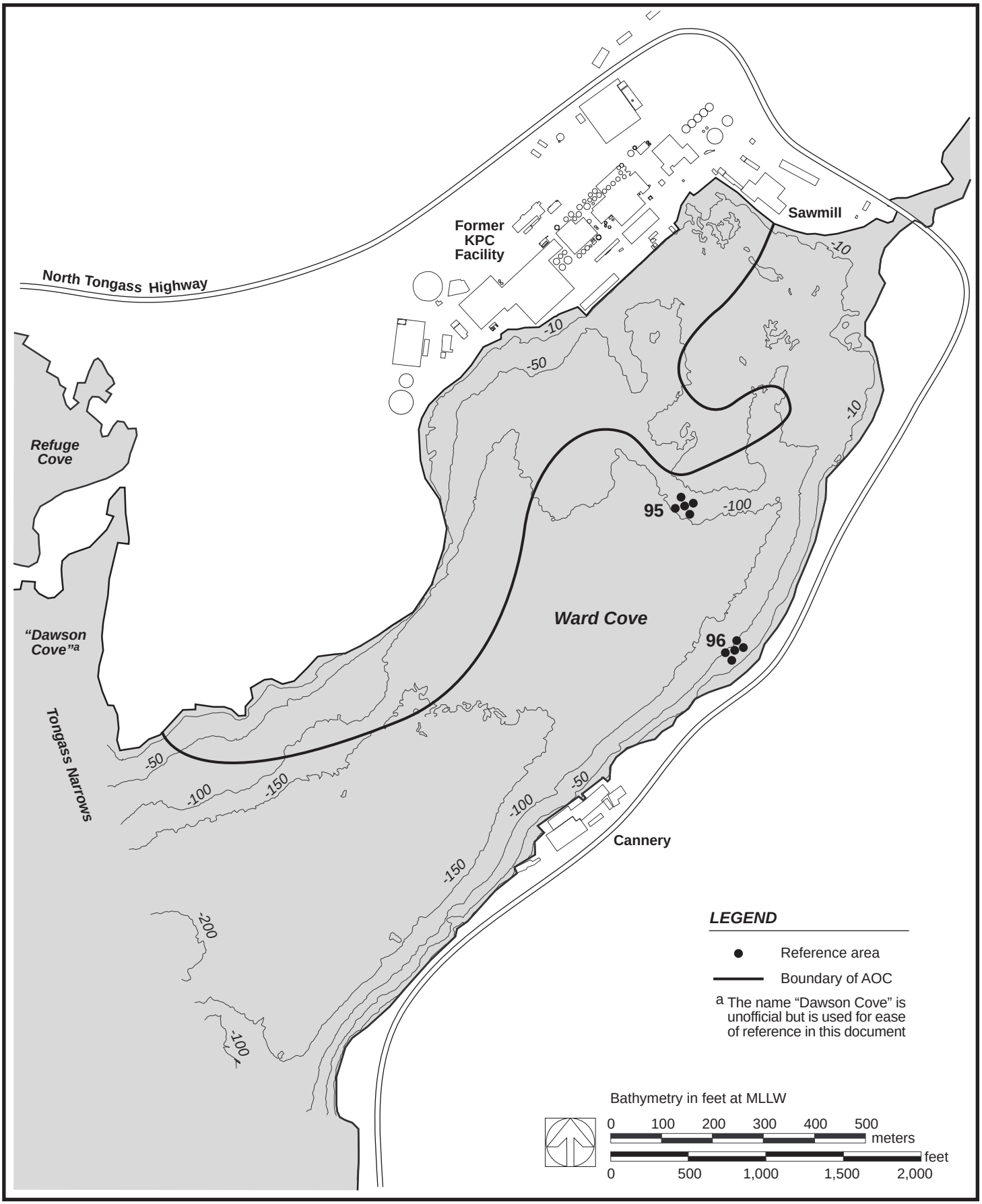

Figure 3. Reference areas for long-term monitoring in Ward Cove

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Laboratory Methods

The methods used to analyze sediment samples for ammonia, 4-methylphenol, grain size distribution, organic content, and total solids will be consistent with those used in the RI/FS in 1995–1996. The analyses will be completed as follows:

- Ammonia: EPA Method 350.3 (U.S. EPA 1983), a potentiometric procedure for ammonia in water, modified to include sediment extraction with 2M potassium chloride
- 4-Methylphenol: EPA Method 3550B (U.S. EPA 1996), gas chromatography/mass spectrometry with selected ion monitoring
- Grain size distribution: PSEP (1986), wet sieving and pipet analysis for gravel, sand, silt, and clay
- Organic carbon: Standard Method 5310B (Franson 1992), sample combustion and infrared detection, with modifications to accommodate the sediment matrix
- Total solids: PSEP (1986), gravimetric analysis.

The methods used to conduct the 10-day sediment toxicity tests based on *Rhepoxynius abronius* will be consistent with those used in the RI/FS in 1995–1996, which are based on PSEP (1995). A major exception will be that a single sample at each location will be analyzed at all but four of the sampling locations. In contrast, five replicate samples were analyzed for each sediment sample collected in the RI/FS. As discussed previously, sediments from four representative monitoring stations will be analyzed using five laboratory replicates so that the monitoring results can be compared with the results obtained in the RI/FS using the same level of replication.

The methods used for the identification and enumeration of the benthic macroinvertebrates collected during the monitoring program will be consistent with the methods recommended by PSEP (1987) and will ensure that samples are analyzed in a quantitative and accurate manner. Major elements of the benthic analyses will be that sediment samples will be sorted with a minimum accuracy of 95 percent and that taxonomic identifications will be made to the lowest taxonomic level practical by qualified experts. As discussed previously, initial taxonomic analyses will be conducted only on the organisms retained on the 1.0-mm screen, whereas organisms retained on the 0.5-mm screen will be archived for potential future analysis.

A detailed description of all laboratory analytical methods is presented in the quality assurance project plan (Appendix B).

Data Analysis and Interpretation

Post-remediation monitoring data will be evaluated using two types of analyses, each of which is intended to address different aspects of progress toward recovery of the benthic community:

- Comparison of thin capped and natural recovery areas to reference areas
- Evaluation of temporal trends in thin capped and natural recovery areas.

Comparison to reference areas will allow a definitive decision to be made regarding the completion of recovery in thin capped and natural recovery areas. If, at the time of any monitoring event, recovery is not complete, then evaluation of temporal trends will allow the rate of progress toward recovery to be evaluated. The evaluation processes is presented schematically in Figure 4.

Reference area comparisons and temporal analyses will be carried out using both benthic infauna and bioassay data. Benthic infauna abundances will be given the greatest weight with regard to conclusions reached, because *in situ* conditions are a better reflection of sediment quality.

The status of recovery will be determined using the results of the sediment toxicity tests (i.e., amphipod survival), as well as results of various kinds of benthic evaluations. The benthic evaluations will include comparisons between the remediated and reference areas with respect to the following metrics:

- **Total abundance:** the total number of benthic organisms in each sample
- **Total richness:** the total number of benthic taxa in each sample
- **Swartz's dominance index:** the minimum number of taxa that account for 75 percent of total abundance
- **Major taxa abundance:** the total number of organisms in each major taxon (molluscs, polychaetes, crustaceans, echinoderms, and others)
- **Major taxa richness:** the number of taxa in various major taxonomic groups (molluscs, polychaetes, crustaceans, echinoderms, and others).

All of the benthic metrics described above have been found to be effective assessment tools in benthic monitoring programs in Puget Sound (SEA and Weston 1999). Although several other benthic metrics were evaluated for use in Puget Sound (e.g., species diversity, evenness), they were not selected for use in monitoring programs (SEA and Weston 1999).

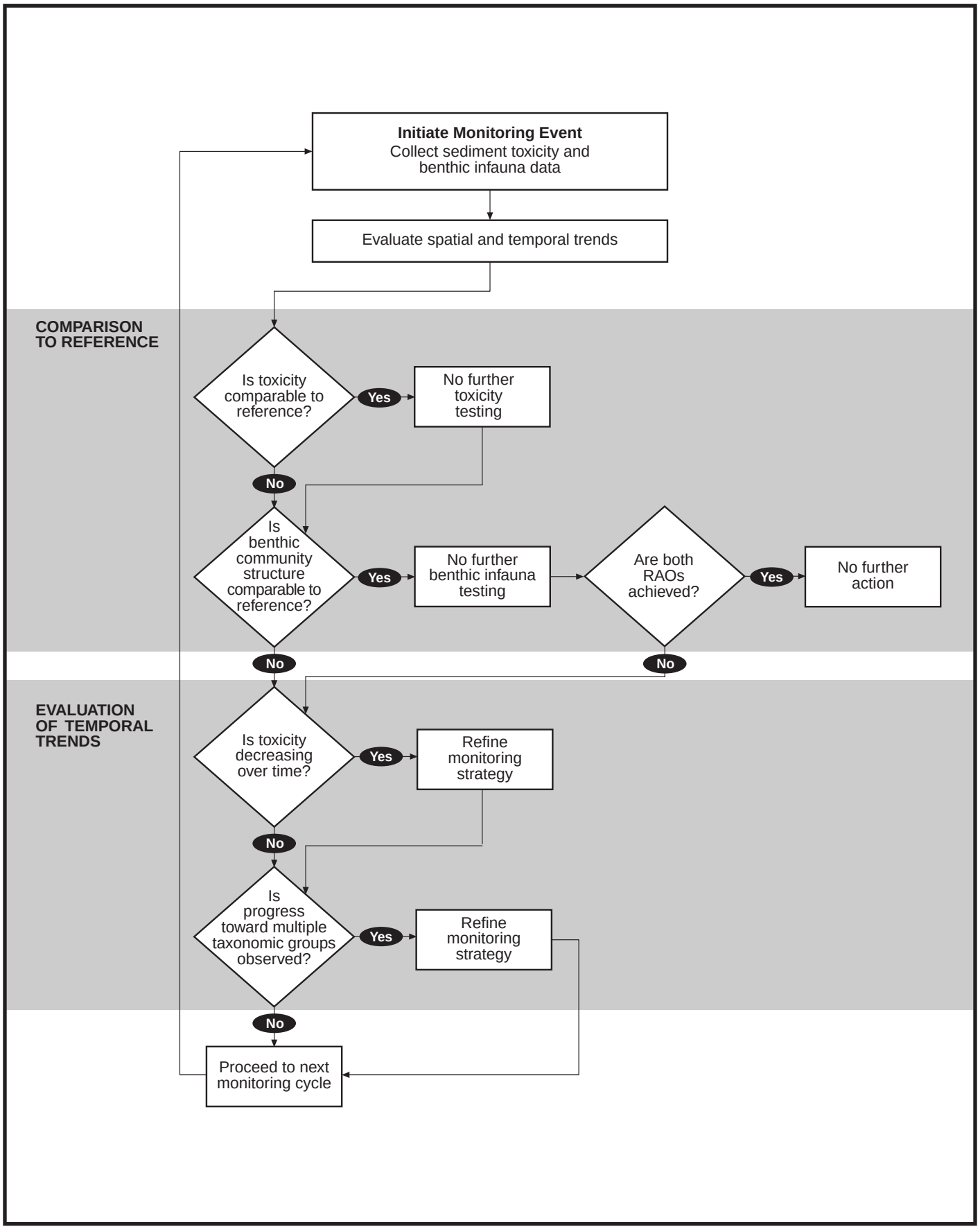

Figure 4. Overview of process for evaluating monitoring data

As discussed previously, qualitative observations of benthic community characteristics will also be made to determine whether the communities are recovering according to the classical patterns identified for disturbed benthic habitats (e.g., Pearson and Rosenberg 1978; Rhoads et al. 1977, 1978; Rhoads and Boyer 1982). Those patterns include initial colonization by "pioneering" species, subsequent modification of physical/chemical characteristics, and final colonization by deeper dwelling "equilibrium" species. In general, equilibrium species are associated with a deeply oxygenated sediment surface where the redox potential discontinuity commonly reaches depths of greater than 10 cm. The earliest benthic communities in the recovery process tend to consist of large numbers of a few species, whereas the equilibrium communities are characterized by a greater number of species and a more even distribution of individuals among species. The pioneering species are generally small, opportunistic, tube-dwelling polychaetes, which are often followed by tube-dwelling amphipods. Most pioneering species feed near the sediment surface or from the water column and are thereby largely isolated from potentially toxic conditions in deeper sediments. The activities of these species (e.g., bioturbation, irrigation, particle reworking) modify the physical/chemical properties of the sediments so that additional species can colonize them.

It is expected that benthic recovery in Ward Cove will follow the classical pattern described above. To help determine the degree of recovery during each sampling event, the identities and relative abundances of the benthic species found in the sediments will be compared with literature accounts of life history characteristics to determine the stages of recovery of the various benthic communities and the degrees of similarity with communities in the reference areas. Both numerically dominant and non-numerically dominant taxa will be considered.

Monitoring data from the different strata of thin capped and natural recovery areas will be analyzed separately. Each stratum will be treated as a single unit during analysis of recovery progress. That is, recovery of the benthic community will be assessed for each stratum as a whole rather than for individual stations within any stratum. Any observed variability between stations within a stratum will be used to assess the statistical significance of differences from reference areas—or differences over time—for the entire stratum rather than to evaluate differences in the progress of recovery at individual points.

Individual benthic infauna and toxicity samples will be spatially distributed throughout each stratum to allow an overall assessment to be conducted (see Figures 2a, 2b, and 3). All of the individual samples from within a stratum will be treated as replicates for the purpose of data analysis.

Because of the number of qualitative and quantitative measures that will be used to evaluate achievement of the RAOs, there may be conflicting indications of progress after any monitoring event. The number of combinations of such conflicting indications is very large: the number of indicators in conflict, the ecological relevance of each, the strength of the conflicting indications, and the interactions between trends and states all

may vary. Because of the large number of possible cases, this monitoring plan does not attempt to enumerate all the combinations or to prescribe the actions to be taken in each case. Appropriate interpretation of monitoring data therefore relies on application of relevant technical expertise.

Comparison to Reference Areas

Recovery of the Ward Cove benthic community will be considered to be complete when there is no statistically significant difference between both toxicity and benthic infauna in any of the thin capped or natural recovery areas and conditions at the reference stations. Therefore, all of the areas will be evaluated in a single analysis. A summary of the methods that will be used to make comparisons with reference conditions is presented in Table 2. For the sediment toxicity tests, if the reference results are not considered valid estimates of true reference conditions, the results of the laboratory negative controls will be used for comparisons with results from the remediated areas.

Species richness, species abundance, Swartz's dominance index, and sediment toxicity will be evaluated using Dunnett's test. Data may be transformed prior to analysis, depending on the characteristics of the data. Major taxa richness data will be evaluated using the technique of multivariate analysis of variance (MANOVA), to account for the multiple dependent variables (major taxon abundances). Separate Dunnett's tests will be carried out for data from each sampling stratum. This analysis will be conducted after each monitoring event.

If differences in major taxa richness or abundance are found by the MANOVA analysis, the nature and extent of the changes will be evaluated with regard to biological significance and consequences.

Any significant ($p \leq 0.05$) pairwise differences found for amphipod survival will be subjected to an additional screening step to ensure that the differences are more than statistical artifacts. For amphipod mortality, differences must be statistically significant and the absolute value of survival must be less than 75 percent. This screening criterion has been found to be effective during extensive use in Washington State (Ecology 1998).

In addition to the screening steps described above, the minimum detectable difference for each statistical comparison will be calculated for a range of power (e.g., 0.6, 0.7, 0.8) for each non-significant result. The results will then be evaluated to ensure that there was sufficient statistical power to reasonably discriminate a significant difference. A stepwise description of the statistical analyses to be conducted is included in Appendix F.

After the first monitoring year, monitoring results from individual strata will be interpreted in relation to RAOs. If conditions are comparable to reference for both toxicity and benthic infauna in a specific stratum (i.e., RAOs have been achieved), no further monitoring or possibly surrogate monitoring parameters (e.g., monitoring of grain size or sediment profile imaging) may be recommended to EPA. During subsequent

Table 2. Summary of planned methods of data analysis for evaluating recovery of benthic macroinvertebrate communities in Ward Cove

Analysis	Data Analyzed	Statistical Test
First Monitoring Year (2004)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity compared to RI/FS data	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Other Stations		
Benthic community analyses		
Successional stage	Species identities, abundances, and successional stage ("pioneering" or "equilibrium")	N/A
Total richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Total abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic major taxa abundance compared to reference areas	Total number of individuals of each major taxon	MANOVA
Benthic major taxa richness compared to reference areas	Total number of species in each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Second Monitoring Year (2007)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to RI/FS and Year 1 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Table 2. (cont.)

Analysis	Data Analyzed	Statistical Test
Other Stations		
Benthic community analyses		
Successional stage	Species identities, abundances, and successional stage	N/A
Taxonomic richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic community structure compared to reference areas	Total number of individuals of each species	MANOVA
Taxonomic richness trend	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance trend	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index trend	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic major taxa abundance trend	Total number of individuals of each major taxon	MANOVA
Benthic major taxa richness trend	Number of species of each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to Year 1 data	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Third Monitoring Year (2010)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to RI/FS and Year 1 and Year 2 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Table 2. (cont.)

Analysis	Data Analyzed	Statistical Test
Other Stations		
Benthic community analyses		
Successional stage	Species identities and abundances	N/A
Taxonomic richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic community structure compared to reference areas	Total number of individuals of each species	MANOVA
Taxonomic richness trend	Number of species in site strata and reference areas	Regression (p = 0.05 for slope)
Organism abundance trend	Total number of organisms	Regression (p = 0.05 for slope)
Swartz's dominance index trend	Number of taxa making up 75 percent of total abundance	Regression (p = 0.05 for slope)
Major taxa abundance trend	Total number of individuals of each major taxon	MANOVA
Major taxa richness trend	Number of species of each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to Year 1 and Year 2 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Note: MANOVA - multivariate analysis of variance
RI/FS - remedial investigation and feasibility study

monitoring events, demonstration of significant improvements over time (i.e., reductions in toxicity or increases the number of taxonomic groups) may result in recommendations to EPA to modify the monitoring design. The AOC is highly variable in terms of water depth, slope, sediment texture, and physical complexity; benthic infauna communities are expected to vary in response to this habitat diversity. In addition, seasonally low oxygen conditions are observed in the deeper water of Ward Cove, probably associated with the elevated organic loads discharged by a local fish processor and aggravated by seasonal stratification and nutrient recycling. These variable conditions and stressors are likely to affect benthic infauna communities, and will be considered in interpreting benthic community metrics. Future changes in conditions in part or all of Ward Cove (e.g., changes in cannery operation, El Niño weather events) will also be considered during interpretation of monitoring data.

Areas in which thin capping has taken place are expected to recover faster than those areas designated for natural recovery alone. However, for any stratum, remedial measures will be considered to have been successful if there is no significant difference between stations within the AOC and the reference stations at the time of each monitoring event. This information will be used to refine the monitoring strategy after each monitoring event. For example, if both toxicity and benthic infauna at the shallow, thin-capped stratum (Stratum 1 on Table 1) are not statistically different from reference after the first monitoring event in 2004, monitoring of this stratum may be dropped from future monitoring events.

Evaluation of Temporal Trends

The time course of changes in each variable (e.g., species richness or toxicity) in each monitoring stratum (e.g., shallow-water capping area) will be evaluated independently. The existence of statistically significant temporal trends will be determined using regression analysis, Dunnett's test, or MANOVA; different methods will be used at different points in the monitoring program and for different variables. Data may be transformed as needed to satisfy the assumptions of the statistical methods employed.

A Dunnett's test will be used to determine whether there are significant temporal changes in species richness, organism abundance, or toxicity when there are data from only two points in time. Regression analysis will be used when there are data from three or more points in time for these same variables. Because sediment toxicity data were collected in 1996 and 1997 (after cessation of mill discharge), an analysis of temporal trends in toxicity will be conducted after the first post-remediation sampling is completed, for only the subset of locations that were sampled either in 1996 or 1997 and during post-remediation monitoring. For other toxicity data and for benthic infauna measurements, analyses of temporal trends will be conducted only after the second post-remediation sampling is completed. MANOVA will be used to determine whether there are significant differences in major taxa abundances at different monitoring times. The analyses to be carried out to evaluate temporal trends are summarized in Table 3.

Table 3. Summary of methods for interpreting temporal trends

Monitoring Variable	Monitoring Period 1	2	3
Toxicity, 1995–1996 duplicate stations	Dunnett's test	Regression	Regression
Toxicity, all other stations (strata)	None	Dunnett's test	Regression
Benthic species richness and abundance	None	Dunnett's test	Regression
Benthic major taxa richness	None	MANOVA	MANOVA
Benthic major taxa abundance	None	MANOVA	MANOVA

Note: MANOVA - multivariate analysis of variance

For any stratum in which a significant difference from reference stations is observed at the time of the third post-remediation sampling event, the regression analysis will be used to estimate (extrapolate to) the time at which recovery is expected to be complete. Extrapolation will be carried out only where regression results are statistically significant—that is, where the rate of change of the variable of interest is significantly different from zero. If necessary, estimated times to recovery will be used to help determine what further monitoring activities may be conducted, if any.

It is possible that a statistically significant regression will be observed for some of the measurement variables but not for others. For example, statistically significant trends might not be found in major taxa richness, whereas other variables might consistently indicate improvement. The lack of a significant regression may mean that the variable is not sufficiently sensitive or the measurement technique cannot be measured precisely enough. Results of the regression analyses for all variables will therefore be interpreted by applying a weight-of-evidence approach. During interpretation of the results of statistical analyses, greater weight will be given to measurements of benthic infauna than to measurements of toxicity, because the former are more directly related to *in situ* sediment quality.

Reporting

The results of the monitoring program and data analyses will be provided in monitoring reports. Every 3 years, a monitoring report will be submitted to EPA 3 months after completion of the field sampling. The monitoring report will include the following:

- Comparison of thin capped and natural recovery areas to reference areas
- Evaluation of temporal trends in thin capped, natural recovery, and reference areas
- Discussion of progress toward achieving RAOs

- Modifications (if any) to the proposed sampling strategy for the next monitoring event
- Records for monitoring costs
- Data from the current monitoring event to support EPA's 5-year review process.

Original laboratory results will be provided in appendices to each monitoring report. An electronic version of all monitoring data will be provided to EPA Region 10 with each report.

After completion of the monitoring program of remedial activities in Ward Cove, a final monitoring report will be prepared. In this report, the results and data for the various field events will be compiled and interpreted and the progress made toward achieving the RAOs will be evaluated.

Schedule

The schedule for monitoring the remedial activities in Ward Cove is summarized in Table 4. All activities are linked to completion of the remedial activities on February 24, 2001. It is assumed that EPA will require 60 days to review all draft deliverables; departures from this assumption will alter the schedule. It is also assumed that the draft and final monitoring plans will be approved by EPA 30 days after receipt.

Field sampling activities for long-term monitoring of the remedial action at Ward Cove is anticipated to occur every third year in July after remedial activities have been completed (i.e., 2004, 2007, and 2010). Sampling is estimated to require 10–15 days, depending on the difficulty of obtaining adequate sediment samples at all stations.

Summary

The remedial strategy for the 80-acre AOC in Ward Cove consists of natural recovery and thin capping (i.e., surface sediment amendment). These remedial measures were selected because sediment toxicity within the AOC was primarily attributed to non-persistent chemicals that are natural degradation products of organic matter and because this condition posed no threat to human health or to fish and wildlife. In a similar fashion, the long-term monitoring strategy for the Ward Cove AOC implicitly recognizes the limited severity of the problem and the inherent uncertainties in the rate of recovery. As monitoring data are developed, a flexible, adaptive risk management strategy will be used to interpret the data and determine appropriate actions. The types of decisions that will be made on the basis of monitoring data include the following:

- Monitoring strategy should be refined (e.g., termination of monitoring efforts in selected strata)

Table 4. Schedule

Milestone	Date
Remedial activities completed	February 24, 2001
Draft monitoring and reporting plan to EPA	March 23, 2001
Receive EPA comments on draft plan	April 24, 2001
Final monitoring and reporting plan to EPA	May 25, 2001
First field sampling event	July 2004
Draft interim monitoring report to EPA	October 2004
Receive EPA comments on draft interim monitoring report	November 2004
Final interim monitoring report to EPA	December 2004
Second field sampling event	July 2007
Draft interim monitoring report to EPA	October 2007
Receive EPA comments on draft interim monitoring report	November 2007
Final interim monitoring report to EPA	December 2007
Third field sampling event	July 2010
Draft final monitoring report to EPA	October 2010
Receive EPA comments on final monitoring report	November 2010
Final monitoring report to EPA	December 2010

- Interpretation approach should be refined (e.g., selection of a subset of appropriate measurement endpoints to assess benthic infauna recovery)
- Monitoring approach should be revised (e.g., based on new information or an innovative assessment method that can better assess progress toward achieving RAOs)
- RAOs have been achieved
- Sufficient progress has been achieved toward RAOs and monitoring efforts are no longer required
- The nature and severity of ecological impacts do not warrant additional monitoring efforts.

These decisions will be made in consultation with EPA and will be communicated to the local community.

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Appendix A

Field Sampling Plan for Sediment Monitoring in Ward Cove

Field Sampling Plan for Sediment Monitoring in Ward Cove

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September 2001

Doc. No.: 8600B0W.001 1903 0901 LJ14

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Acronyms and Abbreviations

AOC	area of concern
COC/SAR	chain-of-custody/sample analysis request (form)
HSP	health and safety plan
KPC	Ketchikan Pulp Company
QAPP	quality assurance project plan
RI/FS	remedial investigation and feasibility study
SOP	standard operating procedure

1. Introduction

This field sampling plan has been prepared as part of the long-term monitoring and reporting plan for the Ward Cove area of concern (AOC) for Ketchikan Pulp Company (KPC), the prior owner of the KPC facility. The long-term monitoring and reporting plan addresses the 80-acre AOC in the Marine Operable Unit, which is located in Ward Cove, Ketchikan, Alaska (see main text).

Sediment samples will be analyzed for ammonia and 4-methylphenol, because these analytes were identified as chemicals of concern in the remedial investigation and feasibility study (RI/FS) (Exponent 1999). Sediments will also be analyzed for grain size distribution and organic content, because those two variables can influence the composition of benthic communities. The potential toxicity of each sediment sample will be evaluated using the 10-day amphipod test based on *Rhepoxynius abronius*. This test was used to characterize sediment toxicity in Ward Cove in the RI/FS (Exponent 1999) and test responses were found to be potentially related to sediment concentrations of ammonia, sulfide, and/or 4-methylphenol. In addition, the characteristics of benthic communities in various parts of Ward Cove will be evaluated directly by collecting and enumerating the organisms found in sediment samples collected from the site.

The sampling methods presented in this appendix are designed to meet the objectives described in the monitoring plan. Field sampling locations and procedures are described in Section 2, and the use of quality control samples is described in Section 3. Field data reporting and field custody procedures are discussed in Sections 4 and 5, respectively. Sample packaging and shipping requirements are outlined in Section 6. The proposed schedule for the sampling event is provided in Section 7, and information on sampling safety is provided in Section 8.

Descriptions of laboratory analytical methods and procedures for data management, analysis, and reporting are presented in the quality assurance project plan (QAPP), provided as Appendix B. To ensure that the data collected under the specifications of this monitoring plan achieve an acceptable level of quality, rigorous quality assurance and quality control procedures will be followed at all stages of sample collection and analysis. Standard operating procedures (SOPs) for field activities are provided in Appendix C. Depending on field conditions, procedures specified in the referenced SOPs may be modified in the field if necessary. Any such modifications will be noted in the field logbook. Example field data forms are provided in Appendix D.

Site-specific health and safety issues are presented in the health and safety plan (HSP), provided as Appendix E. The site-specific HSP establishes procedures and practices to protect Exponent employees and its subcontractors from potential hazards posed by field activities at the site. The HSP provides measures to minimize potential exposure, accidents, and physical injuries that may occur during daily onsite activities and to minimize the hazards of adverse conditions. Contingency arrangements are also provided in the HSP for emergency situations.

2. Field Sampling

Detailed procedures for sample collection, handling, and shipping are described in this section. Procedures are included for the following tasks:

- Documenting the locations of stations and establishing sample identifiers
- Collecting and compositing sediment samples
- Processing samples to ensure proper subsampling of each matrix
- Cleaning equipment, work surfaces, and sampling implements prior to commencing sampling and between stations
- Completing standard forms to document the collection effort and field conditions.

The anticipated schedule of sample collection and safety considerations are also discussed in this section.

