YEAR 1 MONITORING REPORT

INTERIM REMEDIAL ACTION
LOG POND CLEANUP/HABITAT RESTORATION PROJECT
BELLINGHAM, WASHINGTON

Prepared for

Georgia-Pacific West, Inc.

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December 2001

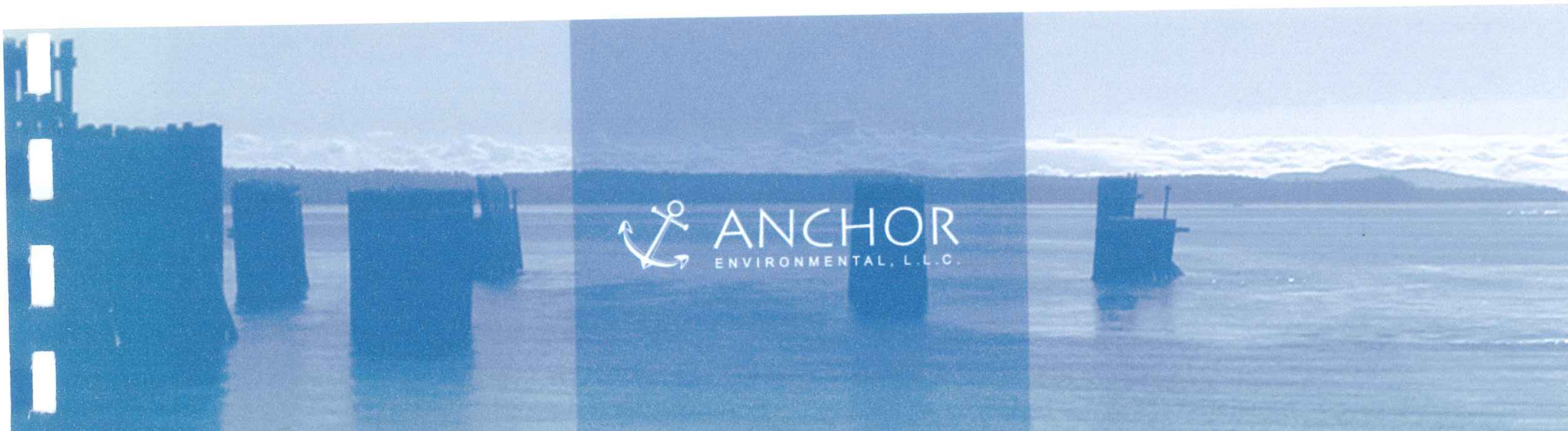

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Table of Contents

List of Tables

List of Figures

List of Appendices

EXECUTIVE SUMMARY

In early 2001, Georgia-Pacific West, Inc. (G-P) completed construction of a combined sediment cleanup/habitat restoration action at the G-P Log Pond in Bellingham Bay. The project converted subtidal mudflat/debris and low intertidal riprap, all of which previously exceeded Washington State sediment quality standards (SQS), into clean intertidal and shallow subtidal silt and sand habitat. Consistent with agency requirements, G-P performed post-construction monitoring within the Log Pond to verify the integrity and performance of the cap, and to document the development of habitat functions within the Log Pond.

This report presents data collected during the first year of post-construction monitoring. The results of Year 1 monitoring are summarized below:

- Surface sediment physical monitoring within the Log Pond verified that the cap/habitat surface has maintained its integrity following construction, and has now developed suitable strength to generally resist further erosion.
- Sampling at the margins of the Log Pond cap documented continued attainment of surface water and sediment quality protection objectives within the nearshore seepage zone of the cap. These data also verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.
- All chemical concentrations in both surface and subsurface zones of the cap/habitat layer were well below SQS chemical criteria. Moreover, samples collected 1.0 to 1.5 feet above the bottom of the cap were also below SQS chemical criteria, indicating that the capping method used by G-P successfully minimized mixing of underlying contaminated sediments into the bottom of the clean cap. These data also verify that chemicals are not migrating vertically into the cap/habitat layer.
- Biological monitoring data revealed that within several months of construction, epibenthic and benthic biomass, species richness, diversity and evenness within the Log Pond recovered to Chuckanut Bay reference values, consistent with remedial design predictions of rapid re-colonization.

Physical, chemical, and biological monitoring of the Log Pond will continue during Years 2, 5, and 10 to document the long-term effectiveness of the remedial/habitat restoration action.

1 INTRODUCTION

In late 2000 and early 2001, Georgia-Pacific West, Inc. (G-P) implemented a combined sediment cleanup/habitat restoration action at the G-P Log Pond, part of the Whatcom Waterway Site located in inner Bellingham Bay, Washington (Figures 1 and 2). The integrated remediation and habitat restoration project was performed as an Interim Remedial Action under the authorities of the State Model Toxics Control Act (MTCA; Chapter 173-340 WAC; RCW 70.105D), as set forth in an Agreed Order for this action between G-P and the Washington Department of Ecology (Ecology). The project was also authorized under Clean Water Act Permit No. 2000-2-00424 administered by the U.S. Army Corps of Engineers (Corps).

G-P prepared a Completion Report for the Log Pond project in May 2001 (Anchor 2001). The Completion Report described the placement of approximately 43,000 cubic yards (cy) of clean cap/habitat restoration material from regional maintenance dredging projects into the Log Pond. Relatively fine-grained Squalicum Waterway dredge materials were used to construct the final Log Pond surface. The total placed thickness ranged from approximately 0.5 feet along the cap perimeter (e.g., adjacent to structures) to 10 feet within the interior of the project area. Nearly all of the Log Pond received more than 3 feet of cap/habitat restoration material, tapering to less than 0.5-foot-thick along the perimeter, consistent with the Agreed Order and associated remedial design (Anchor 2000).

The Log Pond remedial/restoration project converted 1.8 acres of deep subtidal, 2.7 acres of shallow subtidal mudflat/debris, and 1.1 acres of low intertidal riprap, all of which previously exceeded MTCA/Sediment Management Standards (SMS) cleanup criteria, into 2.7 acres of shallow subtidal and 2.9 acres of low intertidal clean silt and sand habitat. The construction project achieved its intended goal of restoring shallow subtidal and low intertidal habitat to the Log Pond.

Consistent with the requirements of the Agreed Order and Corps permit, G-P performed Year 1 post-construction monitoring within the Log Pond beginning shortly after completion of in-water construction activities. As set forth in the final Operations, Maintenance, and Monitoring Plan (OMMP) for the project (included as Appendix C of the Completion Report; Anchor 2001), monitoring is being performed by G-P to verify the integrity and performance of the cap, and to document the development of habitat functions within the Log Pond.

This monitoring report presents data collected to satisfy the Year 1 monitoring requirement of the OMMP. Monitoring activities during Year 1 included:

- Surface sediment physical and chemical monitoring within the Log Pond to verify that the cap/habitat surface has not substantially eroded from propeller wash or storm wave forces, and to demonstrate that surface sediment chemistry within the Log Pond meets SMS Sediment Quality Standards (SQS) chemical criteria
- Sampling of seepage quality at the margins of the Log Pond cap to document attainment and maintenance of surface water quality protection objectives within the nearshore seepage zone of the cap
- Biological monitoring within the Log Pond area, to document the rate of epibenthic and benthic infauna re-colonization

Results of the Year 1 monitoring are presented in the sections below.

2 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 3 – Physical Integrity
- Section 4– Upland Source Control Monitoring – Well Point Water Quality
- Section 5 – Cap Sediment Quality Monitoring
- Section 6 – Biological Monitoring
- Section 7 – References

Figures and Tables summarizing each monitoring element are presented at the end of the text.

Appendices provide supporting project documentation and are organized as follows:

- Appendix A – Sediment Geotechnical Data
- Appendix B – Well Point Field Logs
- Appendix C – Laboratory Report – Well Point Chemistry
- Appendix D – Surface and Subsurface Sediment Field Logs
- Appendix E – Laboratory and Data Validation Reports – Sediment Chemistry
- Appendix F – Huxley College Report – The Log Pond Restoration Project: Structure and Function of the Benthic Community

3 PHYSICAL INTEGRITY

In late February 2001, shortly after completion of in-water construction, G-P performed a detailed bathymetric survey of the Log Pond. These data, presented in the Completion Report (Anchor 2001), provided post-construction baseline information to assess the long-term stability of the cap/habitat system.

The Log Pond cap/habitat restoration action was designed to be maintained at elevations very similar to the initial constructed condition, even following major storm events (Anchor 2000). Nevertheless, disturbances of the surface from variable storm conditions, resulting in dynamic beach equilibrium processes typical of mudflats, are expected to result in periodic disturbances of the cap/habitat surface, leading to localized areas of accretion and erosion. These changes, which are characteristic of such normally dynamic systems, were predicted during remedial design to be relatively minor (Anchor 2000). Based on previous habitat restoration experience in Puget Sound (e.g., Simpson and Champion 1999), the most pronounced changes are expected within the first two years following construction, as the sediment redistributes to achieve its new equilibrium condition.

A range of physical monitoring methods was used during Year 1 to assess the physical integrity of the cap surface. These methods included detailed bathymetric surveys, and physical testing of the cap surface. Physical testing included vane shear strength, moisture content, grain size, and Atterberg limit determinations.

3.1 Bathymetric Survey

In accordance with methods specified in the OMMP (Anchor 2001), a bathymetric survey of the Log Pond was performed on October 9, 2001 over the full extent of the capping area, approximately 7 months after completion of construction. Survey methods and transect locations were equivalent to methods used during the initial February 2001 survey, in order to support detailed comparisons.

A comparison of the February 2001 baseline bathymetry with the October 2001 survey is presented in Figure 3. Overall, the surface of the cap/habitat appeared to consolidate and/or settle by several inches during the initial 7-month period, consistent with design estimates (Anchor 2000). Excluding such consolidation/settlement, more than 95 percent of the cap/habitat surface did not exhibit any discernable change in elevation over the 7-month period. However, localized erosional areas were noted near both the center and margin of the cap/habitat surface, consistent with the expected redistribution/equilibration of the new sediment surface. Localized areas of erosion appeared to be most pronounced adjacent to relatively steep shoreline riprap slopes. The extent of erosion observed in these localized areas typically varied between 0.5 and 1.0 feet. Corresponding areas of sediment accretion were noted near the northeast end of the Log Pond cap.

Based on the October 2001 bathymetric survey, the former Log Pond sediment surface is presently covered by more than 3 feet of cap/habitat restoration material throughout the target capping area, tapering to zero along the perimeter, consistent with the Agreed Order and associated remedial design (Anchor 2000). The cap/habitat layer ranged up to 10 feet thick within the interior of the project area (Figure 4).

3.2 Physical Analyses

As discussed in the Engineering Design Report (Anchor 2000), immediately following construction, the Log Pond mudflat surface may not have achieved sufficient strength to resist erosion from certain wake and wave forces in this area. Accordingly, a log boom was installed near the offshore boundary of the cap to attenuate incoming waves and wakes, mitigating the effect of such forces and facilitating rapid stabilization of the mudflat surface. As the cap/habitat surface consolidates within the first year following construction, the strength of the surface increases. As set forth in the project design, the surface of the Log Pond cap needs to exhibit critical shear strength greater than approximately 0.2 lb/ft^2 in order to resist erosion from ambient wakes and waves.

In order to document the development of shear strength on the Log Pond surface, a number of physical tests were performed in October 2001. Analyses included:

- Vane shear tests
- Moisture content
- Grain size
- Atterberg limit determinations

The results of each test are described below.

3.2.1 Shear Strength

Consistent with OMMP requirements, vane shear tests of surface sediment were completed at six (6) sediment sampling locations within the Log Pond using a field inspection vane tester, consistent with ASTM Method D 2573-94 (Model M-3). Sampling locations are depicted on Figure 5. Vane shear tests were completed at four sub-locations at each sampling site. Each test was positioned at least five vane diameters away from an adjacent test.

Table 1 summarizes the vane shear test results. As the vane shear test was developed for cohesive materials, the results of other physical tests including moisture content, grain size, and Atterberg limits need to be considered when interpreting the vane shear data. The results of these supporting analyses are discussed below.

3.2.2 Moisture Content

A representative surface sediment sample was collected at each of the six (6) sediment sampling locations at the time of vane shear testing (see Figure 5 for locations). All samples were submitted for moisture content analysis. The results are summarized in Table 1 and are included in Appendix A.

3.2.3 Grain Size

Two (2) representative surface sediment samples (WP-1 and WP-2) were submitted for grain size analysis in accordance with ASTM D-422. Two (2) other samples (SS-75 and SS-40) were processed through a No. 200 sieve in accordance with ASTM D-1140 to determine the fines content. The fines content (percent passing the No. 200 sieve) of all four (4) samples was as follows:

- WP-1 - 1.9 percent fines
- WP-2 - 13.2 percent fines
- SS-75 - 15.0 percent fines
- SS-40 - 10.9 percent fines

Samples at Stations SS-76 and SS-301 were not submitted for grain size analysis, as samples SS-40 and SS-75 are representative of these stations.

3.2.4 Atterberg Limit Determination

Two (2) representative surface sediment samples (SS-76 and SS-301) were submitted for Atterberg limit determinations in accordance with ASTM D-4318. Test results, presented in Appendix A, revealed that both samples were not plastic.

3.2.5 Critical Shear Strength

As discussed in the Engineering Design Report (Anchor 2000), the experimental relationship between the critical shear stress and vane shear strength and plasticity measurements was used to evaluate whether sufficient strength has developed on the cap/habitat surface to resist wave- and current-induced erosive forces. The results of this evaluation are summarized in Table 1, and reveal that all sediment samples collected from the surface of the Log Pond cap exhibited critical shear strengths greater than 0.2 lb/ft^2. Thus, approximately 7 months after construction, the entire cap surface appears to have consolidated sufficiently to be able to resist erosion from ambient wakes and waves.

3.3 Summary of Physical Integrity

Based on the discussion above, Year 1 physical monitoring data collected at the Log Pond verify that capping materials placed at the Log Pond have not been eroded significantly by vessel propeller wash or storm wave forces. Moreover, the Year 1 thickness of the Log Pond cap/habitat, extending from the cap perimeter adjacent to structures/riprap into the interior of the project area, is consistent with objectives set forth in the Agreed Order and associated remedial design (Anchor 2000).

These data also verify remedial design predictions that the surface of the Log Pond cap/habitat has developed suitable strength to generally resist further erosion. Nevertheless, periodic disturbances of the surface from variable storm conditions, resulting in dynamic beach equilibrium, are expected to continue to result in disturbances of the mudflat surface. These changes, which are characteristic of such normally dynamic systems, are predicted to be relatively minor, and will be monitored by performing bathymetric surveys during Years 2, 5, and 10, as set forth in the OMMP. Because the critical shear strength specified by the project design has already been achieved, no further vane shear testing or Atterberg determinations are necessary.

4 UPLAND SOURCE CONTROL MONITORING - WELL POINT WATER QUALITY

During remedial design, primary seepage pathways to the Log Pond shoreline were sampled using monitoring wells and shoreline well points (Anchor 2000). These sampling data were evaluated to ensure that water and sediment quality within the Log Pond would be protected following completion of the interim remedial action. Pre-project discharges to the Log Pond were found to be protective of water and sediment quality, provided that concentrations continue to be maintained at or below baseline concentrations.

Under the terms of a separate Agreed Order with Ecology, G-P is currently performing a supplemental remedial investigation/feasibility study (RI/FS) of the former G-P chlor-alkali facility located adjacent to the Log Pond. The supplemental RI/FS is providing data, analyses, and engineering evaluations to develop and evaluate a set of feasible remediation alternatives for the chlor-alkali facility uplands (including groundwater) that will meet environmental standards set forth in MTCA, including protection of the Log Pond, and support site redevelopment plans. This work led to the implementation (in 2001) of additional upland source controls, including reduction of infiltration through paving, to further reduce mercury loading and provide additional protection of the Log Pond. Further upland and shoreline remediation actions are being evaluated. Additional habitat restoration actions within the Log Pond shoreline area (e.g., near riprap and bulkhead structures) are also being considered.

The MTCA Cleanup Standards Regulation (Chapter 173-340 WAC) and State Surface Water Quality Standards (Chapter 173-201A WAC) specify that surface water quality standards are applicable at the point of discharge into surface waters. Well point sampling devices were used during the Year 1 monitoring to evaluate compliance with this criterion. As summarized in the Agreed Order and associated remedial design (Anchor 2000), the applicable surface water quality standards for mercury are:

- Acute criterion (1-hour average concentration) – 1.8 ug/L
- Chronic criterion (48-hour average concentration) – 0.025 ug/L

The objectives of long-term well point water quality monitoring at the Log Pond were to verify compliance of seepage discharges with State Surface Water Quality Standards, and to verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment. This section discusses the collection activities, sample analyses, data quality assessment, and results of the well point monitoring.

4.1 Well Point Sampling Activities

Water quality monitoring was conducted on May 9, 2001 at two (2) well point locations (WP-1 and WP-2) within the Log Pond, in accordance with the OMMP. Well point sampling locations are depicted in Figure 6 and station coordinates are provided in Table 2. Both of the well points were positioned at the margins of the cap. Water samples were collected with a 1-foot-long temporary screen placed within the cap section immediately above the pre-cap sediment surface. Well point field logs are presented in Appendix B.

The May 9, 2001 sampling event coincided with typical maximum seasonal groundwater discharge conditions, and also with a spring tide event characterized by a relatively large daily tidal variation. The well point samples were collected shortly after low tide (-0.8 feet below mean lower low water), in order to characterize minimum tidal dilution conditions. Thus, water samples collected from the well points are generally representative of daily maximum seepage concentrations discharging into the Log Pond, comparable to the acute water quality criterion discussed above. Because of tidal dilution during flood tides, 48-hour average concentrations at the well point locations (comparable to a chronic exposure condition) are much lower (see below).

One filter blank for dissolved mercury analysis was submitted to the laboratory with the well point samples. The purpose of the filter blank was to assess the degree to which dissolved mercury was added or removed during field operations such as equipment decontamination procedures. The equipment decontamination procedures were successful, as evidenced by an acceptably low dissolved mercury concentration detected in the filter blank (see Table 3).

Several minor deviations from the OMMP were necessary:

- Well point station WP-2 was moved north approximately 100 feet from the location proposed in the OMMP. This adjustment was necessary because the original site did not exhibit discernable seepage. The Year 1 WP-2 sample location was positioned within a visible seep, and is more representative of local discharges.

- A hand-auger and sand pack were not needed for the installation of well points. Site conditions were suitable for direct installation of the well points. That is, the well points could be pushed in by hand. Turbidity measurements indicated that suitably low turbidity water (less than 50 nephelometric turbidity units) was withdrawn from the well points within a minute of the start of sampling/pumping activities.

The filter blank for dissolved mercury was collected at the laboratory upon sample delivery.

4.2 Well Point Chemical Analyses

Two (2) well point samples, one each from WP-1 and WP-2, were submitted to Frontier Geosciences, Inc. for low-level total and dissolved mercury in accordance with analytical methods identified in the OMMP. The overall data quality objectives for collection and chemical testing of well point samples were met, as set forth in the OMMP. All data for this project are considered acceptable for use. Laboratory reports for well point chemical determinations are presented in Appendix C.

4.3 Well Point Water Quality Results Discussion

Dissolved mercury concentrations detected at WP-1 and WP-2 were 0.0059 ug/L and 0.0074 ug/L, respectively. As discussed in the Engineering Design Report (Anchor 2000), dissolved mercury concentrations are more representative (than total concentrations) of mercury available for transport. Dissolved mercury concentrations detected in WP-1 and WP-2 were well below both the acute (1.8 ug/L) and chronic (0.025 ug/L) water quality standards for mercury, and were also below conservative sediment protection criteria discussed in the Design Report.

Total mercury concentrations detected at stations WP-1 and WP-2 were 0.0579 ug/L and 0.0304 ug/L, respectively. Although total mercury concentrations detected in these well points were somewhat greater than the 0.025 ug/L chronic (48-hour-average) water quality criterion, the well point data are representative of minimum tidal dilution conditions, and overestimate the average concentration that would be comparable to the chronic criterion, as outlined above. Based on tidal dilution modeling performed at other similar shoreline sites within the Whatcom Waterway area (Anchor and Aspect 2001; ReTec 2001), 48-hour-average seepage concentrations are expected to be at least 4 times lower than peak (i.e., low tide) seep discharge concentrations. Thus, compliance with water quality criteria is indicated.

Shoreline well point samples collected during Year 1 were similar to or lower than pre-construction baseline concentrations. Total and dissolved mercury concentrations in shoreline well points sampled in April 2000 averaged 0.0490 ug/L and 0.0125 ug/L, respectively, compared with May 2001 averages of 0.0442 ug/L and 0.0067 ug/L, respectively.

Based on the discussion above, Year 1 water quality monitoring data collected at the Log Pond indicate compliance of seepage discharges with State Surface Water Quality Standards. These data also verify remedial design predictions of limited mobility of mercury within the Log Pond cap/habitat embankment.

As set forth in the OMMP, well point monitoring will continue during Years 2, 5, and 10 to document attainment and maintenance of surface water quality protection objectives within the nearshore seepage zone of the cap. As appropriate, the Year 5 monitoring report will include a statistical evaluation of mercury concentration trends, and a detailed evaluation of compliance with applicable water quality standards.

5 CAP SEDIMENT QUALITY MONITORING

As part of the Whatcom Waterway Site RI/FS (Anchor Environmental and Hart Crowser 2000), surface sediment samples were collected in 1996 at representative locations within the Log Pond. The RI/FS concluded that the Log Pond contained the highest mercury levels at the Site, with surface sediment mercury concentrations ranging from 1 to 12 milligrams per kilogram (mg/kg; dry weight basis) as well as elevated phenol concentrations (to 1.8 mg/kg dry weight) and greater than 50 percent wood material by volume.

As discussed above, a clean sediment cap was constructed in the Log Pond in late 2000/early 2001. The bottom (Phase I) layer of the cap was constructed with sand, and was placed in a manner that minimized the potential for mixing of the cap with underlying sediments. Finer-grained native silt material was used for the final (Phase II) cap surface, providing a base seeding of endemic Bellingham Bay benthic fauna, facilitating rapid colonization of the mudflat.

The SMS (Chapter 173-204 WAC) specify that sediment quality criteria are applicable within the upper biologically mixed layer of sediments, which has been generally defined in Bellingham Bay as the top 12 cm of sediment (Anchor Environmental and Hart Crowser 2000). As set forth in the OMMP, sampling of surface sediments at four (4) Whatcom Waterway RI/FS locations, along with surface sediments in shoreline seepage zones (near WP-1 and WP-2) determine compliance with SMS criteria. Applicable SQS chemical and optional confirmatory biological testing criteria for surface sediments are set forth in the Agreed Order and associated Engineering Design Report (Anchor 2000). Sediment coring was also performed during Year 1 to verify the predicted lack of upward migration of mercury through the cap.

This section discusses the collection activities, sample analyses, data quality assessment, and results associated with the sediment samples collected as part of the OMMP. Sample collection logs for surface and subsurface sediments are provided in Appendix D.

5.1 Surface Sediment Sampling Activities

Surface sediment samples from the 0 to 12-cm biologically mixed surface layer were collected at six (6) locations within the G-P Log Pond June 29, 2001 in accordance with the OMMP. Surface sediment sampling locations are depicted in Figure 5; station coordinates are provided in Table 2.

5.2 Subsurface Sediment Sampling Activities

Subsurface sediment samples were collected at four (4) locations within the G-P Log Pond June 27-29, 2001 in accordance with the OMMP. Subsurface sediment sampling locations are depicted in Figure 5 and station coordinates are provided in Table 2. Sediment sampling logs are presented in Appendix D.

As described in the OMMP, sample intervals were selected from the sediment cores collected based on physical observations, particularly the delineation of Phase I and II capping layers. The Phase I cap consisted of a fine to medium sand while the Phase II cap primarily consisted of a very sandy silt to very silty sand. Target intervals for each sediment core were as follows:

- Interval A – 0.4 to 1.0 feet below mudline
- Interval B – 1.0 to 1.5 feet below mudline
- Interval C – 1.0 to 1.5 feet above the Phase I/II cap interface
- Interval D – 1.0 to 1.5 feet above the bottom of the Phase I cap
- Interval E – 1.0 to 1.5 feet below the bottom of the Phase I cap (representing the material present prior to cap placement)

Due to the variation in Phase I and Phase II cap thickness throughout the capping area, it was not possible to collect all interval types for all cores. However, sample collection and processing procedures for the subsurface sediment samples did not deviate substantively from the OMMP, and did not affect the quality or usability of the data. A summary of interval types collected and their sample numbers is presented below:

- Core SC-40 – The Phase I/II cap interface was identified at 1.0 foot below mudline with the bottom of the Phase I cap at 1.3 feet below mudline. Interval E was collected at 2.3 to 2.8 feet below mudline and was identified as Sample SC-40E.
- Core SC-75 – The bottom of the Phase I cap was identified at 1.4 feet below mudline. Interval E was collected at 2.4 to 2.9 feet below mudline and was identified as Sample SC-75E.
- Core SC-76 – The Phase I/II cap interface was identified at 2.6 feet below mudline with the bottom of the Phase I cap at 4.0 feet below mudline. Interval A was collected at 0.4 to 1.0 feet below mudline and was identified as Sample SC-76A.

Interval B was collected at 1.0 to 1.5 feet below mudline and was identified as Sample SC-76B. Interval C was collected at 2.0 to 2.5 feet below mudline and was identified as Sample SC-76C. Interval D was collected at 2.6 to 3.0 feet below mudline and was identified as Sample SC-76D. Interval E was collected at 5.0 to 5.5 feet below mudline and was identified as Sample SC-76E.

- Core SC-301 – The Phase I/II cap interface was identified at 3.0 feet below mudline with the bottom of the Phase I cap at 6.3 feet below mudline. Interval A was collected at 0.4 to 1.0 feet below mudline and was identified as Sample SC-301A. Interval B was collected at 1.0 to 1.5 feet below mudline and was identified as Sample SC-301B. Interval D was collected at 4.8 to 5.3 feet below mudline and was identified as Sample SC-310D. Interval E was collected at 7.3 to 7.8 feet below mudline and was identified as Sample SC-301E.

5.3 Field Quality Assurance Samples

Two types of field blanks were collected for the surface and subsurface sediment samples. One equipment rinsate blank for surface sediments, one equipment rinsate blank for subsurface sediments, and one field blank were submitted to the laboratory with the sediment samples for chemical analyses. The purpose of the equipment rinsate and field blanks was to assess the degree to which a parameter of interest was added or removed during field operations such as equipment decontamination procedures. The equipment rinsate blank was prepared by pouring distilled water over the decontaminated sampling and compositing equipment into an appropriate (pre-preserved, if necessary) sample jar. The field blank was collected by pouring distilled water directly from its container into an appropriate (pre-preserved, if necessary) sample jar. The rinsate and field blanks were analyzed for total mercury and miscellaneous extractable compounds. No compounds or analytes were detected in the equipment rinsate or field blanks (see Table 4).

5.4 Surface and Subsurface Sediment Chemical/Physical Analyses

Six (6) surface sediment and eleven (11) subsurface sediment samples were submitted to Analytical Resources, Inc. (ARI) for chemical and physical testing in accordance with Puget Sound Estuary Program (PSEP) protocols (PSEP 1997) as specified in the OMMP.

The overall data quality objectives for collection and chemical testing of sediment samples were met, as set forth in the OMMP. All data for this project are considered acceptable for use as qualified. The data validation report is presented in Appendix E of this report.

5.5 Sediment Quality Results Discussion

In accordance with the OMMP, all sediment chemistry data were compared to the Washington State SQS chemical criteria. The sediment chemistry results along with SQS chemical criteria are provided in Table 4.

All total mercury and miscellaneous extractable organic chemical concentrations in both surface and subsurface sediment samples collected within the cap/habitat layer (i.e., above pre-construction Interval E sediments) were well below SQS chemical criteria. Even the Interval D samples, collected 1.0 to 1.5 feet above the bottom of the Phase I cap, were well below SQS chemical criteria, indicating that the Phase I capping method successfully minimized mixing of underlying contaminated Interval E sediments into the bottom of the clean cap. These data also verify that that mercury and miscellaneous extractable compounds are not migrating vertically into the cap/habitat layer.

As set forth in the OMMP, surface sediment monitoring within the Log Pond will continue during Years 2, 5 and 10 to document the effectiveness of the cap/habitat restoration action in achieving and maintaining SMS criteria. Sampling will be coordinated with benthic macroinvertebrate sampling activities (see Section 6). In addition, during Years 5 and 10, sediment cores will be collected at representative locations within the Log Pond to verify the predicted lack of upward migration of mercury through the cap. Possible contingency actions are discussed in the OMMP (Anchor 2000).

After the 5-year and 10-year monitoring periods, the data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5-year MTCA remedial action review. This review will determine the need for and/or scope of future monitoring that could be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

6 BIOLOGICAL MONITORING

The integrated remediation and habitat restoration action at the Log Pond was designed to improve the overall quality and function of aquatic habitat in this area. Significant long-term habitat functional benefits anticipated by this action include:

- Increased epibenthic production
- Increased rearing area for juvenile salmonids and other resources
- Enhanced migratory corridor and habitat connectivity

While the MTCA process does not require evaluation of this habitat restoration action, because of the integrated nature of this project, biological monitoring has been incorporated in the OMMP. The habitat monitoring plan described in the OMMP (Anchor 2000) was designed to allow verification of predicted habitat function improvements, particularly relative to epibenthic and benthic infauna production. Tissue monitoring was also performed to verify that the cap is effective in controlling bioaccumulation exposures, and to ensure that productive biological communities become established in the Log Pond area.

As discussed in the Whatcom Waterway Site RI/FS (Anchor and Hart Crowser 2000), mercury has been observed to bioaccumulate in certain Site fish and shellfish populations, particularly Dungeness crab. As with other fish and shellfish species, mercury concentrations in Dungeness crab muscle tissue are highest in older crab individuals, consistent with age-dependent bioaccumulation of mercury. However, even the maximum adult tissue concentrations reported in this area are below conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood.

With the exception of beach seine monitoring elements, Year 1 biological monitoring was performed in accordance with the OMMP. However, while beach seining was authorized under the Agreed Order and by a permit from the U.S. Fish and Wildlife Service (USFWS), the required permit for this activity from the National Marine Fisheries Service (NMFS) was not forthcoming. Therefore, in accordance federal regulations, no beach seine monitoring to document utilization of the Log Pond during the juvenile salmonid outmigration period was performed during Year 1.

6.1 Benthic/Epibenthic Re-colonization

Using methods described in the OMMP, benthic and epibenthic re-colonization within the Log Pond was evaluated by Western Washington University's Huxley College of Environmental Studies. Huxley's benthic/epibenthic community report is included as Appendix F.

6.1.1 Benthic and Epibenthic Sampling Activities

Biological sampling included collection of triplicate epibenthic and benthic samples at three (3) stations within the Log Pond (SS-74, SS-75, and SS-76; Figure 5), and two comparable reference stations is Chuckanut Bay. The Chuckanut Bay reference stations were selected to represent similar water depth, sediment grain size composition, sediment organic content, and exposure characteristics as the Log Pond stations; sampling data confirmed this match. Epibenthic sampling occurred on May 14-15 and June 25, 2001, approximately 3 and 4 ½ months, respectively, following completion of construction activities in the Log Pond. Benthic sampling was conducted on June 25, 2001.

6.1.2 Benthic and Epibenthic Sample Analysis

Benthic and epibenthic invertebrates were sorted and identified to the lowest taxonomic level. The dry weight biomass of each broad taxonomic group (e.g., annelids, polychaetes, molluscs, and crustaceans) was also measured.

Statistical analyses of the macroinvertebrate samples included calculations of the total number of invertebrate species, the Shannon-Weiner diversity index, and Pielou's evenness index. Differences between the Log Pond and Chuckanut Bay data were evaluated using analysis of variance (ANOVA) and hierarchical cluster analyses.

6.1.3 Benthic and Epibenthic Re-colonization Results

No significant ($P > 0.05$; ANOVA) differences in either epibenthic or benthic biomass were observed between the Log Pond and the Chuckanut Bay reference area (biomass tended to be higher in the Log Pond, though this difference was not significant). Similarly, the Log Pond and Chuckanut Bay reference area samples exhibited similar numbers of invertebrate species, and had similar levels of diversity and evenness, for both epibenthos and benthos.

Cluster analysis results revealed that the structure of the epibenthic community was similar between the Log Pond and Chuckanut Bay. However, the structure of the benthic community appeared different between the two sites, as the Log Pond community was dominated by polychaetes, while the Chuckanut Bay community contained a higher proportion of crustaceans.

As described in more detail in Appendix F, the Year 1 benthic and epibenthic sampling data document that a healthy invertebrate community was established within the Log Pond within several months following completion of construction, consistent with remedial design predictions (Anchor 2000). As set forth in the OMMP, benthic and epibenthic sampling will continue during Year 2. The need for and/or scope of subsequent evaluations of benthic/epibenthic re-colonization in Years 5 and 10 will be determined based on an evaluation of data from the first two years of monitoring.

6.2 Bioaccumulation Monitoring

This section discusses the collection activities, sample analyses, data quality assessment, and results associated with the juvenile Dungeness crab bioaccumulation samples collected as part of the OMMP.

6.2.1 Juvenile Crab Sampling Activities

Juvenile crab bioaccumulation sampling was conducted on July 31, 2001 at three (3) locations (Stations SS-74, SS-75, and SS-76) within the G-P Log Pond in accordance with the OMMP. Juvenile crab sampling locations in the G-P Log Pond are depicted in Figure 5 and station coordinates are provided in Table 2.

Sample collection and processing procedures for the juvenile crab sampling did not deviate from the OMMP, with the exception that juvenile crab tissue samples were not collected from the reference area in Chuckanut Bay. Shrimp pots were placed at two locations within Chuckanut Bay for approximately 8 hours without trapping any crabs.

6.2.2 Juvenile Crab Sample Analysis

Three juvenile crab replicate samples from each of the three (3) sampling stations, with two to three individual juvenile crabs comprising each replicate, were submitted to Frontier Geosciences, Inc. for the analysis of total mercury. The tissue samples were analyzed in accordance with the OMMP using Frontier's total mercury method FGS-011.

The overall data quality objectives for collection and chemical testing of the crab tissue samples were met, as set forth in the OMMP. All data for this project are considered acceptable for use.

6.2.3 Juvenile Crab Results

Juvenile Dungeness crabs ranging in carapace length from 53 to 73 mm were collected for analysis. Whole-body total mercury concentrations in juvenile crab tissues (including carapace) ranged from 0.015 to 0.049 milligrams per kilogram (mg/kg; wet weight basis), averaging 0.023 mg/kg throughout the G-P Log Pond area (Table 5). The average whole-body total mercury concentration in juvenile crab tissues prior to construction averaged 0.019 mg/kg, which does not differ significantly from the Year 1 post-construction average of 0.023 mg/kg. These values, however, are more than 10 times lower than conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood (Anchor and Hart Crowser 2000).

As set forth in the OMMP, bioaccumulation sampling will continue during Years 2, 5 and 10, to document the continued effectiveness of the restoration action.

After the 5-year and 10-year monitoring periods (potentially including juvenile salmonid beach seining, pending NMFS permitting), the biological monitoring data will be summarized and reviewed by Ecology (in consultation with the Corps and other agencies, consistent with the Bellingham Bay cooperative agreement) as part of the 5 year MTCA remedial action review. This review will determine the need for and/or scope of future monitoring that may be implemented as part of the long term monitoring assessment of the integrated Bellingham Bay Pilot Project.

7 REFERENCES

Anchor, 2000. Interim Remedial Action: Log Pond Cleanup/Habitat Restoration – Engineering Design Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. July 2000.

Anchor, 2001. Interim Remedial Action: Log Pond Cleanup/Habitat Restoration – Completion Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. May 2001.

Anchor and Aspect, 2001. Remedial Investigation/Feasibility Study, Holly Street Landfill Redevelopment Project. Draft Final Report prepared for City of Bellingham by Anchor Environmental, L.L.C, Seattle, WA and Aspect Consulting, L.L.C. November 2001.

Anchor and Hart Crowser, 2000. Remedial Investigation/Feasibility Study, Whatcom Waterway Site, Bellingham, Washington, prepared for Georgia-Pacific West, Inc. by Anchor Environmental, LLC and Hart Crowser. July 2000.

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final Report. Prepared for U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, Washington. (Including associated documents: recommended quality assurance and quality control guidelines for the collection of environmental data in Puget Sound; recommended guidelines for measuring metals in Puget Sound water, sediment and tissue samples; and recommended guidelines for measuring organic compounds in Puget Sound water, sediment and tissue samples.)

ReTec, 2001. Remedial Investigation and Feasibility Study, Roeder Avenue Landfill, Bellingham, Washington, Draft Report prepared for the Port of Bellingham by ThermoRetec Consulting Corporation. October 1, 2001.

Simpson and Champion, 1999. Federal Consent Decree Exhibit A: Monitoring Plan, Post Ten-Year Contingency Monitoring and Adaptive Management Plan, St. Paul Waterway Area

Sediment Remedial Action and Habitat Restoration Project. Simpson Tacoma Kraft Company and Champion International Corporation. October 1999.

Table 1
Vane Shear Summary Data, Georgia-Pacific Log Pond (October 9, 2001)

Location	Description	Coordinates: Easting	Coordinates: Northing	Mudline Elevation in feet MLLW	Vane Diameter in mm	Vane Scale Reading	Undrained Shear Strength: in T/m^2	Undrained Shear Strength: in tons/ft^2	Undrained Shear Strength: lb/ft^2	Moisture Content (%)	Total Solids (%)	Critical Shear Strength: τ_c (lb/ft^2)	Critical Shear Strength: Average τ_c (lb/ft^2)
SS-75	Very fine sandy silt (non plastic)	1,240,496.80	641,661.90	-15.0	25.4	4.0	2.0	0.20	400	61.0%	37.9%	0.33	0.31
						3.2	1.6	0.16	320			0.29	
						3.2	1.6	0.16	320			0.29	
						3.8	1.9	0.19	380			0.32	
SS-76	Slightly fine sandy to sandy silt (sl. Plastic)	1,240,831.40	641,873.00	-11.9	25.4	1.5	0.7	0.07	150	56.7%	36.2%	0.19	0.21
						1.7	0.8	0.08	170			0.20	
						2.5	1.2	0.12	250			0.25	
						1.8	0.9	0.09	180			0.21	
SS-40	Fine sandy to very sandy silt (non plastic)	1,240,264.10	641,420.50	-13.9	32.0	2.2	1.1	0.11	220	58.0%	36.7%	0.23	0.27
						2.5	1.2	0.12	250			0.25	
						3.0	1.5	0.15	300			0.28	
						3.5	1.7	0.17	350			0.31	
SS-301	Silt (sl. Plastic)	1,240,531.20	641,435.20	-10.8	32.0	2.2	1.1	0.11	220	81.6%	44.9%	0.23	0.23
						2.8	1.4	0.14	280			0.27	
						2.1	1.0	0.10	210			0.23	
						1.7	0.8	0.08	170			0.20	
WP-1	Slightly silty fine to medium sand	1,240,470.20	641,216.20	-5.5	32.0	3.0	1.5	0.15	300	30.5%	23.4%	0.28	0.29
						2.8	1.4	0.14	280			0.27	
						4.2	2.0	0.21	420			0.35	
						2.7	1.3	0.13	270			0.26	
WP-2	Silty fine to medium sand with clay balls	1,240,748.40	641,469.60	-5.0	32.0	3.2	1.6	0.16	320	33.2%	24.9%	0.29	0.30
						3.4	1.7	0.17	340			0.30	
						2.9	1.4	0.14	290			0.27	
						3.9	1.9	0.19	390			0.33	

Dunn (1959) determined τ_c for sediments ranging from sand to silty clay (Vanoni 1975):
(for cases where $5 < I_p < 16$)

$$\boxed{\tau_c = 0.001(S_v + 180)\tan(30 + 1.73 I_p)}$$

τ_c = critical shear stress, lb/ft^2
S_v = vane shear strength, lb/ft^2
I_p = plasticity index
argument in degrees

Table 2
G-P Log Pond Sampling Station Coordinates (Actuals)

Station ID	Latitude	Longitude
Well Points		
WP-1	48 44.7567	122 29.4667
WP-2	48 44.8105	120 29.3956
Surface Sediments		
SS-40	48 44.7918	122 29.5146
SS-75	48 44.8314	122 29.4588
SS-76	48 44.8677	122 29.3764
SS-301	48 44.7950	122 29.4492
WP-1	48 44.7593	122 29.4628
WP-2	48 44.8018	122 29.3946
Subsurface Sediments		
SC-40	48 44.7931	122 29.5139
SC-75	48 44.8300	122 29.4552
SC-76	48 44.8681	122 29.3769
SC-301	48 44.7993	122 29.4501
Crab Tissue		
SS-74	48 44.7667	122 29.4633
SS-75	48 44.8300	122 29.4617
SS-76	48 44.8617	122 29.3917
CH-1	48 41.8433	122 30.3500
CH-2	48 41.8433	122 30.3917

Note:

Station coordinates are reported in NAD 83 north zone.

Table 3
Water Quality Chemistry Data

Parameter	Chemical Criteria Units	Chemical Criteria Chronic	Chemical Criteria Acute	WP-1	WP-2
Field Measurements					
Turbidity	NTU	na	na	5	2
Conductivity	uS/cm @ 25C	na	na	46,300	23,800
Temperature	Deg C	na	na	11.9	12.4
pH	pH units	na	na	7.1	7.6
Redox	mV	na	na	-146	-151
Dissolved oxygen	mg/L	na	na	0.2	0.4
Mercury					
Dissolved mercury	ug/L	0.025	1.8	0.0059	0.0074
Total mercury	ug/L	0.025	1.8	0.0579	0.0304

Table 4
Surface and Subsurface Sediment Physical and Chemistry Data

Parameter	Chemical Criteria			WP-1	WP-2	SS-40	SC-40E	SS-75	SC-75E	SS-76	SC-76A	SC-76B	SC-76C	SC-76D
	Units	SQS	CSL	0 - 0.3 ft	0 - 0.3 ft	0 - 0.3 ft	2.3 - 2.8 ft	0 - 0.3 ft	2.4 - 2.9 ft	0 - 0.3 ft	0.4 - 1.0 ft	1.0 - 1.5 ft	2.0 - 2.5 ft	2.6 - 3.0 ft
Conventional Parameters														
Gravel	%	na	na	5.1	1.2	0.3	1.9	0.4	17.6	1.6	0.2	0.8	1.0	1.8
Sand	%	na	na	94.2	55.7	84.1	37.9	92.8	19.7	61.4	98.8	98.2	98.1	96.6
Silt	%	na	na	0.7	35.7	11.8	28.1	4.4	31.0	29.1	1.0	1.0	0.9	1.6
Clay	%	na	na	0.0	7.4	3.8	32.1	2.4	31.7	7.9	0.0	0.0	0.0	0.0
Fines	%	na	na	0.7	43.1	15.6	61.2	6.8	62.7	37.0	1.0	1.0	0.9	1.6
Total solids	%	na	na	83.6	66.1	68.4	54.1	72.4	42.9	56.6	84.1	83.4	85.0	81.8
Total organic carbon	%	na	na	0.13	1.9	1.6	5.7	1.0	7.5	3.1	0.14	0.13	0.10	0.36
Metals in mg/kg dry weight														
Mercury	(mg/kg)	0.41	0.59	0.05 U	0.07 U	0.12	4.53	0.07 U	3.44	0.13	0.04 U	0.05 U	0.04 U	0.05 U
Semivolatiles in ug/kg dry weight														
Phenol	(ug/kg)	420	1200	19 U	19 U	19 U	87	19 U	54	19 U	19 U	19 U	19 U	20 UJ
2-Methylphenol	(ug/kg)	63	63	19 U	19 U	19 U	19 U	19 U	20 U	19 U	19 U	19 U	19 U	20 UJ
4-Methylphenol	(ug/kg)	670	670	19 U	19 U	19 U	210	19 U	110	19 U	19 U	19 U	19 U	20 UJ
2,4-Dimethylphenol	(ug/kg)	29	29	19 U	19 U	19 U	42	19 U	20 U	19 U	19 U	19 U	19 U	20 UJ
Pentachlorophenol	(ug/kg)	360	690	96 U	95 U	97 U	97 U	94 U	99 U	96 U	95 U	96 U	96 U	98 UJ
Benzyl Alcohol	(ug/kg)	57	73	19 U	19 U	19 U	19 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Benzoic Acid	(ug/kg)	650	650	190 U	190 U	190 U	190 U	190 U	200 U	190 U	190 U	190 U	190 U	200 UJ

Notes:
SC-XXA - denotes the sample interval 0.4 to 1.0 ft below mudline
SC-XXB - denotes the sample interval 1.0 to 1.5 ft below mudline
SC-XXC - denotes the sample interval 1.0 to 1.5 ft above the Phase I/II cap interface
SC-XXD - denotes the sample interval 1.0 to 1.5 ft above the bottom of the Phase I cap
SC-XXE - denotes the sample interval 1.0 to 1.5 ft below the bottom of the Phase I cap
U indicates undetected at detection limit shown.
Y indicates raised reporting limit due to interference.
- Denotes exceedance of marine Sediment Quality Standard (SQS) chemical criteria (Chapter 173-204 WAC).
- Denotes exceedance of marine Cleanup Screening Level (CSL) chemical criteria (Chapter 173-204 WAC).

Table 4
Surface and Subsurface Sediment Physical and Chemistry Data

Parameter	Units	Chemical Criteria SQS	CSL	SC-76E 5.0 - 5.5 ft		SS-301 0 - 0.3 ft		SC-301A 0.4 - 1.0 ft		SC-301B 1.0 - 1.5 ft		SC-301D 4.8 - 5.3 ft		SC-301E 7.3 - 7.8 ft	
Conventional Parameters															
Gravel	%	na	na	1.1		0.0		0.1		0.0		3.8		16.2	
Sand	%	na	na	11.0		8.5		8.4		5.9		94.3		31.3	
Silt	%	na	na	52.7		76.0		75.4		76.1		1.9		27.5	
Clay	%	na	na	35.2		15.5		16.1		18.0		0.0		25.0	
Fines	%	na	na	87.9		91.5		91.5		94.1		1.9		52.5	
Total solids	%	na	na	44.5		53.6		51.9		53.2		83.3		49.0	
Total organic carbon	%	na	na	6.1		1.9		2.2		2.2		0.14		7.1	
Metals in mg/kg dry weight															
Mercury	(mg/kg)	0.41	0.59	1.42		0.11		0.09	U	0.10		0.04	U	1.87	
Semivolatiles in ug/kg dry weight															
Phenol	(ug/kg)	420	1200	68		19	U	20	U	19	U	20	U	20	U
2-Methylphenol	(ug/kg)	63	63	19	U	19	U	20	U	19	U	20	U	20	U
4-Methylphenol	(ug/kg)	670	670	150		19	U	20	U	19	U	20	U	20	U
2,4-Dimethylphenol	(ug/kg)	29	29	19	U	19	U	20	U	19	U	20	U	20	U
Pentachlorophenol	(ug/kg)	360	690	96	U	95	U	99	U	95	U	98	U	98	U
Benzyl Alcohol	(ug/kg)	57	73	19	U	19	U	20	U	19	U	20	U	20	U
Benzoic Acid	(ug/kg)	650	650	190	U	190	U	200	U	190	U	200	U	200	U

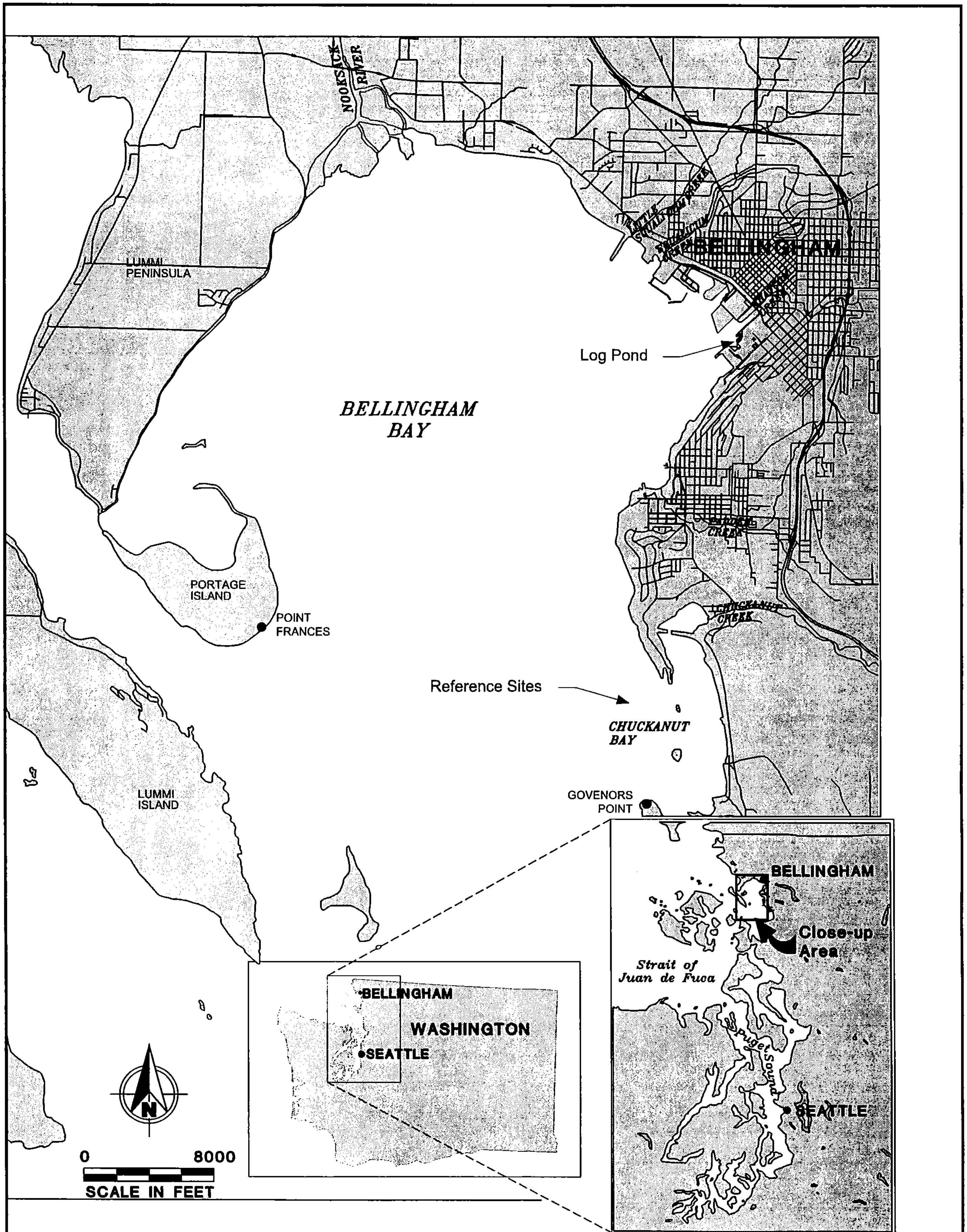
Notes:
SC-XXA - denotes the sample interval 0.4 to 1.0 ft below mudline
SC-XXB - denotes the sample interval 1.0 to 1.5 ft below mudline
SC-XXC - denotes the sample interval 1.0 to 1.5 ft above the Phase I/II cap interface
SC-XXD - denotes the sample interval 1.0 to 1.5 ft above the bottom of the Phase I c
SC-XXE - denotes the sample interval 1.0 to 1.5 ft below the bottom of the Phase I ca
U indicates undetected at detection limit shown.
Y indicates raised reporting limit due to interference.
- Denotes exceedance of marine Sediment Quality Standard (SQS) chemical criteria
- Denotes exceedance of marine Cleanup Screening Level (CSL) chemical criteria (C

Table 5
Crab Tissue Chemistry Data

Station	Sample Number	Total Mercury (mg/kg; wet wt)
SS-74	SS-74A	0.0207
	SS-74B	0.0487
	SS-74C	0.0176
SS-75	SS-75A	0.0171
	SS-75B	0.0237
	SS-75C	0.0150
SS-76	SS-76A	0.0258
	SS-76B	0.0167
	SS-76C	0.0237
Average Mercury Concentration		**0.0232**

Note:

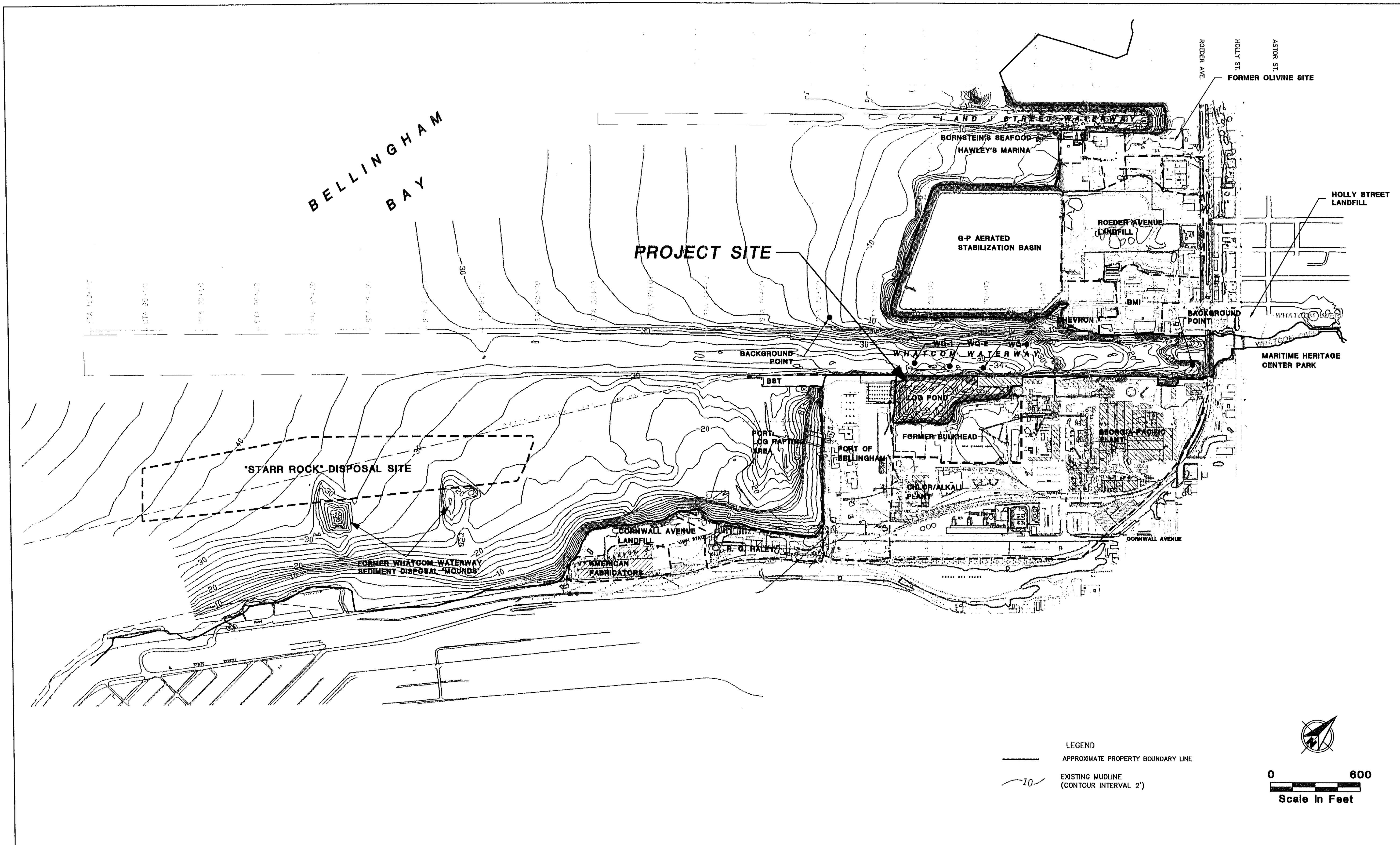
Mercury concentrations have been blank corrected.