2.1 Station Locations

Sediment samples will be collected from 37 stations along the north shoreline of Ward Cove, following field procedures that are consistent with PSEP protocols (PSEP 1986a,b, 1989a,b). In addition, 10 surface sediment samples will be collected from two reference areas outside the AOC, but within Ward Cove (i.e., five samples from each reference area). These reference areas will be located near 1995–1996 Stations 26 and 40. The shallow (40–50 ft MLLW) reference area will be located near Station 26 and the moderate (90–100 ft MLLW) reference area will be located near Station 40. Samples from the very shallow (<20 ft MLLW) and deep (>120 ft MLLW) strata within the AOC will be compared against the shallow and moderate reference areas, respectively. The station locations are shown in Figures A-1a and A-1b. The reference area locations are shown in Figure A-2. The exact locations of the stations in the AOC and at the reference areas will be determined in the field by the field team leader.

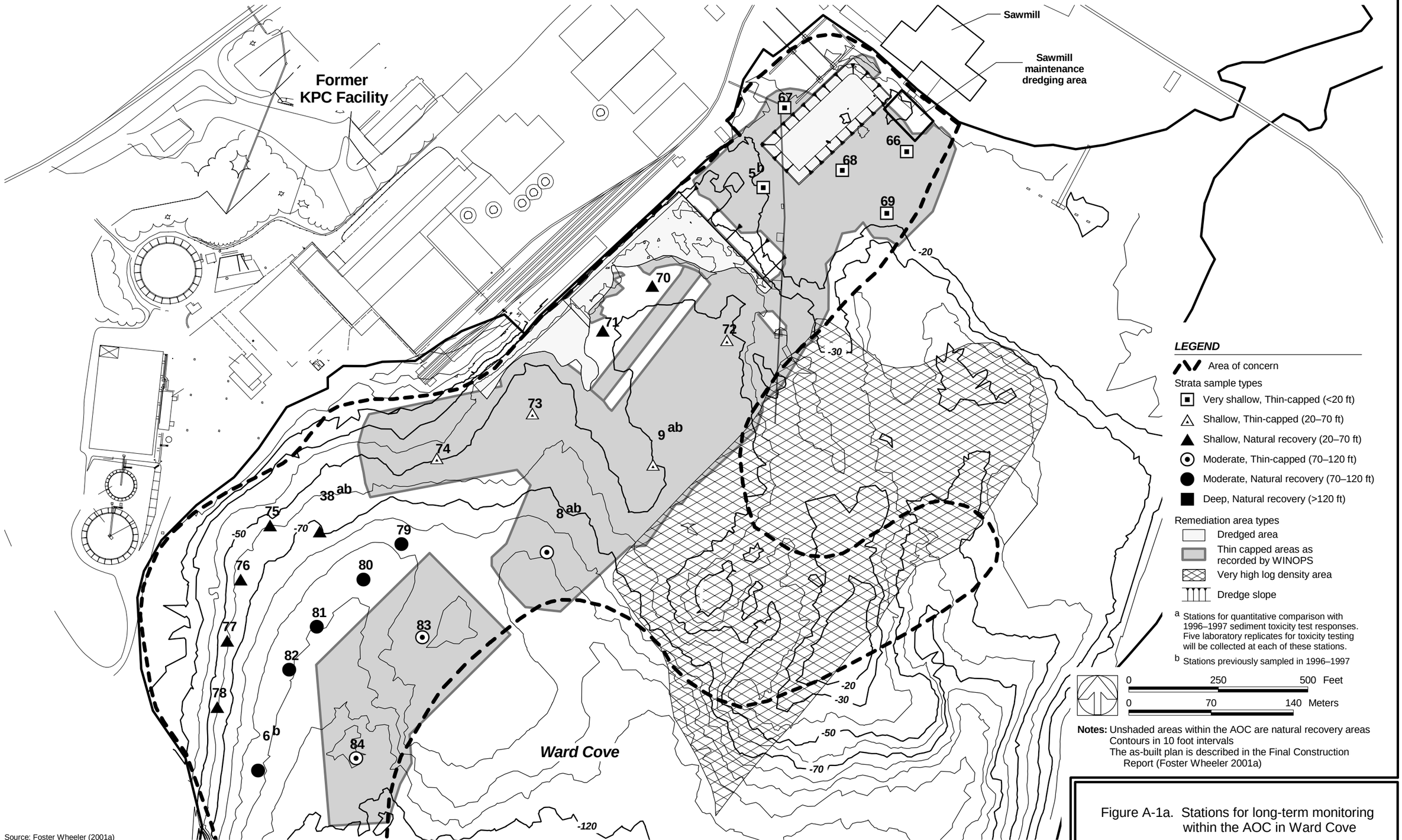

Figure A-1a. Stations for long-term monitoring within the AOC in Ward Cove

8600B0W.001 1903 | Mar 23,2001 | WP north | WP north layout | g:\kpc\projects\long-term monitoring.apr

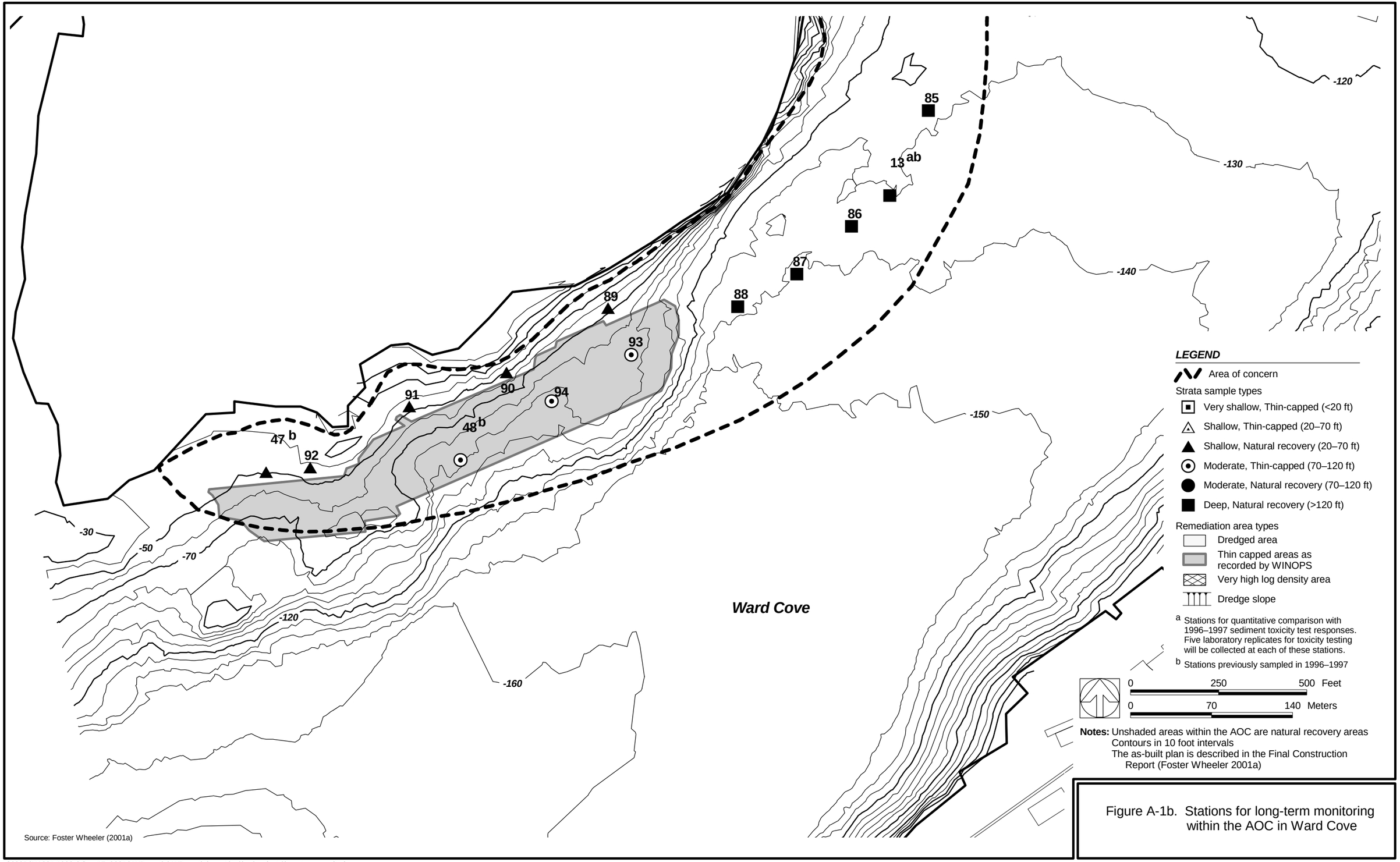

Figure A-1b. Stations for long-term monitoring within the AOC in Ward Cove

8600B0W.001 1903 | Sep 17, 2001 | WP south | WP south layout | g:\kpc\projects\long-term monitoring.apr

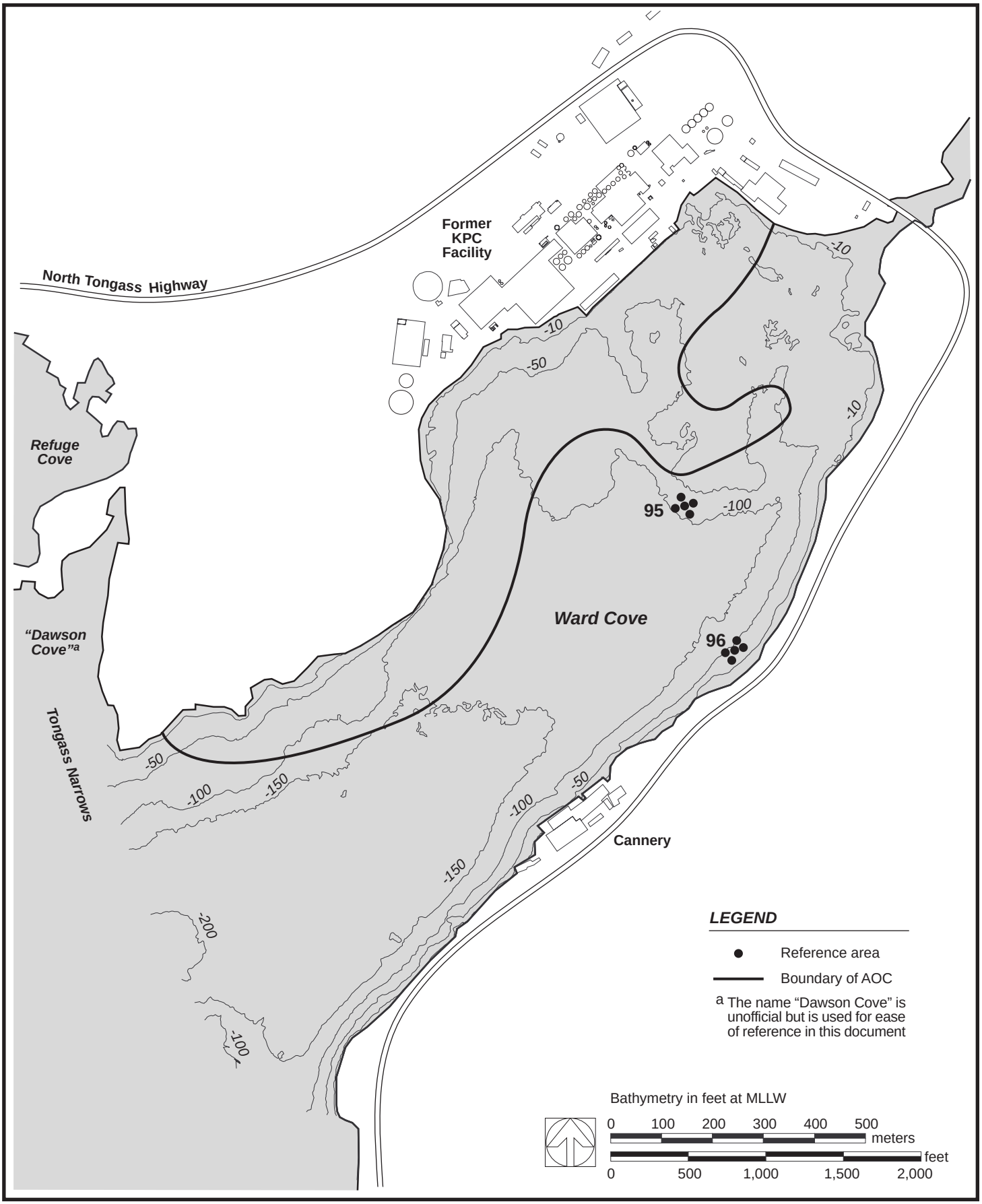

Figure A-2. Reference areas for long-term monitoring in Ward Cove

The number and type of sediment samples to be collected during long-term monitoring are summarized below:

- **Surface Sediment Samples—**A composite sample of surface sediment (0–10 cm sediment horizon) will be collected from 39 stations in Ward Cove. A field duplicate sample for chemistry analyses will be collected from two of the stations along the north shoreline of Ward Cove. Subsamples from each sediment sample will be analyzed for selected chemical compounds (ammonia and 4-methylphenol), and conventional parameters (grain size distribution, organic content, and total solids), the 10-day amphipod toxicity test using *Rhepoxynius abronius*, and benthic infauna community analysis.
- **Archive Samples—**Subsamples from all stations will be archived for possible future chemical analyses. Benthic macroinvertebrates retained on the 0.5-mm screen will be archived for potential future analysis.

2.2 Vessel Operation and Navigation

The specific sampling vessel that will be used during the field effort will be identified by Exponent, in consultation with KPC. The vessel operator will be thoroughly familiar with accurate deployment and retrieval of the sampling gear. Vessel positioning will be achieved with a differential global positioning system integrated with Hypack navigation software capable of locating the survey vessel with an absolute accuracy of ±2 m and a repeatable accuracy of ±1 m. Differential corrections will be obtained from the U.S. Coast Guard beacon on Annette Island. The positioning system used for this sampling effort will provide latitude and longitude coordinates for the station locations. Water depth will be noted, and all sample locations will be documented.

The specific personnel to be used during the field effort will be identified by Exponent. During the sampling cruise, the sampling team will consist of a vessel operator, a field team leader, and two or three crew members. The field team leader will be responsible for all decisions concerning sample collection. If a significant deviation from this field sampling plan needs to be considered because of conditions encountered during sampling (e.g., repositioning of a station location), the field team leader will notify the Exponent project manager, the KPC project manager, and the U.S. Environmental Protection Agency project manager.

2.3 Sample Identifiers

Sample identifiers will be established before field sampling begins and assigned to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes: 1) to identify related samples (i.e., replicates) to ensure proper data analysis

and interpretation, 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples, and 3) to track individual sample containers to ensure that the laboratory receives all of the material associated with a single sample. To accomplish these purposes, each container is assigned a sample number and a tag number. These codes and their uses are described below:

- **Sample Number—**The sample number is an arbitrary number assigned to each sediment sample collected. All subsamples of a composited field sample will have the same sample number. Each field replicate of a given type will have a different sample number, and the sample numbers of related field replicates will not necessarily have any shared content. The sample number appears on the sample containers and the chain-of-custody/sample analysis request (COC/SAR) forms.
- **Tag Number—**A different sample tag number is attached to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, each container will have the same sample number and a different sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted). The sample tag number will appear on the COC/SAR forms. Tag numbers are used by laboratories only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Sample numbers will be assigned sequentially in the field; sample tags will be preprinted with tag numbers.

2.4 Sampling Procedures

In this section, procedures are described for collecting sediments using a grab sampler. Sample collection and handling methods (including criteria for judging the acceptability of samples) are described in greater detail in the following sections.

2.4.1 Surface Sediment Sample Collection

Surface sediment samples will be collected using a 0.06-m^2 stainless-steel van Veen grab sampler in accordance with standard methods used by PSEP (1986a,b; 1989a,b). Before sampling begins at a station, the van Veen grab sampler and all other sampling equipment will be scrubbed with Alconox®, rinsed with site seawater, rinsed with acetone and then hexane, air-dried, and rinsed with site seawater. The acetone and hexane rinsates will be collected in a container, and the small volume collected will be allowed to evaporate.

After a sediment sample is retrieved and judged to be acceptable for chemical analyses and toxicity testing (see discussion below), the overlying water will be siphoned off and the upper 10 cm of sediment will be collected in accordance with PSEP (1986a) guidelines. Stainless-steel spatulas and spoons will be used to collect the sediment. A stainless-steel ruler will be used to ensure that the sampling criterion for adequate penetration depth is met and that the correct amount (i.e., 10 cm) of sediment has been removed. Sediment touching the sides of the grab sampler will not be collected. Although the target sediment horizon is 0–10 cm, shallower horizons may be collected at selected stations if the target horizon cannot be sampled after repeated attempts.

At each sampling station, one or more grab samples will be collected for chemical analyses and toxicity testing. The surface (top 10 cm) sediment will be collected from each grab sample, and the sediment will be composited. The sediment sample at each station will be composited in a stainless-steel bowl and covered with aluminum foil until a sufficient volume of sediment is collected for both chemical and toxicity testing. Sediment in the bowl will then be mixed using a large stainless-steel spoon to achieve a uniform texture and color before subsamples are taken and transferred to precleaned glass containers with Teflon®-lined lids.

Material collected in the grab sampler will be evaluated for acceptability according to whether the following criteria are met:

- The sampler is not overfilled
- Overlying water is present
- The overlying water is not excessively turbid
- The sediment surface is relatively undisturbed
- A sediment penetration depth of at least 11 cm is attained.

The field team leader will evaluate all samples collected. If a sample fails to meet the above criteria, it could be rejected and discarded away from the station. However, if the only limitation in the sample acceptability is the penetration depth, the sample will be retained in a separate container in the event that the target sediment horizon of 0–10 cm cannot be sampled.

A single sample will be collected at each station for toxicity testing. An exception to this replication scheme will be made at a subset of four stations (Stations 8, 9, 13, and 38) that were selected to compare sediment toxicity results from the long-term monitoring program with results obtained in 1995–1996 during the RI/FS (Exponent 1999). Each of these stations will be positioned at the location sampled in 1995–1996 and five replicate toxicity tests will be evaluated at each of these stations so that the results can be compared among time periods using the same level of replication.

2.4.2 Benthic Infauna Sample Collection

Sediment for benthic infauna community analysis will be collected using a 0.06-m^2 stainless-steel van Veen grab sampler in accordance with standard methods used by PSEP (1986a,b; 1989a,b). The sediment in the grab sampler will be evaluated for acceptability according to the requirements described in the previous section. All of the sediment and overlying water collected in each grab sample will be sieved. A single grab sample (i.e., replicate) will be collected at each station.

Sediments collected for benthic community analysis will be sieved sequentially using mesh sizes of 1.0 and 0.5 mm. However, initial taxonomic analyses will be conducted only on the organisms retained on the 1.0-mm screen, whereas organisms retained on the 0.5-mm screen will be archived for potential future analysis. Retained material will be transferred to appropriate containers, fixed with formalin, stained with rose bengal (125 mg/L), and transferred to the laboratory for taxonomic analysis.

2.4.3 Sample Handling

All sample containers will be provided by the chemical and toxicity testing laboratories and prepared in accordance with PSEP guidelines (PSEP 1986a) prior to field operations. Sample containers for chemical analyses and toxicity testing will be kept closed and in a cooler until use. As they are collected, samples will be fully labeled, recorded in the field logbook along with other pertinent collection data, and returned to coolers as soon as possible. Immediately after they are filled, all sample containers containing sediment for chemical analyses and toxicity testing will be placed on ice in a cooler at 4°C. For those subsamples that will be frozen (i.e., chemical archive samples), sufficient headspace will be left in each jar to accommodate expansion during freezing. Samples collected for benthic infauna community analysis will be stored in an upright position at a cool temperature and away from direct sunlight. All samples will be stored in a secure place, where containers are not susceptible to breakage.

Sediment samples for all chemical analyses and toxicity testing will be shipped on ice (4°C) to the testing laboratories and will be stored at 4°C until analysis and final disposition of the samples. All field samples, except archived chemical and benthic infauna samples, will be analyzed as soon as possible after receipt at the laboratory. Maximum sample holding times are stipulated in the QAPP (Appendix B). Archived sediment samples will be placed at an angle to minimize breakage and will be placed in an outer plastic bag to avoid cross contamination should breakage occur. The archived samples for possible future chemical analyses will be held frozen at the laboratory pending a decision to begin analyses within the specified holding time for frozen samples.

Samples in glass containers will be packed in bubble-wrap plastic to prevent breakage, and chain-of-custody seals will be placed across the cooler lids. Chain-of-custody forms will be enclosed in the coolers with the samples and will be signed at the laboratory upon receipt. Samples will be shipped or sent by courier to arrive at the participating

laboratories within 3–5 days of sample collection. A copy of the signed chain-of-custody form will be returned by the testing laboratory to Exponent and filed in the project file. Sample packaging and shipping requirements are described in SOP 2, *Sample Packaging and Shipping* (Appendix C).

3. Field Quality Control Sample Procedures

The following quality control samples will be collected in the field and analyzed by the chemical analytical laboratory with the natural samples:

- **Field duplicates—**Field duplicate surface sediment samples will be collected and analyzed to assess the variability of chemical concentrations at a location. Field duplicates provide a measure of the total analytical bias (field and laboratory variance) including bias resulting from the heterogeneity of the replicate sample set itself. Field duplicates will be collected at a minimum frequency of 1 per 20 samples. It is anticipated that three field duplicates will be collected during the sampling event. A minimum of one field duplicate will be collected from each type of remedial action area in the AOC (i.e., thin capped area and natural recovery area).
- **Equipment rinsate blanks—**Equipment rinsate blanks will be collected for surface sediment samples to help identify possible contamination from the sampling environment or from the sampling equipment (e.g., grab, bowls, spoons). Equipment rinsate blanks will consist of running distilled/deionized water over the sampling equipment after decontamination. An equipment rinsate blank will be collected once during the sampling event from the grab sampler.

4. Field Documentation

The integrity of each sample from the time of collection to the point of data reporting must be maintained throughout the study. Proper record-keeping and chain-of-custody procedures will be implemented to allow samples to be traced from collection to final disposition. The various logs, forms, and labels required to adequately identify and catalogue sampling location and sample information include the following:

- **Field Logbook—**A bound, waterproof field logbook with consecutively numbered pages will be used. All daily field activities will be documented in indelible ink in this logbook; all entries will be signed and dated and no erasures will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark that is signed and dated by the sampler. Field logbooks will be stored in a secure manner when not in use. The field team leader will record the following information daily in the field logbook:
  - Project name, project location, and project number
  - Project start date and end date
  - Date and time of entry (24-hour clock)
  - Time and duration of daily sampling activities
  - Weather conditions
  - Name of person making entries and other field personnel
  - Onsite visitors, if any
  - The sample identifier and analysis code for each sample to be submitted for laboratory analysis
  - The sampling location name, date, gear, water depth, and sampling location coordinates
  - Specific information on each type of sampling activity
  - A description of the sample (source and appearance, such as sediment type, color, and odor)
  - The sample number, analysis code, and tag number for each sediment subsample

- The number of photographs taken at the sampling location, if any
- Variations, if any, from specified sampling protocols and reasons for deviation.

- **Station/Sample Log—**Each gear deployment event will be recorded on a station/sample log sheet. One or more station/sample log sheets will be completed for each station sampled. The station name, date, gear, cast number, depth, and location coordinates will be recorded on each log sheet.
- **Sample Label—**A sample label will be completed for each sample. A sample label will be placed on the outside of all sample containers. An internal label on waterproof paper will also be placed inside each benthic community sample container. All sample label entries will be made with indelible ink, except for the internal label used with the benthic community samples, which will be made with pencil. Sample containers will be labeled at the time of sampling with the following information: sample number, site name, sampling date and time, sampling personnel, preservative (if appropriate), and tag number.

The field team leader is responsible for properly completing all logbooks and forms. In addition, a sampling location map will be updated during sampling and will be maintained throughout the sampling event. Station and sample logs must be completed at the time the observations are made. Copies of all logbooks and forms will be retained by Exponent. Appendix D contains examples of the forms that are used to record information at each sampling location.

5. Field Custody Procedures

The integrity of each sample from the time of collection to the point of data reporting must be maintained throughout the study. Proper record-keeping and chain-of-custody procedures will be implemented to allow samples to be traced from collection to final disposition. The various forms required to adequately identify and catalogue sampling location and sample information include the following:

- **Chain-of-Custody/Sample Analysis Request Form—**The sample identifier and tag numbers of each sample container will be recorded on a COC/SAR form (example provided in Appendix D). The signed COC/SAR form will be secured to the inside top of each cooler identifying the sample collection date and time, the type of sample, the project, and the field personnel. The COC/SAR form will also identify the preservative or other sample pretreatment applied and the analyses to be conducted by referencing a list of specific analytes or the statement of work for the laboratory. The COC/SAR form will be sent to the laboratory along with the sample. The chain-of-custody forms will be completed in triplicate, with one copy retained by the field team leader.
- **Custody Seal—**Two custody seals (example provided in Appendix D) will also be placed across the lid of the cooler (front right and back left) prior to shipping.

At the end of each day and prior to shipping or storage, chain-of-custody entries will be made for all samples. Finally, information on the labels and tags will be checked against field logbook entries and samples will be re-counted.

The field team leader is responsible for properly completing all forms. COC/SAR forms will be completed and signed before the end of each sampling day and before the samples pass from the control of the field team leader. COC/SAR forms will be signed at each additional point of transfer of samples between the field and the chemical testing, toxicity testing, and benthic taxonomy laboratories and within each laboratory. Copies of all forms will be retained by the field team leader.

6. Sample Packaging and Shipping

All sample containers will be provided by the laboratory and prepared in accordance with U.S. EPA (1986) prior to field operations. Only new sample containers (e.g., I-CHEM® 200 or Industrial Glassware, or the equivalent) will be used for sample collection. The laboratory will provide the appropriate size container for the type of sample to be tested. Sample containers will be kept closed and in a cooler or in the shipping package until use. Immediately after they are filled and labeled, all chemical and toxicity testing sample containers will be placed on ice in a cooler at 4±2°C. For archive sediment samples, sufficient headspace will be left in each jar to accommodate expansion during freezing.

Maximum sample holding times are stipulated in the QAPP (Appendix B).

Samples in glass jars that are shipped will be packed in bubble-wrap plastic to prevent breakage. All sample jars and bottles will be placed in individual resealable plastic bags, combined COC/SAR forms will be enclosed in the coolers, and chain-of-custody seals will be placed across the cooler lids. A copy of the form, signed upon receipt at the laboratory, will be returned to the field sampling contractor and filed in the project file. Sample packaging and shipping requirements are described in SOP 2 (provided in Appendix C).

7. Schedule

Sampling for long-term monitoring of the remedial action at Ward Cove is anticipated to occur every third year in July after the remedial activities have been completed (i.e., 2004, 2007, and 2010). Sampling is estimated to require 11 days. The sequence of sample collection will be arranged to maximize efficiency while minimizing potential cross-sample contamination. The actual sequence in which the stations will be visited will be determined in the field by the field team leader.

8. Sampling Safety

Safety hazards are associated with the equipment and supplies that will be used, as well as with the general rigors of work on the water. The HSP is provided in Appendix E; its purpose is to identify potential hazards, institute procedures for minimizing those hazards, document the proper responses in case of accident and injury, and make this information known to all shipboard personnel. Before sampling begins, a health and safety briefing will be held onboard the sampling vessel.

To ensure safe and efficient shipboard operations, the field team leader will be designated the safety officer responsible for all shipboard operations, including evaluating hazardous conditions, ensuring compliance with safety precautions, and suspending shipboard operations if necessary. A halt to or suspension of operations can also be dictated by the vessel operator.

8.1 Hazards

Hazards encountered during sampling are generally classified as either chemical or physical. Chemical hazards are primarily associated with the materials used to clean sampling gear. Physical hazards are associated with the gear and conditions of work on the water.

8.1.1 Chemical Hazards

Stations to be sampled during the survey are not expected to contain concentrations of chemicals (including natural sulfide) that pose a hazard to human health. If excessive odor, nonaqueous liquids, or organic enrichment is observed during field operations, the sampling plan will be reassessed. Precautionary steps may include artificially ventilating the rear deck, instituting suitable protective measures for the crew, or relocating or eliminating the sampling station.

Acetone and hexane will be used to clean the sampling equipment. Both are clear, colorless, volatile solvents with strong odors. Formalin will be used to preserve the benthic infauna samples. Formalin is a colorless, reactive chemical with a strong odor. Acetone, hexane, and formalin will be used only on the open deck, and personnel must wear protective gloves when handling these liquids.

Material safety data sheets for acetone, hexane, and formalin are included in the HSP (Appendix E).

8.1.2 Physical Hazards

Gear deployment and retrieval present hazards because of the weight of the sampling gear, its suspension above the deck, and the risk of entanglement or accidental or premature release or closure. While gear deployment hazards are expected to be minimal, there are physical hazards associated with the van Veen grab sampler.

During sampling gear retrieval, at least one crew member will watch for the sampling gear to appear and alert the winch operator. Failure to observe the sampling gear and stop the winch can break the cable, loosen the sampling gear, and possibly injure personnel with falling gear or the end of the broken cable. The winch drum, the blocks, and the area between the sampling gear and the rail, deck, or other large equipment present significant pinching and crushing hazards. Personnel will be instructed to keep their hands, feet, and clothing clear of these points.

Lines, hoses, hatch covers, and mud on the deck present tripping, slipping, and falling hazards. Every crew member will be instructed to keep the working surface of the deck clear and clean by coiling hoses and lines and rinsing accumulations of mud from the deck. In addition, all crew members will remain aware of hatch cover positions and other gear at all times.

A drowning hazard exists for shipboard personnel working on the water primarily from tripping (discussed above) or excessively rough weather. Flotation vests will be worn by all personnel on deck. The vessel is also equipped with throwable life rings, and each crew member will be briefed on the use and storage location of these rings.

Fatigue presents a hazard when working on the water and can be compounded by the motion of the vessel, exposure, or hypothermia. Personnel will monitor their own conditions and capabilities and are responsible for taking appropriate measures to relieve fatigue or exposure. The field team leader may also direct any member of the crew to cease working.

8.2 Safe Work Practices

Precautions for handling chemicals include wearing gloves, restricting use to the deck, storing and dispensing them from narrow-mouth bottles or squirt bottles, and exercising care in use. Solvent rinsate from sampling gear will be collected in a container so excess solvent is not spilled on the deck. The sea condition and presence of wakes or other disturbances will be noted to avoid spillage.

All crew members will wear hard hats when working on the rear deck. Work gloves will be available but not required (impermeable gloves are required when using acetone or hexane). Flotation vests will be worn by all personnel on the rear deck.

During gear deployment and retrieval, personnel should pay close attention to the position of the gear, the motion of the boat, obstructions on the deck that could impede

their mobility, and actual or potential fouling of the gear. Hands and feet must never be placed underneath sampling gear.

Weather conditions will be monitored by the field team leader and vessel operator. The vessel is supplied with emergency flotation equipment and fire extinguishers. Food and shelter (the vessel's cabin) will be provided for the sampling crew. Each crew member will be required to bring clothing appropriate for the weather to minimize the hazards of exposure and hypothermia.

8.3 Emergency Planning

If an emergency or accident occurs during sampling, the field team leader and vessel operator will determine the appropriate response. They will assess the severity of the incident and, if appropriate, contact emergency assistance. The vessel operator is responsible for moving the boat into position to receive emergency aid, if necessary. A basic first-aid kit will be kept onboard to treat minor cuts or scrapes. All field personnel have received first-aid and CPR training. All accidents must be reported to the field team leader and will be recorded in the cruise log. Contact information for local emergency services, hospitals, and ambulance services will be onboard the vessel in a location known to and accessible to all personnel. Emergency contact information is provided in the HSP (Appendix E).

9. References

Exponent. 1999. Ward Cove Sediment Remediation Project. Detailed technical studies report. Volumes I and II. Remedial investigation and feasibility study plus appendices. Prepared for Ketchikan Pulp Company, Ketchikan, AK. Exponent, Bellevue, WA.

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PSEP. 1989a. Recommended guidelines for measuring organic compounds in Puget Sound sediment and tissue samples. U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Puget Sound Estuary Program, Seattle, WA.

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Appendix B

Quality Assurance Project Plan for Sediment Monitoring in Ward Cove

Quality Assurance Project Plan for Sediment Monitoring in Ward Cove

Prepared for

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Prepared by

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September 2001

Doc. No.: 8600B0W.001 1903 0901 LJ14

Quality Assurance Project Plan for Sediment Monitoring in Ward Cove

Prepared by: Exponent
September 2001

Prepared for: Ketchikan Pulp Company

Approvals:

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Barry Hogarty, KPC Project Manager

Lucinda Jacobs, Exponent Project Manager

Maja Tritt, Exponent QA/QC Coordinator

Jane Sexton, Exponent Field Team Leader

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Environmental & Natural Resources Division
801 B Street, Suite 504
Anchorage, AK 99501-3657

A copy of this quality assurance project plan will also be provided to all contractors hired by Ketchikan Pulp Company to complete any phase of long-term sediment monitoring, including field sampling crews and testing laboratories.

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Acronyms and Abbreviations

AOC	area of concern
COC/SAR	chain-of-custody/sample analysis request (form)
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
KPC	Ketchikan Pulp Company
LC_{50}	concentration lethal to 50 percent of the test population
LCS	laboratory control sample
MQO	measurement quality objective
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance and quality control
QAPP	quality assurance project plan
RI/FS	remedial investigation and feasibility study
RPD	relative percent difference
SDG	sample delivery group
SIM	selected ion monitoring
SOP	standard operating procedure
TOC	total organic carbon

Introduction

This quality assurance project plan (QAPP) describes the quality assurance and quality control (QA/QC) procedures that will be used to support the analytical data generated as part of the long-term sediment monitoring program for the remediation areas in Ward Cove, Alaska. These QA/QC procedures ensure that the data generated during this site monitoring program are representative of actual field conditions and meet the project's quality objectives. This QAPP was developed using guidance provided by the U.S. Environmental Protection Agency (EPA) (U.S. EPA 1998, 1999a).

A complete description of the project, including results from previous investigations and rationale for the current sampling specifications, tentative dates for the fieldwork, and the intended end use of the data acquired from this field effort is provided in the work plan for the site monitoring program (main text of this report).

This QAPP contains the following sections:

- Section 1. Project Management
- Section 2. Data Acquisition
- Section 3. Assessment and Oversight
- Section 4. Data Verification, Validation, and Usability
- Section 5. References.

1. Project Management

Well-defined project management procedures, quality assurance and quality control (QA/QC) procedures, and quality assessment checkpoints are instrumental in the execution of a successful field effort and the generation of well-documented, high-quality data. This section of the quality assurance project plan (QAPP) includes descriptions of the project structure and management procedures that relate to project quality assurance.

1.1 Project Organization

Ketchikan Pulp Company (KPC) will be responsible for planning and managing the long-term sediment monitoring program, with regulatory oversight and approval by EPA Region 10. Table B-1 identifies the personnel responsible for planning and implementing field and laboratory operations and QA/QC procedures for this project and describes each individual's tasks for project management and quality assurance. Laboratory quality assurance officers, also described in Table B-1, will be identified at each contract laboratory to ensure that appropriate procedures are followed during sample analysis and preparation of the data packages and electronic deliverables. The laboratory quality assurance officers will be identified prior to submittal of samples.

Each laboratory will provide its quality assurance manual for review and approval by the project QA/QC coordinator. The manuals will include a description of the laboratory organization, personnel, and responsibilities; facilities and equipment; analytical methods and QA/QC protocols; and routine procedures for sample custody and data handling. The laboratory quality assurance manuals will be provided to EPA Region 10 if requested.

No changes in the QAPP procedures will be permitted without written justification and a detailed explanation of the intended change. All changes are subject to approval by the Exponent QA/QC coordinator and project manager, the KPC project manager, and the EPA project manager. A description of all changes, with justification, will be included in applicable quality assurance or data reports generated for this project.

1.2 Project Description

The monitoring program will focus on evaluating changes in the three major indicators of sediment quality: sediment chemistry, sediment toxicity, and benthic macroinvertebrate communities. The specific components of sediment quality used for the Ward Cove monitoring program are as follows:

Table B-1. Project personnel and responsibilities

Personnel	Responsibilities
Karen Keeley EPA Region 10 Project Manager	Provide final approval of the sediment monitoring plan.
Phillip Benning Ketchikan Pulp Company Project Manager	Overall responsibility for KPC activities. Oversee all program activities to ensure compliance; perform technical oversight and consultation on major quality assurance problems; provide final approval of all necessary actions and adjustments for activities to accomplish project objectives.
Jane Sexton Integral Project Manager	Oversee all RI/FS program activities under KPC's direction to ensure appropriate quality control review; provide technical oversight; implement necessary actions and adjustments for activities to accomplish project objectives.
Kimberly Magruder Carlton Integral Chemistry Laboratory QA/QC Coordinator	Provide technical quality assurance assistance; oversee quality assurance activities to ensure compliance with chemical analyses detailed in the QAPP; coordinate and supervise data validation and data quality report preparation; review and submit quality assurance reports.
Jane Sexton Integral Toxicity Testing and Benthic Taxonomy Laboratory QA/QC Coordinator	Provide technical quality assurance assistance; oversee quality assurance activities to ensure compliance with toxicity testing and benthic taxonomic analyses detailed in the QAPP; coordinate and supervise data validation and data quality report preparation; review and submit quality assurance reports.
Jane Sexton Integral Field Team Leader	Coordinate and supervise field activities; ensure field procedures are completed in accordance with FSP and QAPP; authorize and document minor adjustments to the sampling plan in response to field conditions, as necessary, and notify project manager and QA/QC coordinator; track submittal and receipt of samples at the laboratory; initiate COC/SAR forms.
Database Administrator	Organize and maintain project database. Ensure that the data are stored in accordance with the QAPP. Supervise data management personnel.
Laboratory Quality Assurance Officers	Ensure that sample receipt and custody records are properly handled and data are reported within specified turnaround times: calibrate and maintain instruments as specified; perform internal quality control measures and analytical methods as required; take appropriate corrective action as necessary; notify the QA/QC coordinator when problems occur; report data and supporting quality assurance information as specified in this QAPP.

Note: COC/SAR - chain-of-custody/sample analysis request (form)
EPA - U.S. Environmental Protection Agency
FSP - field sampling plan
KPC - Ketchikan Pulp Company
QA/QC - quality assurance and quality control
QAPP - quality assurance project plan

- **Sediment chemistry**—Each sediment sample will be analyzed for ammonia and 4-methylphenol, because these analytes were identified as chemicals of concern in the remedial investigation and feasibility study (RI/FS) (Exponent 1999). Sediments will also be analyzed for grain size distribution and organic content, because those two variables can influence the composition of benthic communities.

- **Sediment toxicity**—The potential toxicity of each sediment sample will be evaluated using the 10-day amphipod test based on *Rhepoxynius abronius*. This test is commonly used to evaluate sediment toxicity on the west coast of the United States (Becker et al. 1990; Swartz et al. 1982; Williams et al. 1986; Chapman et al. 1987) and has standardized and well-established test protocols (PSEP 1995). In addition, this test was used to characterize sediment toxicity in Ward Cove during the RI/FS (Exponent 1999), and test responses were found to be potentially related to sediment concentrations of ammonia, sulfide, and/or 4-methylphenol. Because *R. abronius* has been documented to be sensitive to chemical toxicity and because it is a free-burrowing organism that is directly exposed to sediment contaminants, it will provide an environmentally conservative assessment of the changes in sediment toxicity that will follow remedial activities in Ward Cove.

- **Benthic communities**—The characteristics of benthic communities in various parts of Ward Cove will be evaluated directly by collecting and enumerating the organisms found in sediment samples collected from the site. Benthic communities are commonly used to assess sediment quality because these organisms are relatively stationary and live in close association with bottom sediment (U.S. EPA 1990). The communities in Ward Cove will be sampled using standardized methods and analyzed using a variety of common techniques to ensure that the data are quantitative in nature and that results are analyzed in an objective manner.

The details of the design of the monitoring program are presented in the main text of this sediment monitoring plan. A complete field sampling plan (FSP) is provided in Appendix A.

1.3 Quality Objectives and Criteria for Measurement Data

The primary quality objective for measurement data is to obtain results that are of known and acceptable quality and are representative of the conditions present at the site. The sampling plan for sediment monitoring has been developed to ensure the collection of sufficient samples from appropriate locations to provide statistically significant and representative data for chemical concentrations, sediment toxicity, and benthic communities. Field sampling procedures will include safeguards to ensure that the

samples provided to the laboratories are intact and representative of field conditions, as described in Appendix A of this plan.

Measurement quality objectives (MQOs) have been established for this project to ensure that chemical, biological, and toxicity data are of known and sufficiently high quality to support the project objectives. Quantitative MQOs are provided in Table B-2. To confirm that project MQOs for precision and accuracy are achieved, analytical results for field and laboratory quality control samples will be evaluated, as discussed in the sections below. The equations used to assess precision, accuracy, and completeness are provided in Section 4.2 of this QAPP. Quality control results that do not meet target values will be qualified during data validation, and their limitations will be noted in the data quality and usability report for the project, as discussed in Section 4.2 of this QAPP. To ensure comparability and representativeness of the laboratory data, standard instrumentation will be used for the analyses and the instruments will be properly calibrated and maintained.

1.4 Special Training and Certification

Procedures to be completed for this study are, for the most part, routine. Standard procedures will be used to collect the sediment samples and to complete laboratory analyses and toxicity testing. Identification and enumeration of benthic macroinvertebrates will be completed by taxonomists and technicians who specialize in this area of expertise. All field personnel will have completed the 40-hour Hazardous Waste Operations and Emergency Response training with annual refresher courses as required by the Occupational Safety and Health Administration. No other special personnel or requirements are identified in the FSP.

1.5 Documents and Records

Procedures, observations, and test results will be documented for all sample collection, laboratory analysis and reporting, and data validation activities. In addition to data reports provided by the laboratories, reports will be prepared that address data quality and usability, provide tabulated laboratory and field data, and interpret the sediment monitoring data. Internal and external reporting procedures for this study are described in this section.

1.5.1 Field Records

Field records will be maintained during all stages of sample collection and preparation for shipment to the laboratories. Field records will include the following items:

- Field logbook to record daily sampling activities and conditions
- Combined station/sample log to document station locations, and date and time of collection

Table B-2. Summary of measurement quality objectives

Analysis	Method Reference	Units	Method Reporting Limit	Bias (percent)	Preci-sion (RPD)	Complete-ness (percent)
Chemical Analyses						
4-Methylphenol	GC/MS with SIM	µg/kg	10	50–150	±50	100
	EPA 350.3M	mg/kg	1	75–125	±35	100
Total organic carbon	Standard Method 5310B	percent	0.5	75–125	±35	100
Ammonia						
Grain size	PSEP	weight percent	0.1	75–125	±35	100
Total solids	PSEP	weight percent	0.1	75–125	±35	100
Toxicity Test						
Amphipod mortality (*R. abronius)*	PSEP (1995)	percent survival, percent non-reburial	--	--	--	100
Benthic Enumeration	PSEP (1987)	abundance	--	--	--	100

Note: EPA - U.S. Environmental Protection Agency
GC/MS - gas chromatography/mass spectrometry
PSEP - Puget Sound Estuary Program
RPD - relative percent difference
SIM - selective ion monitoring
-- - not applicable

- Sample labels
- Combined chain-of-custody forms/sample analysis request (COC/SAR) forms
- Custody seals to monitor cooler security during shipment
- Photographic documentation (if any).

Detailed descriptions of the information that will be reported on each form are provided in Appendix A of this plan.

In addition to the standard field records, the following reports may be completed if a deviation from the sampling plan or QAPP is encountered or to document an audit:

- Corrective action reports documenting any problems encountered during field activities and corrective actions taken
- System and performance audit reports completed during the investigation
- A summary of any changes made to documented procedures and the rationale for the changes.

1.5.2 Laboratory Data Reports

The laboratories will perform data reduction as described in each test method for this project (Table B-2) and submit a complete data package with full documentation for all analyses or other determinations. The laboratory quality assurance officer is responsible for reviewing the laboratory data packages and checking data reduction prior to submittal to Exponent. Any transcription or computation errors identified during this review will be corrected by the laboratory.

Data reporting requirements for chemical analyses, toxicity tests, and benthic community enumeration are summarized in the following sections.

1.5.2.1 Chemical Analyses

The analytical laboratories will provide all information required for a complete quality assurance review, including the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- A summary of analyte concentrations (to two significant figures, unless otherwise justified) and method reporting limits

- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions
- Initial and continuing calibration data, including instrument printouts and quantification summaries for all analytes
- Results for method and calibration blanks
- Results for all QA/QC checks, including laboratory control samples (LCSs), matrix spike samples, surrogate spikes, duplicate matrix spike samples, and laboratory duplicate or triplicate samples
- Original data quantification reports for all analyses and samples
- All laboratory worksheets and standards preparation logs (data include final dilution volumes, sample sizes, wet-to-dry ratios, and spiking and standards preparation procedures for all analyses).

1.5.2.2 Toxicity Tests

The following information will be reported by the toxicity testing laboratory to allow a complete quality assurance review of the sediment toxicity data:

- Results for all water quality measurements made during testing (i.e., ammonia, dissolved oxygen, pH, temperature, and salinity)
- The 10-day survival value for each exposure chamber and the mean and standard deviation for each treatment
- The 10-day survival value for each exposure chamber and the mean and standard deviation for the negative control (i.e., laboratory reference sediment)
- The 96-hour LC_{50} values for the positive control tests
- Information on the source of test organisms (i.e., must be from the same source)
- Information on the type of test chambers used (must be identical), and information on the amount of sediment and overlying water in each test chamber (must also be identical)
- Paper copies of all laboratory data sheets
- Descriptions of any problems that may have influenced data quality and any corrective actions taken by the laboratory (may only be taken with the project QA/QC officer's concurrence).

1.5.2.3 Benthic Macroinvertebrates

The following information will be reported by the taxonomic laboratory to allow a complete quality assurance review of the benthic invertebrate enumeration data:

- The number of individuals of each taxon found in each replicate sample. Data for each replicate sample will be reported as numbers of individuals per sample for each species (or lowest identifiable taxon).
- Information on standard invertebrate metrics such as taxonomic richness, community evenness, Shannon-Wiener diversity, and percent composition in functional feeding groups.
- Information on the sample-sorting efficiency (a minimum of 95 percent of the total number of individuals in each sample is required [i.e., no more than 5 percent of the organisms in a given sample can be missed by the original sorter]).
- Information on accuracy of the taxonomic identifications by each taxonomist (i.e., accurate for at least 95 percent of the total number of species).
- Project reference collection of all taxa and a list of all literature used for taxonomic identifications of each taxon.
- Paper copies of all laboratory data sheets.

1.5.3 Data Quality and Usability Report

A data quality and usability report will be prepared in conjunction with a data report for each monitoring event. The data quality report will summarize the results of the data validation and data quality review and will describe any significant quality assurance problems that were encountered. The report will include the following items:

- Executive summary of overall data quality and recommendations for data use and limitations
- Description of sample collection and shipping, including chain-of-custody and holding time documentation
- Description of analytical methods and detection limits
- Description of data reporting
- Description of completeness relative to QAPP objectives

- Description of precision relative to QAPP objectives, including results for field and laboratory replicate analyses
- Description of accuracy relative to QAPP objectives, including results of matrix spikes, LCSs, and surrogate recoveries
- Description of any contamination in field and laboratory blanks and implications for bias of the data or false positives
- Identification of all cases where MQOs were not met and summary of the significance of these deviations.

All data and any qualifiers applied to the data as a result of the quality assurance review will be reported in the final data report.

Data for toxicity testing and benthic macroinvertebrate populations will be reviewed and procedures and results compared to requirements specified in the method descriptions (Table B-2). The results of these reviews will be included in the data quality report.

1.5.4 Location of Records and Reports

The electronic and hard copy data generated for this study will be retained at the Exponent's office in the custody of the project data manager. Field logs, sample records, and chain-of-custody records will be kept with the Exponent project files for reference purposes.

2. Data Acquisition

2.1 Sampling Design

The design of the benthic monitoring program for Ward Cove builds on different categories of benthic strata, which are based on water depth and on the kind of remedial action taken. Multiple sampling stations will be evaluated within each benthic stratum to enhance estimates of average (or mean) conditions in the stratum and to provide a measure of within-stratum variability. A detailed description of the monitoring program design is provided in the main text.

Sediment samples will be collected from 37 stations in the area of concern (AOC) and from 2 reference areas in Ward Cove but outside the AOC. The locations of sampling stations and the various benthic strata of the area of concern in Ward Cove are presented in Figures A-1a and A-1b and Figure A-2 of the FSP (Appendix A). The top 10 cm of sediment in one or more grab samples will be collected at each sampling station and composited. At four stations (Stations 8, 9, 13, and 38), five replicate sediment samples will be collected for toxicity testing. Although the target sediment horizon is 0–10 cm, shallower horizons may be collected at selected stations if the target horizon cannot be sampled after repeated attempts. A detailed description of the sampling design is provided in Appendix A of this document.

Sampling for long-term monitoring of the remedial action at Ward Cove is anticipated to occur every third year in July after the remedial activities have been completed (i.e., 2004, 2007, and 2010). Sampling is estimated to require 10–15 days (depending on the difficulty of obtaining adequate sediment samples at all stations). The sequence of sample collection will be arranged to maximize efficiency while minimizing potential cross-sample contamination. The actual sequence in which the stations will be visited will be determined in the field by the field team leader.

2.2 Sampling Methods

Surface sediment samples will be collected using a 0.06-m^2 stainless-steel van Veen grab sampler in accordance with standard methods used by the Puget Sound Estuary Program (PSEP) (PSEP 1986, 1997). The field team leader will evaluate all samples for acceptability. Samples that do not meet acceptance criteria will be rejected and discarded away from the station. Grab samples will be collected from every station and composited for chemical analysis and toxicity testing. Samples will be stored on ice or in a refrigerator at 4°C until shipment to the laboratories for testing.

Detailed descriptions of field methods and related quality assurance procedures are provided in Appendix A of the sediment monitoring plan, including the following:

- Identifying and documenting the location of sampling stations (Section 2.1)
- Decontaminating equipment and work surfaces prior to sample collection, between samples, and between sampling events (Section 2.4.1)
- Collecting sediment samples for chemical and toxicity testing (Section 2.4.1)
- Preparing composite samples and collecting subsamples for laboratory testing (Section 2.4.1)
- Collecting samples for enumeration of benthic infauna (Section 2.4.2).

Requirements for sample containers, preservation, and holding times, as well as the sample mass required by the laboratory for each analysis, are summarized in Table B-3. New I-Chem® 300 series or equivalent sample containers, with certificates of analysis, will be provided by the laboratories. Procedures for labeling, processing, and shipping samples are described in Appendix A of the sediment monitoring plan.

2.3 Sample Handling and Custody

A continuous record of the possession and proper handling of samples must be documented so that sample custody and handling is traceable from the time of sample collection until the analytical data have been validated and accepted for use.

2.3.1 Field Sampling Operations

Sample custody documentation is initiated in the field as each sample is collected. A designated sampler assumes custody of the samples as soon as they are collected. A sample label is attached to each sample jar as it is filled in the field. An example of a sample label is included in Appendix D. The sample information will be recorded by the field samplers onto the sample log forms at the time of collection. Sample identifiers will consist of coded information as described in Appendix A of the sediment monitoring plan.

At the end of each day and prior to shipping or storage, COC/SAR forms (Appendix D) will be completed for all samples. The information on the sample labels will be rechecked and verified against field logbook entries and the COC/SAR forms. Any necessary changes to COC/SAR forms, sample container labels, or the field logbook will be made by striking out the error with one line and reentering the correct information. The new entries will be initialed and dated.

Table B-3. Sample preservation and holding time requirements

Analyte	Approximate Laboratory Subsample	Container	Preservation and Handling	Maximum Holding Time (from date of collection)
Chemical Parameters				
4-Methylphenol	50–100 g	Wide-mouth glass jar; Teflon®-lined lid	4°C	14 days to extraction[a,b]
Ammonia	20 g	Wide-mouth, high-density polyethylene jar	4°C (do not freeze)	7 days
Total organic carbon	1 g	Wide-mouth, high-density polyethylene jar	4°C or freeze	28 days 6 months
Grain size	250 g	Wide-mouth, high-density polyethylene jar	4°C (do not freeze)	28 days
Total solids	10 g	Wide-mouth, high-density polyethylene jar	4°C	180 days
Toxicity Test				
Amphipod mortality (*R. abronius)*	1.25 L	2 X 1-L glass jar, Teflon®-lined lid	No headspace; store in dark; 4°C	14 days
Benthic Enumeration	NA[c]	1 X 1-L wide-mouth, high-density polyethylene jar	Sieve sediment in field; add 10 percent formalin with rose bengal stain	Not established

[a] Samples collected for analysis of 4-methylphenol may be archived in the freezer (–20°C) for up to 1 year (PSEP 1997).

[b] Extracts must be analyzed within 40 days of extraction.

[c] Approximate laboratory subsample dependent on volume of benthic macroinvertebrates collected at each station.

2.3.2 Shipping

All samples will be accompanied by COC/SAR forms (Appendix D) during shipment. The custodial sampler provides the first signature on the COC/SAR form when relinquishing custody to another member of the field team for documentation or packing or to the shipping company or laboratory courier. The COC/SAR forms will be generated using computer spreadsheet software. Sample information from the COC/SAR forms will be transferred electronically into the database. Paper copies of completed COC/SAR forms will be provided by the laboratories with the data packages and will be stored with the data by the project data manager.

When samples are shipped, the sample containers will be placed in plastic bags, securely packed inside the shipping coolers, and placed on ice as specified in Standard Operating Procedure (SOP) 2 for shipping samples (Appendix C). All glass containers will be wrapped in bubble wrap. The original COC/SAR forms will be enclosed in a plastic bag and taped to the inside lid of the cooler. The cooler will be taped closed by wrapping fiber tape completely around it. This End Up labels and Fragile—Glass labels, as well as any other required shipping labels, will be attached to the cooler, and the cooler will be sealed with two custody seals on adjacent sides of the lid. Packaging will conform to U.S. Department of Transportation regulations. Shipping procedures for environmental samples and restricted articles are described in SOPs included in Appendix C of the sediment monitoring plan.

The field personnel will be responsible for sample custody and appropriate sample storage prior to shipment, as well as for packing and shipping samples in a manner that allows the laboratory sufficient time to meet holding time requirements. The technical field personnel will also contact the laboratory project manager and the project manager to notify them of the sample shipment.

2.3.3 Laboratory Operations

The laboratory project manager will verify receipt of each sample shipment and will contact the sample manager to provide notification that all samples were received and to relay any concerns or observations regarding sample integrity or documentation. The laboratory project manager will also be responsible for ensuring that laboratory chain-of-custody forms and tracking records are completed upon receipt of the samples and maintained through all stages of laboratory analysis. Storage information must be maintained until disposal of the samples. The sample tracking records must show the date of sample extraction or preparation and the date of instrument analysis for each analytical procedure. These records will be used to determine compliance with holding time requirements.

The laboratories will maintain daily temperature logs for all refrigerators and freezers that contain samples for this project. These logs will be stored at the laboratory and copies will be provided to KPC if requested. The laboratory project manager will notify the

project QA/QC coordinator if storage temperatures deviate from those specified in Table B-3.

2.4 Analytical Methods

Sediment testing will be completed using PSEP (PSEP 1986, 1987, 1995, 1997), EPA SW-846 (U.S. EPA 1996), or other EPA-approved or -recommended methods when available and will include all associated QA/QC procedures recommended in each method. All laboratories for this study will have established protocols and quality assurance procedures that meet or exceed any applicable EPA guidelines. Laboratory procedures for chemical analyses, toxicity testing, and benthic community evaluations are summarized below.

2.4.1 Chemical Analyses

Chemical analyses will be completed for 4-methylphenol, ammonia, total organic carbon (TOC), grain size, and total solids. The target method reporting limits for chemical analyses are provided in Table B-2. These reporting limits can reasonably be expected from a competent laboratory and are consistent with results obtained previously for sediment from Ward Cove (Exponent 1999). The actual detection limits attained during this site investigation may be elevated with respect to target detection limits if interferences are encountered because of the sample matrices.

Analysis for 4-methylphenol will be completed using gas chromatography/mass spectrometry with selected ion monitoring (SIM). The method detection limit for this analysis is expected to be 10 μg/kg or less, consistent with the detection limit range of 10–50 μg/kg recommended by PSEP (PSEP 1997) and with detection limits reported in previous studies. Samples will be extracted by sonication using EPA Method 3550B (U.S. EPA 1996). Because SIM provides better sensitivity than full-scan mass spectrometry, the extraction procedures recommended by PSEP (1997) to improve detection limits (extraction of 50–100 g of sediment and concentration to 0.5 mL of extract) are not necessary and will not be used. All sediment samples will be subjected to gel permeation chromatography (EPA Method 3640A) or other cleanup procedures to remove interferents as necessary. QA/QC procedures will be completed as described in EPA Method 8270C (U.S. EPA 1996), with modifications made as necessary to accommodate the greater sensitivity of the SIM method (e.g., lower spiking levels for surrogate compounds, matrix spikes, and internal standards) and the analysis of a single target compound.

Conventional wet chemistry analyses will be completed according to the methods indicated in Table B-2 with the following modifications:

- EPA Method 350.3, a potentiometric procedure for ammonia in water, will be modified to include sediment extraction with 2M potassium chloride.