99-030-01 GPB001-02 12/18/01

ANCHOR ENVIRONMENTAL, L.L.C.

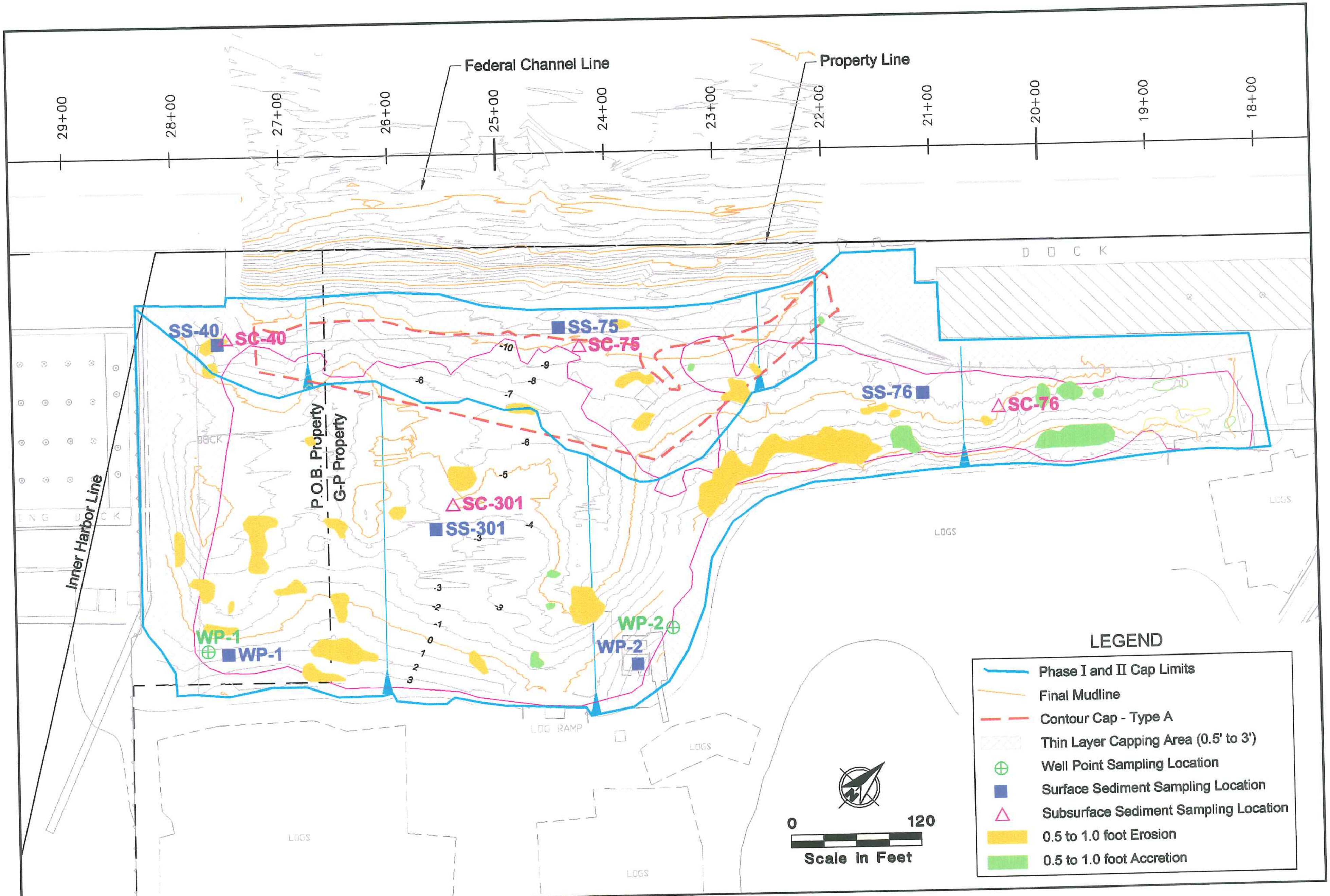
Figure 1
Vicinity Map



00-0030-01 GPB002-01 12/18/01

ANCHOR ENVIRONMENTAL, L.L.C.

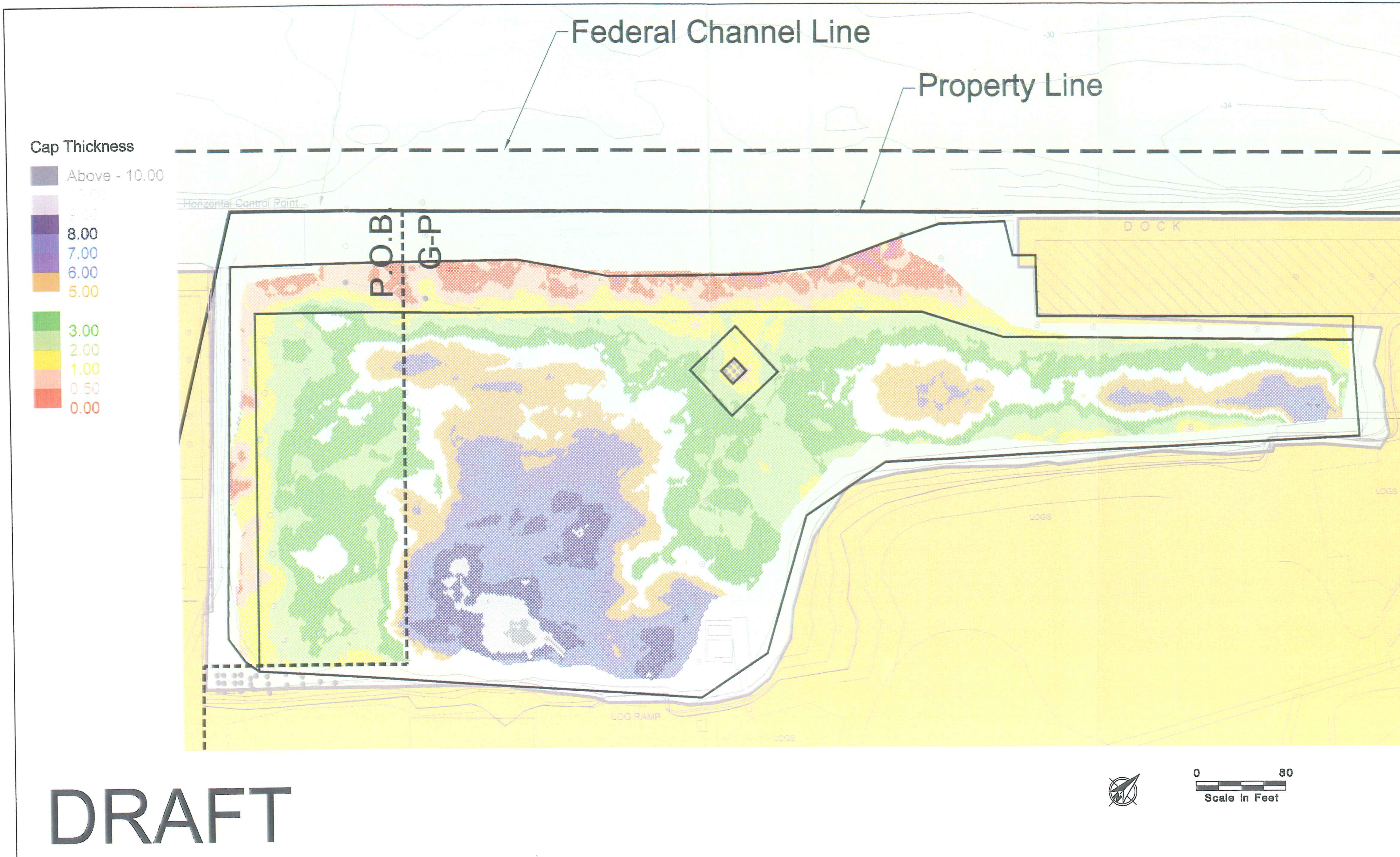
Figure 2
Log Pond Project Area
Log Pond Cleanup and Habitat Restoration



00-0030-01 GPB020-01 12/18/01

ANCHOR ENVIRONMENTAL, L.L.C.

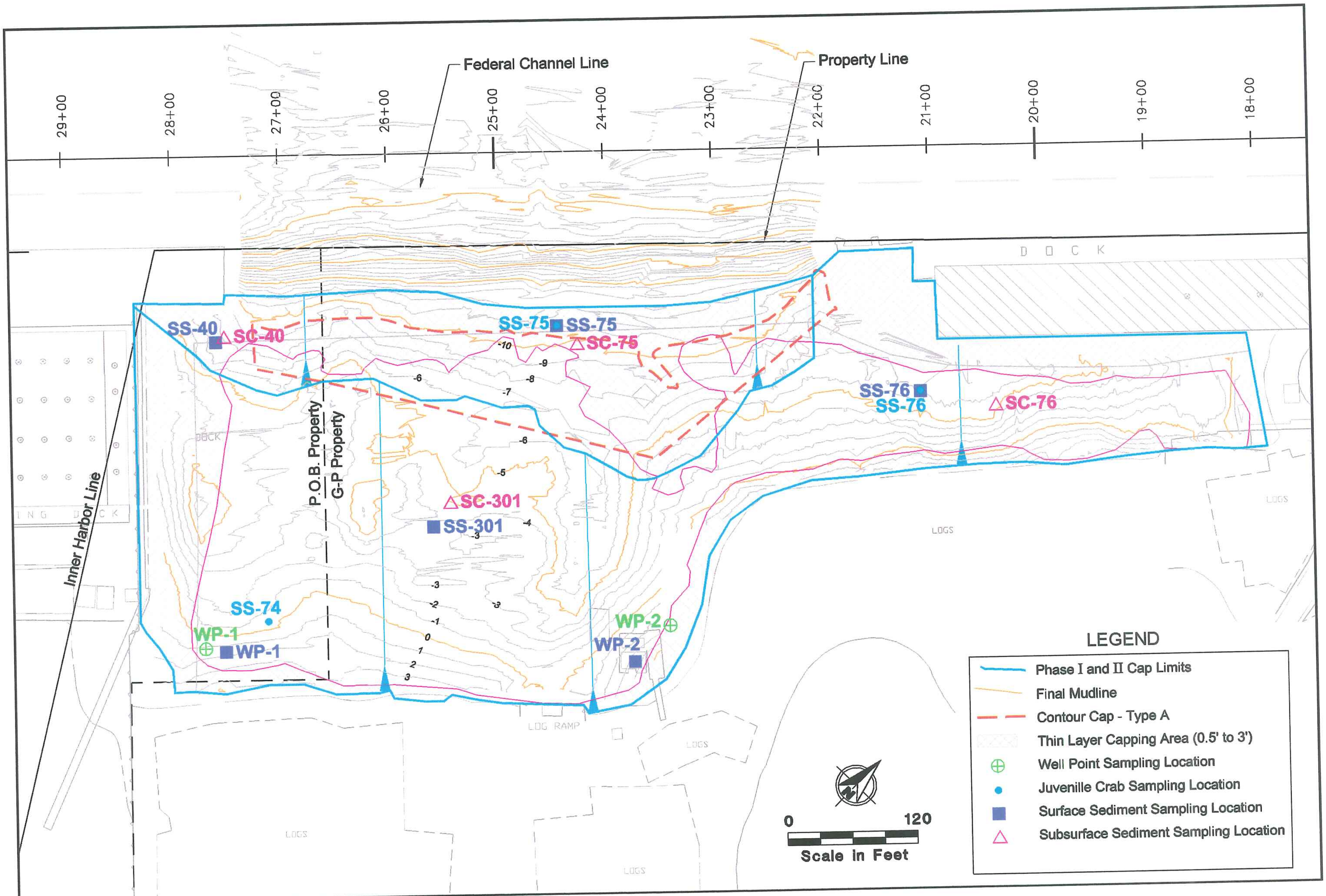
Figure 3
Change in Log Pond Surface - 7 Months After Construction



99-0030-01 GPB-14-01 12/18/01

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 4
Total Cap/Habitat Layer Thickness - October 2001
Log Pond Cleanup and Habitat Restoration



00-0030-01 GPB022-01 12/1901

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 5
Log Pond Sampling Locations

APPENDIX A
SEDIMENT GEOTECHNICAL DATA

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

1001 SW Klickitat Way, Suite 107
Seattle, WA 98134
(206) 287-9122

October 24, 2001

Ms. Kim Magruder
Anchor Environmental, L.L.C.
1411 4th Ave., Ste 1210
Seattle, WA 98101

Re: GP-OWMP, REGL Project No.: 1049-429

Dear Ms. Magruder,

The results of the grain size, 200 wash, and Atterberg are discussed on the attached narrative, summary tables and plots.

Please call me to discuss any questions, or comments you may have on the data or its presentation.

Best Regards,
Rosa Environmental & Geotechnical Laboratory, LLC.

Harold Benny
Harold Benny
Laboratory Manager

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

1001 SW Klickitat Way, Suite 107
Seattle, WA 98134
(206) 287-9122

Client: Anchor Environmental, L.L.C.	REGL Project No.: 1049-429
Client Project: GP-OWMP	Client Project No.: 000030-07 Task 2

Case Narrative

1. Six samples were received on October 10, 2001 for grain size, 200 wash, and Atterberg limits.
2. The samples were set up on October 16th and completed on October 23rd.
3. Two samples were tested for grain size analysis per ASTM D-422.
4. Two samples were tested for 200 wash in accordance with ASTM D-1140.
5. In accordance with ASTM D-4318, 2 samples were tested for Atterberg limits.
6. Sample SS-76 was sandy and tore during the liquid limit and would not roll during the plastic limit.
7. Sample SS-301 was too silty and would not roll during the plastic limit.
8. Moisture content was requested via email from Ms. Magruder and is reported on the attached table.
9. There were no other anomalies in the samples or methods on this project.

Released by: Sharon Davis Date: 10/24/01
Title: Laboratory Lead

Approved by: Harold Benny Date: 10/24/01
Title: Laboratory Manager

1049-424

Chain of Custody Record & Laboratory Analysis Request

Page 1 of 1 Turnaround Requested: STANDARD

Anchor Contact: KIM MAGRUDER

ANCHOR ENVIRONMENTAL, L.L.C.
1411 4th Avenue, Suite 1210
Seattle, WA 98101
Ph: (206) 287-9130 Fax: (206) 287-9131

Lab Contact: HAROLD BENNY	Proj. Name: GP-OWMP
Lab: REG	Proj. Number: 000030-07 T2
Address: 1001 SW KLICKITAT WAY #107 SEATTLE, WA 98134	Sampler: JOHN VERDUIN
Phone: (206) 287-9122	Shipping Method: HAND DELIVERED
Fax: (206) 264-1995	AirBill: N/A

Sample ID	Sample Date	Sample Time	Sample Martix	# Containers	200 WASH	FULL GRAIN SIZE	ATTERBERG LIMITS	Add'l: Moisture Content per email							Notes/ Comments:
SS-75	10/9/01	0905	SED	1	X			X							10216
SS-40	↓	1027	↓	↓	X			X							211
SS-76	↓	1009	↓	↓			X	X							212
SS-301	↓	1045	↓	↓			X	X							213
WP-1	↓	1100	↓	↓		X		X							214
WP-2	↓	1115	↓	↓		X		X							215

K. Magruder

Relinquished: (Signature)	Relinquished: (Signature)	Relinquished: (Signature)	Special Instructions/Notes
Kim Magruder			
Printed Name: KIM MAGRUDER	Printed Name:	Printed Name:	
Company: ANCHOR ENVIRONMENTAL	Company:	Company:	
Date/Time: 10/10/01 1800	Date/Time:	Date/Time:	
Received By: Sharon Davis	Received By:	Received By:	
Printed Name: Sharon Davis	Printed Name:	Printed Name:	
Company: ROSA	Company:	Company:	# of Coolers: / Cooler Temp(s):
Date/Time: 10/10/01 1800	Date/Time:	Date/Time:	COC Seals Intact? / Bottles Intact?

ROSA ENVIRONMENTAL GEOTECHNICAL LABORATORY

Anchor Environmental, L.L.C.
GP-OWMP

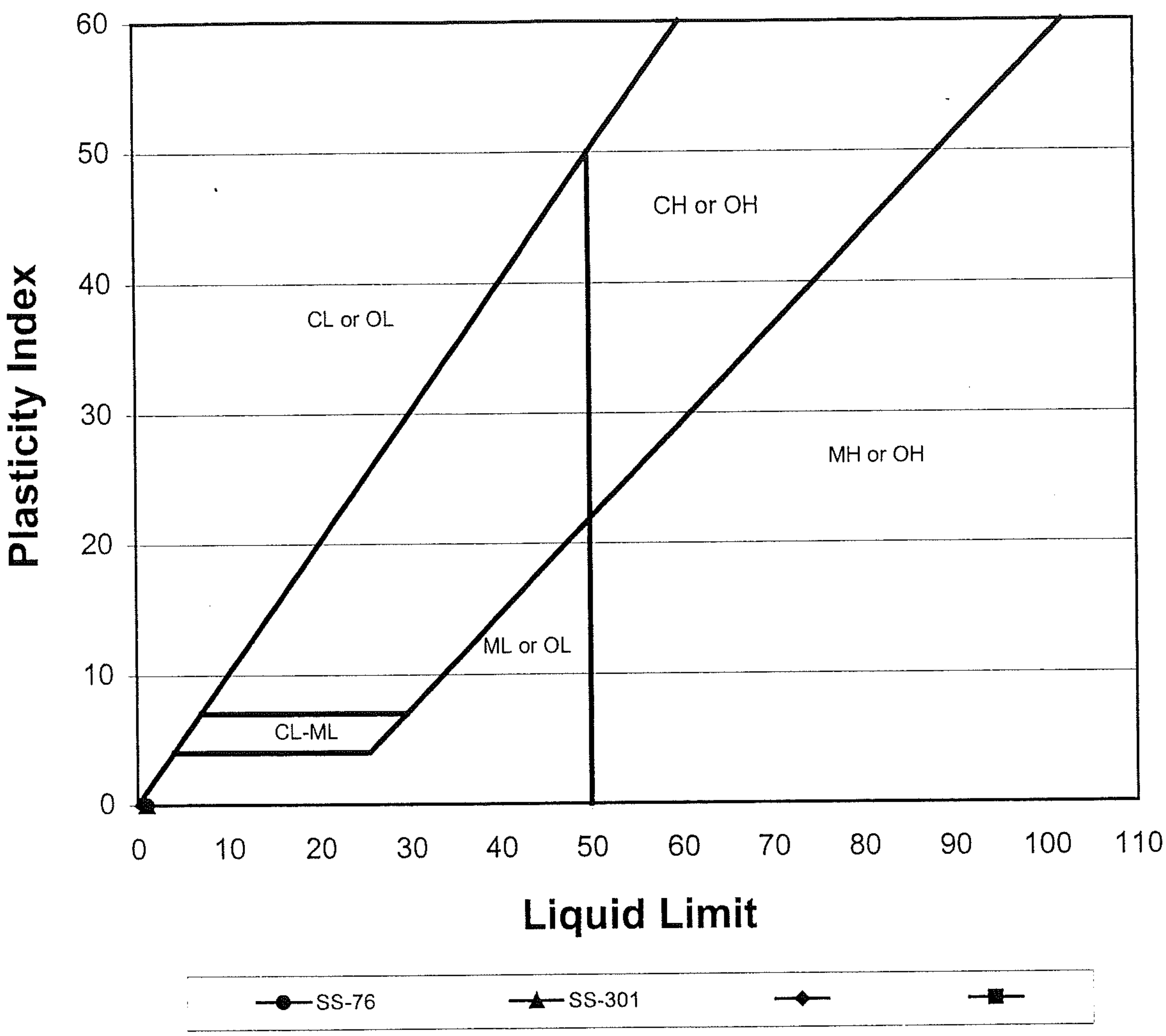
Boring Number	Moisture Content (%)	% moisture ~~Total Solids~~ (%)	Total Solids (%)
SS-75	61.0	100 - 37.9 =	62.1
SS-40	58.0	100 - 36.7 =	63.3
SS-76	56.7	100 - 36.2 =	63.8
SS-301	81.6	100 - 44.9 =	55.1
WP-1	30.5	100 - 23.4 =	76.6
WP-2	33.2	100 - 24.9 =	75.1

10/29/01
K. [illegible]

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Anchor Environmental, Inc.
000030-07T2

Atterberg Limits



Sample Number	Depth	Plasticity Index	Liquid Limit	Plastic Limit	Classification
SS-76	NA	NA	NA	NA	Non-Plastic
SS-301	NA	NA	NA	NA	Non-Plastic

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Anchor Environmental, L.L.C.
GP-OWMP

Percent Finer Than Indicated Size

Sieve Size (microns)	2"	1"	3/4"	1/2"	3/8"	#4	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)
WP-1	100.0	100.0	100.0	100.0	100.0	97.1	93.0	80.1	52.8	26.9	4.8	1.9
WP-2	100.0	100.0	100.0	100.0	100.0	98.0	91.2	69.8	35.9	25.7	18.8	13.2

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Anchor Environmental, L.L.C.
GP-OWMP

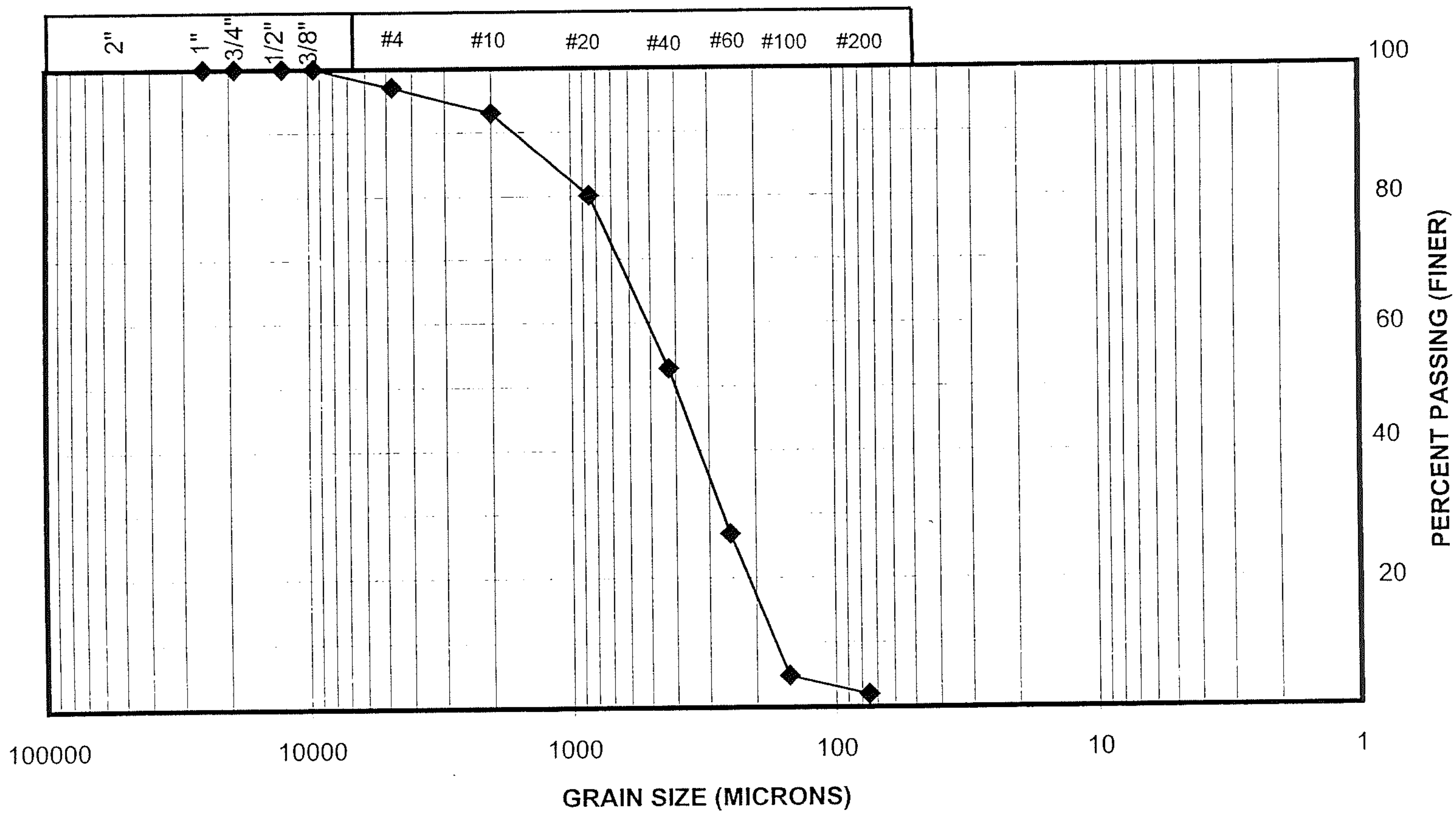
Percent Retained in Each Size Fraction

Sieve Size (microns)	>4750	4750-2000	2000-850	850-425	425-250	250-125	125-75	<75
WP-1	2.9	4.2	12.9	27.3	25.9	22.1	2.9	1.9
WP-2	2.0	6.7	21.4	33.8	10.2	6.9	5.6	13.2

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY, LLC.

ASTM D-422 GRAIN SIZE DISTRIBUTION

Project: GP-OWMP
Sample No.: WP-1

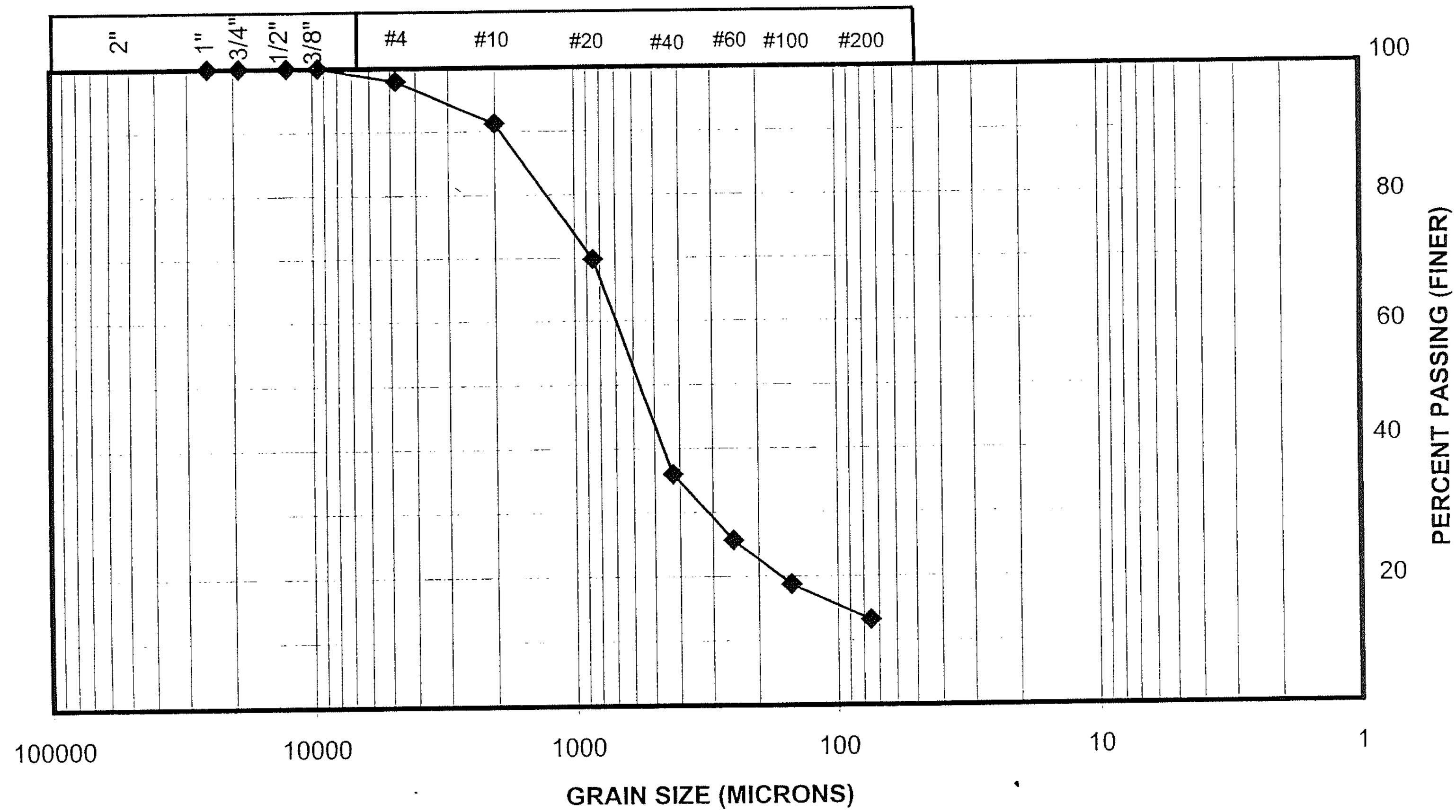


1049-429

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY, LLC.

ASTM D-422 GRAIN SIZE DISTRIBUTION

Project: GP-OWMP
Sample No.: WP-2



1049-429

Rosa Environmental and Geotechnical Laboratory, LLC

Anchor Environmental L.L.C.

Project: GP-OWMP

Sample Identification	Percent Fines (-#200 Sieve)
SS-75	15.0
SS-40	10.9

ROSA ENVIRONMENTAL GEOTECHNICAL LABORATORY

Anchor Environmental, L.L.C.
GP-OWMP

Boring Number	Moisture Content (%)
SS-75	61.0
SS-40	58.0
SS-76	56.7
SS-301	81.6
WP-1	30.5
WP-2	33.2

APPENDIX B
WELL POINT FIELD LOGS

GROUND WATER MONITORING

Well Number: WP-1 Location: GP Log Pond south Date 9 May 2001
Time Collected 1330

Person(s) Sampling: Paul Schlenger (Anchor), Ken Koenig (BEK)
Weather Conditions: sunny
Sampling Equipment: well point

Casing Elevation (ft): ________ Depth to Bottom (ft): ________

Depth to Water (ft): ________ Measured Depth (ft): ________

Water Elevation (ft) ________ Diameter: 2 in.

Well Volume: ________ Calculation Well volume=r2h/(7.48)
r= casing radius in ft.
well established 1300 hrs; flow rate 2 min 40 sec / liter
h= depth of water

Purge Data:

					Historical Range
Volume Purged:	0 L	2.4 L	3.4 L		
(NTU) Parameter Turbidity	96.5	11.2	5.1		
Temperature °C	12.5	11.9	11.9		
pH	6.03	6.87	7.07		
S/cm@25C Conductivity	45,400	46,300	46,300		
Eh	-54	-129	-146		
Dissolved Oxygen mg/L	4.36	0.41	0.16		

Samples Collected:

(TSS, TDS, Tannins and Lignins)
(Cl, NO2, NO3, NH4, SO4) SO3
(dissolved Fe, Mn, Zn, As, Ba, Cr, Pb, Hg field filtered)
(total metals Fe Mn, Zn, As, Ba, Cr, Pb, Hg)
(TOC, COD)
(Volatiles)

Observations and Comments:
dissolved Fe filtered at testing laboratory (ARI)
(Color, Turbidity, Odor, etc.)
Filter blank conducted at Frontier lab using identical, clean tubing

GROUND WATER MONITORING

Well Number: WP-2 Location: GP Log Pond north Date 9 May 2001
Time Collected 1425

Person(s) Sampling: PS, KK
Weather Conditions: sunny
Sampling Equipment: well point

Casing Elevation (ft): Depth to Bottom (ft): ________

Depth to Water (ft): ________ Measured Depth (ft): ________

Water Elevation (ft) ________ Well Casing 2 in.

Well Volume: ________ Calculation Well volume=r2h/(7.48)
well established 1305 hrs, flow rate 2 min 40 sec. / liter
r= casing radius in ft.
h= depth of water

Purge Data:

					Historical Range
Volume Purged:	0 L	1.5	3.4		
(NTU) Parameter Turbidity	41.4	9.5	1.9		
Temperature °C	13.0	12.6	12.4		
pH	7.59	7.60	7.64		
uS/cm@25C Conductivity	24,400	24,100	23,800		
Eh	-123	-139	-151		
Dissolved Oxygen	4.99	1.27	0.40		

Samples Collected:

(TSS, TDS, Tannins and Lignins)
(Cl, NO2, NO3, NH4, SO4) SO3
(dissolved Fe, Mn, Zn, As, Ba, Cr, Pb, Hg field filtered)
(total metals Fe Mn, Zn, As, Ba, Cr, Pb, Hg)
(TOC, COD)
(Volatiles)

Observations and Comments:
dissolved Fe filtered at testing laboratory (ARI)
(Color, Turbidity, Odor, etc.)

APPENDIX C
LABORATORY REPORT – WELL POINT CHEMISTRY

May 29, 2001

Steve Cappellino
Anchor Environmental
1411 4th Avenue, Suite 1210
Seattle, WA 98101

SUBJECT: Results for water samples collected on May 2,9 and 10, 2001.

Dear Mr. Cappellino,

Enclosed are the results for the water samples collected on May 2, 9 and, 2001. The samples were received by Frontier Geosciences in good condition on May 3 and May 10, 2001 within a sealed cooler at 3.0 °C and 1.0 °C, respectively.

Following sample receipt, samples for total Hg analysis were oxidized with 1% - 10% (turbidity dependent) (v/v) with BrCl. Samples were analyzed for total Hg in accordance Frontier's standard operating procedure FGS-069.1. Aliquots of the samples are weighed out in Teflon containers, $NH_2OH \cdot HCl$ is added to destroy free halogens, and then each sample is poured into pre-purged bubblers. Then $SnCl_2$ is added to reduce Hg (II) to Hg^0, which is then purged onto gold traps as a preconcentration step. The Hg^0 contained on the gold traps was then analyzed by thermal desorption into a CVAFS, using the dual amalgamation technique. Peak areas are accessed by integrators. Net THg concentrations were calculated according to the following formula, where **PA** is the integrator peak area, **b** is the mean bubbler blank, **V** is the digest volume, **B** is the mean BrCl method blank (ng/L), F_D is the dilution factor associated with preserving the samples, and **S** is the calibration curve slope in units/ng, for the set of samples, calculated similarly:

$$[THg]\ (ng/L) = \frac{([(PA-b/S)/(V)] - B)}{F_D}$$

There were no significant analytical issues and all QC is within Frontier's established control limits with the following exception:

The original analysis of the MS/MSD performed on the sample F52EMW145 yielded poor recoveries. The samples were reanalyzed with a different aliquot volume and reanalysis showed acceptable recoveries. MS/MSD values are reported from the reanalysis.

The second preparation blank analyzed for these set of samples caused an unusually high estimated MDL. The blank was not reanalyzed for confimation. Since all of the samples were above the estimated MDL, no further action was taken.

Please feel free to contact me if you have any questions or concerns.

Sincerely,

Frank Colich for
Misty Kennard
Project Coordinator
FrankC@frontier.wa.com

Trace Metals Results for Anchor Environmental - Steve Cappellino

Reported May 29, 2000
Frontier Geosciences Inc., 414 Pontius Ave. N, Suite B, Seattle WA 98109

Sample Results

Analyte Sample ID	Date Collected	Analysis Date	Hg (ng/L) Total	Hg (ng/L) Diss.
U52EMW195	5/2/01	5/21/01	88600	-
F52EMW195	5/2/01	5/21/01	94400	-
U52AMW1	5/2/01	5/21/01	15.6	-
F52AMW1	5/2/01	5/21/01	6.32	-
U52EMW145	5/2/01	5/21/01	59800	-
F52EMW145	5/2/01	5/21/01	50000	-
U52EMW15	5/2/01	5/21/01	5240	-
F52EMW15	5/2/01	5/21/01	3920	-
U52EMW29D	5/2/01	5/21/01	27.8	-
F52EMW29D	5/2/01	5/21/01	6.36	-
U52EMW25	5/2/01	5/21/01	13700	-
F52EMW25	5/2/01	5/21/01	10200	-
U52EMW35	5/2/01	5/21/01	142	-
F52EMW35	5/2/01	5/21/01	103	-
U52AMW2	5/2/01	5/21/01	16800	-
F52AMW2	5/2/01	5/21/01	31300	-
U52AMW3	5/2/01	5/21/01	18700	-
F52AMW3	5/2/01	5/21/01	30900	-
U52EMW135	5/2/01	5/21/01	1520	-
F52EMW135	5/2/01	5/21/01	241	-
U52EMW155	5/2/01	5/21/01	3560	-
F52EMW155	5/2/01	5/21/01	2770	-
U52EMW28D	5/2/01	5/21/01	303	-
F52EMW28D	5/2/01	5/21/01	21.8	-
UFB	5/2/01	5/21/01	< 0.61	-
FFB	5/2/01	5/21/01	< 0.61	-
WP - 1 D	5/9/01	5/18/01	-	5.86
WP - 1 - T	5/9/01	5/18/01	57.9	-
WP - 2 - D	5/9/01	5/18/01	-	7.37
WP - 2 - T	5/9/01	5/18/01	30.4	-
FB99	5/10/01	5/18/01	-	0.49

- Analysis not requested

Trace Metals Results for Anchor Environmental - Steve Cappellino

Reported May 29, 2000

Frontier Geosciences Inc., 414 Pontius Ave. N, Suite B, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ng/L)	Analysis Date	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
Hg	5/21/01	F52EMW35	102.6	105.1	103.9	2.4

Quality Control Data - Matrix Spike/Matrix Spike Duplicate Report

Analyte (ng/L)	Analysis Date	Sample QC'd	Sample Mean	Spike Level	MS	% Rec.	MSD	% Rec.	RPD
Hg	5/21/01	U52EMW35	141.9	416.0	531.3	93.6	535.7	94.7	0.8
	5/21/01	F52EMW35	103.9	208.0	274.2	81.9	268.3	79.1	2.2
	5/18/01	WP - 1 - T	57.94	137.3	186.7	93.8	180.6	89.4	3.3

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

Trace Metals Results for Anchor Environmental - Steve Cappellino

Reported May 29, 2000

Frontier Geosciences Inc., 414 Pontius Ave. N, Suite B, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (µg/L)	Analysis Date	PBW1	PBW2	PBW3	PBW4	Mean	Std Dev	Est. MDL
Hg (ng/L)	5/21/01	0.05	0.35	-0.03	-	0.12	0.20	0.61
	5/18/01	0.00	-0.08	-0.02	-	-0.03	0.04	0.12

Est. MDL = Estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Standard Reference Material Report

Analyte (µg/L)	Analysis Date	SRM Identity	Cert. Value	Obs. Value	% Rec.
Hg (ng/L)	5/21/01	NIST 1641d	1590000	1536000	96.6
	5/18/01	NIST 1641d	1590000	1583000	99.6

SRM Identity = Standard reference material identity

Cert. Value = Certified value

Obs. Value = Experimental result

% Rec. = Percent recovery

APPENDIX D
SURFACE AND SUBSURFACE SEDIMENT FIELD LOGS

JUNE 26, 2001

02:00 LOAD BOAT

06:30 ~~ARRIVE AT GP LOG POND~~ KAW
LEAVE MARINA

CREW: BILL TOWERSKI, DALE ~~DICKINSON~~ DICKINSON KW
ERIC PARKER, KIM MAGNANDER

WEATHER: CLEAR SKIES W/ SOME SCATTERED CLOUDS (SUNNY).
55-60°F VERY LIGHT WIND

09:00 ARRIVE AT LOG POND. (CANNOT GET ACCESS BEYOND LOG BOOM, CALLED CHIP HILARDES OF GEORGIA PACIFIC TO GET PERMISSION TO ~~ACCESS~~ KW OPEN ONE OF THE BOOMS ON THE NW CORNER OF PAN HANDLE (LEFT MESSAGES ON HIS OFFICE & CELLPHONE VOICEMAIL). CALLED CLAY PATMONT OF ANCHOR TO REPORT SITUATION — CLAY SAID TO PROCEED WITH OPENING BOOM.

Put A Sleeve

09:15 CHIP RETURNED CALL - WILL COME OUT & TAKE A LOOK. SAID ITS OKAY TO ~~REMOVE~~ KW OPEN UP OURSELVES.

09:25 CHIP ARRIVED @ DOCK - LOG BOOM WAS RE-CONFIGURED, SO THE ~~GAP~~ PRE-EXISTING GAP IS CLOSED.

6/

09:40 OPENED LOG BOOM & GAINED ACCESS TO LOG POND.

09:55 AT STATION SC-B2

10:10 ~~BEGIN~~ KW DRIVING CORE - 16'

MUDLINE = 5.2' - 5.7 = - 0.50 MLLW (TIDE = +5.7)

~~HA~~ DIFF. PENETRATION TOP 4-6' GRADUATING TO MODERATE TO ~~ET~~ KW END OF DRIVE.

SC-B2

EST. DRIVE DEPTH = 14'

SLIGHT TO MODERATE (MUSTY MOD.) H_2S ODOR WHEN PULLING CORE.

COORDINATES — SC-B2-A
48 44.7627 N (LAT)
122 29.4862 W (LONG)

16' - 2.75' = 13.3' RECOVERED

10:30 STATION SC-~~B1 B3~~ B1 KW -

MUDLINE = 4.8'(FT) - 5.5 KW = -0.7 MLLW

SC-B1 KW

PENETRATION = MODERATE THROUGHOUT (THROUGHOUT) MOMENTARY ~~ST~~ KW PAUSES DURING DRIVING WHERE DEBRIS OR STIFFER SED. MAY BE.

SLIGHT H_2S ODOR WHEN PULLING CORE

EST. DRIVE DEPTH = 14'-15'

RECOVERED 16 - 2.2 = 13.8

COORDINATES — SC-B1-A
48 44.7641 N (LAT) 122 29.4891 W (LONG)

SLIGHT OILY SHEEN AT SURFACE (5-8 FLOORETTES)

6/26/01

1035 – TIDE GOING OUT PRETTY FAST
WILL COLLECT SC-B3 ~~[illegible]~~ KG
ASAP & PROCESS ALL 3
(CUT SECTIONS)
AT ONCE.

10:45 – AT SC-B3
MUDLINE = 3.8′ – 5.2′ = −1.4′ MLLW
DUE TO LOW WATER-LEVEL WILL
DRIVE A 14′ CORE HERE
INSTEAD OF 16′. CAN'T DRIVE
16′ CORE AT THIS LOW WATER
LEVEL.

* BILL DOESN'T SEE ANY INDICATION
OF WOOD DEBRIS IN AREA B
(BASED ON OBSERVED PENETRATION
RESISTANCE).

10:55 – SC-B3 ATTEMPT #1 MUDLINE = 4.1′ – 4.9′ = −0.80 MLLW
DRIVE W/ 14′ TUBE STARTED
PENETRATION = STIFF THROUGHOUT
~~REFUSAL @~~ KG
LOST CORE CUTTER/TRAP UPON
RETRIEVAL, AS A RESULT WE
LOST THE SEDIMENT. WILL ATTEMPT
AGAIN.

Blank
K. [illegible]

6/26/01

11:10 SC-B3 ATTEMPT # 2 (B IN BILL'S LOG)
MUDLINE = 3.9' - 4.5' = 0.6 MLLW
STIFF DRIVING FROM 2.4'
& INTERMITTENT THROUGHOUT
STIFF TO HARD
MAY BE DEBRIS?
STIFF PULLING OUT AT 3' BELOW MUDLINE
MODERATE H_2S ODOR WHEN PULLING
COORDINATES:
48 44.7608 N (LAT)
122 29.4846 W (LONG)
RECOVERY
~~16'~~ - 2.25 = 13.8' RECOVERED
14' - 2.25 = 11.8'
11:20 → ~~12:55~~ 12:00 LUNCH BREAK
K[illegible]
12:00 → 13:45 CUT CORES SC B1, B2, B3
INTO ≤ 3' SECTIONS.
13:45 STATION SC-A2
MUDLINE = 5.8' - 0.6' = 5.2' MLLW
REFUSAL @ 4' BELOW MUDLINE
PC of EELGRASS STUCK TO CORE WHEN
BEING PULLED UP.
WOOD DEBRIS W/ DENSE PACK SAND/SILT.
SUSPECT LARGE PC. of WOOD DEBRIS, BECAUSE
CUTTER WASN'T BENT!

Kr
SC-~~AN~~ A2 - REJECTED

1405 ~~SC-A1~~ Ka SC-A1 ATTEMPT 1
MUDLINE = 6.9 - 0.2' = 6.7' MLLW
DIFF @ 6'
↳ HARD DRIVING - THROUGHOUT TO DIFF.
RECOVERY = 16' - 4.1 = 11.9'
WILL KEEP.
COORDINATES ;
48 44.7912 N (LAT)
122 29.5212 W (LONG)

1435 SC-A3
EASY DRIVE TILL 6' BELOW MUDLINE
MUDLINE = 6.1' ~~+0~~ - .3' = 6.4' MLLW
COORDINATES =
48 44.7896 N (LAT) 122 29.5154 W (LONG)
SLIGHT FLOURETTES OF OIL DISPERSING ON SURFACE WATER AS ~~THE~~ Ka THE CORE WAS BEING PULLED.
RECOVERY = 16' - 3.3 = 12.7'

1436 - 15:50 CUTTING CORES SC-A~~2~~1 Kaw
& SC-A3 INTO 3' SECTIONS

Blank Page

K. Magruder

SCKw

15:50 SS-40

7.3' = MUDLINE

CORE DRIVE : −12.8' + −0.9' = 13.7' MLLW

HARD DRIVING DOWN TO 6' BELOW MUDLINE

VERY DIFFICULT DRIVING BEYOND THAT.

OIL SHEEN (FLOORETTES) DISPERSING AT SURFACE WHEN VIBRATING CORE.

RECOVERY = 14' − 2.6 = 11.4'

COORDINATES =

48 44.7731 N (LAT)

122 29.5139 W (LONG)

16:55 HEADING TOWARD SS-301, BUT RAN AGROUND (LOCATION MARKED ON MAP. HAVE TO ~~WIT~~ WAIT FOR TIDE TO COME IN MORE BEFORE WE CAN TRY TO PUSH THE OIL BOOM OUT TO ACCESS DEEPER WATER.

WEATHER IS CHANGING − 5-10mph FROM SW. MORE LIGHT CLOUDS ~~ROLLING~~ IN.

SETTLING

~~17:30~~ 6/26/01
~~15:30~~ MODERATE SUCCESS W/ MOVING
KM LOG BOOM. STILL CAN'T ACCESS
SS-301. WILL ATTEMPT TO COLLECT
CORES AT STATIONS 75 & 76

17:55 STATION SC-76
-7.6' = MUDLINE + 0.8' = 6.8' MLLW
MUDLINE OTB
DRIVE 10 ft
MODERATELY DIFFICULT TO 6-7' MUDLINE OTB
HARD DRIVING TO 10' (REFUSAL)
COORDINATES:
48 44.8681 N (LAT) 122 29.3769W (LONG)
RECOVERY = 14 - 6.1 = 7.9'

18:30 COMPLETED CUTTING SC-76
CORE INTO 3' SECTIONS

~~18:30~~ 18:10 KM ~~18:40~~ ~~Log Boom~~ KM
CLOSING UP LOG BOOM &

18:40 HEADING TOWARD SC-75

18:44 LOWERING BOOM FOR SC-75
CORE WHEN HYDRAULIC ~~CABLE~~ VALVE KM
BECAME IMPINGED ON A PIECE
OF WOOD ~~[illegible]~~ WHICH BROKE KM
THE VALVE. A-FRAME HAS
NO HYDRAULICS.

19:15 BILL FIXED HYDRAULICS &
HEADING BACK TO MARINA TO
[illegible]

6/27/01
PROCESSED ALL CORES FROM 6/26
AT BEK FACILITY.
CREW = ERIC PARKER
KIM MAGRUDER
BRIAN GOURAN (BEK)
7:30am - 21:00
~~DBB~~ KM

6/28/01
08:30 BOAT LEFT DOCK FOR
COLLECTION OF SC-301, SC-75,
AND SC-A2 CORES.
~~08:40~~ KM CREW: BILL JAWORSKI
DAVE ~~B~~ KM DICKINSON
ERIC PARKER
KIM MAGRUDER
KM WEATHER: 55°F, OVERCAST,
< 5 KNOTS WIND

08:45 OPENING LOG BOOM

09:10 SECURING BOAT FOR STATION
~~SC~~ KM SC-A2 CORE

09:12 SC-A2 ATTEMPT 2 MUDLINE = 9.5
DRIVING: DIFICULT @ 3' ← REFUSAL
WILL CLEAN TUBE & RELOCATE
STATION. CORE WAS RINSED OUT
UNDER WIST PIER. CONTAINED ~40-50%
WOOD CHIPS/SAWDUST.