- Analyses for TOC in sediment samples will be completed according to Standard Method 5310B (Franson 1992) with modifications made to accommodate the sediment matrix. This procedure was approved by the Washington State Department of Ecology (Ecology 1993) for use in Puget Sound. The method includes sample combustion and infrared detection to measure the evolved carbon dioxide. Correction to true dry weight will be made if necessary to compensate for the incomplete drying step inherent in the TOC procedure (the volatile nature of some organic compounds precludes drying samples for TOC analysis at high temperatures).

2.4.2 Toxicity Tests

This acute test measures mortality and failure to rebury in adult amphipods exposed for 10 days to test sediment. The test species used in this study will be *Rhepoxynius abronius.* Protocols and QA/QC performance standards for this toxicity test are described in PSEP (1995).

Adult amphipods will be collected in the field and acclimated to the test water temperature and salinity for 3–4 days prior to testing. For each toxicity test replicate, 20 amphipods will be exposed to a 2-cm layer of bedded test sediment in a 1-L chamber filled with clean seawater. After the 10-day exposure period, the surviving amphipods in each test chamber will be sieved from the sediment and counted. Percent mortality will be determined relative to the total of 20 individuals added to each chamber at the beginning of the test. The survivors will then be exposed to clean control sediment, and the number that fail to rebury will be determined. Percent nonreburial will be determined relative to the number of survivors in each test chamber.

All toxicity tests will be conducted using positive and negative controls; blind testing of samples; and measurements of salinity, pH, temperature, dissolved oxygen, and ammonia. For this study, cadmium will be used as the reference toxicant and a sediment sample from West Beach on Whidbey Island, Washington, will be used as the negative control.

2.4.3 Benthic Macroinvertebrate Assemblages

Sediment samples for benthic macroinvertebrate enumeration and identification will be sieved sequentially using mesh sizes of 1.0 and 0.5 mm and preserved in the field prior to shipment. Initial taxonomic analyses will be conducted only on the organisms retained on the 1.0 mm screen, whereas organisms retained on the 0.5 mm screen will be archived for potential future analysis. At the laboratory, detritus will be removed from the 1.0 mm samples by technicians. Benthic taxonomists will sort the invertebrates in each 1.0 mm sample. After sorting has been completed, organisms will be identified to the lowest taxonomic level possible; the target being species level. All taxa will be identified in their entirety. All taxonomic identifications will be made by qualified taxonomists and

will be based on published keys. For incomplete specimens, only the anterior or posterior ends will be enumerated, depending upon the taxon. All identifications will be made using binocular-dissecting or compound microscopes. If possible, at least two pieces of literature will be used for each species identification. Moreover, each species identification will be verified by a taxonomic expert or checked against a reference specimen from a verified reference collection.

After completing taxonomic identifications, all organisms will be placed in vials containing 70 percent ethyl alcohol, 25 percent water, and 5 percent glycerine. These vials will be sealed. A label will be affixed to each vial with the following information: survey name, sample number, and date of collection.

Each taxonomist will record initial identifications and counts on sample data sheets. Any pertinent notes and comments on the organisms in each sample will also be recorded. The taxonomist will then sign and date the sample data sheet. All data sheets will be kept in the laboratory at all times so the laboratory supervisor can check questionable identifications and follow the progress of each sample.

2.5 Quality Control

Quality control samples and procedures are used to obtain quantitative information regarding the execution of field sampling and laboratory testing activities. Quality control results may be used to estimate the magnitude of bias and level of precision inherent in the test data. A variety of quality control samples will be collected in the field and initiated by the laboratories for every test.

2.5.1 Field Quality Control

Field quality control samples will include equipment rinsate blanks and field duplicate samples. These quality control samples will be collected or prepared by sampling personnel in the field and submitted to the laboratory as natural samples. Equipment rinsate blanks will be used to identify possible contamination from the sampling environment or from sampling equipment. These blanks will be collected by pouring deionized and distilled water over the decontaminated sampling equipment and into a sample jar. One equipment rinsate blank will be collected for each sampling event and will be analyzed for 4-methylphenol and ammonia.

Field duplicate samples will be collected to assess the homogeneity of the samples collected in the field and the precision of the sampling process. Field duplicates will be prepared by collecting two aliquots of sample from the homogenization bowl and submitting them for analysis as separate samples. At least one field duplicate will be collected from each remediation area (i.e., thin capped area and natural recovery area) for each sampling event.

In the field, the acceptability of all grab samples used to provide sediment for all testing will be determined by the field team leader using the following standardized criteria:

- The sampler is not overfilled
- Overlying water is present
- The overlying water is not excessively turbid
- The sediment surface is relatively undisturbed
- The depth of penetration is at least 11 cm.

If a sample fails to meet any of the above criteria, it will be rejected and discarded away from the station.

2.5.2 Laboratory Quality Control for Chemical Tests

Each analytical protocol used in this site investigation (Table B-2) includes specific instructions for analysis of quality control samples and completion of quality control procedures during sample analysis. These quality control samples and procedures verify that the instrument is calibrated properly and remains in calibration throughout the analytical sequence and that the sample preparation procedures have been effective and have not introduced contaminants into the samples. Additional quality control samples are used to identify and quantify positive or negative interference caused by the sample matrix. Each method protocol provides control limits that indicate acceptable conditions for analysis of samples as well as unacceptable conditions that would necessitate reanalysis of samples.

The following laboratory quality control procedures are required for most of the protocols for chemical analyses:

- **Calibration and Verification—**Initial calibration of instruments will be performed at the start of the project and when any ongoing calibration does not meet control criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibration will be performed as specified in the analytical methods to track instrument performance. In the event that a continuing calibration does not meet control limits, analysis of project samples will be suspended until the source of the control failure is either eliminated or reduced to within control specifications. Any project samples analyzed while the instrument was out of calibration will be reanalyzed.

- **Method Blanks—**Method blanks are used to assess possible laboratory contamination of samples during all stages of preparation and analysis. Blank corrections will not be applied by the laboratories

to the original data. A minimum of 1 method blank will be analyzed for every sample preparation group or 1 for every 20 samples, whichever is more frequent.

- **Laboratory Control Samples—**LCSs (reference material or spiked blanks) will be used as a check on overall method performance. An LCS will be analyzed for every sample delivery group (SDG) or for every 20 samples, whichever is more frequent.

- **Matrix Spike Samples and Matrix Spike Duplicates—**Matrix spike samples are used to assess the effects of the sample matrix on the accuracy of analytical measurements. For ammonia and TOC analyses, a minimum of 1 matrix spike will be analyzed for each SDG or for every 20 samples, whichever is more frequent. For organic analyses (i.e., for 4-methylphenol), duplicate matrix spike samples are used to assess both accuracy and precision. For organic compound analyses, 1 matrix spike and 1 matrix spike duplicate will be analyzed for every SDG or for every 20 samples, whichever is more frequent. Unspiked laboratory duplicates (described below) are used to assess the precision of data for inorganic analytes.

- **Laboratory Duplicates and Triplicates—**Replicate laboratory analyses are indicators of laboratory precision. For conventional analyses, 1 laboratory duplicate will be analyzed for every SDG or for every 20 samples, whichever is more frequent. Triplicate analyses will be completed for grain size distribution for one sample in every SDG.

- **Surrogate Spike Compounds—**Surrogate spike compounds will be added to all field and quality control samples for organic analyses (i.e., 4-methylphenol) to evaluate the recovery of analytes from each sample. Recoveries for these surrogate compounds will be reported by the laboratories; however, the laboratories will not correct sample results using these recoveries.

2.5.3 Laboratory Quality Control for Toxicity Tests

Laboratory QA/QC procedures for the amphipod mortality test include the use of positive and negative controls and daily measurement of water quality conditions (i.e., temperature, salinity, pH, and dissolved oxygen) in each test chamber. Appropriate ranges of water quality variables are as follows:

- Temperature: 15 ± 1°C

- pH: 8 ± 1 pH units (desirable)

- Salinity: 28 ± 1 ppt
- Dissolved oxygen: >5 mg/L (desirable).

All procedures will be carried out according to PSEP (1995) guidance. Only healthy organisms will be used for testing. Positive and negative controls will be tested concurrently with each toxicity test series. Reference toxicants (i.e., positive controls) will be used to provide insight into mortalities or increased sensitivity that may have occurred as a result of disease or the potential stresses related to handling, acclimation, and testing (e.g., loading density). Negative controls will be used to confirm the viability of the test organisms in the absence of stressors introduced with the test sediment. Results from a series will not be accepted if mean mortality in the negative controls exceeds 10 percent.

2.5.4 Laboratory Quality Control for Benthic Assemblages

At least 25 percent of one replicate from each sample will be re-sorted for QA/QC purposes. Re-sorting is the examination of a sample or subsample that has been sorted once and is considered free of organisms. It is critical that the re-sorted sediment aliquot be a representative subsample of the total sediment sample. Care should be taken to examine the preservative in each sample for any organisms that may be floating in the preservative. Re-sorting should be conducted using a dissection microscope capable of magnification to 25X. A partial re-sorting of every sample ensures that any gross sorting errors are detected. Re-sorting will be conducted by an individual other than the one who sorted the original sample.

Each sample aliquot that is selected for re-sorting will be checked for removal of ≥95 percent of total organisms. Thus, each sample elicits a decision concerning a possible re-sort. If a sample is found that does not meet the recommended 95 percent removal criterion, the entire sample will be re-sorted.

When taxonomic error or inconsistency is found, all previous results generated by the taxonomist responsible for the error or inconsistency should be evaluated to identify those samples that may be affected. This process, which should be carefully documented by the laboratory, can be very time-consuming. However, upon completion of all taxonomic work, few (if any) taxonomic errors or inconsistencies should remain in the data set. Avoiding errors and inconsistencies through the constant interchange of information and ideas among taxonomists is the best way to minimize time lost from faulty identifications.

When all identification and QA/QC procedures are completed, the jars containing the vials of identified species will be topped off with a solution of 5 percent glycerine/70 percent ethyl alcohol. The lids will then be sealed tightly with black electrical tape to prevent evaporation. Each container will be labeled clearly with the survey name, date of collection, and number and type of samples within.

2.6 Instrument and Equipment Testing, Inspection, and Maintenance

Preventive maintenance of field equipment and laboratory instruments is essential if project resources are to be used in a cost-effective manner. Preventive maintenance will take two forms: 1) a schedule of preventive maintenance activities to minimize downtime and ensure the accuracy of measurement systems and 2) availability of critical spare parts and backup systems and equipment. The performance of these maintenance procedures will be documented in field and laboratory notebooks.

The field team leader will be responsible for ensuring that routine preventive maintenance is performed and documented for all field instrumentation and equipment (e.g., global positioning system and sampling gear). The laboratory quality assurance officers will be responsible for ensuring that routine preventive maintenance is performed and documented for each analytical instrument and that spare parts or additional instruments are available in case of instrument breakdown or failure. Instrument quality control procedures (e.g., initial and continuing calibration, LCSs, calibration blanks) will be used to verify the continuing acceptable performance of each instrument. Details are provided in the referenced method descriptions (Table B-2) and the laboratory SOPs and quality assurance manuals.

2.7 Instrument and Equipment Calibration

Initial and continuing calibration procedures for laboratory instruments will be performed in accordance with the cited analytical method for each analysis (Table B-2). The method descriptions for each analysis specify acceptance criteria for initial and continuing calibration and state the conditions where recalibration is necessary.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology or other documented, reliable, commercial sources. At the laboratories, standards are validated prior to use to verify their accuracy by comparison with an independent standard. Reagents are examined for purity by performing method blank analyses.

Field instruments will not be required for field measurements or for health and safety monitoring.

2.8 Inspection and Acceptance of Supplies and Consumables

Supplies and consumables are required for sample collection and laboratory activities. During sample collection, the most critical supplies affecting data quality are those used for decontamination of the sampling equipment. Solvents of appropriate, documented purity will be used for decontamination. Acceptance for all supplies will require an intact seal upon receipt, maintenance at appropriate temperature, and use only prior to the expiration date. The date opened and initials of the individual who opened the container

will be written on the solvent bottle and on any smaller containers used to transfer solvent, such as a squirt bottle. This method of documentation allows any contamination problem to be traced to its source and will enable identification of related samples that may have been affected. Acceptance requirements will include a basic inspection of all containers received and rejection of unacceptable supplies.

Reagents of appropriate purity and suitably cleaned equipment must also be used for all stages of laboratory analyses. In addition, the laboratories must ensure that the concentrations of calibration and spiking standard are accurate and that instrumentation is functioning properly. The lot numbers of all standards are routinely tracked by the laboratories, from purchase of stock standards to preparation of secondary and working calibration standards. All calibration and spiking standards are checked against standards from another source. LCS results provide an additional check for accuracy. Details for acceptance requirements for supplies and consumables at the laboratories are provided in the laboratory SOPs and quality assurance manuals.

2.9 Non-direct Measurements

The only non-direct measurements to be used will be toxicity test results obtained for Ward Cove samples in 1996 and 1997. These data were collected and reported as part of the Ward Cove detailed technical studies (Exponent 1999), were subjected to a thorough data validation review, and have been accepted by EPA, the U.S. Army Corps of Engineers, and KPC. Interpretation of monitoring results may also rely on a base of knowledge about benthic community dynamics, as established by scientific papers published in peer-reviewed journals.

2.10 Data Management

Computerized systems will be used to record, store, and sort the technical data that will be generated to support the monitoring program. Automated data handling increases data integrity by reducing errors, omissions, and ambiguities that can be introduced by manual procedures. In addition, automated procedures will be used by the laboratories to capture and summarize analytical results. In this case, electronic data files can be imported directly from the laboratory to the project database, minimizing both data entry effort and opportunities for error. Sampling location coordinates will be entered into the database to enable the generation of maps and figures using ArcView® software.

Field logbooks, station/sample forms, and COC/SAR forms are prepared by the field team while sample collection activities are in progress. Sample information from the field is entered manually into the database. Each data record will include a unique sample code, station ID, sample type (matrix), analyte, analyte concentration, and concentration units. Data from the laboratories are entered directly from the electronic disk deliverables. A small portion of the laboratory data may be entered manually if electronic data cannot be supplied. Electronic data summaries are produced to support data validation procedures. Data qualifiers are entered into the database when validation

is completed and verified, and the data set is approved as final. All manual and electronic entries are verified by the data manager or validation personnel.

Project data tables and reports are prepared using customized retrievals that filter and sort the data according to criteria specified by the user. The data are automatically formatted for direct use with statistics software packages and various geographic information system software. The maintenance of a single, authoritative database prevents the proliferation of multiple versions of data and the introduction and proliferation of errors.

3. Assessment and Oversight

3.1 Assessment Activities

Assessment activities for each monitoring event will include readiness reviews prior to commencement of each phase of project work and surveillance while work is in progress. In addition, a technical systems audit may be conducted if problems are encountered during sample collection or analysis.

Readiness reviews are completed to ensure that the components of a project are in place so that work can be completed efficiently. Two readiness reviews will be conducted, one prior to the initiation of fieldwork and the other prior to data interpretation activities for each monitoring event.

The field team leader will verify that the following conditions are met prior to field sampling:

- All of the field equipment is ready and available, and shipment to the sampling site has been arranged
- The field sampling team has been scheduled, and transportation has been arranged
- Subcontractors (e.g., vessel operator and all laboratories) have been contracted and scheduled.

The data manager, at the project manager's direction, will finalize the project data after all results have been received from the laboratory, data validation has been completed, and data qualifiers have been entered into the database. This process constitutes the readiness review for data use. The project manager will be responsible for addressing any deficiencies in the readiness review. No report will be prepared.

Project surveillance will be conducted throughout the course of each monitoring event to ensure that every phase of work (fieldwork, laboratory analysis, data review/validation, data interpretation, and report preparation) follows the quality assurance procedures outlined in this QAPP. The project manager will be responsible for conducting surveillance with the assistance of the field sampling director, data validation manager, laboratory quality assurance officers, and lead technical personnel. Technical problems will be noted in the field sampling or quality assurance report if appropriate. Any non-compliance issues will be addressed as described below in Section 3.2.

Technical system audits will be conducted if problems are encountered during sampling and analysis operations. If completed, these audits will be conducted by the project

QA/QC coordinator or designee or by the laboratory quality assurance officer. These audits may consist of onsite reviews of field activities or laboratory analyses. Technical system audits may include, but are not limited to, the following components:

- Field and laboratory personnel, facilities, and equipment
- Chain-of-custody procedures and records
- Instrument calibration and maintenance procedures and records
- Standards preparation and verification procedures and records
- Documentation of analytical methods
- Sample storage conditions
- Data reduction, processing, and reporting procedures
- Documentation of control procedures.

All personnel engaged in sampling and analysis tasks will have appropriate training and required certifications. All laboratories are required to have written procedures addressing internal QA/QC; these procedures must be submitted to KPC and will be reviewed by the project QA/QC coordinator to ensure compliance with this QAPP. The QA/QC coordinator will discuss any serious problems with the project manager. The EPA Region 10 and KPC project managers will be notified of the situation. Any problems identified during the course of the project that affect data quality will be discussed in the quality assurance report.

3.2 Response Actions

While the entire quality assurance program is designed and implemented to avoid problems, it also serves to identify unexpected or unavoidable problems that may be encountered during sample collection and analysis. An important part of any quality assurance program is a well-defined policy that can effectively correct these problems after they have been identified.

3.2.1 Short-Term Corrective Action

Short-term corrective actions fall into two categories: 1) handling analytical instrument or field equipment malfunctions, and 2) handling nonconformance or noncompliance with the quality assurance requirements that have been established for the project.

During field operations and sampling procedures, the field team leader will be responsible for correcting equipment malfunctions. Acceptable equipment operating parameters and control limits are specified in the operating instructions and SOPs

(Appendix C). If any piece of equipment fails to meet established quality control criteria or cannot be properly repaired, it will be replaced. All equipment malfunctions and subsequent corrective measures will be documented in the field log.

The laboratory quality assurance officers are responsible for ensuring that laboratory results comply with project, method, and laboratory quality control requirements and that all analytical instruments and laboratory equipment are properly maintained. Acceptable instrument operating parameters, control limits for quality control results, and required corrective actions are specified in the laboratory SOPs, method protocols, and manufacturers' instructions provided with laboratory instruments. Control limit specifications are designed to help analysts detect the need for corrective action. Often an analyst's experience will be most valuable in identifying suspicious data or malfunctioning equipment. Immediate corrective action must be taken by the laboratory if any phase of the sample preparation and analysis process is considered suspect. Any corrective actions will be noted in the laboratory notebooks and, if appropriate, discussed in the case narratives for all affected sample sets.

3.2.2 Long-Term Corrective Action

In addition to short-term corrective actions taken by field and laboratory personnel, a mechanism is required to address long-term, systemic corrective actions. The need for long-term corrective action may be identified by an overview of compliance with standard quality control procedures, control charts, and performance or system audits. Any quality control problem that cannot be solved by immediate corrective action falls into this long-term category. The long-term system will be used to ensure that the condition is reported to the person who is responsible for the corrective action and follow-up plan.

The required corrective actions will vary, depending on the nature of the problem; however, the essential steps in the closed-loop, long-term corrective action system are as follows:

- Identify the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Determine a corrective action to eliminate the problem
- Establish responsibility for implementing the corrective action, and implement the corrective action
- Verify that the corrective action has eliminated the problem
- Document the complete process of establishing and implementing the corrective action in a project memorandum that specifies the problem

areas requiring corrective action and how they were detected, the individual initiating corrective action, the samples concerned, the acceptable data range, the measures taken to correct the problems, and the individual approving the corrective action.

The QA/QC coordinator, who has the authority to enforce necessary corrective measures, will routinely review the documentation of corrective actions.

3.3 Reports to Management

Reports will be prepared for any condition that requires corrective action and for technical system audits (if conducted). The reports will be prepared by the individual who conducted the audit, approved by the project QA/QC coordinator, and provided to the KPC and Exponent. Any significant problems identified in any of these reports will be discussed with EPA Region 10.

Upon completion of the site investigation, a data quality report will be prepared that will include the following items:

- A discussion of sampling procedures and any anomalies encountered during sample collection
- A discussion of laboratory procedures
- A discussion of quality control procedures and data validation results
- A description and discussion of any other conditions that may have affected the quality of the data
- A summary of the quality of the project data
- A description of the data usability and limitations for the project.

The report will be prepared by or under the direction of the field activities manager (for discussions related to fieldwork) and the QA/QC coordinator (for data quality evaluation). The report will provided to EPA Region 10.

4. Data Verification, Validation, and Usability

Data verification and validation are conducted to establish the data quality and usability for the project. Data verification is the process of determining whether samples have been collected and analyzed according to procedures prescribed in the sediment monitoring plan, SOPs and method descriptions, and this QAPP. Data verification includes checking for compliance of procedures with the project plan, correctness of protocols used in the field and at the laboratory, comparability of the data collection and analysis procedures, and completeness of the data set and supporting documentation. Data validation is the process of evaluating the technical quality of the verified data with respect to the project data quality objectives (DQOs). Data validation and verification criteria and procedures are described below in Sections 4.1 and 4.2. Procedures for determining data usability are provided in Section 4.3.

Data Verification and Validation Requirements

Requirements for field and laboratory procedures and data quality are described in this section. Adherence to these procedures by field and laboratory personnel will be verified as described in Section 4.2.

4.1.1 Requirements for Verification of Field Procedures

Field procedures will be followed as described in this QAPP, the FSP (Appendix A), and the SOPs (Appendix C). All protocols related to sample collection, storage, shipping, and handling include requirements for quality assurance procedures and documentation of activities. Any deviations from specified procedures should be documented in detail in the field logbook and fully justified. Specific requirements include, but are not limited to, the following:

- Sampling locations must be fully documented and correct. Errors in the sampling location (e.g., as the result of malfunction of the global positioning system unit) may result in the rejection of data.
- Sample collection, compositing, and homogenization procedures must be completed as planned and fully documented. Difficulties encountered during sampling that may affect the representativeness of the sample should be minimized.
- Sample shipping and handling procedures must be completed as described in the sediment monitoring plan. Maintaining appropriate sample temperatures during field activities and shipping is particularly important.

- Results for field quality control samples should meet control limits. The MQO for precision (Table B-2) will be used as the control limit for field duplicates. Equipment rinsate blank contamination will result in the qualification of related data as described in the functional guidelines (U.S. EPA 1994, 1999b).

Failure to meet these requirements may result in qualification or rejection of data during data validation (see Section 4.2).

4.1.2 Requirements for Verification of Laboratory Procedures

Laboratory procedures should be followed as described in this QAPP, the method descriptions cited in Table B-2, and the laboratory quality assurance plan and SOPs. Any deviations from the specified procedures should be documented in detail and fully justified in the case narrative for the data package.

Chemical data will be evaluated according to criteria specified in the functional guidelines for data validation (U.S. EPA 1994, 1999b). Data may be qualified as estimated or rejected if any of the following quality control samples and procedures do not meet control limits:

- Sample holding times (specified in Table B-3 of this QAPP)
- Method of analysis
- Initial and continuing instrument calibration
- Calibration and method blanks
- LCSs
- Matrix spike samples
- Matrix duplicates or matrix spike duplicates
- Surrogate recovery
- Analyte identification and quantification.

Toxicity test data will be qualified as estimated or rejected if quality control results do not meet the criteria specified in the method description (PSEP 1995). Data will be qualified as estimated or rejected if results for any of the following procedures do not meet control limits:

- Positive control tests
- Negative control tests
- Water quality conditions.

The toxicity test data will not be accepted if the mean mortality of amphipods in the negative controls exceeds 10 percent.

Data for benthic macroinvertebrate assemblages will be verified and validated primarily by the taxonomic laboratory. Any errors will be corrected at the laboratory and samples will be re-counted or identifications corrected if necessary. The laboratory will be contacted if errors are found during Exponent's data review. Data may be qualified as estimated or rejected if the laboratory is unable to resolve errors.

4.2 Verification and Validation Methods

Verification procedures will be completed in the field during sample collection and in the laboratory during sample analysis and testing. In addition, verification and validation of all field and laboratory documentation and reports will be conducted after the analyses and tests are completed. The data will be released for interpretation only after validation has been completed and all qualifiers have been correctly entered into the database.

4.2.1 Field Procedures

The conformance of field activities to specifications in the sampling plan will be verified by the field team leader on an ongoing basis while field activities are in progress. Additional verification will be provided through oversight of the field activities by the project manager. Verification procedures will include the review of any deviation from prescribed sampling procedures described in the field logbook.

Planned sampling locations are described in the FSP. If a sample cannot be collected as planned, the project manager will be notified and an alternate location or sampling method will be selected if possible. The review process will include immediate evaluation of any sampling difficulties so that an alternate field procedure or location may be established quickly, if necessary.

Sample completeness will be verified at the end of each sampling day and again when samples are packed for shipment to the laboratory. Laboratory personnel will provide an additional completeness check when the samples are received and logged in and checked against the COC/SAR forms.

Sample identification information in the sample logs and COC/SAR forms will be verified by the data manager or sampling personnel when the field data are entered into the database. Station location information will be verified by the project manager or

designee when station coordinates are used to generate project maps. Any discrepancies will be brought to the attention of the field team leader, who will be responsible for resolving the issue. Any deviations that affect data quality or completeness will be discussed in the data quality report, and data will be qualified or rejected, as appropriate.

4.2.2 Chemical Analyses

Verification and validation of chemical data will be completed at the laboratories and by Exponent. The laboratory will be responsible for verifying data quality during and after sample analyses. Any nonconformance issues identified during the laboratory's quality assurance checks will be corrected and noted by the laboratory. Close contact will be maintained between the project QA/QC coordinator and the laboratory project manager so that any quality issues can be resolved in a timely manner. Any data quality deviations will be discussed in the laboratory case narrative, including the direction or magnitude of any bias to the data, if possible.

Data validation and verification will be completed by Exponent prior to finalization of the data and release of the data set for interpretation. Chemical data will be validated according to EPA Level 3 criteria (U.S. EPA 1995). Level 3 validation includes evaluation of the results for quality control samples (i.e., surrogate recoveries, calibration and method blanks, matrix spikes and matrix spike duplicates, and LCSs) with respect to control limits. Initial and continuing calibration results will be reviewed, but calculations and transcriptions will not be checked. Qualifiers will be applied to the results according to procedures described in the EPA Contract Laboratory Program national functional guidelines for data review (U.S. EPA 1994, 1999b), as applicable, with modifications made as appropriate to accommodate method-specific quality control requirements. For conventional analyses, data qualifiers will be applied when the quality control results do not meet MQOs (Table B-2).

4.2.2.1 Algorithms to Assess Quality Control Results

Data verification includes checking that quality control procedures were included at the required frequencies and that the quality control results meet control limits defined in the method descriptions or by the project MQOs. The equations that will be used to determine whether measurement targets for project MQOs were met for each quality control procedure are provided below.

Duplicate Analyses—Precision for duplicate chemical analyses will be calculated as the relative percent difference (RPD) between the duplicate samples. The formula that will be used to assess precision for both laboratory and field duplicate samples is as follows:

$$\mathrm{RPD} = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

where:

D1 = sample value

D2 = duplicate sample value.

Matrix Spikes and Surrogate Recoveries—Spiked samples provide an indication of the bias of the analysis system. The recovery of matrix spikes and surrogate spikes will be calculated as the ratio of the recovered spike concentration to the known spiked quantity:

$$\%R = \frac{A - B}{C} \times 100$$

where:

A = the analyte concentration determined experimentally from spiked sample

B = the background level determined by a separate analysis of the unspiked sample

C = the amount of the spike added.

Completeness—Completeness will be calculated for each sample type by dividing the number of valid measurements (all measurements except rejected data) actually obtained by the number of valid measurements that were planned:

$$\%\text{Completeness} = \frac{\text{Valid Data Obtained}}{\text{Total Data Planned}} \times 100$$

To be considered complete, the data sets must also contain all quality control check analyses that verify the precision and accuracy of the results.

4.2.2.2 Detection and Quantification Limits

The detection limit of the sample preparation and analysis process is defined as "the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte is greater than zero" (40 CFR 136B). In other words, it is the point at which qualitative, not quantitative, identification can be made. In practice, the limit of detection is defined as three times the standard deviation of the blank or background response adjusted for the amount of sample typically extracted and the final extract volume of the method.

Best professional judgment is used to adjust the limit of detection upward in cases where high instrument precision (i.e., low variability) results in a calculated limit of detection and equivalent instrument response less than the absolute sensitivity of the analytical instrument. The actual reporting limit for environmental samples is generally higher than the instrument detection limit because the sample matrix tends to contribute to fluctuations in the instrument's background signal. Laboratory personnel will determine reporting limits based on their experience with samples of similar matrix to those collected for this study and on the response of each instrument to samples for this study. The method reporting limits will be verified during data validation.

4.2.3 Toxicity Tests

The following procedures and results will be verified for toxicity test data:

- Use of the correct test procedures
- Identity of the test organisms
- Results for positive and negative controls
- Results of measurements for salinity, conductivity, hardness, pH, alkalinity, temperature, dissolved oxygen, and ammonia in the test water.

Results from a series will not be accepted if mean mortality in the negative controls exceeds 10 percent. Results for the positive controls (tests using reference toxicants) will be reviewed to evaluate mortalities or increased sensitivity that may have occurred as a result of disease or the potential stresses related to handling, acclimation, and testing (e.g., loading density).

4.2.4 Benthic Macroinvertebrate Identification

The data validation process for the taxonomic identification of macroinvertebrates includes reviewing the reported data; checking for completeness, consistency of the results, and transcription errors; and recalculating results when feasible. The following information will be reviewed, and verified and validated when feasible:

- Assemblages of species, as determined by visually surveying and mapping the species composition and distribution (i.e., qualitative estimates)
- The results of the taxonomic verification for each taxon as part of the distribution survey

- The number of individuals of each taxon found in each sample
- Standard invertebrate metrics such as taxonomic richness, community evenness, Shannon-Wiener diversity, and percent composition in functional feeding groups.

4.3 Reconciliation with User Requirements

The goal of data validation is to determine the quality of each data point and to identify data points that do not meet the project DQOs. Nonconforming data may be qualified as estimated or rejected as unusable during data validation if criteria for data quality are not met. Rejected data will be flagged as unreportable in the project database and will automatically be excluded from all data retrievals. These data will not be used for any purpose. An explanation of the rejected data will be included in the data validation report. If the rejected data are needed to make a decision, then it may be necessary to resample. Any decision to resample will be based on discussions among the project management team (EPA Region 10, KPC, and Exponent).

Data qualified as estimated (*J*) will be used for sediment monitoring and will be appropriately qualified in the final project database. These data are less precise or less accurate than unqualified data. The data users and the Exponent project manager are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses for sediment monitoring. The data quality report will include all available information regarding the direction or magnitude of bias or the degree of imprecision for qualified data to facilitate the assessment of data usability. The monitoring report will include a discussion of data limitations and their effect on data interpretation activities.

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Appendix C

Standard Operating Procedures

Exponent™

SOP 2
SAMPLE PACKAGING AND SHIPPING

Specific requirements for sample packaging and shipping must be followed to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein.

EQUIPMENT REQUIRED

Specific equipment or supplies necessary to properly pack and ship environmental samples include the following:

- Ice in sealed bags or Blue Ice®
- Sealable airtight bags
- Plastic garbage bags
- Coolers
- Bubble wrap
- Fiber reinforced packing tape
- Scissors
- Chain-of-custody seals
- Airbills for overnight shipment
- Chain-of-custody record/sample analysis request forms.

PROCEDURE

The following steps should be followed to ensure the proper transfer of samples from the field to the laboratories:

1. Appropriately document all samples using the proper logbooks (see SOP 4) and chain-of-custody record/sample analysis request forms (example provided in Attachment 2-1).

2. Make sure all applicable laboratory quality control sample designations have been made on the chain-of-custody record/sample analysis request forms. Samples that will be archived for future possible analysis should be clearly identified on the chain-of-custody record/sample analysis request form. Such samples should also be labeled on the chain-of-custody record/sample analysis request form as "Do Not Analyze: Hold and archive for possible future analysis" as some laboratories interpret "archive" to mean continue holding the residual sample after analysis.

3. Notify the laboratory contact and the project QA/QC coordinator that samples will be shipped and the estimated arrival time. Send copies of all chain-of-custody record/sample analysis request forms to the QA/QC coordinator.

4. Samples will be placed in secure onsite storage or remain in the possession of the sampling personnel before shipment. Any temporary sample storage areas will be locked and secured to maintain sample integrity and chain-of-custody requirements.

5. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.

6. Check sample containers against the chain-of-custody record/sample analysis request form to ensure all samples intended for shipment are accounted for.

7. Store each sample container in a sealable bag that allows the sample label (example provided in Attachment 2-1) to be read. Volatile organic analyte (VOA) vials for a single sample must be encased in bubble wrap before being sealed in bags.

8. Choose the appropriate size cooler (or coolers) and line with bubble wrap.

9. Fill the cooler with the samples, separating glass containers with bubble wrap and allowing room for ice to keep the samples cold. Add enough ice or Blue Ice® to keep the samples refrigerated overnight. Ice should be enclosed in sealable plastic bags to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it will insulate the containers from the ice. After all samples and ice have been added to the cooler, use bubble wrap to fill any empty space to keep the samples from shifting during transport.

10. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the quality assurance project plan calls for one.

11. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it shut with fiber-reinforced packing tape. If the cooler has a drain at the bottom, it should be taped shut in the same manner.

12. Fill out the chain-of-custody/sample analysis request form as described in SOP 5, and retain the back copy of the form for the project records before sealing the cooler. Store the signed chain-of-custody record/sample analysis request forms in a sealable bag and tape them to the inside of the cooler lid. For a shipment containing multiple coolers, indicate on the outside of this cooler "Chain-of-Custody Inside."

13. As security against unauthorized handling of the samples, apply one or two chain-of-custody seals across the opening of the cooler lid (example provided in Attachment 2-1). Be sure the seals are properly affixed to the cooler so they are not removed during shipment.

14. Label the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care."

15. If an overnight courier is used, fill out the airbill as required and fasten it to the top of the cooler. The identification number sticker should be taped to the lid, because tracking problems can occur if a sticker is removed during shipment.

ATTACHMENT 2-1

Example Chain-of-Custody Record/Sample Analysis Request Form, and Label and Custody Seal

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SOP 4
FIELD DOCUMENTATION

All information relevant to field operations must be properly documented to ensure that activities are accounted for and can be reconstructed from written records. Several types of logbooks will be used for this purpose and should be consistently used by field crews (e.g., field logbooks, sample logbooks, field data logbooks). Logbooks will be labeled on the cover with the project name, dates of field work, and the Exponent contract number. Each logbook for a particular project will be numbered (e.g., Shell Oil Remedial Investigation—Fieldbook Number 2).

The information recorded in each logbook should be written in indelible ink. All corrections should consist of a single line-out deletion, followed by the author's initials and the date. Field logbooks will be photocopied after each period in the field, and photocopies will be stored in the project files. After field activities are completed, logbooks will be stored in the permanent project file. No bound logbooks should be discarded, even if they are illegible or contain inaccuracies that require a replacement document. When not in use, all logbooks will be stored in the permanent project file.

FIELD LOGBOOKS

The purpose of the field logbook is to document events that occur and record data measured in the field to the extent that someone not present at the site can reconstruct the activity without relying on the memory of the field crew. A separate bound logbook with consecutively numbered pages will be used for each field project. Each page in the field logbook will be initialed and dated by all persons making entries on that page. The author will sign and date the last page at the end of each day, and a line will be drawn through the remainder of the page. The logbooks, at a minimum, must contain the following information:

1. A purpose and description of the field task
2. The time and date the field work began
3. The location and description of the work area, including sketches, map references, and photograph log, if appropriate
4. The names and titles of field personnel and anyone present during the field work, including the times they are present
5. The name, agency, and telephone number of any field contacts

6. The meteorological conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change
7. Details of the field work performed, with a description of any deviations from the sampling and analysis plan or field methods
8. All field measurements made (unless a specific logbook is available for this purpose), including the time of measurement
9. Notations of field measurement equipment instrument numbers, calibration supplies, procedures, and results of calibrations, if applicable
10. Any field results not appearing in the field data logbook, including station identification and location, date, and time of measurement
11. Cross-references of numbers for duplicate samples
12. References to other logbooks used to record information (e.g., station log, sample log, health and safety log).

SAMPLE COLLECTION FIELD FORMS

Appropriate sample collection field forms will be used to record the relevant sample information during a sampling event. For instructions regarding proper use of sample identifiers, sampling personnel should consult the field sampling plan.

SAMPLE LABELS

Exponent sample labels (tags) are designed to uniquely identify each container that is used for a sample. Field crews will be provided with preprinted sample labels, which must be affixed to each sample container used. The labels should be filled out at the time the samples are collected and should consist of the following information:

1. Sample number
2. Site name
3. Date and time sample is collected
4. Initials of the samplers
5. Preservatives used, if any
6. A unique tag number (preprinted on the tag, if possible) consisting of six digits, used to identify individual containers.

PHOTOGRAPHS

In certain instances, photographs of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Photographs should include a measured scale in the picture, when practical. Telephoto or wide-angle shots will not be used because they cannot be used in enforcement proceedings. The following items should be recorded in the field logbook for each photograph taken:

1. The photographer's name, the date, the time of the photograph, and the general direction faced
2. A brief description of the subject and the field work portrayed in the picture
3. The sequential number of the photograph and the roll number on which it is contained.

The slides, prints, or disks (as appropriate) and associated negatives will be placed in the project files after the film is developed. (Any supporting documentation from the field logbooks will be photocopied and placed in the task files to accompany the slides, prints, or disks.

SOP 5
SAMPLE CUSTODY

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP 4, which covers the use of sample logbooks, and SOP 2, which covers sample packaging and shipping. Chain-of-custody record/sample analysis request forms (Attachment 5-1) ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

PROCEDURE

The chain-of-custody record portion of the form is the most critical because it documents sample possession from the time of collection through the final disposition of the sample. The sample analysis request portion of the form provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

The chain-of-custody record/sample analysis request form will be completed after each field collection activity and before the samples are shipped to the laboratory. Sampling personnel are responsible for the care and custody of the samples until they are shipped. When transferring possession of the samples, the individuals relinquishing and receiving the samples must sign the chain-of-custody record/sample analysis request form(s), indicating the time and date that the transfer occurs. Copies of the forms will be made and kept by Exponent, and the originals will be included with the samples in the transfer container. The following guidelines will be followed to ensure consistent shipping procedures and to maintain the integrity of the samples:

1. Each chain-of-custody record/sample analysis request form must be appropriately signed by the sampling personnel. The person who relinquishes custody of the samples must also sign this form.

2. The chain-of-custody record/sample analysis request form should not be signed until the information has been checked for inaccuracies by the lead sampler. All changes should be made by drawing a single line through the incorrect entry and initialing and dating it. Revised entries should be made in the space below the entries. On the handwritten chain-of-custody record/sample analysis request forms, spaces remaining at the bottom of the page after corrections are made should be marked out with single lines. This procedure will preclude any unauthorized additions.

3. At the bottom of each chain-of-custody record/sample analysis request form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date that the transfer occurred. The time that the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.

4. If samples are sent by a commercial carrier not affiliated with the laboratory, such as Federal Express or UPS, the name of the carrier should be entered in the "received by" block. The time of transfer should be as close to the actual drop-off time as possible. After the chain-of-custody record/sample analysis request forms are signed and copied, they should be sealed inside the transfer container.

5. If errors are found after the shipment has left the custody of Exponent personnel, a corrected version of the forms must be made and sent to all relevant parties. Minor errors can be rectified by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.

6. Samples that are archived internally at Exponent should be accompanied by a chain-of-custody record/sample analysis request form. While samples remain in Exponent's custody before being shipped, all containers will be kept in sight of Exponent personnel or in a secured area to preclude tampering with the samples.

ATTACHMENT 5-1

Example Chain-of-Custody Record/Sample Analysis Request Form

Exponent™

SOP 6B
PREPARATION OF FIELD QUALITY CONTROL SAMPLES—SEDIMENT

This SOP describes the purpose, preparation, and collection frequency of equipment rinsate blanks, replicate samples, trip blanks, and reference materials for solid matrices.

As part of the QA/QC program, all field quality control samples will be sent blind to the laboratories. To accomplish this, the samples will be sent in the same form as regular samples, including all containers, sample numbers, and analytes. The sample ID for field quality control samples should allow data management and data validation staff to identify them as such. Under no circumstances should the laboratory be allowed to use reference materials, rinsate blanks, or trip blanks for matrix spike and matrix spike duplicate analysis. The laboratory should be instructed to contact the project QA/QC coordinator when a laboratory quality control sample is not specified on the sample analysis request form for a sample digestion group so that one can be assigned.

All field quality control samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP 2, *Sample Packaging and Shipping*. Sample custody will be maintained in accordance with procedures outlined in SOP 5, *Sample Custody*.

Field quality control samples will be prepared at least once per sampling event, and certain types will be prepared more often at predetermined frequencies. If the number of samples taken does not equal an integer multiple of the intervals specified in this SOP, the number of field quality control samples is specified by the next higher multiple. For example, if a frequency of 1 quality control sample per 20 is indicated and 28 samples are collected, 2 quality control samples will be prepared. The text below describes the preparation and frequency of field quality control samples required for sediment sampling activities.

EQUIPMENT RINSATE BLANKS

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment or from improperly decontaminated sampling equipment. Equipment rinsate blanks will be prepared by processing a representative amount of laboratory deionized water through the decontaminated sample collection equipment, then transferring the water to the appropriate sample containers and adding any necessary preservatives. Because the matrix for rinsate blanks is water, rather than solids, bottle types and volumes should be coordinated with the laboratory. Equipment rinsate blanks will be prepared for sediment core sampling and analyzed for all inorganic, organic, and conventional analytes at least once per sampling event.

The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator.

Sediment collected with the gravity corer comes in contact with the polycarbonate tube that holds the sample and the stainless-steel bowl used for homogenizing the sediment sections. To prepare the equipment rinsate blank, the core tube and stainless-steel bowl will be decontaminated and allowed to air-dry as specified in SOP 104, *Sediment Coring Procedures Using Slide Hammer and Gravity Corers*. The procedure will likely require two people to be done effectively. One person should hold the polycarbonate tube at an angle above the stainless-steel bowl. While this person slowly turns the tube, the second person pours deionized water through the tube into the bowl. When the bowl is one-half full, the sample bottles will be filled with the water and preserved as necessary. The process will be repeated until all sample bottles are filled. When finished, the ends of the tube will be capped and the bowl covered with aluminum foil (dull side down) for use at the next station.

FIELD TRIPLICATE SAMPLES

Field triplicate samples are co-located samples collected in an identical manner over a minimum period of time to provide a measure of the analytical precision (field and laboratory) variance, including variance resulting from sample heterogeneity. Field triplicates will consist of three samples (one sample and two replicates) collected consecutively at the same location and placed in different bottles for separate analysis. Each replicate will have a unique sample number to distinguish it from the others. The three samples will be sent to the laboratory and analyzed for identical chemical parameters but will not be distinguishable by the laboratory as being replicates. Field triplicates will be collected for sediment core and surface sediment sampling at a minimum frequency of 1 per 50 samples or once per sampling event, whichever is more frequent.

TRIP BLANKS

Trip blanks will be used to help identify cross-contamination in the shipment of aqueous samples for analyzing volatile organic compounds (VOCs) only. Trip blanks will be prepared in the field office by pouring deionized water into two 40-mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure that no air bubbles exist.

The blanks will be transported unopened to and from the field in the cooler with the VOC samples. One trip blank will be sent with each shipment of samples for analyzing VOCs for sediment core and surface sediment sampling.

REFERENCE MATERIALS

Reference materials are materials of known composition that have been prepared by and obtained from EPA-approved sources and that have undergone multilaboratory analyses using a

standard method. Reference material samples provide a measure of analytical performance and/or analytical method bias of the laboratory. Several reference materials may be required to cover all analytical parameters. Reference materials will be prepared for sediment core and surface sediment sampling at a minimum frequency of 1 per 50 samples or once per sampling event, whichever is more frequent. Details on preparation of the reference materials can be found in SOP 71B, *Preparation of Reference Materials—Sediment*.

Exponent™

SOP 51A
STATION POSITIONING USING THE TRIMBLE PATHFINDER™ PRO XRS

This standard operating procedure (SOP) describes the use of Trimble's global positioning system (GPS) Pathfinder™ Pro XRS equipment used for positioning sampling vessels and locating sampling stations. The Pro XRS offers the sub-meter accuracy often required for documenting sampling station locations and for relocating previously sampled stations.

PRO XRS DESCRIPTION

The Pro XRS combines a high-performance GPS receiver and antenna, beacon differential receiver, and satellite differential receiver in one compact unit. With the Pro XRS, operators can gather GPS data of sub-meter accuracy using their choice of differential correction sources (i.e., free beacon differential signals [e.g., Coast Guard beacons] or real-time satellite differential signals from OmniSTAR) without establishing a reference station. Correction of data is required to gain sub-meter accuracy. Free beacon signals allow differential corrections to be performed after data collection by using a nearby beacon as the base station. For satellite-based signals, a built-in virtual base station allows for real-time data correction, eliminating the need for post-processing data.

The Pro XRS also includes Trimble's advanced Everest™ technology, which allows users to collect accurate positions data near walls, water, vehicles, or other surfaces that reflect satellite signals. Reflected signals, also called multipath signals, make it difficult for GPS receivers to accurately determine position. Everest uses a patented technique to remove multipath signals before measurements are used to calculate position.

EQUIPMENT REQUIRED

GPS Pathfinder™ Pro XRS consists of the following:

- GPS receiver in backpack casing (with system batteries and cables)
- Hand-held data logger (TDC1) and cable
- Pro XRS antenna, range poles, and cable
- Compass and tape measure

- Spare 12-volt camcorder and 9-volt batteries (2 each) (use only Kodak, Duracell or Energizer 9 volt batteries)
- Battery charger and power cord.

PRO XRS SETUP

Follow these procedures for the proper setup of the Pro XRS:

1. Ensure connections between batteries, receiver and data logger are correct and secure. The coaxial antenna cable connects from the GPS receiver port "ANT" to the base of the antenna. The TDC1 cable connects from the bottom of the TDC1 to the receiver port "B." The dual Y-clip cables should be connected from the batteries to the TDC1 cable via a "pig-tail"-type connector.
2. Screw the 3 long antenna poles together (the shorter pole may be added if necessary for taller users). Screw on the antenna and connect its cable.
3. Put backpack and shoulder strap on. The pouch for the data logger should be in place around the waist strap.
4. Place antenna in the side pouch of the back-pack. Wind cord around pole, and use Velcro on the shoulder strap to secure the antenna.

BASIC OPERATION OF THE PRO XRS

Recording a Feature

Before beginning field use, ensure that all GPS configurations and settings are set correctly for the particular use of the Pro XRS and that an appropriate data dictionary is loaded onto the TDC1 (See Attachment 51A-1 and 51A-2 for typical settings). These steps outline the basic use of the GPS to document a sample position or any other defined "feature." Note that the TDC1 has both hard-keys and soft-keys that allow for its operation. The hard keys are all the keys (e.g., letters and numbers) on its surface. The soft-keys are the F1 through F5 hard keys. The function of these changes depending upon the context. These keys will be referred to with arrows around them (<soft-key>).

1. Turn data logger on outside in an open area. Wait for antenna to receive satellite signals. The display will read "Recording Almanac," "Too few SVs," and "PDOP too high." Continue to wait until enough satellites (4) are acquired, and the PDOP is below 6.0.

2. Ensure that the OmniSTAR satellite in use is the correct one for your geographical location. There are 3 satellites which cover the United States – each covering approximately one-third of the width of the continental United States, with overlapping coverage on the periphery. This setting can be checked/changed by accessing the "Integrated DGPS" menu. (Press GPS, press <DGPS STATUS>, press <SETUP>.) The satellite setting in this menu should indicate the appropriate region: AMSC – Eastern USA, Central USA, or Western USA.

3. Select DATA CAPTURE, and open a new rover file. This file should be named according to the format: mmddxxxn; where "mm" is the month; "dd" is the date; "xxx" is the user's initials; and "n" is a number to indicate different files on the same date, if necessary (e.g., 0219cnc1). This naming convention allows future users and GIS staff to track the individual responsible for the file.

4. Pick the appropriate data dictionary to use with the rover file. Only one dictionary can be used with a rover file. The data dictionary entitled "General sampling," contains features with attributes common to many Exponent projects. Additionally, SOP 51B explains how to create a data dictionary using Pathfinder Office. It is very important to use a data dictionary and be familiar with its attributes before recording information in the field.

5. Move to the location of the first feature for which you want to record the GPS position. Select the appropriate feature. Log data points in accordance with the feature type. Point features should have at least 10 points collected at a single location. Line features should be collected while moving. If movement is stopped, press the <PAUSE> key. When movement starts again, press the <RESUME> key. Area features should be collected with enough points to define the outline of the area (e.g., a square building would have four single points collected on each corner and the <PAUSE> key would be used between each of the points).

6. Depending on the setup of the data dictionary, each feature may have one or more feature attributes. An attribute is used to record additional data associated with the feature. For example, the attributes assigned to a sediment sampling station could be sample number, station ID, sampling gear, sediment color, odor, etc. (The <PAUSE> key should be used while recording feature attributes to avoid too many data points being collected at one point feature. [Body movements while logging attributes for an extended time can decrease the accuracy of collection.] The <PAUSE> key must be used when recording attributes of a line or area feature because only one data point should be collected in a single location.) Once all attributes are entered, press OK to complete the feature and move on to a new feature.

7. When all features in a given area have been recorded, press CLEAR to exit data capture. When the Pro XRS is not in use, it should be turned off. If you need to come back to the same rover file later in the day, the rover file may be reopened at that time. (When starting a new day, a new rover file must be created to allow easier post-processing of position information.)

8. At the end of each day, the rover file should be downloaded to a PC by using Pathfinder Office software.

Feature Collection Options

Offsets—The Pro XRS can collect a point or line feature while standing at a set distance away from the feature. This option may be necessary because of obstructions such as tree cover, buildings, or car traffic. For a point feature, measure the distance between the object you want recorded and the Pro XRS antenna. Use the compass to determine the bearing (e.g., west is 270°). The bearing is the direction the point should be moved for it to be located in the correct place (e.g., if you are due north of the feature, the bearing is south or 180°; i.e., the position you want recorded is south of where you are standing). Estimate the inclination from the feature to the GPS antenna (if altitude determination is critical, a clinometer should be used). The inclination is the degree angle up from the feature to the antenna (e.g., if the feature is 5° below the antenna position, –5° would be entered). During data capture, from within the feature, press the <OFFSET> button, and enter the distance, bearing, and inclination. Press OK to complete the feature.

Note: This procedure describes an offset of a single feature. A constant offset may be applied to all features collected as well.

Nesting—While recording a line feature or an area feature, a point feature may be collected to avoid backtracking. While recording the line or area feature, press <PAUSE> and then <NEST>. The Pro XRS will prompt for collection of a new feature. Move to the feature, and collect data as for any other point feature. When the feature is complete, press OK. The Pro XRS is ready to resume collecting data as part of the line/area feature: press <RESUME>. (Remember to continue moving before pressing resume to avoid having multiple positions recorded in the same place in the line or area feature.)

Segmenting—While moving along a line feature, changing the attributes of that line may be necessary (e.g., because of a change in surface type from paved to dirt road). This change may be done without having to begin a new feature by pressing <PAUSE> and then . Change the appropriate attributes and then press <RESUME> to continue recording.

Repeat—The function allows the collection of a new feature with the same feature attributes as the previous feature. If features are not exactly the same, it also allows editing of the attributes.

Quickmark—Allows collection of point features while moving (e.g., from a car or a boat) by estimating the exact location. The use of this feature will not result in positionally accurate locations.

REVIEWING/EDITING FEATURES

It is possible to review or edit features collected in the field while still in the data capture mode. For example, it may be necessary to document the GPS location in the field logbook or to edit one of the feature's attributes.

Without exiting data capture, press <VIEW>. (If data capture is already complete, just press VIEW and then select the appropriate rover file.) This step will display a list of data points including each feature collected. Scroll to the appropriate feature, and follow the steps below depending on the required action:

- To view the GPS location (e.g., lat/lon), press <POS>
- To edit the attributes, press ENTER. Make any necessary edits to the attributes by scrolling through.
- To change or add an offset, press <POS>, then press <OFFSET>. Make any necessary changes.
- To create a waypoint (see section on Navigation), press <POS>, then press <WAYPT>. Name the waypoint appropriately.
- To delete a feature collected in error, press <DEL>.

NAVIGATING TO AN EXISTING LOCATION

Waypoints

To use the Pro XRS to navigate to a previously established position, this position must be loaded into the data logger as a waypoint. Waypoints may be entered into the TDC1 by:

- Manually entering coordinates
- Choosing previously recorded locations and importing them into the TDC1 by using Pathfinder Office

- Defining a location stored in a rover file saved to the TDC1 as a waypoint (see Reviewing/Editing Features, above).

Navigating

There are three modes of navigation with the Pro XRS:

- <NAV1>: for navigating with a compass across an open area
- <NAV2>: for navigating in areas where obstacles restrict movement
- <NAV3>: for traveling along the shortest path without a compass.

Navigation allows you to navigate from one waypoint to another. In this situation, both the starting and the ending locations must be entered into the TDC1 as waypoints. More likely, you will be navigating from your current position (an undefined position) to a known location, which is entered as a waypoint. To do this:

1. Choose Navigation from the main menu.
2. Press <START> to choose the starting waypoint "?". If the start position is a waypoint, select it from the list.
3. Press <END> and then select the desired waypoint to navigate to.
4. Allow the fields described below to guide you to the end waypoint.

Depending upon the NAV mode, some of the following fields will be displayed. Use them to guide your movement, keeping in mind the delay inherent in constantly recalculating the current position with respect to the end position.

- Dist to go: distance remaining between current position and waypoint
- Brng to go: directional path to follow
- Heading: angle at which you are traveling from north
- Time: ground speed and estimate of time to reach waypoint
- Change course: modification needed to your current bearing
- Go (North/South): distance from current position to end waypoint as 2 Cartesian distances
- Go (East/West): distance from current position to end waypoint as 2 Cartesian distances

- X-track Go: direction and distance to the shortest line between the start and end waypoints.

DOWNLOADING ROVER FILES

Upon returning to the office, all rover files should be downloaded from the TDC1 to a PC for post-processing. After downloading, all rover files and waypoints should be removed from the TDC1 to conserve memory. See SOP 51B for downloading instructions. Rover files may be deleted from the Data Capture menu.

1. From the main menu, select data capture, then delete file(s).
2. Select the rover file to be deleted, and press <ENTER>.
3. Confirm the deletion of this file by pressing <YES>.

Data dictionaries can be deleted in the same manner by selecting Data dictionaries from the Data Capture menu. Waypoints may be deleted by selecting Waypoints from the Utilities menu.

ATTACHMENT 51A-1

Pro XRS Settings

Exponent™

ATTACHMENT 51A-1
PRO XRS SETTINGS

The following are lists of menus that can be accessed through the TDC1 keypad. Please ensure that settings are correct before proceeding. Please do not make changes to the settings unless necessary. Each menu will list the all available subheading, the correct setting, and the available <soft-keys> to access additional menus. Comments are included only where necessary.

GPS OPERATIONS

Access this menu by pressing the GPS key.

	Comment
Position	indicates current position or last available position
Receiver status	
Satellite info	
DGPS status	
Navigation	alternative path to access navigation functions
Waypoints	lists all waypoints available, or entry of additional waypoints
2D Altitude	
Disconnect	

<SETUP>

ROVER OPTIONS

Access this menu by pressing <SETUP> from the GPS Operations menu. Then select Rover options.

	Setting	**Comment**
Logging intervals		
Point feature	1s	
Line/area feature	2s–5s	depending upon speed of movement
Not in feature	None	
Velocity	None	
Minimum pos	10	
Carrier phase min time	10mins	
Pos Mode	Manual 3D	
Elev Mask	15°	

SNR Mask	6.0	
PDOP Mask	6.0	
PDOP Switch	6.0	
Audible click	Yes	
Log DOP data	Yes	
Dynamics code	Land	may be changed to sea or air, as appropriate

<RTCM> <ANTEN> <OUTPUT>

RTCM INPUT OPTIONS

This menu can be accessed from the Rover options menu by pressing <RTCM>.

	Setting	**Comment**
RTCM input mode	Auto	
RTCM version	Auto	
RTCM station	Any	
Warning time	20s	
Log PP data	Yes	"yes" to be enable post-processing of real-time corrected data
Baud rate	9600	
Data bits	8	
Stop bits	1	
Parity	None	

<DGPS>

INTEGRATED DGPS

This menu can be accessed from the RTCM input option menu by pressing <DGPS>.

	Setting	**Comment**
Source	Satellite	
Provider	Omnistar	
Satellite	AMSC – Eastern USA	should be changed to as appropriate: Eastern, Central, Western
Frequency	(automatically updated by selection in satellite field)	
Data rate	(automatically updated by selection in satellite field)	

ANTENNA OPTIONS

This menu can be accessed from the Rover options menu by pressing <ANTEN>.

	Setting	Comment
Height	6 ft	adjust accordingly to antenna height
Measure	Vertical	
Type	MS	
Confirm	Per file	can be changed to “Per feature” if antenna height varies and elevation is critical

OUTPUT OPTIONS

This menu can be accessed from the Rover options menu by pressing <OUTPUT>.