6/28/01

09:35 SC-A2 ATTEMPT 3 KL
MOVING LOG BOOM TO GET
BETTER ACCESS TO A NEW LOCATION
09:45 DECIDED NOT TO MOVE LOG
BOOM NOW WILL TRY ATTEMPT
3 – NO GOOD; WILL HAVE TO
MOVE LOG BOOM FOR BETTER
ACCESS. HIT REFUSAL AT
2'.
10:12 SC-A2 ATTEMPT #4
(after moving log boom)
MUDLINE = 0-10.3
REFUSAL @ 3' ABAN'K
WOODY DEBRIS AT BASE OF CORE
& THROUGHOUT. SOME SHEEN
PRESENT – SUSPECT ITS CREOSOTE
FROM PILINGS IN AREA. STRONG H_2S ODOR
10:35 SC-A2 ATTEMPT #5
VERY DIFFICULT TO DRIVE FROM
~~AT 0 TO 2~~ 2-7'
0-2' DIFFICULT 7'-14' DIFFICULT
MUDLINE = -6.9+5.0' = -1.9' MLLW
RECOVERY = 16' TUBE – 8.5' = 7.5' RECOVERED
WILL KEEP.
COORDINATES:
48 44.7956 N (LAT) 122 29.5216 W (LONG)

DALE NOTED VISIBLE SHEEN (FROM TOP OF SED IN CORE. (SMALL FLOORETTES)
11:20 SS-301 MUDLINE = -9.1 + 5.3 = -3.8 MLLW
0-6' DRIVE = EASY
6-7' = STIFF (DEBRIS?)
7-11 = EASY TILL REFUSAL AT 11'

SOME SILT IN CORE TUBE WHILE
PULLING. BOTTOM OF CORE CUTTER
WAS FILLED W/WOOD CHIPS & SOME
SILT.
RECOVERY = 14' - 6.1 = 7.9'
WILL KEEP. NEED ~ 5'
COORDINATES:
48 44.7966 N (LAT)
122 29.4495 W (LONG)
12:20 SC-75 ATTEMPT #1
MUDLINE = -9.9'
12:27 ~~REFUSAL~~ KL REFUSAL @ 4.1'
REJECTED
12:30-1300 – REPLACED TRANSDUCER
& BR KL CLEANED OUT CORE
TUBES. TUBES WERE ~~EMPTIED~~ KL
EMPTIED OFFSITE IN WU JUST
OUTSIDE OF LOG POND AREA.
15.8

1300 SC-75 ATTEMPT # 2 WOOD DEBRIS AT END OF CORE TUBE
MUDLINE = 15.8'
DRIVE = 1.5' TO REFUSAL

13:10 TALKED W/ CLAY RE: DIFFICULTIES W/ STATION - OKAY TO MOVE IT 20-30' IF ~~we~~ KM WE NEED TO.

13:18 SC-75 ATTEMPT # 3
MUDLINE = -14.5'
DRIVE : -13' + 4.8' = -8.2' MLLW

SAND & SHELLS AT BOTTOM OF CORE TUBE
6-8' STIFF (DEBRIS 6-8)
>8' FAIRLY EASY
10-12' DIFFICULT
DIFFICULTY PULLING CORE UP
COORDINATES:
48 44.8300 N (LAT)
122 29.4552 W (LONG)

RECOVERY 14' - 2.2 = 11.8'
KM

14:00 BACK AT DOCK TO UNLOAD & PROCESS CORES @ BEK

06/29/01

0800 CREW: D. DICKINSON, K MAGRUDER, B. GOURDON
WEATHER 60-65°F, SUNNY, CLEAR SKIES VERY LITTLE WIND.
COLLECTED 6 GP LUMMI GRABS W/ POWER GRAB.

1230 - 1400 BACK AT DOCK (WIND HAS PICKED UP TO 10 KNOTS) KM
UNLOADING SURFACE GRABS EQUIPMENT & COOLERS & LOADING CORE EQUIPMENT ON BOARD

14:10 ~~KM~~ SC-301 RECOLLECTING B/C ~~WE~~ KM NEEDED ~~BETTER RECOVERY~~ TO RETRIEVE MORE SEDIMENT THAN WE DID THE 1ST TIME

14:40 SC-301 ATTEMPT # 1
6.1' RECOVERED MUDLINE = 16.1'
RINSED OUT - LAST 1' WAS GP LOG POND MATERIAL. WILL TRY TO COLLECT ANOTHER CORE IN SAME LOCATION W/ BETTER RECOVERY. RINSE OUT CORE TUBE OUT TO MIDDLE OF WW TO

15:25 SC-301 ATTEMPT # 2
MUDLINE = 10.0'
DRIVE = 7.5' WHERE WE HIT REFUSAL.
WILL RINSE OUT IN WW & TRY AGAIN.

15:50 SS-301 ATTEMPT # 3

MUDLINE = -9.8' +1.6' =

DRIVE = DEBRIS @ ~4'

9.8' CORE 8.1' RECOVERED

CUT FOR PROCESSING — 1.5' ABOVE CUTTER IS SAND W/ H₂S ODOR WILL CORE AGAIN.

17:04 SC-301 ATTEMPT # 4

-9.9' = MUDLINE

DRIVE = 13'

11.1' RECOVERED (14 - 2.9)

COORDINATES:

48 44.7993 N (LAT)

122 29.4501 W (LONG)

WILL PROCESS CORE & HEAD TOWARD SHORE.

End of Sampling

K. [signature]

SHIPPED 6/07/01

Visual Classification of Undisturbed Sample

ANCHOR ENVIRONMENTAL L.L.C.

Job: GP OMMP
Job No.: 000030-07
Exploration No.:
Sample No.: SC-40
Depth of Sample: -13.7' MLLW
Sampled Length (feet; from log):
Sample Recovery (feet):

Date: 6/27/01 Time: 2000
Sample Pushed By: Marine Sampling Systems
Sample Logged By: B. Gouran / Kim Magruder
Type of Sample: ☐ Shelby ☒ Other
Diameter of Sample (inches):
Sample Quality: ☒ Good ☐ Fair ☐ Poor ☐ Disturbed
Average % Compaction =

% Composition	Sample Interval in Feet	Represent at Depth Interval (add Compact.)	CONSISTENCY	MOISTURE	COLOR	Size % G Max.	Size % S Range	Size % F (PI)	Depth Feet (Theoretical / Actual) Core Sections	Sample Sketch	Classification and Remarks
0–1			Medium Dense	Damp	Dark Gray	0	100%	0	Phase I/II Interface		Cap (Phase II); Phase I/II Interface @ 1.0' depth
1–2			Soft	Moist	Gray/Silt	0	5%	95%	1; Bottom of Phase I		Slight sandy to moderate sulfide odor w/ shell fragments throughout and small fibrous wood debris; Bottom of Phase I Cap @ 1.3' dep
2–3	SC-40E		Soft to Medium Dense; Soft	Wet	Dark Gray		10–5	90–95	2		Section A↑
3–4			Medium Dense	Damp			80% – 100%	20% – 0	3		Concentrated shell fragments
4–5			Dense	Moist – Damp					4; Shell fragments throughout, some wood debris		Large Gravel 2x2"
5–6									5		Section B↑
6									6		

COLLECTED 6/28/01 13:18

Visual Classification of Undisturbed Sample

ANCHOR ENVIRONMENTAL L.L.C.

Job GP OMMP	Date 6/28/01 1600
Job No. 000030-07	Sample Pushed By MARINE SAMPLING SYSTEMS
Exploration No.	Sample Logged By K. MARWOOD
Sample No. SC-75	Type of Sample ☐ Shelby ☒ Other
Depth of Sample -8.2' MLLW	Diameter of Sample (inches) 3.75" ID
Sampled Length (feet; from log)	Sample Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed
Sample Recovery (feet)	Average % Compaction =

% Composition	Sample Interval in Feet	Represent at Depth Interval (add Compact.)	CONSISTENCY	MOISTURE	COLOR	Size % G Max.	S Range	F (PI)	Depth Feet Theoretical / Actual Core Sections	Sample Sketch	Classification and Remarks
0–1			MED DENSE	DAMP TO MOIST	GRAY TO DK GRAY	0	100	0		SOME SHELL FRAG THROUGHOUT	
1–2			SOFT	MOIST TO WET	DK GRY		10-20	20-40	2.4' RECOVERED 1.8		PHASE I CAP ↑; 30-50% WOOD WASTE
2–3	SC-75E	~20% WOOD WASTE									2-6 2"x3" PL FRAGS REMOVED; 2-1"x2" PL WOOD REMOVED; SECTION A ↑
3–4											KNOT
4–5		SOFT	WET SOFT	WET MOIST TO WET	SOFT						30-40% WOOD WASTE
5–6											SECTION B ↑

SHIPPED 6/29/01

Visual Classification of Undisturbed Sample

ANCHOR ENVIRONMENTAL L.L.C

Job: GP IMMP
Job No. [illegible]30-09
Exploration No.
Sample No. SC-76
Depth of Sample: ~6.6' mud
Sampled Length (feet; from log)
Sample Recovery (feet)

Date: 6/27/01 1630
Sample Pushed By: Marine Sampling Systems
Sample Logged By: K. [illegible]
Type of Sample: ☐ Shelby ☒ Other
Diameter of Sample (inches)
Sample Quality: ☒ Good ☐ Fair ☐ Poor ☐ Disturbed
Average % Compaction =

% Composition	Sample Interval in Feet	Represent at Depth Interval (add Compact.)	CONSISTENCY	MOISTURE	COLOR	Size % G Max.	Size % S Range	Size % F (PI)	Depth Feet (Theoretical / Actual) Core Sections	Sample Sketch	Classification and Remarks
1845	0–1	SC-76A	Dense	Damp	Med. Gray	0	100	0	0		Fine silt deposit / Cap
185[illegible]	1	SC-76B							1		← Shell Fragment
1900	2	SC-76C							2		Shell = 1x2" @ 2.4'; Phase I / Phase II Interface @ 2.6' depth; Section A↑
1905	3	SC-76D			Dark Gray				3		
	4		Soft → Stiff	Moist	Black		5%	100 → 95%	4	Shell Fragments throughout	Phase I Cap Bottom @ 4' depth
									Moderate Sulfide odor		Woody Debris Chunks ~1x2"
19[illegible]	5	SC-76E							5		1x3" & 1x2" wood Chunks
											Strong Sulfide odor; Section B↑
	6								6		
	7								7		
	8								8		

6/29/01 [illegible]

Visual Classification of Undisturbed Sample

ANCHOR ENVIRONMENTAL, L.L.C.

Job: ~~[illegible]~~ GP [illegible]	Date: 6/29/01
Job No. 000030-09 T1	Sample Pushed By: Marine Sampling Systems
Exploration No.	Sample Logged By: R. [illegible]
Sample No. SC-301	Type of Sample: ☐ Shelby ☒ Other
Depth of Sample	Diameter of Sample (inches): 3.75" ID
Sampled Length (feet; from log)	Sample Quality ☐ Good ☐ Fair ☐ Poor ☐ Disturbed
Sample Recovery (feet)	Average % Compaction =

% Composition	Sample Interval in Feet	Represent at Depth Interval (add Compact.)	CONSISTENCY	MOISTURE	COLOR	Size % G Max.	Size % S Range	Size % F (PI)	Depth Feet (Theoretical / Actual) Core Sections	Sample Sketch	Classification and Remarks
0			SOFT	WET	Pk Grey	0	45%	95-100			
1	SC-301A (0.55); SC-301B (1.00)								1		
2				MOIST					2		
3			MED DENSE	DAMP	DK GRY to GREY	0	100	0	Phase [illegible] 3	WOOD DEBRIS PLANT HOLES	3" dia x 1" long wood pc removed; SECTION A ↑; 2" dia x 3" long wood pc removed
4									4	[illegible]	
5	SC-301D (4.20)								5		SECTION B ↑
6			DENSE → MED DENSE	MOIST TO DAMP	GRY BLK		0	100	6		PHASE I CAP ↑
7							10-15	85-90	[illegible] 7	30-40% WOOD WASTE; 5% WOOD WASTE	LOG BOOM MATERIAL
8	SC-301E								8		SECTION C ↑
9									9		

SEDIMENT GRAB COLLECTION FORM

Project Name: LPP UMMP
Project No. 00050-07 T1
Date: 6/29/01
Station: SS-75
Compass Bearings: 43 47.334 N (LAT)
122 39.4582 W (LONG)
NAD83
Start time:
Stop time:
Weather:
Crew: D.Dickinson, B. Gourdin, K. [illegible]

Field Test Results:

Salinity: ______ ppt
Ammonia: ______ Mg/L
Grain Size: ______ MI course: ______ MI fines: ______
Comments:

Grab No: 1 Bottom depth: 16.1' Penetration depth: 24 cm Time: 1205

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Comments: TOP 4 cm SOME PLANT/WOOD DEBRIS

Sediment type:	*Sediment color:*	*Sediment odor:*	
cobble	D.O. → BROWN TOP ONLY	none	H_2S
gravel	gray TOP 4 cm	slight	Petroleum
sand C M F	black Mottled Grey	moderate	Other:
silt clay → TRACE	brown Brown	strong	
organic matter [illegible]	brown surface	overwhelming	

Grab No: [illegible] Bottom depth: Penetration depth: Time:

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Comments:

Sediment type:	*Sediment color:*	*Sediment odor:*	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Grab No: Bottom depth: Penetration depth: Time:

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Comments:

Sediment type:	*Sediment color:*	*Sediment odor:*	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Grab No: Bottom depth: Penetration depth: Time:

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Comments:

Sediment type:	*Sediment color:*	*Sediment odor:*	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Recorded by: [illegible signature]

SAMPLING DATE: 6/29/01 SHIPPING DATE:

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Project Name: GP CMMP **Project No:** 000030-07 T1 **Station ID:** SS-76

Sampling Crew: K [illegible] B [illegible] D. Dickinson

Sampling Vessel: [illegible] Sampling Method: Power Grab

Subcontractor(s): [illegible] (BOK) D Dickinson (MCS)

Station Coordinates: N / Lat. 48° 44.8677' N Weather: Sunny & Clear 60°F

E / W / Long. 122° 29.3164' W Lt wind @ S

Datum: NAD 83 / WGS 84 Zone:

Sample Number: SS-76

Analysis:

Field Test Results Comments:

Salinity: ppt

Ammonia: mg/L

Grain Size: ml Coarse: ml Fines:

Grab Number: 1 Bottom Depth: 9.9' Penetration Depth: 25 cm Time: 1024

Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O. Top cm	none	H2S	1 Juv. English sole 1 Juv. Sand shrimp Woody debris throughout large & small chunks w/in top 5 cm
gravel	gray — below	slight	Petroleum	
sand C M F [illegible]	black — @ 3 cm	moderate	other:	
silt clay — top cm	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:

Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:

Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:

Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Recorded by: [illegible signature]

SHIPPING DATE:

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Project Name: GP-WMMP **Project No:** 020130-07 T1 **Station ID:** WP-2

Sampling Crew: K. Hamaker, B. Gordon, D. Dickinson
Sampling Vessel: Nancy Anne
Sampling Method: ~~Power grab~~ By hand ~~on~~ beach
Subcontractor(s): B. Gordon (BEC) D. Dickinson (MSS)
Station Coordinates: N./Lat. 48° 44.[illegible]' N
E/W/Long. 122° 29.5946' W
Weather: Sunny/Clear, 60-62°F, No wind
Datum: NAD 83 / WGS 84 Zone:

Sample Number: WP-2 Core Collect
Analysis:

Field Test Results
Salinity: ______ ppt
Ammonia: ______ mg/L
Grain Size: ml Coarse: ______ ml Fines: ______
Comments:

Grab Number: 1 Bottom Depth: ~~NA~~ 0.5' Penetration Depth: ~~NA~~ 10cm Time: 09:52
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	rejected large piece wood in jaws of grab
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: 2 Bottom Depth: 0.3' Penetration Depth: 23cm Time: 09:55
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle) 0-10cm collected

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	Shell fragments in upper cap layer
gravel	gray	slight	Petroleum	
sand C M F cap layer	black with H	moderate	other:	
silt clay under cap	brown sand	strong		
organic matter	brown surface	overwhelming		

Grab Number: ______ Bottom Depth: ______ Penetration Depth: ______ Time: ______
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: ______ Bottom Depth: ______ Penetration Depth: ______ Time: ______
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Recorded by: [signature]

SHIPPING DATE:

SEDIMENT GRAB COLLECTION FORM

Project Name: GP CHIMP
Project No. CCC030-07 T1
Date: 6/29/01
Station: SS-40
Compass Bearings:
LAT: 48° 44.7918' N NAD83
LONG 122° 29.5146' W
Start time:
Stop time:
Weather: [illegible] 60°F [illegible]
Crew: K. [illegible], D. Dickinson, B. [illegible]

Field Test Results:

Salinity: ____ ppt
Comments:
Ammonia: ____ Mg/L
Grain Size: ____ MI course: ____ MI fines: ____

Grab No: 1 Bottom depth: 11.4' Penetration depth: 24 cm Time: 10:50

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble below	D.O. Top 2cm	none	H_2S
gravel 12cm	gray below	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay 2cm	brown	strong	
organic matter	brown surface	overwhelming	

Comments: TRACE PLANT FIBERS, SHELL FRAGMENTS, & WOODY DEBRIS

Grab No: ____ Bottom depth: ____ Penetration depth: ____ Time: ____

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Grab No: ____ Bottom depth: ____ Penetration depth: ____ Time: ____

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Grab No: ____ Bottom depth: ____ Penetration depth: ____ Time: ____

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Recorded by: [illegible signature]

SAMPLING DATE: 6/7/11/01 SHIPPING DATE:

ANCHOR ENVIRONMENTAL, L.L.C. Surface Sediment Field Sample Record

Project Name: GP-OMMP **Project No:** 000030-07 **Station ID:** WP-1

Sampling Crew: K. MACRUDER, D. DICKINSON, B. GEVRAN
Sampling Vessel: NANCY ANNE
Sampling Method: ~~By HAND ON BEACH~~ POWER GRAB
Subcontractor(s): D. DICKINSON (NSS) B. GEVRAN (BEK)
Station Coordinates: N / Lat. 48° 44.7593' N
E / W / Long. 122° 29.4628' W
Weather: Sunny, calm 60°F wind 5kts S
Datum: NAD 83 / WGS 84 Zone:

Sample Number:
Analysis:

Field Test Results
Salinity: ppt
Ammonia: mg/L
Grain Size: ml Coarse: ml Fines:
Comments:

Grab Number: 1 Bottom Depth: ~~NA~~ 3.1' Penetration Depth: ~~C. TO B.~~ 26-25 cm Time: 11:40
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O. - BROWN TOP	none	H2S	TRACE SHELL FRAGMENTS
gravel — TRACE	gray — BROWN	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: Bottom Depth: Penetration Depth: Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	
gravel	gray	slight	Petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Recorded by: K. Macruder

SHIPPING DATE:

SEDIMENT GRAB COLLECTION FORM

Project Name: GP CAMP

Project No. [illegible] T1

Date: 6/29/01

Station: SS-~~[illegible]~~ 301

Compass Bearings:
LAT: 48° 44.7950'N
LONG: 122° 29.4492'W

Start time:

Stop time:

Weather: [illegible]/clear, 60°F [illegible] skies

Crew:

Field Test Results:

Salinity: ______ ppt

Ammonia: ______ Mg/L

Grain Size: ______ MI course: ______ MI fines: ______

Comments:

Grab No: 1 Bottom depth: 74' Penetration depth: 29 cm Time: 1111

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O. Brownish (or tan)	none	H_2S
gravel	gray (some green/white)	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown —underlying	strong	
organic matter	brown surface	overwhelming	

Comments: ONE WORM (SMALL ?TUBE WORM)

Grab No: ______ Bottom depth: ______ Penetration depth: ______ Time: ______

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Grab No: ______ Bottom depth: ______ Penetration depth: ______ Time: ______

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Grab No: ______ Bottom depth: ______ Penetration depth: ______ Time: ______

Bioassay / chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment type:	Sediment color:	Sediment odor:	
cobble	D.O.	none	H_2S
gravel	gray	slight	Petroleum
sand C M F	black	moderate	Other:
silt clay	brown	strong	
organic matter	brown surface	overwhelming	

Comments:

Recorded by: [illegible signature]

Chain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
400 Ninth Avenue North
Seattle, WA 98109-4708
206-621-6490 206-621-7523 (fax)

Turn Around Requested: 14 DAY FAXED PRELIMS
25 DAY FINAL HARDCOPY

Report to: Kim, MAGRUDER	Proj Name: GP OUW	
Company: MAGRUDER ENVIR.	Proj Number: 000030-07 T1	
Address: 1411 - 4TH AVE STE 1210 SEATTLE, WA 98101	Sampler: K. MAGRUDER, B. GAVIN, D. DICKINSON	
Phone: 206 - 287 - 9130	Shipping Method: HAND	
Fax: 206 287 - 9131	AirBill:	

Analyses Requested: TOTAL SOLIDS, TOC, MOISTURE; GRAIN SIZE; MISC. EXTRACTABLES; ATTERBERG

Sample ID	Sample Date	Sample Time	Sample Matrix	No Containers	TOTAL SOLIDS, TOC, MOISTURE	GRAIN SIZE	MISC. EXTRACTABLES	ATTERBERG							Notes/Comments
SS-75	6/30/01	1200	SED	4	X	X	X	X							
~~SS-76~~ SS-76	↓	1024	↓	↓	X	X	X	X							
WP-2	↓	0952	↓	↓	X	X	X	X							
SS-10	↓	1050	↓	↓	X	X	X	X							
WP-1	↓	1140	↓	↓	X	X	X	X							
SS-301	↓	1111	↓	↓	X	X	X	X							

Relinquished: (Signature)	Relinquished: (Signature)	Relinquished: (Signature)	Special Instructions/Notes
[signature]			
Printed name: Kim MAGRUDER	Printed name:	Printed name:	
Company: MAGRUDER	Company:	Company:	
Date: 7/2/01 Time: 1250	Date: Time:	Date: Time:	

Received by:	Received by:	Received by:	
Printed name:	Printed name:	Printed name:	
Company:	Company:	Company:	Number of Coolers:
			Cooler Temp(s):
Date: Time:	Date: Time:	Date: Time:	COC Seals Intact?
			Bottles intact?

Chain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
400 Ninth Avenue North
Seattle, WA 98109-4708
206-621-6490 206-621-7523 (fax)

Turn Around Requested: 4 Day Faxed Results
28 Day Final Hardcopy

Report to: Kim Maguire	Proj Name: 62 OMMP
Company: Anchor ENV	Proj Number: 000030-07 T1
Address: 1411 4th Ave Ste 1210 Seattle, WA 98101	Sampler: K. Magruder, B. Goodwin
Phone: 206 287 9130	Shipping Method: Hand
Fax: 206 287 9131	AirBill:

Analyses Requested: Total Solids, TOC, Percent Moisture | Grain Size | Misc. Extractables

Sample ID	Sample Date	Sample Time	Sample Matrix	No Containers	Total Solids, TOC, Percent Moisture	Grain Size	Misc. Extractables	Notes/Comments
SC-301A	6/29/01	2055	SED	3	X	X	X	
SC-301B		2100			X	X	X	
SC-301D		2120			X	X	X	
SC-301E		2140			X	X	X	
SC-75E	6/30/01	1600			X	X	X	

Relinquished: (Signature)	Relinquished: (Signature)	Relinquished: (Signature)
Printed name: Kim Magruder	Printed name:	Printed name:
Company: Anchor	Company:	Company:
Date: 7/2/01 Time: 1250	Date: Time:	Date: Time:

Received by:	Received by:	Received by:
Printed name:	Printed name:	Printed name:
Company:	Company:	Company:
Date: Time:	Date: Time:	Date: Time:

Special Instructions/Notes

Number of Coolers:
Cooler Temp(s):
COC Seals Intact?
Bottles Intact?

Chain of Custody Record & Laboratory Analysis Request

Page 1 of 2 Turnaround Requested: STD. [illegible]; 28 DAYS [illegible] HARDCOPY

Anchor Contact: KIM [illegible]

ANCHOR ENVIRONMENTAL, L.L.C.
1411 4th Avenue, Suite 1210
Seattle, WA 98101
Ph: (206) 287-9130 Fax: (206) 287-9131

Lab Contact: MARK HARRIS	Proj. Name: HP-CMMP
Lab: ANALYTICAL RESOURCES	Proj. Number: 000033-09 T1
Address: [illegible] - 9TH AVE N, SEATTLE, WA 98109	Sampler: K. [illegible]
Phone: 206 621-6190	Shipping Method: HAND
Fax:	AirBill:

Analyses Requested

Sample ID	Sample Date	Sample Time	Sample Martix	# Containers	[illegible]	[illegible]. EXTRACTABLES									Notes/ Comments:
CMMP-RB	7/03/01	1035	WTR	2	X	X									
CMMP-FB	7/03/01	1040	WTR	2	X	X									

Relinquished: (Signature) [illegible]	Relinquished: (Signature)	Relinquished: (Signature)	Special Instructions/Notes
Printed Name: K. [illegible]	Printed Name:	Printed Name:	
Company: ANCHOR ENVIRONMENTAL	Company:	Company:	
Date/Time: 7/03/01 1250	Date/Time:	Date/Time:	
Received By:	Received By:	Received By:	
Printed Name:	Printed Name:	Printed Name:	
Company:	Company:	Company:	# of Coolers: / Cooler Temp(s):
Date/Time:	Date/Time:	Date/Time:	COC Seals Intact? / Bottles Intact?