	Setting	Comment
Output	None	
Baud rate	9600	

ATTACHMENT 51A-2

Additional Settings for the Pro XRS

ATTACHMENT 51A-2
ADDITIONAL SETTINGS FOR THE PRO XRS

Additional Pro XRS settings can be found in the configuration menu. Items of particular importance are indicated in italics.

CONFIGURATION

This menu can be accessed by pressing FUNC followed by GPS.

	Description
GPS	Alternate path to access the ***Rover options*** menu
Coordinate system	Changes coordinate system among latitude/longitude, UTM, and other coordinate systems. System can be converted, if necessary, after data capture by using Pathfinder Office software.
Units and display	Changes various units, for example: length (e.g., feet, meters), altitude reference (e.g., MSL), ***North reference*** (i.e., true or magnetic). Units can be converted, if necessary, after data capture by using Pathfinder Office software.
Time and date	Changes to ***local time***, 24 hour clock, date format, etc.
Quickmarks	Set-up parameters for use with quickmarks.
Constant offset	Set-up parameters for use with a constant offset.
External sensors	Connections with external sensors.
Hardware (TDC1)	TDC1 settings such as beep volume, contrast, ***internal and external battery status***, software version.

CONTRAST AND BACKLIGHTING

The TDC1 display can be viewed in various light settings. Pressing FUNC, then L turns on the display backlight for viewing in dim lighting. In addition, the contrast can be adjusted by pressing FUNC, then → or ←.

Exponent™

SOP 71B
PREPARATION OF REFERENCE MATERIALS–SEDIMENT

Reference materials will be used in the field quality control program to provide a measure of laboratory accuracy. Reference materials used for the project must be from EPA-approved sources and be submitted for all available project analytes. A minimum frequency of reference material analysis will be 1 per 50 samples or once per sampling event, whichever is more frequent. If the number of samples lies between multiples of 50, the higher multiple should be used to determine the number of reference material samples to submit.

Reference materials for sediments are typically prepared by a certified laboratory and are ready to be transferred to the appropriate sample container. In preparing the sample for shipment, field personnel should read and fully understand the instructions provided with the reference material and should follow SOP 6B, *Preparation of Field Quality Control Samples–Sediment*. The field method presented below describes typical preparation requirements and standard laboratory practices that may not be covered in the instructions provided by the manufacturer.

EQUIPMENT REQUIRED

Equipment required for the preparation of reference materials for solids includes the following:

- Reference material with instructions
- Reference material logbook
- Stainless-steel spoon
- Deionized water
- Industrial detergent
- Decontamination solvents (methanol, hexane)
- Decontamination acid (10 percent nitric acid)
- Squirt bottles for decontamination
- Top-loading scale.

MINIMUM DOCUMENTATION REQUIREMENTS

All reference material preparations must be documented in a project logbook developed for that purpose. Pages must be numbered and nonremovable. All entries must be in ink, and any mistakes must be corrected by drawing a single line through the error and initialing it. Logbook information required for each reference material includes the name of the person preparing the sample, the date, sample identification (e.g., sample number, sample ID, tag number), the reference material lot and batch numbers, the analytes, and the steps followed in preparing the sample. The reference material samples also must be documented in the sample logbook along with the other environmental samples. It should be clearly stated that the samples are reference materials.

The purpose of reference material samples is to provide a check on the quality of work by the primary and referee laboratories; therefore, it is extremely important that the samples are not identified as quality control samples by those running the analyses. To accomplish this, the samples must be sent to the laboratory in the same form as regular samples, including all containers, sample numbers, and analytes (e.g., if the reference material includes only benzene, but monochlorobenzene analysis is normally done from the same container, the sample analysis request should include both).

The sample ID for reference materials should allow data management and quality control staff to trace the sample back to a particular reference material concentration (e.g., use the reference material lot and batch numbers in the sample ID, or use a single ID for all reference materials in a sampling event that can be matched with the lot and batch numbers in the reference material logbook).

Under no circumstances should the laboratory be allowed to use a reference material sample for matrix spike and matrix spike duplicate analysis. The laboratory should be instructed to contact the project QA/QC coordinator whenever a laboratory quality control sample is not specified for a sample delivery group in the sample analysis request so that one can be assigned.

REFERENCE MATERIAL SAMPLE PREPARATION

The following steps will be taken to prepare the reference material samples:

1. Read the instructions provided with the reference material carefully, including the Material Safety Data Sheet and other safety information. Also, note any information that may relate to the holding time for the reference material.

2. Remove the reference material container from its packaging, and check for any inconsistencies between the identification information given on the container and the instructions. Record any discrepancies in the reference material logbook.

3. Reference materials that are in dry powder form may be poured directly into the sample bottle, provided no contact is made between the two containers. Samples that cannot be poured should be transferred using a stainless-steel spoon.

4. The spoon, and any other items that will come in contact with the reference material, must be cleaned appropriately. Clean the items with Alconox® or a similar industrial detergent and rinse thoroughly with tap water. For metal reference materials, rinse with dilute acid before the final deionized water rinse. For organic reference materials, rinse with appropriate solvents after rinsing with deionized water. Consult the project QA/QC coordinator and health and safety officer for the appropriate cleaning chemicals to use and any related safety information. Spoons used for powdered reference materials should be air-dried to avoid clumping of the sample. Solvent-cleaned glassware should be set aside until all of the solvent has volatilized.

5. Weigh out approximately the amount required for analysis using a scale. To do this, weigh the sample container to be filled to establish a tare weight, then add the proper amount of sample.

6. Pour or spoon out the contents of the container (or containers, if more volume is required than is provided with a single reference material) directly into a sample bottle of the appropriate material for the analytes. Avoid contacting the lip of the reference material bottle with the sample container because it is a possible source of external contamination.

7. Create sample identifiers consistent with those used for environmental samples being sent to the laboratory, and label the bottle accordingly.

8. Store and ship the samples according to SOP 102, *Preservation and Handling of Samples*, and SOP 2, *Sample Packaging and Shipping*.

9. Date and store all records of the reference material, including the container used (this information may be needed in the future if tracking problems occur).

10. Copy and send all relevant information regarding the preparation and documentation of all reference materials to the appropriate staff, who include, at a minimum, the project QA/QC coordinator and data management coordinator.

11. Keep an inventory of reference materials used on the project that can be checked after each sampling event. Order any reference materials as necessary to ensure that they will be available at the appropriate time. Solid reference materials can usually be saved if only a portion of the volume is used.

12. Inorganic reference materials can be stored in a cool dry place. Organic reference materials should be stored frozen at –20°C.

SOP 100
SURFACE SEDIMENT SAMPLING USING A MODIFIED VAN VEEN GRAB SAMPLER

This standard operating procedure (SOP) describes the procedures used to collect surface sediment with a modified van Veen grab sampler. Surface sediment is typically analyzed for various physical and chemical variables. For the purposes of this SOP, surface sediment is defined as the upper 10 cm of the sediment column.

A modified stainless-steel van Veen grab sampler is capable of collecting acceptable samples from a variety of substrates, such as mud, sand, gravel, and pebbles (APHA 1989). The modified van Veen grab sampler incorporates several design improvements over the traditional van Veen grab sampler that improve the quality of the sediment samples. The modified grab sampler has two doors on top to allow easy access to the sediment for visual characterization and subsampling of surface sediments. The interiors of the doors are made of screens to minimize the bow wake and the resulting disturbance of the sediment surface when the grab sampler is lowered to the bottom. Rubber flaps cover each screen as the grab sampler is retrieved to prevent disturbing the sediment sample as it is raised through the water column. The arms of the modified grab sampler are lengthened and arced to provide a stronger seal when the grab sampler is closed, thereby minimizing sample leakage when the grab sample is retrieved. Finally, the modified grab sampler has four detachable, epoxy-coated lead weights that allow the weight and penetration of the grab sampler to be optimized with respect to the kind of sediment being sampled.

The procedures for collecting surface sediment samples using the modified van Veen grab sampler are described below.

EQUIPMENT REQUIRED

Equipment required for sediment sampling using the van Veen grab sampler includes the following:

- Stainless-steel van Veen grab sampler (typically 0.06 m^2 or 0.1 m^2)
- Winch and hydrowire (with load capacities ≥3 times the weight of a full sampler)
- Sample collection table
- Teflon® or polyethylene siphon (inner diameter = 1.27 cm, length = 60–90 cm)

- Stainless-steel ruler
- Stainless-steel spatulas
- Stainless-steel spoons
- Stainless-steel mixing bowl or pot
- Scrub brush
- Squirt bottles (for solvents)
- Alconox® (laboratory detergent)
- Acetone and hexane (if applicable for a specific project)
- Socket and crescent wrenches (for adding or removing the detachable weights of the grab sampler)
- Water pump and hose (for rinsing the grab sampler, sampling utensils, and sample collection table).

DECONTAMINATION

Before each station is sampled, decontaminate the inner surfaces of the grab sampler and all stainless-steel sample compositing equipment. Sediment sampling and compositing equipment will be decontaminated using the following general sequence: site water rinse, Alconox scrub and rinse, site water rinse, solvent rinse with acetone and hexane (respectively), and a final site water rinse. Equipment used for compositing the sediment samples will follow the same basic decontamination sequence except that the final rinse will be with laboratory-grade distilled/ deionized water. If there is a significant lapse of time between decontamination of the sample compositing equipment and collection of the sample, then the decontaminated compositing equipment will be protected from additional contamination by wrapping it in foil (with the dull side of the foil touching the equipment) and, if necessary, placing it in clean bags for transport.

All solvent rinsates will be collected into a bucket or tub and allowed to evaporate over the course of the day. Any rinsate that has not evaporated by the end of the sampling event will be containerized and disposed of in accordance with federal regulations.

GRAB SAMPLER DEPLOYMENT

1. Attach the grab sampler to the hydrowire with a swivel. The swivel minimizes the twisting forces on the sampler during deployment and ensures that proper contact is made with the bottom. For safety, the hydrowire, swivel, and all shackles should have a load capacity at least 3 times the weight of a full sampler.

2. Place the grab sampler on the sample collection table, and open it.
3. Ensure that the two release chains and the two retrieval chains are hanging free and are not wrapped around the arms of the sampler.
4. Attach the ring of the release chains to the release mechanism, and insert the safety pin to prevent the mechanism from being activated prematurely.
5. Start the winch, raise the release mechanism and the sampler, and swing it outboard.
6. Remove the safety pin from the trigger, and lower the sampler through the water column at a slow and steady speed (e.g., 30 cm/second).
7. Allow the grab sampler to contact the bottom gently, with only its weight being used to force it into the sediments. The sampler should never be allowed to "free fall" to the bottom because this may result in premature triggering, an excessive bow wake, or improper orientation upon contact with the bottom.
8. Allow approximately 60 cm of slack in the hydrowire after contact with the bottom is made to ensure that the release mechanism is activated.

GRAB RETRIEVAL

1. After the grab sampler has rested on the bottom for approximately 5 seconds, begin retrieving it at a slow and steady rate (e.g., 30 cm/second).
2. Ensure that the sampling vessel is not headed into any waves before the sampler breaks the water surface to minimize vessel rolling and potential sample disturbance.
3. After the grab sampler breaks the water surface and is raised above the height of the sample collection table, swing the grab sampler inboard, and gently lower it onto the table, maintaining tension on the hydrowire to prevent the grab sampler from rolling when it contacts the table.
4. When the grab sampler contacts the table, insert wedges under both jaws so that the grab sampler will be held in an upright position when tension on the hydrowire is relaxed.
5. Relax the tension on the hydrowire, and remove the release and retrieval chains from the surface of the grab sampler.
6. Open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:

- The sampler is not overfilled with sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
- Overlying water is present (indicating minimal leakage)
- The overlying water is not excessively turbid (indicating minimal disturbance or winnowing)
- The sediment surface is relatively undisturbed
- The desired penetration depth is achieved.

If a sample fails to meet the above criteria, it will be rejected and discarded away from the station.

Penetration depth should be determined by placing a decontaminated stainless-steel ruler against the center of the inside edge of the opening on the top of one side of the grab sampler and extending it into the grab sampler until it contacts the top of the sample. The penetration depth is determined by the difference between that measurement and the total depth of the grab sampler.

SAMPLE REMOVAL AND PROCESSING

1. For acceptable samples, remove the overlying water by slowly siphoning it off near one or more sides of the grab sampler. Ensure that the siphon does not contact the sediments or that fine-grained suspended sediment is not siphoned off. If sediment is suspended in the overlying water, do not proceed with siphoning until the sediment is allowed sufficient time to settle.
2. After the overlying water is removed, characterize the sample as specified in the study design. Characteristics that are often recorded include:
   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Approximate percentage of moisture
   - Biological structures (e.g., chironomids, tubes, macrophytes)
   - Approximate percentage of biological structures
   - Presence of debris (e.g., twigs, leaves)
   - Approximate percentage of organic debris

- Presence of shells
- Approximate percentage of shells
- Stratification, if any
- Presence of a sheen
- Odor (e.g., hydrogen sulfide, oil, creosote).

3. After the sample is characterized, remove the top 10 cm using a stainless-steel spatula or spoon. Unrepresentative material (e.g., large shells, stones) should be carefully removed without touching the sediment sample under the supervision of the chief scientist and noted on the field logbook.

4. Remove subsamples for analysis of unstable constituents (e.g., volatile organic compounds, acid-volatile sulfides), and place them directly into sample containers without homogenization.

5. Transfer the remaining surface sediment to a stainless-steel mixing bowl for homogenization. Additional grab samples may be required to collect the volume of sediment specified in the study design. The mixing bowl should be covered with aluminum foil while additional samples are being collected to prevent sample contamination (e.g., from precipitation, splashing water).

6. After the surface sediment for a sample is collected, move the sampling vessel away from the station, open the jaws of the grab sampler, attach the ring of the deployment chains to the release mechanism, insert the safety pin, start the winch, raise the grab sampler, and allow the remainder of the sediment sample to fall onto the sample collection table. Discard this material away from the station, and rinse away any sediment adhering to the inside of the grab sampler. The grab sampler is now ready for additional sampling at the same station or decontamination before sampling at a new station.

7. After a sufficient volume of sediment is transferred to the mixing bowl, homogenize the contents of the bowl using stainless-steel spoons until the texture and color of the sediment appears to be uniform.

8. After the sample is homogenized, distribute subsamples to the various containers specified in the study design and preserve the samples as specified in the study design.

REFERENCES AND OTHER SOURCES

APHA. 1989. Standard methods for the examination of water and waste water. Seventeenth Edition. Prepared and published by American Public Health Association, the American Water Works Association, and the Water Pollutant Control Federation.

Exponent™

SOP 101
DECONTAMINATION OF EQUIPMENT—SEDIMENTS

To prevent potential cross contamination of samples, all reusable sediment sampling equipment will be decontaminated before each use. A decontamination station will be set up onsite in a clean location, upwind of actual sampling locations. Decontaminated equipment will be stored away from areas that may cause recontamination, and rinsate blanks will be collected according to SOP 6B, *Preparation of Field Quality Control Samples—Sediment*. When handling decontamination chemicals, field personnel will follow all relevant procedures outlined in the site health and safety plan.

EQUIPMENT REQUIRED

Equipment required for decontamination includes the following:

- Plastic brushes
- Extension arm for cleaning core liners
- Squirt bottles
- 5-gal plastic bucket(s)
- Tap water or site water
- Alconox® or similar industrial detergent
- Acetone (for organic contaminants)
- Hexane (for organic contaminants)
- 0.1 normal nitric acid (HNO_3) for inorganic contaminants
- Sealable waste containers equipped with a funnel
- Aluminum foil
- Core liner caps or plastic wrap and rubber bands.

DECONTAMINATION PROCEDURES

Potential sources of contamination of samples include the stainless-steel equipment used to prepare the samples (e.g., bowls, spoons, spatulas), the polycarbonate core liners and extruding tube, and the sampler. The following steps should be followed to properly clean all equipment that comes into contact with the samples:

1. Rinse the equipment thoroughly with tap or site water to remove most of the remaining sediment. This step should be performed onsite for all equipment, including core liners that will not be used again until the next day of sampling. Pieces that do not need to be used again that day may be set aside and thoroughly cleaned in the field laboratory at the end of the day.

2. Pour a small amount of concentrated industrial detergent into a 5-gal bucket and fill it with tap or site water.

3. Scrub the equipment in the detergent solution using a plastic brush with rigid bristles. For the polycarbonate core liners, use a brush attached to an extension to reach the entire inside of the liners, scrubbing with a back-and-forth motion. Be sure to clean the outside of core liners, bowls, and other pieces that may be covered with sediment.

4. Rinse the equipment with tap or site water and set aside to drain.

5. Wash the equipment with acetone from a squirt bottle, and let the excess solvent drain into a waste container equipped with a funnel. Acetone acts primarily as a drying agent, but it also works as a solvent for some organic contamination. Core liners must be held over the waste container and turned slowly to be effectively cleaned. The sample apparatus may be turned on its side and opened to be washed more effectively. Set the equipment in a clean location and allow it to air dry.

6. Rinse the air-dried equipment with hexane from a squirt bottle, and let the excess solvent drain into the waste container. The opening of the squirt bottle may need to be widened to allow enough solvent to run through the core liners without evaporating. Hexane acts as the primary organic solvent, but it is insoluble with water. If water beading occurs, it may mean that the equipment was not thoroughly rinsed with acetone. When the equipment has been thoroughly washed with hexane, set it in a clean location and allow the hexane to evaporate before using it for sampling.

7. If inorganic compounds are being sampled, rinse the equipment a final time with clean water, 0.1 normal nitric acid, and water.

8. Wrap small stainless-steel items in aluminum foil (dull side facing the cleaned area) after decontamination is completed. Seal the polycarbonate core liners at both ends with either core caps or cellophane plastic and rubber bands.

9. When not in use, keep the waste solvent container closed and store in a secure area. The waste should be transferred to empty solvent bottles and disposed of at a licensed facility.

SOP 102
PRESERVATION AND HANDLING OF SAMPLES

This SOP defines bottle types and preservation and handling techniques for environmental samples. All bottles will be precleaned and provided by either a supply house or a subcontracted laboratory.

If preservatives are added before the bottles are brought into the field, each bottle must be marked to identify the preservative. Preserved bottles must be closed tightly and kept upright during storage. Test bottles will be prepared for each sampling site to determine the volume of preservative to use.

Immediately after collection, samples will be placed in coolers on ice. To ensure that bottles are kept at the proper temperature when stored onsite, each refrigerator must be monitored with its own thermometer. Daily readings will be recorded in a logbook to be kept near the refrigerators.

Preservation and handling guidelines for site analytes are provided in Table 102-1. Analytes with similar bottle and preservative requirements will be analyzed from the same container when possible.

TABLE 102-1. RECOMMENDED PRESERVATION AND HANDLING PROCEDURES FOR SAMPLES[a]

Analyte	Matrix	Container	Preservation and Handling	Holding Time (from date of collection)
Acid-volatile sulfides	Solids	HDPE	Fill bottle, leaving no headspace Store samples in the dark at −20°C	14 days
Alkalinity	Water	HDPE	Store samples at 4°C	14 days
Ambrosia pollen	Solids	HDPE	Store samples at 4°C	No specific holding time
Ammonia-nitrogen	Water	HDPE	Preserve with 1:1 sulfuric acid (H_2SO_4) to a pH of 2 or less Store samples at 4°C	28 days
Carbon dioxide	Water	HDPE	Fill bottle, leaving no headspace Store samples at 4°C	1 day, but analysis should be performed onsite when possible
Carbonate	Solids	HDPE	Store samples at 4°C	28 days
Chloride	Solids	HDPE	Store samples at 4°C	28 days
	Water	HDPE	Store samples at 4°C	28 days
Grain size	Solids	HDPE	Store samples at 4°C	28 days
Lead-210 and cesium-137	Solids	HDPE	Store samples at 4°C	365 days
Mercury species[b]	Solids	HDPE	Store samples at 4°C	28 days
	Water	TFE® bottle and lid	Fill bottle, leaving no headspace Store samples at 4°C	28 days, but analyze samples as soon as possible after collection
	Tissue	Sealed polyethylene bag	Eviscerate; store samples below −10 °C	28 days, but analyze samples as soon as possible after collection
Percent lipids	Tissue	Aluminum foil; sealed polyethylene bag	Store samples at −20 °C[c]	360 days[d]
Percent moisture	Solids	HDPE	Store samples at 4°C	No specific holding time
Polychlorinated biphenyls	Solids	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
	Tissue	Sealed polyethylene bag	Eviscerate, store samples at −20 °C	360 days
Polycyclic aromatic hydrocarbons	Solids	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
TAL and site metals and cyanide (except mercury)	Solids	HDPE	Store samples at 4°C	180 days

TABLE 102-1. (cont.)

Analyte	Matrix	Container	Preservation and Handling	Holding Time (from date of collection)
	Water	HDPE	Preserve with 1:1 nitric acid (HNO_3) to a pH of 2 or less Store samples at 4°C	180 days
	Tissue	Aluminum foil; sealed polyethylene bag	Eviscerate; store samples at 4°C	180 days; CN: 14 days
TCL pesticides and polychlorinated biphenyls	Solids	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
	Water	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
	Tissue	Aluminum foil; sealed polyethylene bag	Eviscerate; store samples at 4°C	7 days[e]
TCL and site semivolatile organic compounds	Solids	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
	Water	Glass, with TFE®-lined lid	Store samples in the dark at 4°C	7 days[e]
	Tissue	Aluminum foil; sealed polyethylene bag	Eviscerate; store samples at 4°C	7 days[e]
TCL and site volatile organic compounds	Solids	Glass, with TFE®-lined lid	Fill bottle, leaving no headspace Store samples in the dark at 4°C	7 days
	Water	40-mL glass vial with TFE®-lined septum	Fill bottle, leaving no headspace Invert and tap vial to ensure no air bubbles are present Store samples in the dark at 4°C	7 days
	Tissue	Aluminum foil; sealed polyethylene bag	Eviscerate; store samples at 4°C	7 days
Total inorganic carbon	Solids	HDPE	Store samples in the dark at 4°C	28 days
		Glass, with TFE®-lined lid	Store samples in the dark at 4°C	28 days
Total and dissolved organic carbon	Solids	HDPE	Store samples in the dark at 4°C	28 days
		Glass, with TFE®-lined lid	Preserve with 1:1 sulfuric acid (H_2SO_4) to a pH of 2 or less Store samples in the dark at 4°C	28 days
Total sulfate	Solids	HDPE	Fill bottle, leaving no headspace Store samples in the dark at –20 °C	28 days

Water

TABLE 102-1. (cont.)

Analyte	Matrix	Container	Preservation and Handling	Holding Time (from date of collection)
	Water	HDPE	Store samples at 4°C	28 days
Total sulfide	Solids	HDPE	Fill bottle, leaving no headspace Store samples in the dark at –20 °C	7 days
	Water	HDPE	Preserve with 4 mL 2N zinc acetate per liter of sample, and NaOH to a pH of 9 or greater Store samples at 4°C	7 days
Total suspended solids	Water	HDPE	Store samples at 4°C	7 days

Note: HDPE - high-density polyethylene
TAL - target analyte list
TCL - target compound list

[a] For more information, see the project quality assurance project plan or laboratory statements of work.

[b] Sampling for mercury and handling containers requires extreme care to avoid contaminating the samples.

[c] Samples that will also be analyzed for Contract Laboratory Program target list analytes will be stored at 4°C.

[d] Samples that will also be analyzed for Contract Laboratory Program target list analytes must be analyzed within 7 days.

[e] Samples must be analyzed within 40 days of extraction.

SOP 104
SEDIMENT CORING PROCEDURES USING SLIDE-HAMMER AND GRAVITY CORERS

This standard operating procedure (SOP) describes the procedure for collecting and processing sediment core samples using slide-hammer and gravity corers. These corers can be used for sampling both coarse, consolidated sediment and fine-grained, cohesive sediment. The same corer barrel is adapted for use as either a slide-hammer or gravity corer by changing a few parts. In both coring methods, heavy weights are supported overhead by ropes or cables and pulleys. Therefore, hardhats are required in the vicinity of the equipment. Sample processing using a hydraulic extruder is also described.

Both corers rely on a one-way valve at the top of the corer that allows water to pass through the corer while being lowered and provides suction to prevent the sample from slipping out while being raised. The corers use 3-in. outside diameter tubing with a 1/16-in. wall thickness. The main corer barrel accepts liners that are 150 cm long and can be used for cores of up to about 140 cm long. Cores up to 3 m in length can be collected by adding 1-m and 1.5-m barrel extensions. Before use, the corer should be inspected for worn and damaged parts and should be cleaned.

SLIDE-HAMMER CORING

This coring method uses a slide hammer that pounds the corer into the sediment with repeated impacts. This method is most useful in nearshore zones where the sediment is difficult to penetrate and would require more than 500 lb of static weight if a gravity corer were used. The slide-hammer corer is illustrated in Figure 104-1. The slide-hammer corer uses one cable for lowering and retrieving the corer and one rope for actuating the hammer. The slide hammer works best when the hammer is heavier than the rest of the corer so, before use, all of the weights should be removed from the corer. The following procedures are based on using the corer aboard a pontoon boat equipped with a 12-ft tripod, a power winch, and a hole in the floor centered below the tripod. Because the coring is typically done in shallow water, the boat must be anchored with at least three anchors so the boat will not drift.

1. With the corer laying flat on the boat, screw the hammer guide onto the impact plate, slide the hammer onto the hammer guide, and screw the eyebolt onto the top of the hammer guide (see Note 1). Run the main cable and the hammer rope through the appropriate pulleys. Attach the main retrieval line to the eyebolt. *Caution*: When handling the slide-hammer assembly, be careful to keep hands away from the area where the hammer slides to avoid injury.

2. After the ball and valve are cleaned, align the holes in the top of the corer and impact plate, and attach the impact plate to the top of the corer with the 0.5-in. diameter bolt. Inspect the bolt periodically for wear near the cap and 3.5 in. from the cap.

3. Attach the two thimbles at the ends of the slide-hammer bridle to the two eyebolts at the top of the hammer with small carabiniers, and secure the middle thimble to the hammer rope. The hammer rope should be at least 0.5 in. in diameter so it is easy to hold by hand.

4. Insert the 3-in. outside diameter polycarbonate liner into the corer barrel, making sure that about 0.75 in. protrudes out the end (see Note 2). Wrap the threads on the corer with Teflon® plumber's tape, and screw the nose piece onto the barrel by hand until it is as tight as possible.

5. Slide the hammer down to the impact plate, being careful to keep hands free from the path of the hammer, and raise the corer to the vertical position using the main retrieval cable.

6. Lower the corer and let out the hammer rope at the same rate. As the corer is being lowered, valve popping can be heard as water displaces air inside the corer. Continue lowering the corer slowly until the nose piece contacts the sediment. Keep tension on the main retrieval cable, measure the length of the core needed from the water surface upward, and mark this point on the main cable with a piece of tape.

7. With just enough tension on the main retrieval cable to keep the corer vertical but still allow the cable to be let out at a rate of a few inches per impact, lift the hammer about 4 ft, and release the rope. Caution: Before releasing the hammer rope, be sure that no one is standing on the rope or that the rope is not caught on anything.

8. Repeat Step 7 until the piece of tape is slightly below the water. When lifting the hammer, be careful not to lift so fast and high that it hits the eyebolt at the top of the hammer guide and hammers the corer back out of the sediment. Depending on how much the sediment core is compacted, it may be necessary to pound the corer until the tape is well below the water surface. Penetration should be stopped before the headspace between the sediment-water interface and the valve is less than about 15–20 cm.

9. When the corer has been pounded to the necessary depth, start retrieving the corer slowly at first until it is free of the sediment, and then more rapidly until the nose piece is above the water. Slow the rate of retrieval until the nose piece clears the deck, and stop when there is 6 in. of clearance. Have two bolted rubber stoppers on top of one single stopper next to the hole in the deck and lower the corer onto the rubber stoppers until they are completely inside the nose piece. *Caution*: When guiding the corer onto the stopper, keep hands away from the area between the nose piece and the deck.

10. Cover the hole and tie-off the hammer rope to a cleat. With two people supporting the corer in a vertical position, release some, but not all, tension on the main retrieval cable. Disconnect the impact plate from the corer by removing the 0.5-in. bolt. Increase tension on the main retrieval line until the impact plate is free of the corer. *Caution*: When the impact plate is free of the corer, it is able to swing so it should be stabilized immediately. This can be a problem when the boat is rocking. While maintaining tension on the main cable, untie the hammer rope, and lower the slide hammer assembly to the deck. Connect the shackle to the top of the corer with the 0.5-in. bolt, and connect the main cable to the shackle.

11. Lift the corer about 1 ft with the main cable. While one person holds the corer barrel so it does not turn, unscrew the nose piece slowly. When it is unscrewed, be prepared to support the weight of the liner and sample by holding the nose piece and the stoppers from the bottom, then lower the nose piece and liner to the deck. While stabilizing the liner and corer, lift the corer until it is free of the liner. Lower the corer onto the deck, and cover the hole. For cores 1.5 m and longer, see Note 3.

12. Remove the nose piece from the liner by pushing down and rocking it slowly from side to side. The single stopper will come off with the nose piece, but the others should remain in place. Watch carefully that the other stoppers do not slip. In moving the liner with the sample, always support the liner from the bottom so the stoppers cannot slip.

13. Process the sample as described in the *Sample Extrusion and Sectioning* section.

GRAVITY CORING

This method uses gravity to force the corer into the sediment. It is designed for use in soft sediment that is typically found in more than 20 ft of water. However, it may be used in shallower waters if the sediment is soft. The gravity corer is illustrated in Figure 104-2. The weight can be adjusted using any combination of six 60-lb weights and one 30-lb weight (in addition to the barrel, which weighs 10 lb/ft) to achieve the necessary penetration. This gravity corer is not designed for free-fall into the sediment. Because gravity coring is much faster than slide-hammer coring and water depths are usually greater, boat drift is not a problem, and anchoring is not necessary.

1. With the corer laying on the deck, insert the liner into the corer barrel until it contacts the bottom of the valve seat; about 0.75 in. of liner should protrude from the corer barrel. Wrap the threads with Teflon® plumber's tape where the nose piece screws in. Screw on the nose piece, making sure the liner seats on the lowest shoulder inside the nose piece (about 1 in. from the bottom edge of the nose piece). Tighten as much as possible by hand.

2. Add the appropriate amount of weight to the corer and secure it with a hose clamp. Slide the weights upward until the top of the top weight is a few inches below the vent holes. Slide the shaft collar upwards until it contacts the bottom of the bottom weight, and tighten it so it will not slip when it supports all the weights. It is a good idea to wrap a few layers of duct tape right below the shaft collar so that if it slips, it will become wedged on the tape.

3. Attach the shackle to the top of the corer with the 0.5-in. bolt, and connect the retrieval cable to the shackle.

4. While supporting the corer so that it does not swing freely, raise it with the winch. Watch the weights to see that they do not slip. Lower the corer at any rate that is practical until the nose is about 10 ft above the sediment, then reduce the rate to about 1 ft/second. This reduces the shock wave preceding the corer and helps retrieve a good interface. Let the line go slack for about 5 seconds (see Note 4).

5. Pull the corer slowly at first to break it loose from the sediment. Raise the corer up through the water column at a rate that is practical until the top of the corer approaches the surface, then slow the retrieval rate to about 1 ft/second. As soon as the nose clears the water surface, stop retrieval, push a double rubber stopper up into the corer, and support the stoppers so they are not pushed out by the sample. Have another stopper ready on the deck. Raise the corer, and lower it onto the other stopper to push the double stopper further into the liner. *Caution*: When guiding the corer onto the stopper, keep hands away from the area between the nose piece and the deck.

6. Lift the corer about 1 ft with the main cable. With one person holding the corer barrel so that it does not turn, unscrew the nose piece slowly. When it is unscrewed, be prepared to support the weight of the liner and sample by holding the nose piece and the stoppers from the bottom, then lower the nose piece and liner to the deck. While stabilizing the liner and corer, lift the corer until it is free of the liner. Lower the corer onto the deck, and cover the hole. For cores 1.5 m and longer, see Note 3.

7. Remove the nose piece from the liner by pushing down and rocking it slowly from side to side. The single stopper will come off with the nose piece, but the others should remain in place. Watch carefully that the other stoppers do not slip. In moving the liner with the sample, always support the liner from the bottom so the stoppers cannot slip.

8. Process the sample as described in the *Sample Extrusion and Sectioning* section.

MAINTENANCE AND TROUBLESHOOTING

Cleaning the Ball Valve

The ball valve should be cleaned 1) at a minimum on each day of sampling, 2) if there is evidence that sediment entered the valve, and 3) whenever coring is conducted in nearshore zones where the sediment is sandy. A diagram of the valve is shown in Figure 104-3. To clean the valve, remove the 0.5-in. bolt from the top of the corer barrel and disconnect the impact plate or the shackle. Before removing the thin ball retaining wire, make sure the ball cannot roll overboard. Then remove the wire, reach in the corer, and remove the ball. Inspect the ball for materials or scratches that may prevent seating or sealing. Wipe off the ball with a paper towel, and place it in a clean place. Do not drop the ball because this will scratch the surface and prevent the ball from seating properly. Also, be careful not to damage the O-ring seal by placing any tools in the valve assembly. Wash out the valve with a hose to remove most of the dirt. Using a paper towel, reach inside the top of the corer, wipe off the valve seat, and inspect the towel for dirt. Take a small quantity of Vaseline® (about the volume of a typical pencil eraser), and rub it on the ball. If the valve needs to be replaced, remove the two valve retaining wires, and slide the valve out.

Insufficient Sample

The corer may not collect enough sample because of 1) inadequate penetration, 2) good penetration but too much compaction, or 3) adequate penetration but loss of sample during retrieval. Solutions to these problems are as follows:

- **Inadequate Penetration—**Add more weight to the corer, or pound it in farther.
- **Too Much Compaction—**Add an extension and more weight to get more penetration.
- **Loss of Sample During Retrieval—**Sample slipping out the bottom of the corer is caused by a loss of suction. There are several places at which suction can be lost: the valve seat, the valve assembly, the nose piece, and couplings between the barrel and extensions. To reduce sample loss, clean the valve seat/O-ring, and grease the ball as described above. Make sure the valve assembly is sealed. Use Teflon® plumber's tape on the threads and duct tape on the outside of the couplings and nose piece.

Penetration of the corer can be measured by putting white Velcro® tape on the outside of the corer. Velcro® tape can also be used on the inside of the liner during testing to see how far up inside the liner the interface moves, how much sample slips out the bottom, and how much compaction occurs.

SAMPLE EXTRUSION AND SECTIONING

Sediment samples are extruded from the core liner using a hydraulic or mechanical extruder and are cut into desired section thicknesses using a calibrated sectioning tube. A diagram of the hydraulic extruder and sectioning apparatus is shown in Figure 104-4. The extruder can be used for 2- to 3-in.-diameter cores and can be used vertically or horizontally.

1. With no core liner attached to the extruder, submerge the inlet hose of the extruder in a bucket of water or overboard into the lake. Pump water through the system rapidly to clear all air out of the hose, valves, pump, and socket. Observe the water coming out of the socket and pump until no air bubbles come out.

2. Rinse grit from the bottom of the core liner so that the liner will slip smoothly onto the socket. With the shaft collar loosened and already around the socket, lift the core liner onto the socket, and push it down onto the socket with a twisting motion. While holding the liner down, pump water through the socket slowly to remove air bubbles at the base of the rubber stoppers. While still holding the liner down, slip the shaft collar up and around the liner, and tighten it very tightly with the hexagonal wrench. Push gently on the pump to check for leaks. Pump until the sediment-water interface is level with the top of the core liner.

3. Place the calibrated sectioning tube on the top of the liner. Hold it down so it seats firmly on the liner, and pump until the desired sample thickness is extruded into the tube. The extruder will extrude about 1 in. of sample per pump. While one person holds the liner steady, another person holds the sectioning tube and cuts the extruded sample by inserting the semicircular cutter between the liner and the tube. Cut the core and slide (do not lift) the cutter and the tube horizontally off the top of the liner. Hold the cutter and tube firmly together. Invert the tube, and slide the cutter out to discharge the sample into the mixing bowl.

4. Repeat Step 3 until the lowest desired depth of sample is collected. Pump the rest of the sample out of the liner with the rubber stoppers.

Notes

1. The eyebolt at the top of the hammer guide may become unscrewed because of the pounding vibrations and should be checked at each station before coring.

2. For long cores that require more than one piece of liner, butt the ends of the two pieces of liner squarely together and tape them securely so no leaks

occur. Do not use too many layers of tape or the liner will not fit into the barrel.

3. For cores 1.5 m and longer, the tripod is not tall enough to lift the corer so that the barrel will clear the top edge of the liner when removing the liner. To remove the liner in this case, upon unscrewing the nose piece, lower the nose piece and liner into a pail that has a rope securely tied to the handle. While the corer is raised by the winch, lower the pail through the hole in the deck and into the water (if necessary) until the top edge of the liner clears the bottom edge of the barrel. Then lift it back onto the deck.

4. If the sediment is too hard for the amount of weight on the corer, and the corer does not penetrate significantly, the corer will contact the bottom, tip over, and fall sideways. When this happens, the line will initially go slack, then quickly snap to the side as the tension increases. In this case, try doubling the weight; if this does not work, try using the slide hammer.

Periodically check the water level in the bucket. If air gets into the system, pumping becomes less efficient. At the end of each day, unscrew the cap at the top of the pump, lift the pump handle to remove it, wipe the O-rings with a paper towel, and grease the O-rings with Vaseline®. Avoid using water with coarse particles because they may interfere with proper valve function.

SOP 120
BENTHIC MACROINVERTEBRATE SAMPLING BY USING A MODIFIED VAN VEEN GRAB SAMPLER

This standard operating procedure (SOP) describes the procedures used to sample benthic macroinvertebrate assemblages by using a modified van Veen grab sampler. Benthic assemblages are typically analyzed for the abundances and biomass of various species and major taxa.

The modified stainless-steel van Veen grab sampler used for this study is capable of collecting acceptable samples from a variety of substrates, including mud, sand, gravel, and pebbles (APHA 1989). The modified van Veen grab sampler incorporates several design improvements over the traditional van Veen grab sampler that allow the collection of better quality sediment samples. The modified grab sampler has two doors on its top surface to allow easy access to the sediment surface for visually characterizing sediments. The interiors of the doors are made of screens to minimize the bow wake and the resulting disturbance of the sediment surface when the grab sampler is lowered to the bottom. Rubber flaps cover each screen as the grab sampler is retrieved to prevent disturbing the sediment sample as it is raised through the water column. The arms of the modified grab sampler are lengthened and arced to provide a stronger seal when the grab sampler is closed, thereby minimizing sample leakage when the grab sample is retrieved. Finally, the modified grab sampler has four detachable, epoxy-coated lead weights that allow the weight and penetration of the grab sampler to be optimized with respect to the kind of sediment being sampled.

The procedures for sampling benthic macroinvertebrate assemblages by using the modified van Veen grab sampler are described below.

EQUIPMENT REQUIRED

Equipment required for sediment sampling by using the van Veen grab sampler includes the following:

- van Veen grab sampler (typically 0.06 m^2 or 0.1 m^2)
- Winch and hydrowire (with load capacities ≥3 times the weight of a full sampler)
- Sample collection table
- Sample collection tub

- Ruler
- Sieve (typically with a 0.595-mm mesh for freshwater studies or a 1.0-mm mesh for marine studies)
- Scoop (for transferring sample aliquots to the sieve)
- Sample containers
- Buffered formalin
- Scrub brush
- Socket and crescent wrenches (for adding or removing the detachable weights of the grab sampler)
- Water pump and hose (for sieving samples and for rinsing the grab sampler, sample collection tub, and sample collection table).

GRAB SAMPLER DEPLOYMENT

1. Prior to deployment, clean the inside of the grab sampler with a scrub brush and site water.
2. Attach the grab sampler to the hydrowire with a swivel. The swivel minimizes the twisting forces on the sampler during deployment and ensures that proper contact is made with the bottom. For safety, the hydrowire, swivel, and all shackles should have a load capacity at least three times that of the weight of a full sampler.
3. Place the grab sampler on the sample collection table, and open it.
4. Ensure that the two release chains and the two retrieval chains are hanging free and are not wrapped around the arms of the sampler.
5. Attach the ring of the release chains to the release mechanism, and insert the safety pin to prevent the mechanism from being activated prematurely.
6. Start the winch, raise the release mechanism and the sampler, and swing it outboard.
7. Remove the safety pin from the trigger, and lower the sampler through the water column at a slow and steady speed (e.g., 30 cm/second).
8. Allow the grab sampler to contact the bottom gently, with only its weight being used to force it into the sediments. The sampler should never be allowed to “free fall” to the bottom because this may result in premature triggering, an excessive bow wake, or improper orientation upon contact with the bottom.

9. Allow approximately 60 cm of slack in the hydrowire after contact with the bottom is made to ensure that the release mechanism is activated.

GRAB RETRIEVAL

1. After the grab sampler has rested on the bottom for approximately 5 seconds, begin retrieving it at a slow and steady rate (e.g., 30 cm/second).
2. Ensure that the sampling vessel is not headed into any waves before the sampler breaks the water surface to minimize vessel rolling and potential sample disturbance.
3. After the grab sampler breaks the water surface and is raised to the height of the sample collection table, rinse away any sediments adhering to the outside of the grab sampler (it is essential that the sediments adhering to the outside of the grab are removed because those sediments and any associated benthic macroinvertebrates are not part of the sample).
4. After rinsing is finished, raise the grab sampler above the height of the collection table, swing it inboard, and gently lower it into the sample collection tub on the sample collection table while maintaining tension on the hydrowire to prevent the grab sampler from rolling when it contacts the bottom of the tub.
5. When the grab sampler contacts the bottom of the tub, insert wedges under both jaws, if necessary, so that the grab sampler will be held in an upright position when tension on the hydrowire is relaxed.
6. Relax the tension on the hydrowire, and remove the release and retrieval chains from the surface of the grab sampler.
7. Open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:
   - The sampler is not overfilled with sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
   - Overlying water is present (indicating minimal leakage)
   - The overlying water is not excessively turbid (indicating minimal disturbance or winnowing)
   - The sediment surface is relatively undisturbed
   - The desired penetration depth is achieved.

If a sample fails to meet the above criteria, it will be rejected and discarded away from the station.

Penetration depth should be determined by placing a ruler against the center of the inside edge of the opening on the top of one side of the grab sampler and extending it into the grab sampler until it contacts the top of the sample. The penetration depth is determined by the difference between that measurement and the total depth of the grab sampler.

SAMPLE REMOVAL AND PROCESSING

1. For each acceptable sample, characterize the sample as specified in the study design. Characteristics that are often recorded include the following:
   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Approximate percentage of moisture
   - Biological structures (e.g., chironomids, tubes, macrophytes)
   - Approximate percentage of biological structures
   - Presence of debris (e.g., twigs, leaves)
   - Approximate percentage of organic debris
   - Presence of shells
   - Approximate percentage of shells
   - Stratification, if any
   - Presence of a sheen
   - Odor (e.g., hydrogen sulfide, oil, creosote).
2. After the sample is characterized, open the jaws of the grab sampler so that its contents (i.e., sediments <u>and</u> overlying water) are released into the sample collection tub.
3. Attach the ring of the release chains to the release mechanism of the grab sampler, insert the safety pin, start the winch, raise the grab sampler, and allow the rest of the sediment sample to fall into the sample collection tub.
4. Rinse any remaining sediment inside the grab into the collection tub, being careful not to overfill the tub with water.

5. After the entire sample has been collected in the sample collection tub, carefully transfer aliquots of the sample to the sieve by using a scoop.

6. Sieve each sample aliquot by rotating the sieve in a bucket of water or by passing a gentle stream of water through the sieve from above (to minimize specimen damage, it is essential that the samples be washed gently).

7. After each aliquot has been sieved, carefully rinse all of the retained material into a sample container, and check the sieve to ensure that no organisms are trapped in its mesh (do not fill any sample container more than three-quarters full to ensure that a sufficient amount of space is available for the fixative).

8. If an organism is found to be trapped in the sieve, dislodge it with a gentle stream of water or by using forceps, and transfer it to the sample container.

9. Continue sieving aliquots of the sample until all of the sample has been processed.

10. After the entire sample has been sieved, clean the sieve by turning it over and back-washing it with a high-pressure spray to dislodge any sediment grains or detritus that are lodged in the mesh.

11. Fix each sample by filling each sample container with a 10–15 percent solution of borax-buffered formalin and inverting the container at least five times to ensure that the fixative penetrates all parts of the sample.

12. Label each sample container, and store it in a protective container.

Exponent™

SOP 423
SAFETY DURING MARINE OPERATIONS

INTRODUCTION

Contractor field projects often require the collection of biological, sediment, and water samples from vessels. In addition to the physical and chemical hazards associated with all field sampling, there are special hazards associated with vessels. This SOP provides guidance for ensuring the safety of contractor and subcontractor personnel when working on the water. These procedures address inland or protected waters only. Additional procedures are required for working on vessels offshore.

TRAINING

Appropriate training is essential for preventing accidents and ensuring the proper completion of all field duties. The following training requirements apply to all field work conducted on the water:

All contractor and subcontractor personnel must participate in an initial safety briefing prior to beginning the field work, whenever new personnel come aboard, and when conditions or tasks change.

- If the field project is conducted at a designated hazardous materials site or there is any potential for chemical exposure, then all contractor and subcontractor personnel must have the appropriate 40-hour hazardous waste operations training and current 8-hour annual refresher training. Supervisors must have completed the 8-hour supervisors training course.
- The field team leader, or site safety officer must have current first aid and cardiopulmonary resuscitation (CPR) training.
- The vessel operator must demonstrate proficiency in the operation of that type of vessel and knowledge of marine safety and navigation rules. Personnel without prior experience will be required to complete training in these subjects.

REQUIRED SAFETY EQUIPMENT

To prevent accidents and ensure adequate preparation for any emergencies that may arise, it is the responsibility of the project manager to secure appropriate safety equipment for the duration of the project. This equipment must include the following:

- **Personal Flotation Devices (PFDs)—**There must be one PFD for every person onboard the vessel, plus an additional throwable flotation device for vessels over 16 ft in length.
- **Fire Extinguisher—**Requirements for fire extinguishers vary based on the vessel length and whether the vessel has inboard engines or closed compartments. Fire extinguishers are recommended for all motorized vessels. Additional information regarding requirements for fire extinguishers can be obtained from the U.S. Coast Guard.
- **First-Aid Kit—**A first-aid kit must be provided during all field projects. The contents of the first-aid kit will vary based on the number of persons present, but at a minimum should include a variety of bandages and compresses, disinfectant, gloves, a CPR shield, eyewash, and an emergency blanket. Additional information regarding requirements for first-aid kits can be obtained from the applicable federal or state department responsible for occupational safety and health.
- **Marine Radio with Weather Channel—**A VHF radio is required by law on commercial vessels and is recommended for all work on open waters. The frequency and call sign of local emergency services must be posted on the vessel and be included in the site health and safety plan.
- **Cellular Telephone—**If a two-way VHF marine radio is not available then a cellular telephone must be onboard.
- **Horn or Bell—**U.S. Coast Guard regulations require a signaling device be onboard all vessels longer than 36 ft and require that all vessels, regardless of length, be capable of making audible signals during certain events (i.e., approaching or overtaking other vessels).
- **Navigation Lights—**The requirements for navigation lights vary based on the length and type of vessel. All vessels operated at night must have the appropriate navigation lights.
- **Oars or Paddles—**Small power boats should be equipped with alternate means of propulsion.
- **Anchor and Suitable Line—**In most cases, vessels should be equipped with one (or two) anchors and sufficient anchor line for expected water depths and bottom conditions.

- **Flares—**A flare kit should be onboard all field vessels.
- **Reach Pole or Shepherd's Hook—**On larger vessels, a reach pole or shepherd's hook must be available to facilitate rescue of any persons who fall overboard.
- **Other Rescue Gear—**On larger vessels, a block and tackle or other means must be available to pull a person from the water.

HAZARDS AND PREVENTION

There are many physical hazards associated with working onboard a vessel. Potential hazards and appropriate precautions are listed below:

- **Slips/Trips/Falls—**The combination of a moving vessel and wet or slippery decks increases the potential for slips, trips, or falls. These can be prevented by increasing your awareness of the surroundings, keeping one hand free for handholds and support, keeping the deck and working areas clear of unnecessary obstacles or hazards, and wearing nonskid boots or shoes.
- **Drowning—**Even the best swimmer can drown if caught unprepared, tired, or weighted down with bulky clothing and boots. Drowning can be prevented by taking precautions against falling overboard (avoid reaching over the side, beware of slips/trips/falls, avoid ondeck work in heavy seas) and by wearing a PFD. PFDs should be worn underneath chemical protective clothing such as Tyvek® coveralls (thus allowing the wearer to remove the coveralls without first removing the PFD) and should be properly secured or buckled.
- **Crushing/Falling Objects—**The use of hoists to lift coring tools and other equipment could result in crushing or other injuries to field workers. These injuries can be avoided by using properly adjusted and maintained hoists, allowing only experienced personnel to operate the hoist, keeping all personnel out of the way during lifting and hoisting, and wearing hardhats to protect against head injuries or bumps.
- **Gear Deployment and Retrieval—**The deployment and retrieval of sampling gear presents a hazard because of the weight of the gear, its suspension over the deck, and the risk of entanglement or accidental and premature release or closure. Setting the triggering mechanism must always be performed when the equipment is resting on a stable surface. During sample retrieval, at least one crew member is required to watch for the appearance of the sampling gear and alert the winch operator. Failure to observe the sampling gear and stop the winch could lead to breakage of the cable, loss of the sampling gear, and possible injury from either the falling gear or the end of the broken cable. All nonessential personnel should stay

clear of the work area during the retrieval and deployment of sampling gear. All personnel should be knowledgeable in the proper hand signals for guiding the winch operator.

- **Cables—**After repeated use, stainless steel cables may fray or break. Sampling personnel must never take ahold of the moving cable unless they are wearing work gloves. Periodically during the sampling event, the site safety officer should inspect the cable for wear, especially where the wire or cable is attached to the sampling equipment.

- **Climate—**Depending on the climate, field personnel may suffer from hypothermia, dehydration, or heat stress. Climate-related illnesses and injuries can be prevented by dressing appropriately for the expected climate and by having additional clothing onboard should personnel get wet or the weather change suddenly. When working in cold, wet weather, appropriate clothing may include raingear, wool, and modern synthetics. Cotton clothing should only be worn during warm, dry weather. In addition, fluid replenishment beverages (to protect against heat stress and dehydration) or warm beverages (to protect against hypothermia) should be available during field work.

- **Unsecured Gear—**Wherever possible, all ondeck sampling and safety gear should be secured to a deck, rail, or bulkhead to prevent loss from unexpected movement caused by wind or waves.

- **Hatches—**All personnel should be alerted to the presence of an open hatch and hatches should not be left open unnecessarily.

- **Chemical and Sample Storage—**To prevent fire, health hazards, or sample contamination, all field chemicals such as solvents and formalin should be stored on deck, not in the cabin, hold, or near samples.

EMERGENCY PROCEDURES

In case of a boating-related injury or fatality, field personnel must:

- Notify emergency medical or rescue personnel immediately (as appropriate). The U.S. Coast Guard emergency frequency is VHF Channel 16.

- Notify the site safety officer, the appropriate project manager, and the corporate health and safety officer immediately. The project manager and corporate health and safety officer will coordinate notifications to the Occupational Safety and Health Administration and the U.S. Coast Guard.

In case of boating-related property damage exceeding $200, field personnel must:

- Notify police or other legal jurisdiction (as appropriate).
- Notify the site safety officer, the appropriate project manager, and the corporate health and safety officer within 48 hours of the incident. The project manager and corporate health and safety officer will coordinate notification of the U.S. Coast Guard.
- Notify the business operations manager to initiate insurance claims.

Appendix D

Example Field Forms

CHAIN OF CUSTODY RECORD/SAMPLE ANALYSIS REQUEST FORM

Page ____ of ____

Project:
(Name and Number)

Exponent Contact: _____ Office: ____

Ship to: _____

Lab Contact/Phone: _____

Samplers:

Analyses Requested

Sample No.	Tag No.	Date	Time	Matrix							Extra Container	Archive	Remarks

Exponent
Environmental Group
Bellevue, WA (425) 643-9803
Boulder, CO (303) 444-7270
Lake Oswego, OR (503) 636-4338
Los Angeles, CA (310) 823-2035
Natick, MA (508) 652-8500

Matrix Code: GW - Groundwater SL - Soil SD - Sediment SW - Surface water

OTHER - Please identify codes _____

Priority: ☐ Normal ☐ Rush Rush time period _____

Shipped via: ☐ FedEx/UPS ☐ Courier Other _____

Condition of Samples Upon Receipt: _____

Custody Seal Intact: ☐ Yes ☐ No ☐ None

Relinquished by: _____ (Signature) Date/Time: _____ Received by: _____ (Signature) Date/Time: _____

Relinquished by: _____ (Signature) Date/Time: _____ Received by: _____ (Signature) Date/Time: _____

Distribution: White and Yellow Copies - Accompany Shipment; Pink Copy - Project File

Exponent™

OFFICIAL SAMPLE SEAL

SAMPLE NO.	DATE
SIGNATURE	
PRINT NAME AND TITLE	

Exponent™

SAMPLE NO.

SITE NAME

DATE | TIME

SAMPLER | PRESERVATIVE

TAG NO. 25101

Appendix E

Health and Safety Plan

Exponent™

HEALTH AND SAFETY PLAN

Site Name Ward Cove Contract No. 8600B0W.001 1903

Proposed Activity Sediment and Benthic Macroinvertebrate Sampling

Prepared by Jane Sexton Date February 15, 2001

Reviewed by Larry Peterson Date March 22, 2001

1. INTRODUCTION

This site-specific health and safety plan, in conjunction with the Corporate Health and Safety Program, establishes procedures and practices to protect employees of Exponent and its subcontractors from potential hazards posed by field activities at Ward Cove. In this health and safety plan, measures are provided to minimize potential exposures, accidents, and physical injuries that may occur during daily onsite activities and adverse conditions. Contingency arrangements are also provided for emergency situations.

2. DISCLAIMER

Exponent cannot guarantee the health or safety of any person entering this site. Because of the potentially hazardous nature of this site and the activity occurring thereon, it is not possible to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety guidelines set forth herein will reduce, but not eliminate, the potential for injury and illness at this site. The health and safety guidelines in this plan were prepared specifically for this site and should not be used on any other site without prior evaluation by trained health and safety personnel.

3. SITE DESCRIPTION

Site name: Ward Cove

Site location or address: 7559 North Tongass Highway
Ketchikan, Alaska

Owners/tenants: Ketchikan Pulp Company (KPC)/Louisiana-Pacific

Current site use: Marine bay adjacent to a sawmill

Past site use (if different): Pulp mill

Designated hazardous waste site: No (federal, state, other) _____

Industrial facility _____ Spill _____ Other Marine waters and sediment

Active _____ Inactive X

Topography: Marine bay measuring approximately ½ mile by 1 mile

Name of and distance to nearest surface water body: Ward Cove is a branch of the Tongass Narrows.

Surrounding land use/nearest population: A cannery is located on one shore; the Ketchikan sawmill and former pulp mill are located on the other.

Site access: KPC facility is on the Tongass Highway.

Nearest drinking water/sanitary facilities: On the sampling vessel and at the KPC facility.

Nearest telephone (list number if possible): KPC (907) 225-2151

All buried utilities must be located prior to drilling or excavating at the site. List procedures to be used to locate utilities or indicate that no subsurface excavation or sampling will occur:

Project personnel will work with facility personnel and local authorities to determine the location of submerged utilities, if any, prior to sediment coring.

Site map attached:

4. PROJECT PERSONNEL

	Name/Affiliation	Work Telephone	Home Telephone
Project manager	Lucinda Jacobs	(425) 643-9803	(206) 324-3380
Field team leader	Jane Sexton	(425) 643-9803	(206) 782-1754
Site safety officer	Jane Sexton	(425) 643-9803	(206) 782-1754
Exponent field personnel			
Facility contact	Barry Hogarty (KPC)	(907) 228-2187 (907) 254-2168	
Client contact (if different)			

5. WORK PROPOSED

Description of proposed work: The collection of surface sediment samples for chemical analysis, toxicity testing, and benthic invertebrate identification and enumeration.

Proposed work dates: July/August 2004, 2007, and 2010.

Subcontractors	Name	Task	Contact	Telephone
	David Evans & Associates	Station positioning	Jon Dasler	(503) 499-0297

6. HAZARD EVALUATION

Potentially hazardous chemicals known or suspected to be onsite (include preservatives and decontamination chemicals):

Chemical of Concern	Concentration (observed or expected)	Medium	OSHA PEL	OSHA STEL	OSHA IDLH	Odor Threshold	IP(eV)	Carcinogen or Other Hazard
Dioxin	1–43 pg/g	sediment	--	--		NA	--	C
Sulfides	62–8,500 mg/kg	sediment	--	--		NA	--	
Methylphenol	ND–9.100 mg/kg	sediment	5 ppm[a]	--		0.05[b]	--	P[b]
Acetone	product	decon	1,000 ppm	--		13–100 ppm	9.69	flammable
Hexane	product	decon	50 ppm	50 ppm		130 ppm	10.18	flammable
Formalin	concentrated	preserva-tive	0.75 ppm	2 ppm	20 ppm	0.027–9,770 ppm	10.88	C,P combustible, reactive

Note: -- - none established; C - carcinogen; IDLH - immediately dangerous to life and health; IP(eV) - ionization potential; ND - not detected; P - poison; PEL - permissible exposure level; STEL - short-term exposure level

[a] PEL for phenol and *o*-cresol (skin).