...ain of Custody Record & Laboratory Analysis Request

Analytical Resources, Incorporated
Analytical Chemists and Consultants
400 Ninth Avenue North
Seattle, WA 98109-4708
206-621-6490 206-621-7523 (fax)

Turn Around Requested: 2 WEEK FAXED PRELIMS
28 DAY HARDCOPY FINAL

Report to: Kim Magruder	Proj Name: GP OMMP
Company: Anchor Env.	Proj Number: 000030-07 T1
Address: 1411 - 4th Ave Ste 1210	Sampler: K. Magruder
Seattle WA 98101	B. Gooding, E. Parker
Phone: 206 287 9130	Shipping Method: Fed Ex
Fax: 206 287 9131	AirBill: 8279 3797 8140

Analyses Requested

Sample ID	Sample Date	Sample Time	Sample Matrix	No Containers	Total Solids, TOC	Grain Size	Misc. Extractables	Notes/Comments
SC-76A	1/29/01	1845	SED	3	X	X	X	
SC-76B	↓	1914	↓	↓	X	X	X	
SC-76C	↓	1900	↓	↓	X	X	X	
SC-76D	↓	1905	↓	↓	X	X	X	
SC-76E	↓	1930	↓	↓	X	X	X	
SC-40E	↓	2030	↓	↓	X	X	X	
Temp Blank								

Relinquished:	Relinquished:	Relinquished:
(Signature) [signature]	(Signature)	(Signature)
Printed name: Kim Magruder	Printed name:	Printed name:
Company: Anchor Env.	Company:	Company:
Date: 1/29/01 Time: [illegible]	Date: Time:	Date: Time:
Received by: [signature]	Received by:	Received by:
Printed name: [illegible]	Printed name:	Printed name:
Company: [illegible]	Company:	Company:
Date: 1/30/01 Time: [illegible]	Date: Time:	Date: Time:

Special Instructions/Notes

Number of Coolers:
Cooler Temp(s):
COC Seals Intact?
Bottles Intact?

FedEx Express USA Airbill

FedEx Tracking Number 8279 3979 8148

1 From Please print and press hard

Date 6/27/01 Sender's FedEx Account Number 2198-9133-4

Sender's Name Kim MAGRUDER Phone (206) 287-9130

Company ANCHOR ENVIROMENTAL

Address 1411 4TH AVE STE 1210 Dept/Floor/Suite/Room

City SEATTLE State WA ZIP 98101

2 Your Internal Billing Reference First 24 characters will appear on invoice. 000030-07 T1

3 To

Recipient's Name MARK HARRIS Phone (206) 621-6490

Company ANALYTICAL RESOURCES INC

Address 400 NINTH AVE NORTH

To "HOLD" at FedEx location, print FedEx address. We cannot deliver to P.O. boxes or P.O. ZIP codes.

Dept/Floor/Suite/Room

City SEATTLE State WA ZIP 98109-4708

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or call 1-800-Go-FedEx® (800)463-3339.

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SAC23

Form I.D. No. 0215

4a Express Package Service — *Packages up to 150 lbs.* Delivery commitment may be later in some areas.

- [X] FedEx Priority Overnight — Next business morning
- [ ] FedEx Standard Overnight — Next business afternoon
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations
- [ ] FedEx 2Day — Second business day
- [ ] FedEx Express Saver — Third business day
- [ ] NEW FedEx Extra Hours — Later drop-off with next business afternoon delivery for select locations

FedEx Envelope rate not available. Minimum charge: One-pound rate

4b Express Freight Service — *Packages over 150 lbs.* Delivery commitment may be later in some areas.

- [ ] FedEx 1Day Freight* — Next business day
- [ ] FedEx 2Day Freight — Second business day
- [ ] FedEx 3Day Freight — Third business day

* Call for Confirmation:

5 Packaging — * Declared value limit $500

- [ ] FedEx Envelope*
- [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak
- [X] Other Pkg. — Includes FedEx Box, FedEx Tube, and customer pkg.

6 Special Handling — Include FedEx address in Section 3.

- [ ] SATURDAY Delivery — RESTRICTIONS: Available only for FedEx Priority Overnight and FedEx 2Day to select ZIP codes
- [ ] SUNDAY Delivery — RESTRICTIONS: Available only for FedEx Priority Overnight to select ZIP codes
- [ ] HOLD Weekday at FedEx Location — RESTRICTIONS: Not available with FedEx First Overnight
- [ ] HOLD Saturday at FedEx Location — RESTRICTIONS: Available only for FedEx Priority Overnight and FedEx 2Day to select locations

Does this shipment contain dangerous goods? One box must be checked.

- [X] No
- [ ] Yes — As per attached Shipper's Declaration
- [ ] Dry Ice — Dry Ice, 9, UN 1845 ___ x ___ kg
- [ ] Cargo Aircraft Only

Dangerous Goods (incl. Dry Ice) cannot be shipped in FedEx packaging or with FedEx Extra Hours service

7 Payment *Bill to:* Enter FedEx Acct. No. or Credit Card No. below.

- [X] Sender — Acct. No. in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [ ] Credit Card
- [ ] Cash/Check

FedEx Acct. No. / Credit Card No. Exp. Date

Total Packages	Total Weight	Total Declared Value†
1	59	$ .00

†Our liability is limited to $100 unless you declare a higher value. See back for details.

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8 Release Signature *Sign to authorize delivery without obtaining signature*

By signing you authorize us to deliver this shipment without obtaining a signature and agree to indemnify and hold us harmless from any resulting claims.

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APPENDIX E
LABORATORY AND DATA VALIDATION REPORTS – SEDIMENT CHEMISTRY

Data Validation and Data Quality Assessment Report

Log Pond Cap Monitoring Round 1
Project Number: 000030-07(T1)

Prepared for:

Anchor Environmental, LLC
1411 4th Avenue
Suite 1210
Seattle, Washington 98101

Prepared by:

Kathy J. Gunderson
981 State Street
Raymond, Washington 98577

October 10, 2001

Approved for Release: ______________________________
Kathy J. Gunderson
Owner, Validation Chemist

1.0 Introduction

This report presents the EPA Level III validation of the samples listed in Table 1. With the exception of grain size, the analyses were performed by Analytical Resources, Incorporated, located in Seattle Washington. The grain size analyses were performed by Rosa Environmental and Geotechnical Laboratory, L.L.C., located in Seattle, Washington. The validation was performed in accordance with the procedures established in the *Contract Laboratory Program National Functional Guidelines for Inorganic and Organic Data Review* (Functional Guidelines) (USEPA 1994, 1994a). Data quality objectives, project detection limits, and quality control (QC) sample frequencies are from *Appendix C Operations, Maintenance and Monitoring Plan Interim Remedial Action Log Pond Cleanup/Habitat Restoration* (OMMP) (Anchor Environmental 2001). The criteria used to qualify data are taken from Functional Guidelines,. the OMMP, the analytical methods, or the professional judgment of the validation chemist.

Sections 2 through 4 present the validation findings and Section 6 defines the data qualifiers. Section 5 evaluates the project data against the data quality objectives set forth in the OMMP. Table 2 presents a summary of the qualified data. Copies of laboratory communications are presented in Appendix A. Data qualifier flags have been added to the sample results in the original report, laboratory electronic data deliverable files, and the Anchor data table.

Table 1 – Sample Data Reviewed

Sample ID	Laboratory Sample ID	SVOAs	Mercury	Conventionals
SC-76A	DH73A	X	X	X
SC-76B	DH73B	X	X	X
SC-76C	DH73C	X	X	X
SC-76D	DH73D	X	X	X
SC-76E	DH73E	X	X	X
SC-40E	DH73F	X	X	X
SC-301A	DH90A	X	X	X
SC-301B	DH90B	X	X	X
SC-301D	DH90C	X	X	X
SC-301E	DH90D	X	X	X
SC-75E	DH90E	X	X	X
SS-75	DH93A	X	X	X
SS-76	DH93B	X	X	X
WP-2	DH93C	X	X	X
SS-40	DH93D	X	X	X
WP-1	DH93E	X	X	X
SS-301	DH93F	X	X	X
OMMP-RB	DH89A	X	X	
OMMP-FB	DH89B	X	X	

SVOA: Phenol, benzyl alcohol, 2- and 4-methylphenol, 2,4-dimethylphenol, benzoic acid, and pentachlorophenol by Method 8270 (USEPA 1996)
Mercury: Total mercury by Methods 7471A and 7470A (USEPA 1996)
Conventionals: Total solids by Method 160.3 (USEPA 1999), total organic carbon by the Plumb Method (Plumb 1981), and grain size by the PSEP Method (PSEP 1996)

2.0 Data Validation of Semivolatile Organics Analyses

2.1 Custody, Preservation, Holding Times, and Completeness – Acceptable with Discussion

All samples were extracted and analyzed within the required holding times. Except as noted below, all samples were received intact and were properly preserved. The data packages are complete and contain results for all samples and tests requested on the chain-of-custody (COC).

The temperature of the samples when they were received at the laboratory was not documented in the data package for sample delivery groups (SDGs) DH90, DH93, and DH89. The laboratory provided the receipt temperatures.

The temperature of the samples in SDGs DH90, DH93, and DH89 were above the recommended temperature range of 2 to 6 °C at the time of laboratory receipt. The temperature of the samples was 20.5 °C. Kim Magruder, of Anchor Environmental, stated that the samples were only above the temperature range a short time during transport to the laboratory. Data qualifiers are not recommended.

2.2 Instrument Tuning and Mass Calibration – Acceptable

The tuning compound decafluorotriphenylphosphate was analyzed at the required frequency and all relative abundance values are acceptable.

2.3 Initial Calibration – Acceptable

Initial calibrations were analyzed at the required frequency. The Functional Guidelines criteria of relative standard deviation values less than or equal to 30% and relative response factors greater than 0.05 were met for all target compounds.

2.4 Continuing Calibration – Acceptable with Qualifications

Calibration verifications were analyzed at the required frequency. Except as noted below, the Functional Guidelines criteria of percent difference values less than or equal to 25 and relative response factors greater than 0.05 were met.

The percent difference values of benzoic acid and 2-fluorophenol in the calibration verification standard analyzed 7-6-01 are above the Functional Guidelines criteria at 25.4% and 26.5%, respectively. Since the response decreased, the benzoic acid results in the associated samples were qualified as estimated (J) or estimated detection limit (UJ) as shown in the following table. Data qualifiers are not required for 2-fluorophenol because it is a surrogate compound.

Sample ID	Analyte	Qualification	Quality Control Exceedance
OMMP-RB OMMP-FB	Benzoic acid	J positive results UJ detection limits	Continuing calibration percent difference greater than 25 (response decreased)

2.5 Blank Analyses – Acceptable

2.5.1 Method Blanks

Method blanks were analyzed at the required frequency and target compounds were not detected above the reporting limits.

2.5.2 Field Blanks

Samples OMMP-RB and OMMP-FB were identified as field blanks. Target compounds were not detected above the reporting limits in either field blank.

2.6 Surrogate Analyses – Acceptable with Qualifications

Surrogate compounds were added to all samples, blanks, and QC samples as required. Except as noted below, the recovery values are within the OMMP criteria.

The 2,4,6-tribromophenol surrogate recovery value for the 7-6-01 method blank is below the OMMP criteria at 45.9%. Data qualifiers are not required for QC samples.

The phenol-d5, 2-fluorophenol, 2,4,6-tribromophenol, and 2-chlorophenol-d_4 surrogate recovery values for sample SC-76D are below the OMMP criteria at 48.2%, 48.7%, 45.3%, and 46.6%, respectively. Functional Guidelines requires qualifying data when two or more surrogate recovery values in the same fraction (base/neutral or acid) are outside criteria. Therefore, the acid analytes were qualified as estimated (J) or estimated detection limit (UJ) as shown in the following table.

Sample ID	Analyte	Qualification	Quality Control Exceedance
SC-76D	Phenol 2-methylphenol 4-methylphenol 2,4-dimethylphenol Benzoic acid Pentachlorophenol	J positive results UJ detection limits	Acid fraction surrogate recovery values below OMMP criteria

2.7 Matrix Spike/Matrix Spike Duplicate Analyses – Acceptable with Discussion

Except as noted below, matrix spike/matrix spike duplicates (MS/MSD) were analyzed at the required frequency and all percent recovery and relative percent difference (RPD) values are within the OMMP criteria.

MS/MSD analyses were not reported for the water samples. Data qualifiers are not required because the water samples are field QC samples and laboratory control sample demonstrates the analytical system is in-control.

2.8 Laboratory Control Sample Analyses – Acceptable with Discussion

Laboratory control samples were reported with the data. Except as noted below, all percent recovery values are within the OMMP criteria of 50 to 135%.

The pentachlorophenol recovery value in the laboratory control sample associated with the sediment samples is below the OMMP criteria at 42.7%. Data qualifiers are not recommended because the MS/MSD is acceptable.

2.9 Standard Reference Material Analyses – Acceptable

The laboratory analyzed the Sequim Bay Fortified Reference Sediment as the standard reference material required by the OMMP. The results are acceptable and meet the criteria of within the 95% confidence interval.

2.10 Internal Standard Evaluation – Acceptable

Internal standards were added to all samples, blanks, and QC samples as required. The recovery and retention time criteria of Functional Guidelines were met.

2.11 Laboratory Reporting Limits – Acceptable with Discussion

The OMMP target detection limits were met, with one exception. The laboratory reporting limit for pentachlorophenol is 100 μg/kg, which is greater than the OMMP target detection limit of 50 μg/kg.

2.12 Field Duplicates

Field duplicates are not associated with this sample set.

2.13 Overall Assessment of Data Useability

The useability of the data is based on the guidance documents listed above. Upon consideration of the information presented here, the data are acceptable except where flagged with data qualifiers that modify the usefulness of the individual values.

3.0 Data Validation of Total Mercury Analyses

3.1 Custody, Preservation, Holding Times, and Completeness – Acceptable with Discussion

All samples were analyzed within the required holding times. Except as noted below, all samples were received intact and were properly preserved. The reports are complete and contain results for all samples and tests requested on the COC.

The temperature of the samples in SDGs DH90, DH93, and DH89 were above the recommended temperature range of 2 to 6 °C at the time of laboratory receipt. The temperature of the samples was 20.5 °C. Kim Magruder, of Anchor Environmental, stated that the samples were only above the temperature range a short time during transport to the laboratory. Data qualifiers are not recommended.

3.2 Initial Calibration – Acceptable

Initial calibrations were analyzed as required and all quality control checks meet Functional Guidelines requirements.

3.3 Calibration Verifications – Acceptable

Initial calibration verifications and continuing calibration verifications were analyzed at the required frequency. All Functional Guidelines criteria were met.

3.4 Blank Analyses – Acceptable

3.4.1 Method Blanks

Method blanks were analyzed at the required frequency. Target analytes were not detected above the reporting limits.

3.4.2 Calibration Blanks

Calibration blanks were analyzed at the required frequency and target analytes were not detected above the reporting limits.

3.4.3 Field Blanks

Samples OMMP-RB and OMMP-FB were identified as field blanks. Target analytes were not detected above the reporting limits in either field blank.

3.5 Duplicate Sample Analyses – Acceptable with Discussion

Except as noted below, sample duplicate analyses were reported at the required frequency and all RPD values are within the OMMP criteria.

Sample duplicate analyses were not reported for the water samples. Data qualifiers are not required because the water samples are field QC samples.

3.6 Matrix Spike Analyses – Acceptable with Discussion

Except as noted below, matrix spike analyses were reported at the required frequency. All percent recovery values are within the OMMP criteria.

Matrix spike analyses were not reported for the water samples. Data qualifiers are not required because the water samples are field QC samples and laboratory control sample demonstrates the analytical system is in-control.

3.7 Laboratory Control Sample Analyses – Acceptable

Laboratory control samples were reported with the water samples. All percent recovery values are within the OMMP criteria.

3.8 Standard Reference Material Analyses – Acceptable

Standard reference materials were analyzed as required by the OMMP. All results are within the OMMP criteria.

3.9 Laboratory Reporting Limits – Acceptable

The OMMP target detection limits were met for all sediment samples.

3.10 Field Duplicates

Field duplicates are not associated with this sample set.

3.11 Overall Assessment of Data Useability

The useability of the data is based on the guidance documents listed above. Upon consideration of the information presented here, the data are acceptable.

4.0 Data Validation of Conventional Parameters

4.1 Custody, Preservation, Holding Times, and Completeness – Acceptable with Discussion

All samples were analyzed within the required holding times. Except as noted below, all samples were received intact and were properly preserved. The report is complete and contains results for all samples and tests requested on the COC.

The temperature of the samples in SDGs DH90 and DH93 were above the recommended temperature range of 2 to 6 °C at the time of laboratory receipt. The temperature of the samples was 20.5 °C. Kim Magruder, of Anchor Environmental, stated that the samples were only above the temperature range a short time during transport to the laboratory. Data qualifiers are not recommended.

4.2 Initial Calibration – Acceptable

Initial calibrations were analyzed as required and all quality control checks are acceptable.

4.3 Calibration Verifications – Acceptable

Initial calibration verifications and continuing calibration verifications were analyzed at the required frequency. All quality control criteria were met.

4.4 Blank Analyses – Acceptable

4.4.1 Method Blanks

Method blanks were analyzed at the required frequency and target analytes were not detected above the reporting limits.

4.4.2 Field Blanks

The field blanks were not analyzed for conventional parameters.

4.5 Duplicate Sample Analyses – Acceptable with Discussion

Sample duplicate analyses were analyzed at the required frequency and all RPD values are within the OMMP criteria.

Duplicate results were not reported for total solids or TOC. The laboratory directed the validation chemist to the raw data for verification of duplicate analysis. According to the raw data, duplicate analyses were preformed on non-project samples and are acceptable.

4.6 Matrix Spike Analyses – Acceptable with Discussion

Matrix spike analyses were reported at the required frequency and all percent recovery values are within the OMMP criteria.

Matrix spike results were not reported for TOC. The laboratory directed the validation chemist to the raw data for verification of matrix spike analysis. According to the raw data, matrix spike analyses were preformed on non-project samples and are acceptable.

4.7 Standard Reference Material Analyses – Acceptable

Standard reference materials were reported for TOC as required by the OMMP. The recovery values are within the OMMP criteria.

4.8 Laboratory Reporting Limits – Acceptable

The OMMP target detection limits were met.

4.9 Field Duplicates

Field duplicates are not associated with this sample set.

4.10 Overall Assessment of Data Useability

The useability of the data is based on the guidance documents listed above. Upon consideration of the information presented here, the data are acceptable.

5.0 Assessment of Data Quality Objectives

5.1 Precision

Precision is a measure of the mutual agreement among individual measurements of the same property, under prescribed similar conditions. Precision is determined through analysis of matrix spike/matrix spike duplicates, sample duplicates, and field duplicate samples. Duplicate samples are evaluated for precision in terms of relative percent difference. Relative percent difference is defined as the difference between the duplicate results divided by the mean and expressed as a percent.

The precision of the data set meets the data quality objective of the OMMP. For the semivolatile organic, mercury, and conventional parameters the MS/MSD and laboratory duplicate RPD values are within the OMMP criteria. Field duplicates are not associated with this sample set.

5.2 Accuracy

Accuracy is the degree of agreement between a measurement and the accepted reference or true value. The level of accuracy is determined by examination of surrogates, matrix spikes, matrix spike duplicates, laboratory control samples, standard reference materials, method blanks, and field blanks. The surrogate, matrix spike, matrix spike duplicate, laboratory control samples, and standard reference material recovery values were compared to the criteria set forth in the OMMP, Functional Guidelines, or the analytical method. Method and field blanks are analyzed to identify compounds that could be introduced during the sampling, laboratory extraction, or analysis phase (i.e., laboratory contaminates) and lead to inaccurate results.

The accuracy of the mercury and conventional data sets meets the data quality objective of the OMMP. The recovery values of the matrix spike, laboratory control samples, and standard reference materials are acceptable and the method blanks and field blanks are free of contamination.

The accuracy of the semivolatile organics data set meets the data quality objective of the OMMP with following exception. The acid analytes of sample SC-76D may be biased low as shown by the low acid surrogate recovery values. The low recovery value of pentachlorophenol in the laboratory control sample does not affect the accuracy of the data set because the MS/MSD is acceptable. The recovery values of the matrix spikes, matrix spike duplicates, and standard reference materials are acceptable and the method blanks and field blanks are free of contamination.

5.3 Representativeness

Representativeness is the extent to which the data reflect the actual contaminate levels present in the samples. Representativeness is assessed through method and field blanks, and proper preservation and handling. Method and field blank analyses allow for the detection of artifacts that may be reported as false positive results. Proper sample preservation and handling ensure that sample results reflect the actual sample concentrations.

The data are assumed to be representative since all samples were analyzed within the required holding times. The temperature upon receipt at the laboratory (20.5 °C) does not affect the representativeness of the data because the categories of target analytes; semivolatile organics, total mercury, TOC, total solids, and grain size, are not adversely affected by short periods at elevated temperatures. The method blanks and field blanks are free of contamination.

5.4 Comparability

Comparability is a measure of how easily the data set can be compared and combined with other data sets. The data are assumed to be comparable since standard EPA methods were used to analyze the samples, the method QC criteria were met, and routine detection limits were reported.

5.5 Completeness

Completeness is expressed as the ratio of valid results to the amount of data expected to be obtained under normal conditions. Completeness is determined by assessing the number of samples for which valid results were obtained versus the number of samples that were submitted to the laboratory for analysis. Valid results are results that are determined to be usable during the data validation review process.

The 100% completeness goal of the OMMP was met. The completeness of this data set is 100%, since all of the samples were analyzed and all the results were determined to be valid.

6.0 Definition of Data Qualifiers

6.1 Inorganic Data Qualifiers

The following data validation qualifiers were used in the review of this data set. These qualifiers are taken from Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA 1994).

U The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

J The associated value is an estimated quantity.

UJ The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

R The data are unusable. (Note: Analyte may or may not be present.)

6.2 Organic Data Qualifiers

The following data validation qualifiers were used in the review of this data set. These qualifiers are taken from Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 1994a).

U The analyte was analyzed for but not detected above the reported sample quantitation limit.

J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".

NJ The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.

R The sample results are rejected due to serious deficiencies in the ability to analyze the samples and meet quality control criteria. The presence or absence of the analyte cannot be verified.

7.0 References

Anchor Environmental. 2001. Completion Report - Interim Remedial Action Log Pond Cleanup/Habitat Restoration Project, Appendix C Operations, Maintenance and Monitoring Plan Interim Remedial Action Log Pond Cleanup/Habitat Restoration, Bellingham, Washington. May 29, 2001.

Plumb. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Technical Report EPA/CE-81-1. U.S. Army Corps of Engineers, Vicksburg, MS.

PSEP. 1996. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Prepared for the U.S. Environmental Protection Agency Region 10, Seattle, WA. January 1996.

USEPA. 1994. Contract Laboratory Program National Functional Guidelines For Inorganic Data Review. United States Environmental Protection Agency. Office of Solid Waste and Emergence Response. February 1994.

USEPA. 1994a. Contract Laboratory Program National Functional Guidelines For Organic Data Review. U.S. Environmental Protection Agency Office of Solid Waste and Emergence Response. February 1994.

USEPA 1999. *Methods and Guidance for Analysis of Water,* Version 2.0. United States Environmental Protection Agency Office of Science and Technology. EPA 821-C-99-004. CD ROM. June 1999.

Table 2
Summary of Qualified Data

Sample ID	Analyte	Qualifier	Reason for Qualification
OMMP-RB OMMP-FB	Benzoic acid	UJ	Continuing calibration percent difference greater than 25 (response decreased)
SC-76D	Phenol 2-methylphenol 4-methylphenol 2,4-dimethylphenol Benzoic acid Pentachlorophenol	UJ	Acid fraction surrogate recovery values below OMMP criteria

Appendix A

Laboratory Communications
(1 page)

APPENDIX F
HUXLEY COLLEGE REPORT –
THE LOG POND RESTORATION PROJECT:
STRUCTURE AND FUNCTION OF THE BENTHIC COMMUNITY

The Log Pond Restoration Project: Structure and Function of the Benthic Community

Brian L. Bingham
Department of Environmental Sciences
Huxley College of the Environment
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Brita Clothier
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Huxley College of the Environment
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Introduction

As part of the comprehensive plan to clean up sediments and restore habitat in Bellingham Bay, the Georgia Pacific Log Pond was capped with clean sediment. The capping modified 1.5 acres of deep subtidal, 2.5 acres of shallow subtidal and 1.6 acres of intertidal riprap, providing 4.0 acres of low intertidal and 1.6 acres of shallow subtidal habitat (Anchor Environmental, 2000).

The capping process occurred in 2 phases. Phase I involved covering existing sediments with a thick layer of clean sediment. In Phase II, a thinner layer of native silt material from Squalicum was placed over the capping material. It was expected that the native silt would already contain an established community of infaunal invertebrates and would provide good settlement habitat for larvae from other regional invertebrate species.

The Log Pond restoration plan includes assessment of the new habitat performance. While capping the sediments in the pond should improve sediment quality, it is important to demonstrate that the sediment cap is controlling bioaccumulation exposures and that the habitat is functioning properly with a healthy, productive benthic community. This is important both for the inherent value of the benthic invertebrate community itself and for the role it plays in the broader Bellingham Bay and regional ecosystems (e.g., as food for juvenile salmonids).

It was predicted that the Phase II sediments would be rapidly recolonized and that a fully functional benthic community would be established by 3 - 4 years after construction of the cap. Documenting the recovery will require regular sampling and monitoring of the infaunal and epibenthic invertebrate fauna. This should be continued until the benthic communities structure approaches that seen in reference sites that have not be impacted by historical commercial/industrial activities. Initial baseline sampling of the Log Pond was done immediately prior to construction and capping activities. Here we report on the second and third rounds of habitat sampling, which took place five and six months after the cap was put in place.

Materials and Methods

We felt that it was important that post-construction data be comparable to baseline data collected before the Log Pond was capped. To ensure this would be the case, we used the same collection methods used in the baseline survey. Those methods are outlined below.

Quantitative sampling of the epibenthos

In accordance with the Operations, Maintenance and Monitoring Plan for the Log Pond Project (OMMP), we used an epibenthic suction pump (Simenstad et al., 1991) to take three replicate samples of the epibenthos at each of 3 fixed stations (SS74, SS75 and SS76) within the log pond (Fig. 1).

The epibenthic pump covered a 0.33 m^2 area of the bottom and enclosed a volume of 7.1 liters. To collect samples, we gently placed the pump on the bottom at the selected station and collected a sample. To ensure that all invertebrates were removed from the pump, we flushed three full volumes of water (21.3 l) through the system. The pump had

0.130-mm screened ports that retained the macroinvertebrates but allowed water to pass through and flush the system. Because the OOMP required sampling a full 0.1 m^2 area for each sample, we repeated the above sampling three times (moving the pump at least 0.5 m each time) to collect three subsamples, which were pooled to form a single sample. We washed the collected material through a 0.253-mm mesh sieve and preserved the sample in 10% buffered formalin. The samples were later transferred to 70% ethanol.

For comparison with the log pond, we established two reference stations in the inner part of Chuckanut Bay (Fig. 1). The stations were chosen to duplicate the Log Pond as closely as possible (e.g., water depth, sediment composition, exposure). We collected triplicate pooled samples at both stations in Chuckanut Bay as described above. Sampling in the Log Pond and at the Chuckanut site was done on May 14 and 15, 2001 and was repeated on June 25, 2001.

In the laboratory, all invertebrates were picked from the samples, sorted and identified to the lowest taxonomic level. Because some samples had very high numbers of invertebrates, it was necessary to subsample some replicates. We did this by thoroughly mixing the sample and removed a measured volume for analysis. All counts were later standardized to permit statistical comparisons.

To determine the biomass composition of each sample, we separated the invertebrates picked from each sample into broad taxonomic groups (i.e., nematodes, annelids, molluscs, and crustaceans). These individual samples were dried in a 60° C oven for 24 hours then weighed.

For each sample, we calculated the total number of invertebrate species, the Shannon-Weiner diversity index (H', using log base *e*) and Pielou's evenness index (J'). To look for differences between the two study sites and between the two sampling dates, we used a 3-way partially nested analysis of variance. Time and Site were fixed main effects. Station (e.g., SS74, CH1) was a random factor nested within site. We used the same model to test for differences in epibenthic biomass. We tested the assumption for all ANOVA analyses. Where the assumption of equal variances was violated, we attempted to correct the violation by transforming the data. If that was unsuccessful, we continued with the analysis, realizing that our analyses would suffer from an increased possibility of Type I error (i.e., finding significant differences that really were not there).

Quantitative sampling of benthic invertebrates

Effectively sampling the epibenthic community required a different protocol. For consistency with pre-construction sampling, we used a 0.023 m^2 petite ponar grab sampler (PSEP 1997a) to collect benthic invertebrates. On each sampling date, three grab samples were taken at each station in the log pond (SC-74, SC-75, SC-76) and at the two reference stations in Chuckanut Bay (CH1, CH2). All ponar samples were collected on June 25, 2001.

The collected samples were washed through a 0.5-mm brass sieve, put in 500 ml glass jars and fixed with 10% buffered formalin. They were later transferred to 70% ethanol, sorted and identified to the lowest possible taxonomic group. After we had sorted and counted all the invertebrates, we grouped them into phyla, oven dried them at 60° C for 24 hours then weighed them to get a dry biomass measurement.

Community analyses

We ran cluster analyses to get a better idea of similarities between the epibenthic and benthic invertebrate communities the Log Pond and in Chuckanut Bay. These analyses go beyond simple counts of species, diversity indices and evenness indices as they consider the species composition of the samples.

We used hierarchical cluster analysis (Ward's method with a Euclidean distance measure) and k-means cluster analysis to reveal patterns in the data. We ran separate analyses for the epibenthic data (all stations in both sites in May and June) and for the ponar data (all stations in both sites on the single June sampling date).

Characterization of the sediments

Because sediment composition can have a strong impact on benthic community structure and composition, we felt it was important to characterize the sediments. To do this, we took a single ponar bottom grab from each station on June 25, 2001. The sediments were held in a -80° C freezer until they could be processed. At that time, a subsample of each sediment collection was washed through a series of sieves that separated the sediment into size fractions. The fractions were oven dried at 60° C for 48 hours and weighed. We used the weights to determine the grain-size composition for each sample. A subsample of the unsorted sediment was also oven dried for 96 hours at 60° C, weighed, and burned at 500° C in a muffle furnace to remove all organic material. The drop in weight was used to calculate a percent organic content of each sediment.

To determine whether sediment composition was different between the Log Pond site and the reference site, we calculated the average percent composition for each sediment fraction at each site. We then compared the sediment size distributions for the two sites with a Kolmogorov-Smirnov test. Organic fraction was compared with a one-way analysis of variance with site (Log Pond vs. Chuckanut) as the main effect.

Results

Biomass measurements

Epibenthic sampling revealed an abundance of invertebrates in the Log Pond and in the reference site (Appendix I - III). Dry biomass measurements ranged from 0.0012 g (in a May sample from SS74 in the Log Pond) to 0.3052 g (in a June sample from SS76 in the Log Pond). There appeared to be a pattern of higher epibenthic biomass in samples from the Log Pond with more invertebrates in the northeastern site (SS76; Fig. 2). However, analysis of variance failed to reveal significant biomass differences between the sample dates or between the sites. Nor were we able to detect significant variation among the sampling stations within the study sites (Table I). It should be noted that the power of this analysis was extremely low. For example, a power value of 0.07 for the Time effect indicates that, given our level of replication, we had only a 7% chance of detecting a real effect. Clearly, increased replication would have greatly increased the strength of our analysis and our confidence in the results.

Invertebrate biomass in ponar samples was generally higher than in the epibenthic samples (Fig. 2). Within these two data sets, however, statistical analysis showed no significant differences between sites and no significant variability among sampling stations (Table II). This was due to 1) the high variability among samples within a station and 2) the very low power of the analyses.

Both the epibenthic and ponar samples contained primarily crustaceans, molluscs, annelids and nematodes. The relative contribution of these groups to the biomass measurements, however, appeared to differ between sites and over time (Fig. 3). The most dramatic pattern was a great increase in the importance of annelids to the total biomass in the June samples. This was particularly evident in the Chuckanut epibenthic samples where % biomass of annelids increased from 0% to nearly 60%. The percent composition of the ponar samples was dramatically different for the Log Pond and Chuckanut samples (taken only in June). The Log Pond samples were dominated by annelids, but the Chuckanut samples held a relatively small proportion of annelids and a much higher proportion of crustaceans.

Invertebrate diversity

A large number of species were collected from both the Log Pond and the Chuckanut study sites (Fig. 4). Statistical analysis showed significant variation among stations and a significant time*station interaction, indicating that the changes were not consistent from station to station (i.e., over time, the number of species apparently went up at SS75, but went down at SS76). None of the other effects were significant, but power of the analyses was again low (Table III).

Plotting community-level indices showed that both diversity and species evenness were consistently higher in June than it was in May (Fig. 4). This is verified in statistical analyses that a significant time effect (Tables IV-V). There was also a significant site effect in the diversity index with the Chuckanut sites showing higher diversity than the Log Pond sites. There was also a significant time*station interaction in the diversity analysis, but that results should be interpreted cautiously given the violation of the homogeneous variance assumption and the borderline significance ($p = 0.04$).

The number of invertebrate species collected in ponar samples was approximately equal to that found in the epibenthic community. However, diversity and evenness were generally lower (Fig. 5). In our statistical analysis of number of species, only station was significant (indicating variability from station to station within the study sites; Table VI). There were no detectable differences in the diversity indices (Table VII). However, sites differed significantly in Pielou's evenness; species evenness was much higher in the Log Pond (Table VIII, Fig. 5). Note, however, that the violated ANOVA assumption makes this conclusion suspect. Power for the main effects in these analyses were again generally low.

Cluster analysis of epibenthic samples showed very strong effects of date on community composition. The analysis produced three data clusters (Fig. 6). Cluster 1 was an outlier group of Log Pond sites (mixing May and June samples). Cluster 2 was composed almost entirely of samples collected in June and Cluster 3 was limited primarily to samples collected in May. There was no separation of sites in this analysis suggesting that the composition of the epibenthic communities in the Log Pond and Chuckanut sites were similar. This was verified by a chi-square association test, which showed no Site contribution to the clusters ($X^2_{8df} = 0.30$, $p = 0.24$).

K-means cluster analysis of the ponar samples showed a very different pattern. The clusters that formed were strongly associated with site differences. A chi-square association test showed a strong site effect (Site $X^2_{4df} = 12.0$, $p = 0.01$). The Log Pond stations fell out strongly in Cluster 1 and all the Chuckanut stations except one fell out in Cluster 2 (Fig. 6). Several invertebrate species contributed heavily to the separation of the clusters. Two polychaetes (*Owenia fusiformis* and *Glycinde polygnatha*) and one bivalve (*Macoma nasuta*) were much more abundant in Cluster 2 sites (i.e., Chuckanut) than in Cluster 1 (Log Pond sites). In contrast, the Log Pond sites had much higher abundance of the polychaete *Leitoscoloplos pugettensis*.

Sediment characteristics

Sediments from both study sites were composed largely of sand in the 0.125 - 0.246 mm size fraction; there was a relatively low proportion of silts (Fig. 7). Kolmogorov-Smirnov analysis showed no significant difference in the distributions of sediment sizes at the two study sites ($D = 0.13$, $p = 0.38$).

The organic content of sediments from the two study sites was less than 4% (Fig. 7). One-way ANOVA failed to detect significant differences between the study sites ($F_{0.05, 1,3} = 0.60$, $p = 0.49$). However, power was again very low (power = 0.08).

Discussion

To assess health of the epibenthic and benthic invertebrate communities in the Log Pond, we chose to compare them to communities from a reference site in Chuckanut Bay. The two sites are similar in depth and exposure. Analyses also suggest that the sediments are similar in grain-size composition and in organic content. This doesn't mean that the two sites are the same, but it does indicate that there are not extreme differences that would preclude comparisons.

Our analyses suggest there is a good biomass of invertebrates in the Log Pond. In fact, there were indications that the biomass was actually higher there than in the reference site, but we were unable to demonstrate it statistically. At the phylum level, the composition of the communities differed, but most of the differences appeared to be related to time rather than to site. The exception to this was in the ponar samples. Most of the invertebrate biomass in the Log Pond samples was polychaete annelids while the Chuckanut samples held a much higher proportion of crustaceans.

The Log Pond and the reference site appeared to hold similar numbers of invertebrate species and to have similar levels of diversity and evenness. There were no obvious indications that a healthy invertebrate community is not developing in the Log Pond sediment cap.

Despite these similarities, there were also indications of basic differences in the structure of the invertebrate community in these two sites. Cluster analysis of data from ponar samples clearly separated the two sites. This indicates basic community-level differences; samples from the Log Pond were much more similar to each other than they were to samples from Chuckanut Bay. The separation of these groups is largely attributable to three polychaete species and a bivalve species. We do not know what factors are contributing to the differences in these species' distributions. It will remain to be seen whether the communities in the two sites converge over time.

A common theme in our analyses was a serious lack of statistical power. This consequence of sampling design could be improved significantly be making some fairly minor changes in the way samples are collected. In particular, we suggest that 1) the data be balanced by taking equal numbers of samples in the Log Pond and in the Chuckanut reference site and 2) that the samples be randomly scattered throughout the area rather than restricted to single sample stations. Both of these changes would significantly improve the power of the statistical analyses and would help us detect real differences. Additionally, this approach would help us deal with violation of statistical assumptions (e.g., non-heterogeneous variances).

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Table I. Analysis of variance table for dry biomass measurements of epibenthic invertebrates. Time had 2 levels (May and June). Site also had two levels (Log Pond and Chuckanut). The assumption of equal variances was violated for this data set. This did not, however, affect our conclusions since no significant effects were found.

Source	SS	df	MS	F	p	Power
Time	5.75E-04	1	5.75E-04	0.44	0.55	0.07
Site	7.42E-03	1	7.42E-03	0.73	0.45	0.09
Time*Site	1.95E-04	1	1.95E-04	0.14	0.72	0.05
Station	3.01E-02	3	1.00E-02	2.98	0.06	0.56
Time*Station	3.92E-03	3	1.30E-03	0.38	0.76	0.11
Error	6.72E-02	20	3.36E-03			
Total	1.09E-01	29				

Table II. Analysis of variance table for dry biomass measurements of invertebrates collected with a ponar grab. The assumption of equal variances was again violated, but conclusions are valid since on significant effects were found.

Source	SS	df	MS	F	P	Power
Site	0.032	1	0.032	0.28	0.62	0.17
Station	0.341	3	0.114	1.34	0.31	0.06
Error	0.843	10	0.083			
Total	1.216	14				

Table III. Analysis of variance table for number of invertebrate species collected in epibenthic samples. The assumption of equal variances was met for these data.

Source	SS	df	MS	F	p	Power
Time	5.97	1	5.97	0.51	0.52	0.08
Site	168.20	1	168.20	4.11	0.13	0.29
Time*Site	3.75	1	3.75	0.32	0.61	0.07
Station	122.66	3	40.88	11.16	**<0.01**	0.98
Time*Station	35.11	3	11.70	3.19	**0.04**	0.64
Error	73.33	20	3.66			
Total	409.02	29				

Table IV. Analysis of variance table for the Shannon-Wiener (H') diversity index. Indices were calculated for each epibenthic sample. The assumption of equal variances was violated for these data and could not be corrected by transformation. Significant results, therefore, must be interpreted cautiously.

Source	SS	df	MS	F	p	Power
Time	3.37	1	3.37	13.94	**0.03**	0.70
Site	1.24	1	1.24	12.37	**0.03**	0.65
Time*Site	0.006	1	0.006	0.02	0.87	0.05
Station	0.30	3	0.10	1.42	0.26	0.17
Time*Station	0.72	3	0.24	3.27	**0.04**	0.65
Error		20	0.07			
Total	5.63	29				

Table V. Analysis of variance table for the Pielou's (J') evenness index. Indices were calculated for each epibenthic sample. The assumption of equal variances was violated for these data and could not be corrected by transformation. Significant results, therefore, must be interpreted cautiously.

Source	SS	df	MS	F	p	Power
Time	0.39	1	0.39	16.47	**0.02**	0.76
Site	0.04	1	0.04	3.05	0.17	0.23
Time*Site	0.0003	1	0.0003	0.01	0.90	0.05
Station	0.04	3	0.01	1.01	0.40	0.18
Time*Station	0.07	3	0.02	0.97	0.15	0.43
Error	0.24	20	0.01			
Total	0.78	29				

Table VI. Analysis of variance table for the number of species collected in ponar grabs. Separate indices were calculated for each. Variances were homogeneous.

Source	SS	df	MS	F	P	Power
Site	98.17	1	98.17	0.97	0.39	0.11
Station	295.55	3	98.51	5.45	**0.01**	0.80
Error	180.66	10	18.06			
Total	574.38	14				

Table VII. Analysis of variance table for the Shannon-Wiener (H') diversity index. Indices were calculated for each ponar sample. Variances were homogeneous.

Source	SS	df	MS	F	P	Power
Site	0.41	1	0.41	1.26	0.34	0.12
Station	0.98	3	0.32	1.28	0.33	0.24
Error	2.54	10	0.25			
Total	3.93	14				

Table VIII. Analysis of variance table for the Pielou's (J') evenness index. Indices were calculated for each ponar sample. The assumption of equal variances was violated for these data and could not be corrected by transformation. The significant site effect, therefore, must be interpreted cautiously.

Source	SS	df	MS	F	P	Power
Site	0.24	1	0.24	9.31	**0.05**	0.54
Station	0.07	3	0.02	0.71	0.56	0.15
Error	0.37	10	0.03			
Total		14				

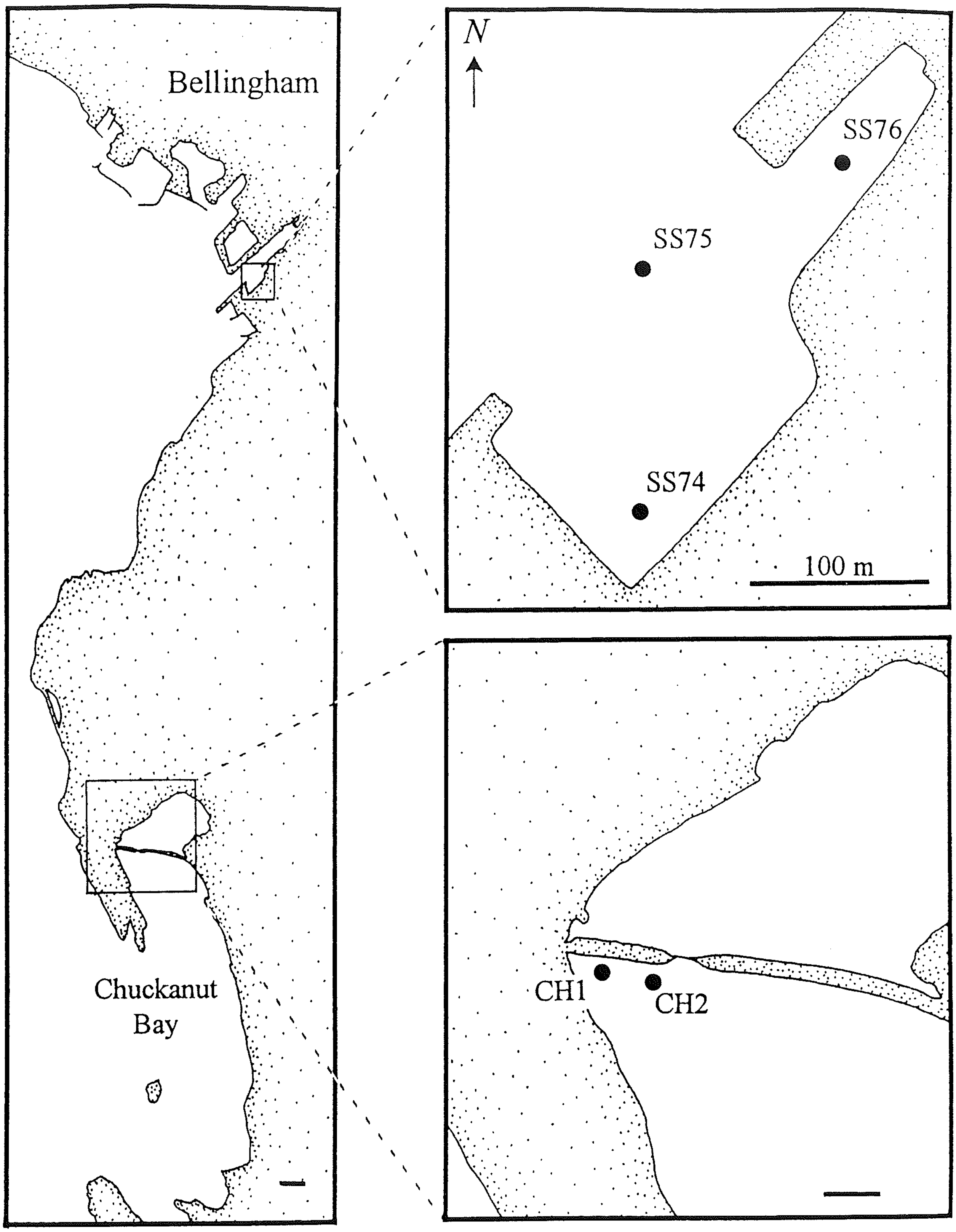


Figure 1. Study sites in the Log Pond and at the Chuckanut reference site. Scale bars on all figures represent 100 m.

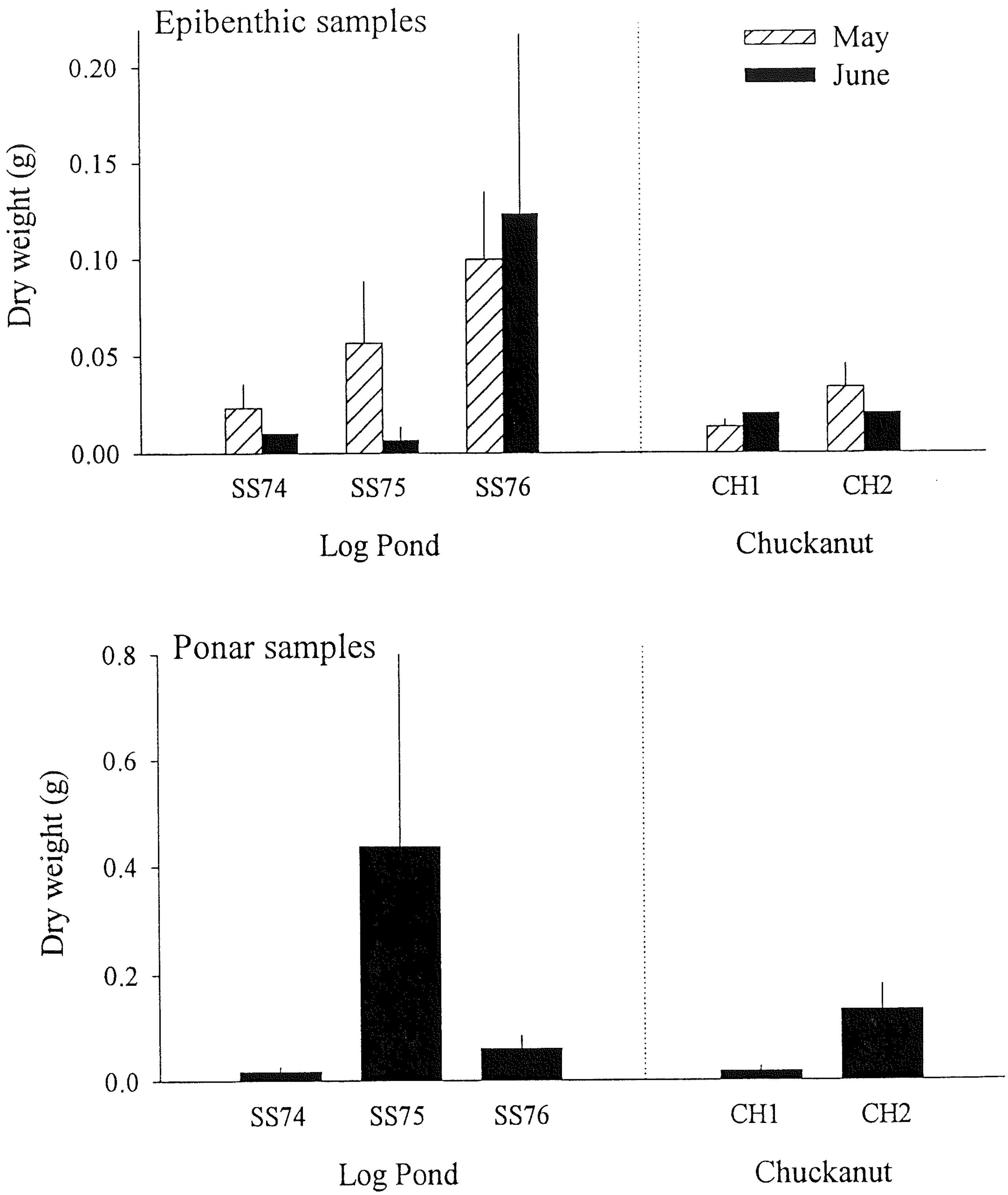


Figure 2. Total dry weights of all invertebrates picked from epibenthic and ponar samples. Standard errors are shown.

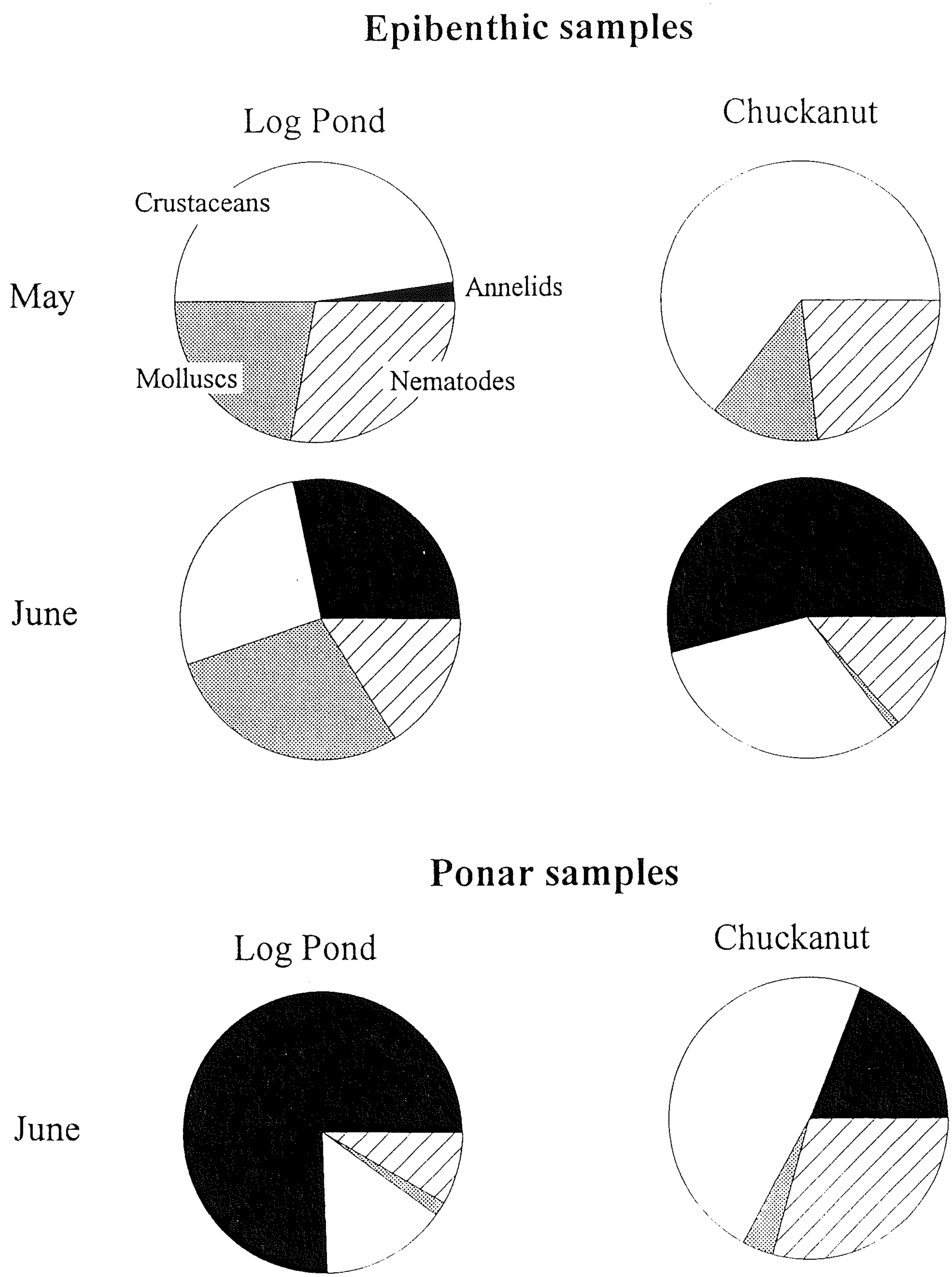


Figure 3. Dry weight composition of invertebrate samples from the Log Pond and Chuckanut study sites.