[b] Phenol.

	Known	Possible	Unlikely
Potential chemical exposure routes at the site:			
Inhalation	X (decon chemicals and preservative)		X (sediment)
Ingestion		X	
Skin absorption		X	
Skin contact		X	
Eye contact		X	
Chemical characteristics:			
Corrosive			X
Ignitable	X (decon chemicals and preservative)		X (sediment)
Reactive	X (acetone and preservative)		X (sediment)
Volatile	X (decon chemicals and preservative)		X (sediment)

	Known	Possible	Unlikely
Radioactive			X
Explosive			X
Biological agent			X
Particulates or fibers			X

If known or likely, describe: Acetone, hexane, and formalin are volatile, and field personnel will stand upwind when using chemicals. These chemicals will not be used unless area is well ventilated.

Possible physical hazards present during site activities:

	Yes	No	Proposed Safety Procedure
Uneven terrain/tripping	X		Keep decks clear, exercise caution, wear properly fitting boots
Heat stress		X	
Cold/hypothermia	X		Keep warm and dry, bring extra clothes, warm food/drink, do not work in extreme conditions without proper equipment and training
Drowning	X		Wear PFDs when working over the water
Falling objects	X		Wear hard hats near overhead hazards (i.e., winch)
Noise		X	
Excavations		X	
Scaffolding		X	
Heavy equipment	X		Stay back from operating equipment (i.e., winch), wear hard hat, coordinate with operator, exercise caution
Material handling	X		Lift properly, do not overload coolers; seek help when moving heavy items.
Compressed air equipment		X	
Confined spaces		X	
Adverse weather	X		Seek shelter during electrical storms; work in adverse conditions only with proper training and equipment
Work in remote areas		X	
Biohazard		X	
Plant/animal hazards		X	
Other Vessel operations	X		Review marine safety SOP

Note: If confined space entry is required, personnel must first obtain a confined space entry permit.

Potential physical hazards posed by proposed site activities:

Activity	Potential Hazard
Sediment sampling	Cold; drowning; falling objects; slips, trips, and falls
Decon of sampling equipment	Dermatitis due to skin contact with acetone, inhalation of acetone and hexane
Preserving of benthic invertebrate samples	Inhalation of formalin
Sample handling/mobilization	Material handling

7. PERSONAL PROTECTIVE EQUIPMENT

Based on the hazards identified above, the following personal protective equipment will be required for the following site activities (specify both an initial level of protection and a more protective level of protection in the event conditions should change):

	Level of Protection	
	Initial	**Contingency**
Sediment sampling	MD	Leave site
Benthic invertebrate preservation	MD	C
Sample handling	D	MD
Decon	MD	C

Each level of protection will incorporate the following equipment (specify type of coveralls, boots, gloves, respiratory cartridges or other protection, safety glasses, hard hat, and hearing protection):

Level D: [X] Long pants/shirt, work shoes or boots, hard hat (near overhead hazard), safety glasses, work gloves (as needed)

Modified D: [X] Same as D, with addition of coated Tyvek coveralls or raingear, chemical resistant steel-toe boots, and chemical resistant boots. Silver shield gloves when handling decon solvents.

Level C: [X] Same as Modified D, with addition of half-face respirator with organic vapor cartridges during chemical decon (only when cross wind or otherwise suitable ventilation is not possible).

Respirator/Respirator Cartridge Information

Is there potential for a respirator to be donned during fieldwork? Yes

If no, proceed to Section 8. If yes, the following section must be completed for each respirator/respirator cartridge combination that will be or potentially will be used during the course of the fieldwork. The

Exponent Environmental Group health and safety manager can be contacted for resources to complete this section.

Respirator Manufacturer #1	MSA
Respirator Cartridge Selected for Use	Formaldehyde cartridge
Respirator Cartridge Change Schedule	The cartridge will not need to be changed.

Justify the cartridge change schedule and present all data used to establish this schedule.

Formalin will be added to the benthic invertebrate samples outdoors in a well ventilated area. It is anticipated that a respirator will not be needed for this activity. If, however, the site safety officer determines that the area is not properly ventilated, then a respirator will be worn for a very limited time while formalin is added to the sample containers. Based on MSA data, this cartridge will last for 3.4 hours (202 minutes) (see attached respirator test data sheet). The cartridge will be changed after 100 minutes of use.

Respirator Manufacturer #2	NA
Respirator Cartridge Selected for Use	NA
Respirator Cartridge Change Schedule	NA

Note: Project personnel are not permitted to deviate from the specified levels of protection without the prior approval of the site safety officer or Exponent Environmental Group health and safety manager.

8. SAFETY EQUIPMENT

The following safety equipment will be onsite during the proposed field activities:

Air Monitoring (check the items required for this project)

- [ ] PID
- [ ] CG/O_2 meter
- [ ] H_2S meter
- [ ] Detector pump and tubes
- [ ] Air sampling pumps
- [ ] Miniram
- [ ] Radiation meter
- [ ] Other: _____

First Aid Kit (mandatory, including adhesive band-aids, gauze, tape, gloves, CPR shield, triangle bandage)
(check additional items required for the site)

- [X] Emergency blanket
- [X] Insect repellent
- [X] Sunscreen
- [ ] Other: _____

Other (check the items required for this project)

- [X] Eyewash
- [X] Drinking water
- [ ] Stopwatch for monitoring heart rate
- [ ] Thermoscan thermometer for heat stress monitoring
- [ ] Survival kit
- [X] Personal flotation device
- [ ] Cool vests
- [ ] Fit test supplies
- [ ] Fire extinguisher
- [ ] Windsock
- [X] Cellular phone
- [ ] Radio
- [X] Global positioning system
- [ ] Other: _____

9. SITE CONTROL

Describe location and designation of each zone:

Exclusion zone: The aft deck of the sampling vessel will be considered to be the exclusion zone. Sample collection and processing will occur in this area. Only properly equipped and trained (i.e., wearing modified D protective clothing) personnel will be allowed in this area. The area will be washed with sea water between sample stations.

Contamination/reduction zone: Chemical decontamination will occur on the aft deck of the sampling vessel, away from other personnel, and in a cross breeze to minimize exposure to volatile decontamination chemicals and preservatives. The rest of the deck will be the contamination reduction zone. Decontamination, sample storage, and other support functions will occur in these areas.

Support zone: The pilot house will be the support zone. No chemical or sample handling activities will occur in this area. Personnel will be required to wash chemicals and sediment from raingear or Tyvek coveralls before entering this area.

Describe controls to be used to prevent entry by unauthorized persons:

No unauthorized personnel will be allowed on the sampling vessel.

10. AIR MONITORING

Air monitoring will be conducted when entering previously uncharacterized sites, when working in the vicinity of uncontaminated chemicals or spills, when opening containers and well casings, and prior to opening and entering confined spaces. Air monitoring must be conducted to identify potentially hazardous environments and determine reference or background concentrations. Air monitoring will be used to define exclusion zones. Air monitoring may also be conducted to evaluate the concentration of chemicals in samples.

The following equipment will be used to monitor air quality in the breathing zone during work activities:

Monitoring Instrument	Calibration Frequency	Parameters of Interest	Sampling Frequency
None. Previous monitoring (data in project file 8600A20.003 and 8600BCH.001) shows that the PEL for formaldehyde was never exceeded. Respirators will be provided if requested by staff, but monitoring data supports the fact that there is no danger to exposure above the PEL. Volatile decon chemicals and preservative will be used outdoors to minimize exposure.			

The following action levels have been established to determine the appropriate level of personal protection to be used during site investigation activities:

Instrument	Reading	Action[a]	Comments
None			

[a] Examples: "upgrade to Level C" or "leave site."

11. DECONTAMINATION

To prevent the distribution of contaminants outside the exclusion zone or cross-contamination of samples, the following procedures will be used to decontaminate sampling equipment:

Sediment sampling equipment (i.e., van Veen grab sampler) will be decontaminated using the following general sequence: site water or tap water rinse, Alconox® scrub using site or tap water, site water or tap water rinse, solvent rinse with acetone and hexane (respectively), and a final site water rinse. Equipment used for compositing the sediment samples (i.e., stainless-steel bowls and spoons) for chemical analysis and toxicity testing will follow the same basic decontamination sequence except that the final rinse will be with distilled/deionized water.

To prevent the distribution of contaminants outside the exclusion zone and personal exposure to chemicals, vehicles will not be allowed inside the exclusion zone. If vehicles are required in the exclusion zone (e.g., drill rigs), the following procedures will be used to prevent contamination or decontaminate the vehicles:

Chemicals and samples will be packaged in secure containers before placement in a vehicle or vessel pilot house. All sampling equipment and protective equipment will be decontaminated before placement in a vehicle or vessel pilot house.

To minimize or prevent personal exposure to hazardous materials, all personnel working in the exclusion zone and contamination reduction zones will comply with the following decontamination procedures:

All personnel will wash sediment and chemicals from their raingear or Tyvek coveralls before leaving the exclusion zone. All gloves, Tyvek, rain gear, and rubber boots will be removed prior to entering the rental vehicle.

Decontamination equipment required on site will include the following:

Scrub brushes, Alconox® buckets, distilled/deionized water, foil, hexane, acetone, plastic bags, paper towels, garbage bags, plastic tubs.

Decontamination wastewater and contaminated materials will be disposed of in the following manner:

Excess solvent rinsates will be collected in a plastic tub and allowed to evaporate during the course of the decontamination activity. Any rinsates that have not evaporated by the end of the decontamination activity will be containerized and disposed of appropriately.

The following personal hygiene practices will be used:

- Long hair will be secured away from the face so it does not interfere with any activities.
- All personnel leaving potentially contaminated areas will wash their hands and faces prior to entering any clean areas or eating areas.
- Personnel leaving potentially contaminated areas will shower (including washing hair) and change to clean clothing as soon as possible after leaving the site.
- No person will eat, drink, or chew gum or tobacco in potentially contaminated areas. Drink containers and drinking of replacement fluids for heat stress control will be permitted only in areas that are free from contamination. Smoking is prohibited in all areas of the site because of the potential for contaminating samples and for health and safety reasons.

12. VEHICLE SAFETY

Exponent's vehicle safety program requires the following:

- All vehicles are to be operated in a safe manner and in compliance with statutory traffic regulations and ordinances
- Operators are to practice defensive driving and drive in a courteous manner
- Operators are required to have a valid driver's license and liability insurance (per local state laws)
- Seat belts are to be worn by the driver and all passengers
- No persons are allowed to ride in the back of any trucks or vans
- Vehicles are to be driven in conformance with local speed limits
- Personnel who are impaired by fatigue, illness, alcohol, illegal or prescription drugs, or who are otherwise physically unfit, are not allowed to drive
- Personnel are to avoid using cellular phones or engaging in other distractions while driving

- All Exponent-owned field vehicles are to be maintained in a safe and clean condition
- All Exponent-owned field vehicles are to be equipped with the following:
  - First-aid kit
  - Fire extinguisher
  - Flares
  - Spare tire and jack
  - Other equipment as required for the project (e.g., tire chains, towing cable, tools, cellular phone or radio)
- Motor vehicle accidents are to be reported to the responsible law enforcement agency, the Exponent Environmental Group risk manager, and the Exponent Environmental Group health and safety manager
- Employees who have experienced work-related vehicle accidents or citations may be required to complete a defensive driving program.

13. SPILL CONTAINMENT

Provisions must be made for spill containment at any site where bulk liquids will be handled.

Will the proposed fieldwork include the handling of bulk liquids, oil, or chemicals (other than water)? Yes X No _____

If yes, describe spill containment provisions for the site:

Decon chemicals: All decon chemicals will be dispensed from capped containers directly into specific squirt bottles that have been permanently marked with the name of the decon chemical and that have screw caps. Decon chemicals will be poured into the squirt bottles while they are over shallow Rubbermaid® tubs to capture any overfill/spills.

Formalin: Formalin will be dispensed from capped containers directly into the sample container with screw caps over shallow Rubbermaid® tubs to capture any overfill/spills.

14. SHIPMENT OF RESTRICTED ARTICLES

Federal laws and international guidelines place restrictions on what materials may be shipped by passenger and cargo aircraft. In the course of this field investigation, the following items will be shipped to and from the site in the following manner:

Item	Hazardous Constituent	Quantity	Packaging	How Shipped
Samples	None			No special procedures will be required
Solvents (name)	Acetone and hexane	1 gal each	Glass bottles protected against breakage in manufacturers'	Barge to Ketchikan, then private vehicle to the site.

Item	Hazardous Constituent	Quantity	Packaging	How Shipped
			shipping containers or plastic bottle jackets	
Calibration gas (name)	None			
Preservatives (name)	Formalin	5 gal	Original package	Barge to Ketchikan, then private vehicle to the site.
Other:	None			

Exponent has arranged with CHEM-TEL to provide a 24-hour emergency contact number for all chemical shipments. CHEM-TEL can also provide advisory services (i.e., information on how to label, ship, and package chemicals). EXPONENT PERSONNEL MUST PROVIDE THE 24-HOUR EMERGENCY NUMBER TO THE SHIPPER.

For ANY shipment (air, rail, sea, or ground) within the United States, Canada, Puerto Rico, and the U.S. Virgin Islands that requires a 24-hour emergency response number (on ANY documents, such as Uniform Hazardous Waste Manifests, Shipper's Declaration of Dangerous Goods, etc.), the telephone number to use is 1-800-255-3924. ANY shipment outside the North American continent should reference "813-248-0573 (use the AT&T collect call operator)" on the document. Having international users call collect will ensure a bilingual operator is available to identify the call as an emergency. After accepting the call, if needed, CHEM-TEL will network with a translation service to prevent communication difficulties if the caller speaks a language other than English. On the shipping documents, please remember to indicate that the phone number specified is an emergency response contact number.

Before shipping chemicals (and listing the CHEM-TEL emergency number), Exponent personnel must fax the shipping document (manifest, declaration of dangerous goods, etc.) to CHEM-TEL informing them of the shipment. The fax number is 813-248-0581.

Regulatory advisory services are available from CHEM-TEL during business hours: 9 a.m. to 5:30 p.m. at 813-248-0573 (EST). This assistance can include determining the proper packaging, labeling, and shipping requirements for shipping hazardous substances.

15. MEDICAL MONITORING

OSHA requires medical monitoring for personnel potentially exposed to chemical hazards in concentrations in excess of the PEL for more than 30 days per year and for personnel who must use respiratory protection for more than 30 days per year. Exponent requires medical monitoring for all employees potentially exposed to chemical hazards.

Will personnel working at this site be enrolled in a medical monitoring program? Yes X No _____

16. HEALTH AND SAFETY TRAINING

State and federal laws establish training requirements for workers at uncontrolled hazardous waste sites (including areas where accumulations of hazardous waste create a threat to the health and safety of an individual, the environment, or both).

Exponent and subcontractor personnel will be required to complete the following training requirements:

Duties	No Special Training[a]	24-hour	40-hour	Supervisor	First Aid/CPR	Other
Exponent Personnel						
Field team leader			X	X	X	
Field personnel			X			
Subcontractors						
Station positioning			X			
Vessel operator						X[a]

[a] Provide explanation or justification: Vessel operator will not be required to have 40-hour training. Vessel operator will stay out of the exclusion zone during sample collection and decon.

17. SITE SAFETY MEETINGS

Site safety meetings must be held before beginning new tasks or when new staff enter a site. Site safety meetings should be held at a minimum of once a week and should be held daily on large projects. Attendance and topics covered must be documented.

18. FACILITY SAFETY PROCEDURES

The client or facility operators require that the following procedures be followed for all personnel at the site:

Personnel entering restricted areas of the facility will wear hard hats and safety glasses.

19. EMERGENCY PLANNING

In case of fire, spill, or other emergency affecting the site, all affected personnel must immediately evacuate the work area and report to the site safety officer at a predetermined location. Field personnel must also immediately notify facility or community emergency response providers unless facility personnel have already initiated this notification.

Designated assembly point: Field vehicle or vessel cabin

In case of injury, field personnel should take precautions to protect the victim from further harm and notify local or facility emergency services. In remote areas, it will be necessary to have first aid-trained

personnel on the field team. The victim may require decontamination prior to treatment—requirements will vary based on site conditions.

Emergency medical care will be provided by:

- [X] Local emergency medical provider (i.e., fire department)
- [ ] Facility emergency medical provider
- [ ] First aid-trained field staff (for remote areas only)

Local Resources	Name	Telephone	Notified Prior to Work (Yes/No)?
Fire	Pond Reef Fire Department	911	No
Police	Alaska State Patrol	911	No
Ambulance	Pond Reef Fire Department	911	No
Hospital	Ketchikan General Hospital	(907) 225-5171	No
Site phone	KPC	(907) 225-2151	Yes

Directions to hospital: The hospital is located at 3100 Tongass Avenue. Turn right when leaving the KPC facility. Drive south on Tongass Highway. Turn left at hospital.

Corporate Resources	Name	Work Telephone	Home Telephone
Exponent Environmental Group health and safety manager	Larry Peterson	(303) 444-7270	(303) 255-1787 (720) 350-8897
Regional health and safety officer	Jane Sexton	(425) 643-9803	(206) 782-1754
Medical consultant	Dr. Jones/ Virginia Mason Clinic	(206) 242-3651	
CHEM-TEL	Emergency No. 1-800-979-0626		

In case of serious injuries, death, or other emergency, the Exponent Environmental Group health and safety manager must be notified immediately. To contact the Exponent Environmental Group health and safety manager (or delegate), try calling Larry Peterson at the work and home numbers listed above. If no response, call the **emergency pager (888) 488-7204**. If no response, call Larry Marx at (425) 643-9803 or (425) 643-6019 or (360) 378-3778.

In case of accident or emergency the client or facility operators require that the following person be notified immediately: Barry Hogarty (907) 228-2187

Other Resources	Agency Name/Location	Telephone
Local OSHA office	U.S. OSHA, Anchorage, AK	(907) 271-5152
State OSHA equivalent	Division of Occupational Safety and Health, Juneau, AK	(907) 465-4855

20. DOCUMENTATION

	Attached	In File	Not Applicable
Exponent site safety acknowledgment forms	X		
OSHA or equivalent state poster	X		
Site safety meeting minutes	X		
Exponent accident/incident report form	X		
Exponent heat stress monitoring form			X
Exponent confined space entry permit			X
Exponent confined space entry checklist			X
Exponent air monitoring record			X
Exponent air sampling record			X
Site map	X		
Work plan		X	
Material safety data sheets	X		
Hospital route	X		
Health and safety training records		X	
Heat stress standard operating procedure			X
Confined space entry information			X
Equipment standard operating procedures (list below)	X		
Other: SOP 423 Safety during Marine Operations	X		

21. LIST OF ATTACHMENTS

Attachment 1. Site Map(s) and Hospital Route
Location of Ward Cove
Site Location and Route to Ketchikan General Hospital

Attachment 2. Regulatory Notices
Job Safety & Health Protection

Attachment 3. Forms
Health and Safety Plan Consent Agreement
Site Safety Meeting Minutes
OSHA Onsite Training Documentation Form
Employee Accident, Injury, Incident and/or Exposure Report

Attachment 4. Standard Operating Procedures
SOP 423, Safety during Marine Operations

Attachment 5. Material Safety Data Sheets
Acetone
Formaldehyde
Hexane

Attachment 6. Miscellaneous
MSA's Cartridge Change Test Program
MSA Respirator Test Data, Acid Gases
MSA Respirator Test Data, Aldehydes

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HEALTH AND SAFETY PLAN CONSENT AGREEMENT

I have reviewed the health and safety plan prepared by _____, dated _____, for the _____ _____ site fieldwork. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines while an employee of Exponent or its subcontractors.

Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date
Employee signature	Firm	Date

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SITE SAFETY MEETING MINUTES

Site Name _____ Contract No. _____

Meeting Location _____

Meeting Date _____ Time _____ Conducted By _____

Pre-fieldwork Orientation _____ Weekly Site Meeting _____ Other _____

Subjects Discussed _____

_____

_____

_____

Safety Officer Comments _____

_____

_____

_____

Name and Signature of Participating Personnel (list company name if subcontractor)

_____

_____

_____

_____

_____

_____

_____

Note: Attach additional pages if necessary. Send this form to the Exponent Environmental Group health and safety manager. Copies will be placed in the appropriate project files.

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OSHA ONSITE TRAINING DOCUMENTATION FORM

In accordance with 29 CFR 1910.120, after an employee completes the OSHA 40-hour training class, 3 days of onsite experience under the direct supervision of a trained, experienced supervisor is required to fulfill the OSHA HAZWOPER training. This form is to be used to document this requirement, and shall be completed by a qualified supervisor (i.e., someone who has completed the 8-hour supervisory training class). Upon completion of this form, please submit it to the Exponent Environmental Group health and safety manager.

EMPLOYEE INFORMATION

Name _____

Signature _____

40-Hour Training Completion Date _____

Dates of Onsite Training _____

Name of Site _____

Type of Site _____

SUPERVISOR CERTIFICATION

Supervisor _____

Signature _____

Appendix F

Stepwise Description of Statistical Analyses

Stepwise Description of Statistical Analyses

Procedure for Comparison of Toxicity and Benthic Macroinvertebrate Data to Reference Conditions

This procedure is to be carried out for toxicity results, total abundance data, total richness data, and the Swartz's dominance index metric.

1. Compute the relevant statistic (e.g., percent survival, number of species) for each station.
2. Review the data for each stratum and reference area to identify possible outliers. A single potential outlier can be tested against the distribution of the remaining samples using a *t*-test with a Type 1 error rate (*p*) of 0.05. If a potential outlier is identified, subsequent analyses should be conducted both with and without the outlier (U.S. EPA 2000).
3. For the amphipod survival test, and for each stratum, evaluate survival with respect to the screening criterion of 75 percent. If survival is less than 75 percent, conduct a statistical comparison to the reference area as described in the following steps.
4. Prepare a probability plot and carry out a Shapiro-Wilk's test of the data for all stations within each stratum and within each reference area, to assess normality of the data. Judgment must be applied to the interpretation of these analyses. If the data for a stratum and its reference area are non-normal and a single transformation can be applied to render all the data normal, then apply the transformation and use a Dunnett's test in the following step. If only one or the other of the stratum and reference area are non-normal, or there is no single transformation that can be applied to both, then use a non-parametric test in the following step.
5. For each stratum and its corresponding reference area, perform a Dunnett's test with a Type 1 one-sided error rate (*p*) of 0.05.
6. If the previous step indicates that there are no significant differences between a stratum and its corresponding reference area, compute the minimum detectable difference (MDD) of the test for power levels of 0.6, 0.7, and 0.8.

Reporting of the results of statistical tests should include, for each stratum (and corresponding reference area):

- The actual Type 1 error rate (*p*)
- Whether or not a statistically significant difference was found (i.e., whether or not *p* was less than 0.05)
- The coefficient of variation of the stratum
- If no significant difference was found, the MDD for each power level.

For all cases in which a power analysis is performed and the MDD for all power levels is greater than the actual difference, then a qualitative interpretation of the results must be made. If the actual differences are determined to be potentially biologically significant, then the absence of a statistically significant difference between a stratum and reference area does not reliably indicate that site conditions are equivalent to reference. If such results are commonly observed in the first or second monitoring periods, revision of the sampling design may be desirable.

Procedure for Comparison of Benthic Major Taxa Data to Reference Areas

This procedure is to be carried out for major taxa as indicated in Table F-1. Multivariate analysis of variance (MANOVA) is used to allow changes in abundances of all major taxa to be simultaneously evaluated in a single analysis. The MANOVA analysis accounts for possible correlations between values for different major taxa within a stratum or reference area. This test requires that the data set contain more cases than dependent variables (i.e., major taxa). Therefore, a single MANOVA will be done for all strata and reference areas, as follows.

1. Carry out steps 1 and 2 as for the comparison of site data to reference area data.
2. For all strata and the reference areas, carry out a Model 1 MANOVA with a Type 1 error rate (*p*) of 0.05.

The MANOVA should initially be run using all groups of major taxa. Additional MANOVAs may be conducted using subsets of the major taxa (e.g., those that have the highest abundances). Reducing the number of dependent variables (major taxa) should provide the test with more power, and may allow it to be applied to subsets of the strata (e.g., for a single reference area and all the associated strata).

Further analysis of the differences in major taxa between an individual stratum and its corresponding reference area may be carried out with a Dunnett's test. The Dunnett's test should be conducted as for other benthic indices.

Procedure for Evaluation of Temporal Trends

This procedure is to be carried out for toxicity results, total abundance data, total richness data, and the Swartz's dominance index metric, as indicated in Table F-1. Temporal trends should be evaluated at the reference areas as well as at each site stratum.

For evaluation of temporal changes over two time periods (e.g., for benthic indices after the second monitoring period), a Dunnett's test should be carried out and evaluated in a manner similar to that used to perform comparisons to reference areas. However, instead of comparing data for a stratum to the corresponding reference, data for a single stratum at the two different time periods should be compared. This comparison should use a one-tailed error rate of 0.05 to assess whether the later data represent a significant improvement over the earlier data.

For evaluation of temporal trends over three or more time periods, a regression analysis should be performed as follows.

1. Carry out steps 1 and 2 as for the comparison of site data to reference area data.
2. Plot the data for each variable in each stratum against time. If later values are higher than earlier values, continue with the regression analysis.
3. Carry out a linear regression of the indices against time. Examine the residuals for uniformity and, if necessary, transform the data and repeat the regression analysis.
4. Test the slope of the regression line for a significant difference from zero using a two-tailed Type 1 error rate of 0.05.

If the slope is significantly different from zero, the data indicate that recovery is under way. The results of regression analyses should be reported including the actual Type 1 error rate observed for each comparison, the slope and intercept of all significant regressions, and a plot of the data with the regression line superimposed. The reference condition for the variable under consideration may be included on the plot to provide a visual indication of the rate of approach to reference conditions.

Reference

U.S. EPA. 2000. Methods for measurement of toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. EPA/600/R-99/064. U.S. Environmental Protection Agency, Washington, DC.

Tables

Table F-1. Summary of planned methods of data analysis for evaluating recovery of benthic macroinvertebrate communities in Ward Cove

Analysis	Data Analyzed	Statistical Test
First Monitoring Year (2004)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity compared to RI/FS data	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Other Stations		
Benthic community analyses		
Successional stage	Species identities, abundances, and successional stage ("pioneering" or "equilibrium")	N/A
Total richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Total abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic major taxa abundance compared to reference areas	Total number of individuals of each major taxon	MANOVA
Benthic major taxa richness compared to reference areas	Total number of species in each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Second Monitoring Year (2007)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to RI/FS and Year 1 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Table F-1. (cont.)

Analysis	Data Analyzed	Statistical Test
Other Stations		
Benthic community analyses		
Successional stage	Species identities, abundances, and successional stage	N/A
Taxonomic richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic community structure compared to reference areas	Total number of individuals of each species	MANOVA
Taxonomic richness trend	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance trend	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index trend	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic major taxa abundance trend	Total number of individuals of each major taxon	MANOVA
Benthic major taxa richness trend	Number of species of each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to Year 1 data	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Third Monitoring Year (2010)		
RI/FS Stations (8, 9, 13, 38)		
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to RI/FS and Year 1 and Year 2 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Table F-1. (cont.)

Analysis	Data Analyzed	Statistical Test
Other Stations		
Benthic community analyses		
Successional stage	Species identities and abundances	N/A
Taxonomic richness compared to reference areas	Number of species in site strata and reference areas	Dunnett's test (p = 0.05)
Organism abundance compared to reference areas	Total number of organisms	Dunnett's test (p = 0.05)
Swartz's dominance index compared to reference areas	Number of taxa making up 75 percent of total abundance	Dunnett's test (p = 0.05)
Benthic community structure compared to reference areas	Total number of individuals of each species	MANOVA
Taxonomic richness trend	Number of species in site strata and reference areas	Regression (p = 0.05 for slope)
Organism abundance trend	Total number of organisms	Regression (p = 0.05 for slope)
Swartz's dominance index trend	Number of taxa making up 75 percent of total abundance	Regression (p = 0.05 for slope)
Major taxa abundance trend	Total number of individuals of each major taxon	MANOVA
Major taxa richness trend	Number of species of each major taxon	MANOVA
Toxicity analyses		
Toxicity compared to reference	Response for all replicates, for each bioassay	Dunnett's test (p = 0.05)
Toxicity trend compared to Year 1 and Year 2 data	Response for all replicates, for each bioassay	Regression (p = 0.05 for slope)

Note: MANOVA - multivariate analysis of variance
RI/FS - remedial investigation and feasibility study