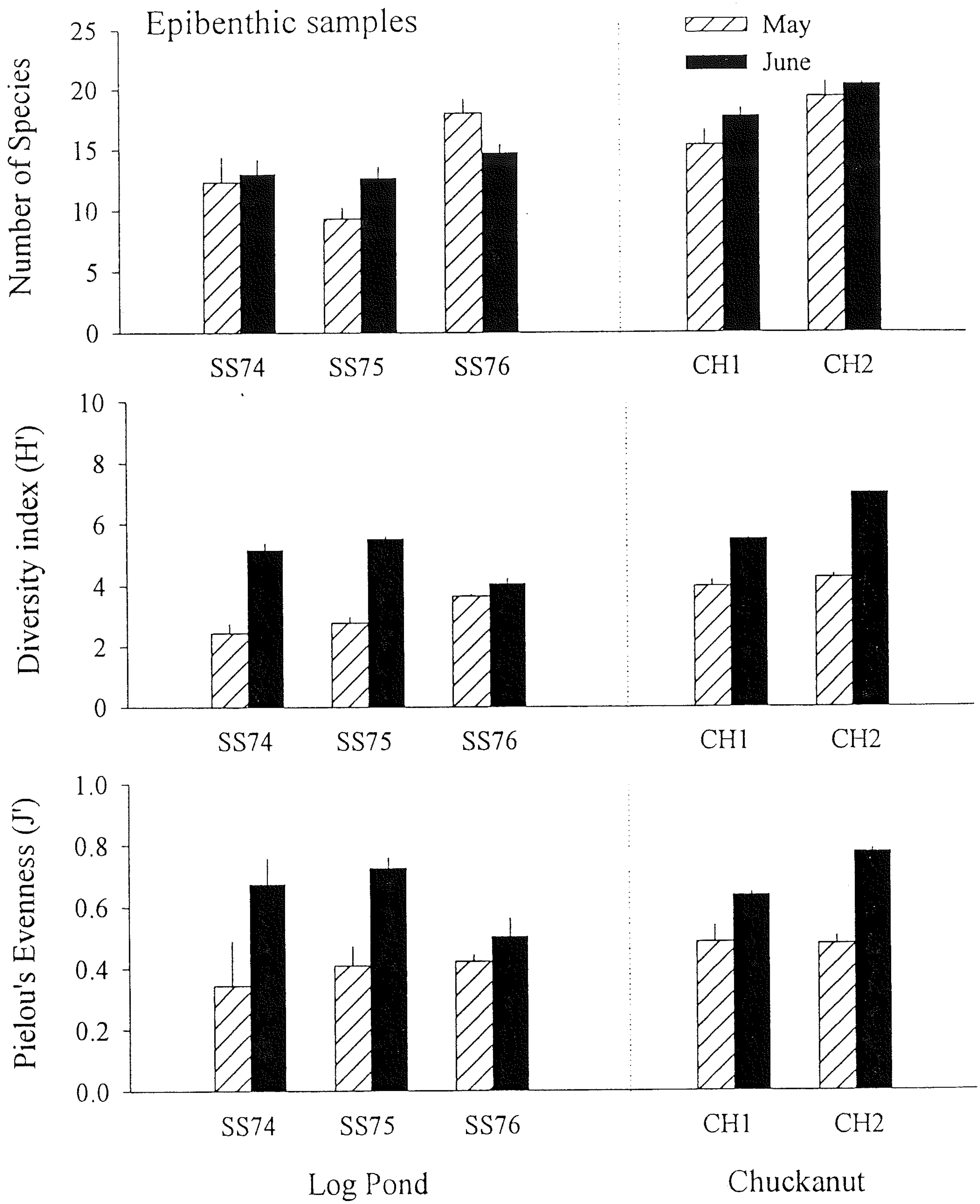


Figure 4. Community composition in epibenthic samples from the Log Pond and Chuckanut sites. Total number of species, the Shannon-Weiner diversity index (H') and Pielou's evenness index (J') are plotted. Standard errors are shown.

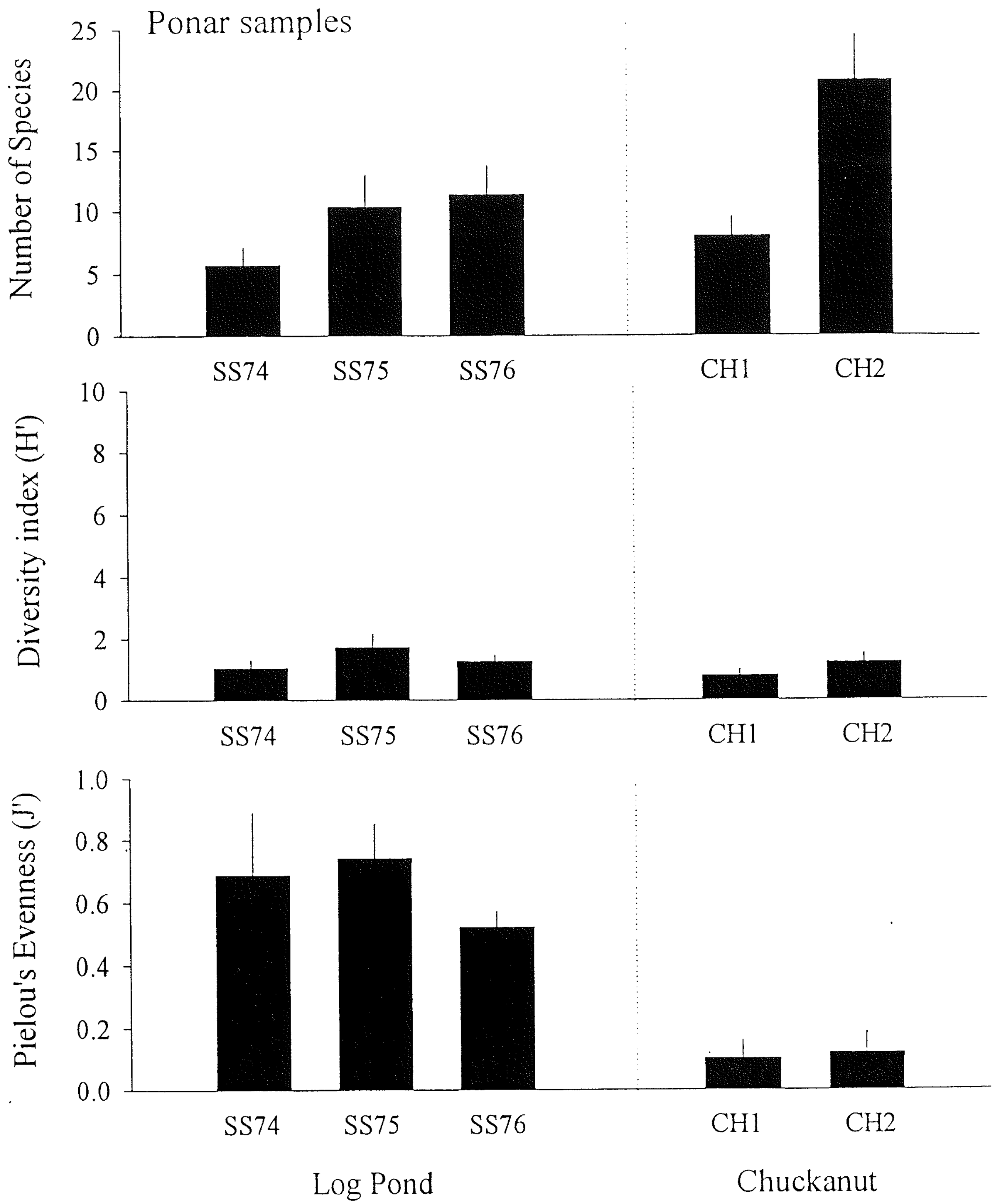
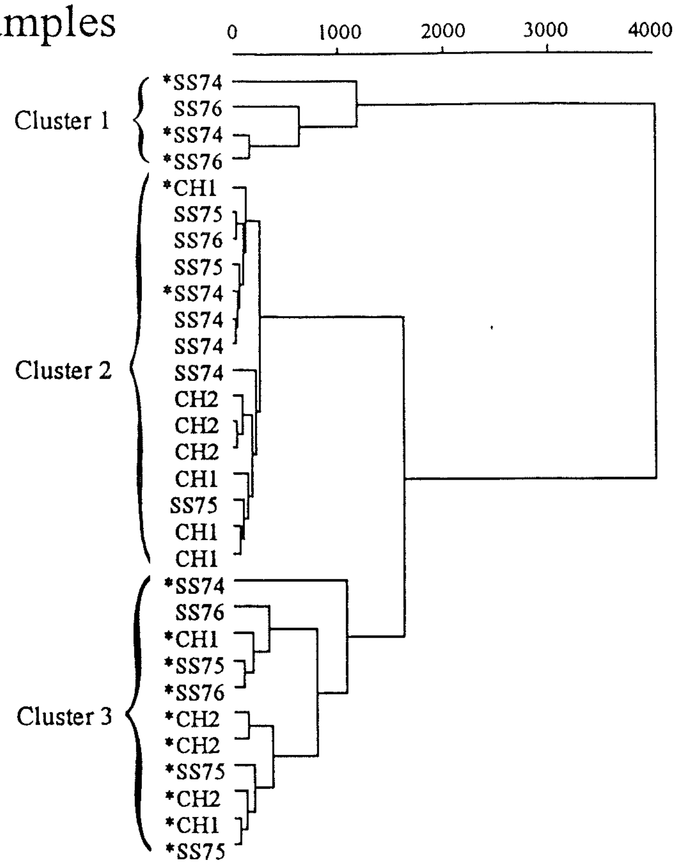


Figure 5. Community composition in ponar samples from the Log Pond and Chuckanut sites. Total number of species, the Shannon-Weiner diversity index (H') and Pielou's evenness index (J') are plotted. Standard errors are shown.

Epibenthic samples



Ponar samples

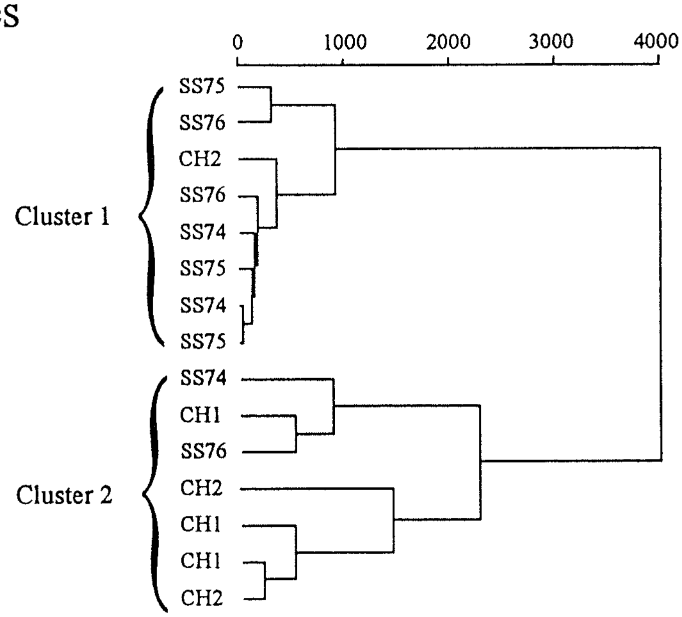


Figure 6. Cluster analysis for invertebrate samples with an epibenthic pump and with a ponar grab in the Georgia Pacific Log Pond and at a Chuckanut Bay reference site. Ward's cluster method with a Euclidean distance measurement was used for the analysis. Asterisks in the Epibenthic Samples cluster indicate samples collected in May. All other samples were collected in June.

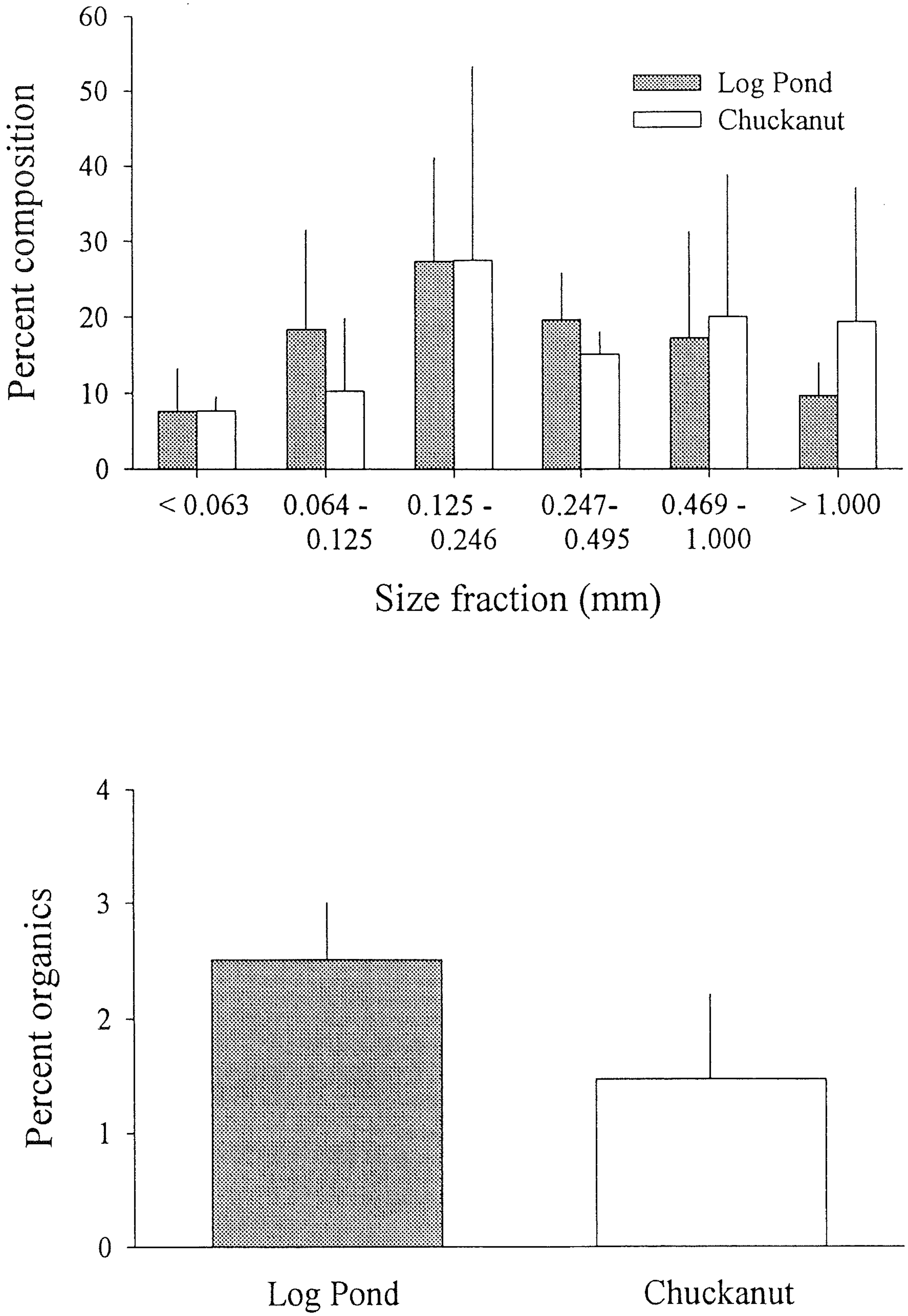


Figure 7. Sediment characteristics at the study sites. Grain-size distribution and percent organic content are plotted. Standard errors are shown.

Appendix I.

Species Checklist for invertebrates collected in the Georgia Pacific Log Pond and in the Chuckanut Reference Site.

Phylum Nematoda
    Unidentified nematodes
Phylum Nemertea
    Unidentified species
Phylum Annelida
    Class Polychaeta
        Order Flabelligerida
            Family Flabelligeridae
                Pherusa sp
        Order Orbiniida
            Family Orbiniidae
    Leitoscoloplos pugettensis (Pettibone, 1957)
        Order Opheliida
            Family Opheliidae
                Armandia brevis (Moore, 1906)
        Order Oweniida
            Family Oweniidae
                Owenia fusiformis
        Order Terebellida
            Family Pectinariidae
                Pectinaria sp.
        Order Capitellida
            Family Capitellidae
                Capitella capitata (Fabricius, 1780)
                Mediomastus sp.
        Order Cossurida
            Family Cossuridae
                Cossura sp.
        Order Phyllodocida
            Family Nephtyidae
                Nephtys longosetosa (Ørsted, 1843)
            Family Nereidae
                Platynereis bicanaliculata (Baird, 1863)
            Family Goniadidae
                Glycinde polygnatha (Hartman, 1950)
            Family Pholoididae
                Pholoe sp.
            Family Phyllodocidae
                Phyllodoce sp.
                Eulalia sp.
            Family Polynoidae

Harmothoe imbricata (Linnaeus, 1766)
Family Syllidae
Exogon lourei (Berkeley & Berkeley, 1938)
Order Spionida
Family Spionidae
Pygospio sp.
Prinospio jubata
Sphiophanes sp.
Polydora sp.
Class Oligochaeta
Unidentified species
Phylum Mollusca
Class Gastropoda
Subclass Opisthobranchia
Order Cephalaspidea
Gastropteron pacificum
Subclass Prosobranchia
Order Archaeogastropoda
Family Trochidae
Margarites sp.
Order Mesogastropoda
Family Lacunidae
Lacuna sp.
Family Rissoidae
Alvania sp.
Order Neogastropoda
Family Nassariidae
Nassarius mendicus (Gould, 1849)
Class Bivalvia
Order Veneroida
Superfamily Galeommatoidea
Family Cardiidae
Clinocardium nuttallii (Conrad, 1837)
Nemocardium centifilosum (Carpenter, 1864)
Unidentified species
Family Tellinidae
Macoma nasuta (Conrad, 1837)
Tellina bodegensis Hinds, 1845
Phylum Arthropoda
Subphylum Crustacea
Class Branchiopoda
Order Cladocera
Family Podonidae
Podon leuckarti (G. O. Sars, 1862)
Class Ostracoda
Suborder Myodocopina

Euphilormedes carcharodonta (Smith, 1952)
Suborder Podocopida
Unidentified ostracod species 1
Unidentified ostracod species 2
Class Cirripedia
Balanus glandula Darwin, 1854
Unidentified cyprid larvae
Class Copepoda
Order Callanoida
Unidentified species
Order Harpacticoida
Harpacticus sp.
Tisbe sp.
Ectinosoma melaniceps
Orthopsyllus illgi
Nannopus palustris
Class Malacostraca
Subclass Phyllocarida
Order Leptostraca
Family Nebaliidae
Nebalia pugettensis (Clark, 1932)
Subclass Peracarida
Order Cumacea
Family Lampropidae
Lamprops sp.
Family Leuconiidae
Nippleucon hinumensis (Gamo, 1967)
Family Nannastacidae
Cumella vulgaris (Hart, 1930)
Order Tanaidacea
Family Paratanaidae
Leptochelia dubia
Family Tanaidae
Sinelobus stanfordi
Order Isopoda
Suborder Asellota
Munna ubiquita Menzies, 1952
Suborder Epicaridea
Cryptoniscid larva
Order Amphipoda
Superfamily Gammaroidea
Family Anisogammaridae
Eogammarus sp.
Superfamily Corophioidea
Family Corophiidae
Corophium sp.

Superfamily Leucothoidea
Family Pleustidae
Thorlaksonius sp.
Suborder Caprellidea
Family Caprellidae
Caprella sp.
Caprella verrucosa (Boeck, 1872)
Order Decapoda
Infraorder Caridea
Family Hippolytidae
Heptacarpus sp.
Infraorder Anomura
Family Paguridae
Pagurus sp.
Infraorder Brachyura
Family Atelecyclidae
Telmessus cheiragonus (Tilesius, 1815)
Family Grapsidae
Hemigrapsus oregonensis (Dana, 1851)
Phylum Phoronida
Family Phoronidae
Phoronis sp.
Phylum Echinodermata
Class Ophiuroidea
Family Amphiuridae
Amphiodia occidentalis (Lyman, 1860)
Phylum Chordata
Subphylum Urochordata
Order Doliolida
Class Larvacea
Oikopleura dioica Fol, 1872

Appendix II. Organisms collected in epibenthic samples from three stations in the Georgia Pacific Log Pond (SS-74, SS-75, SS-76) and from two reference stations in Chuckanut Bay (CH-1, CH-2).

Annelida

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Armandia brevis	5	30	515	10	14
Capitella capitata	0	0	4	0	0
Cossura sp.	0	0	2	8	6
Eulalia sp.	2	0	0	0	5
Exogon lourei	3	17	3	0	0
Glycinde polygnatha	0	0	0	196	0
Harmothoe imbricata	14	26	2	9	31
Leitoscoloplos pugettensis	1	0	5	16	62
Nephtys longosetosa	0	0	0	0	6
Owenia fusiformis	352	420	0	16	387
Pherusa sp.	2	0	0	0	84
Pholoe sp.	16	13	4	8	87
Phyllodoce sp.	0	0	0	0	2
Platynereis bicanaliculata	8	3	0	0	5
Polydora sp.	7	7	2	0	12
Pygospio sp.	0	0	0	0	2
Unidentified oligochaete	6	19	35	8	14

Mollusca

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Alvania sp.	0	210	0	0	0
Clinocardium nuttallii	3	25	0	16	56
Gastropteron pacificum	0	0	2	0	3
Lacuna sp.	0	10	3	8	0
Macoma nasuta	173	409	3	44	194
Margarites sp.	4	92	0	0	5
Nassarius mendicus	0	8	0	8	0
Unidentified bivalve (Family Cardiidae)	165	129	16	93	77
Tellina bodegensis	0	0	0	5	0

Crustacea

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Balanus glandula	0	13	9	0	0
Caprella sp.	2	0	0	0	0
Chironomidae	0	0	4	0	0
Corophium sp.	31	61	0	5	42
Cumella vulgaris	57	180	0	34	28
Ectinosoma melaniceps	305	609	75	48	1089

Eogammarus sp.	16	8	2	12	26
Harpacticus sp.	963	1203	3545	802	1947
Hemigrapsus oregonensis	0	4	0	0	0
Heptacarpus sp.	9	18	0	0	0
Leptochelia dubia	8	19	0	0	0
Munna ubiquita	48	49	0	0	0
Nannopus palustris	29	65	592	0	36
Nebalia pugettensis	3	0	0	0	0
Nippleucon hinumensis	9	10	0	0	35
Orthopsyllus illigi	248	45	8	12	149
Podon leuckarti	69	47	203	64	76
Sinelobus stanfordi	0	0	4	0	0
Tisbe sp.	2809	4653	556	3045	6407
Unidentified callanoid copepod	296	532	94	294	72
Unidentified ostracod species 1	47	46	3	8	2
Unidentified cryptoniscid larva	0	4	0	0	0
Unidentified cyprid larva	48	50	64	40	169
Unidentified zoae larva	3	3	0	8	0

Miscellaneous

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Unidentified foraminiferans	33	73	87	457	2401
Unidentified nematodes	3225	2496	4381	2881	19276
Phoronis sp. (Phoronida)	0	3	0	0	0
Oikopleura dioica (Urochordata)	0	6	0	0	0

Appendix III. Organisms collected in ponar samples from three stations in the Georgia Pacific Log Pond (SS-74, SS-75, SS-76) and from two reference stations in Chuckanut Bay (CH-1, CH-2).

Annelida

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Armandia brevis	10	10	40	10	0
Capitella capitata	0	2	0	0	0
Cossura sp.	0	0	0	10	3
Eulalia sp.	0	0	0	0	3
Exogon lourei	0	0	0	15	0
Glycinde polygnatha	0	1032	0	10	19
Harmothoe imbricata	0	0	0	10	3
Leitoscoloplos pugenttensis	0	8	130	0	3
Mediomastus sp.	20	2	0	10	0
Nephtys longosetosa	0	42	40	0	0
Owenia fusiformis	3046	2642	0	275	1040
Pectinaria sp.	0	0	0	0	3
Pholoe sp.	0	12	0	35	15
Phyllodoce sp. #7	10	14	20	5	6
Platynereis bicanaliculata	0	0	0	0	3
Prinospio jubata	0	6	0	0	0
Sphiophanes sp.	0	6	0	0	0
Unidentified oligochaete	18	12	40	0	0

Mollusca

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Clinocardium nuttalli	22	26	0	0	37
Gastropteron pacificum	0	1	0	0	0
Macoma nasuta	86	144	40	0	3
Tellina modesta	0	34	0	0	0
Alvania sp.	0	36	0	0	3
Margarites sp.	0	28	0	0	3
Unidentified bivalve (Family Cardiidae)	0	44	0	15	58
Lacuna sp.	0	36	0	20	28

Crustaceana

	Station				
	CH-1	CH-2	SS-74	SS-75	SS-76
Balanus glandula	60	16	20	85	9
Caprella verrucosa	2	0	0	0	0
Corophium sp.	0	6	0	15	0
Cumella vulgaris	0	60	0	0	15
Ectinosoma melaniceps	0	2	0	0	0

Euphilormedes carcharodonta	0	4	0	0	0
Harpacticus sp.	0	6	0	0	0
Hemigrapsus oregonensis	0	0	0	5	0
Heptacarpus sp.	30	28	0	0	0
Leptochelia dubia	0	10	0	0	0
Munna ubiquita	0	12	0	0	0
Nannopus palustris	0	0	0	5	0
Nippleucon hinumensis	0	4	0	0	19
Pagurus sp.	0	0	0	14	0
Sinelobus stanfordi	0	38	0	0	0
Telmessus cheiragonus	0	2	0	0	0
Thorlaksonius sp.	0	6	0	0	0
Tisbe sp.	30	4	0	0	0
Unidentified callanoid copepod	20	0	0	0	0
Unidentified ostracod species 2	0	0	0	15	0
Unidentified cyprid larva	0	0	20	0	0

Miscellaneous

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Unidentified foraminiferans	24	28	40	55	0
Unidentified nematodes	1328	738	1210	615	1209
Amphiodia occidentalis (Enchinodermata)	0	4	0	0	0
Fish	0	0	0	0	3