YEAR 2 MONITORING REPORT

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

Prepared for

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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. The integrated remediation and habitat restoration project was performed as an Interim Remedial Action under the authorities of the State Model Toxics Control Act, 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 a Clean Water Act Permit administered by the U.S. Army Corps of Engineers.

Beginning shortly after construction, G-P performed the first year of 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. The first year monitoring, completed seven months following construction, documented successful placement of the cap, development of required cap strength to generally resist erosion, and initial colonization and utilization of the new habitat by a range of endemic species.

To further evaluate cap stability and chemical integrity, and to document the continued development of habitat functions within the Log Pond, G-P conducted a second year of post-construction monitoring beginning in spring 2002 (Year 2 post-construction). This report presents data collected during the Year 2 monitoring, with results as summarized below:

- Bathymetric monitoring verified the continued physical stability and integrity of the cap/habitat surface, and documented net accretion on the cap from regional sediment deposition. Localized zones of intertidal erosion (greater than 1 foot loss of elevation relative to Year 0 conditions) were observed along portions of the Log Pond shoreline, but were limited to relatively small areas immediately adjacent to steep riprap banks. Overall, the cap thickness documented during the Year 2 monitoring is consistent with objectives set forth in the remedial design for this project. However, to limit further embankment erosion, G-P is currently evaluating an integrated shoreline stabilization/habitat enhancement for appropriate sections of the Log Pond. These enhancements, which might include further development of existing habitat functions within the Log Pond by softening the existing shoreline, will be developed in coordination with the cleanup/redevelopment study of the adjacent former Chlor-Alkali Facility uplands, currently being performed under a separate Agreed Order between G-P and Ecology.

- Well point 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 surface sediments of the cap/habitat layer were well below SQS chemical criteria. These data indicate chemicals are not migrating into the cap/habitat layer at levels of potential concern.
- Consistent with the water and sediment quality data, juvenile Dungeness crab whole-body total mercury concentrations in the Log Pond area remain low and are within the low end of the range of values detected in the Bellingham Bay regional reference area near Portage Island.
- Epibenthic and benthic monitoring data indicate that the macroinvertebrate community is now well established in the Log Pond and continues to develop towards a community structure similar to that found in the Chuckanut Bay reference area.
- Fish sampling in the Log Pond documented utilization by juvenile salmonids during their spring outmigration. Five salmonid species (chinook, coho, chum, pink, and steelhead) and three forage fish species were collected in the Log Pond during fish sampling activities.
- Native eelgrass (*Zostera marina*) was observed colonizing the shallow subtidal elevations of the cap/habitat layer. Eelgrass colonization is an unexpected additional benefit of the habitat restoration action.

The Year 2 monitoring data document the continued success of the integrated cleanup and habitat restoration action. Physical, chemical, and biological monitoring of the Log Pond will continue during Years 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 2001a). 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 (Anchor 2001a).

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 2001a), 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. The Year 1

Monitoring Report (Anchor 2001b) presented 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 maintained its integrity following construction, and had 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 SMS Sediment Quality Standards (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.

This monitoring report presents data collected to satisfy the Year 2 monitoring requirements of the OMMP. Monitoring activities during Year 2 included:

- A detailed bathymetry survey (using methods equivalent to those employed during the Year 0 and Year 1 monitoring) to document areas of net accretion and/or erosion on the Log Pond surface, and to generally assess cap stability.
- Surface sediment chemical monitoring throughout the Log Pond to evaluate whether surface sediments within the Log Pond continue to be maintained below SQS chemical criteria.
- Sampling of seepage quality along the Log Pond embankment to evaluate whether surface water quality protection objectives continue to be met 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, as well as juvenile salmonid utilization of the restored habitat.
- Bioaccumulation sampling within the Log Pond and in a regional reference area (near Portage Island), to demonstrate the protectiveness of the cap in controlling bioaccumulation exposures and restoration of aquatic habitat.

Results of the Year 2 monitoring are presented in the following sections of this report.

2 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 3 – Cap 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 report text.

Appendices provide supporting project documentation and are organized as follows:

- Appendix A – Well Point Field Logs
- Appendix B – Laboratory Report – Well Point Chemistry
- Appendix C – Data Validation Reports for Well Point and Sediment Chemistry
- Appendix D – Surface Sediment Field Logs
- Appendix E – Bingham et al. (2002), Huxley College Report – The Log Pond Restoration Project: Structure and Function of the Benthic Community – Year 2 Report
- Appendix F – Laboratory Report – Juvenile Crab Tissue Bioaccumulation Report

3 CAP 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 2001a), 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.

Monitoring conducted in Year 1, seven months after construction, verified that capping materials placed at the Log Pond had not been eroded significantly by vessel propeller wash or storm wave forces. A comparison of the February 2001 baseline bathymetry (Year 0) with the October 2001 survey (Year 1) 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 (Anchor 2001b). 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. The Year 1 thickness of the Log Pond cap/habitat was consistent with objectives set forth in the Agreed Order and associated remedial design (Anchor 2000). Year 1 data also verified remedial design predictions that the surface of the Log Pond cap/habitat had developed suitable strength to generally resist further erosion.

In accordance with methods specified in the OMMP (Anchor 2001a), a bathymetric survey of the Log Pond was again conducted in Year 2 to document areas of net accretion and/or erosion on the Log Pond surface, and to generally assess cap stability. The bathymetric survey was performed on October 1, 2002, over the full extent of the capping area, approximately 19 months after completion of construction. In order to support detailed comparisons, survey methods and transect locations were equivalent to methods used during the initial February 2001 (Year 0) survey and Year 1 monitoring in October 2001.

A comparison of the Year 0 baseline bathymetry with the October 2002 survey is presented in Figure 4. Consistent with the Year 1 monitoring, more than 95 percent of the cap/habitat surface exhibited either no discernable change in elevation, or significant net accretion (greater than 0.5 feet accumulation) over the 19-month period. The area-weighted average elevation of the Year 2 cap/habitat surface was slightly higher (net accretion) relative to Year 1 conditions, likely as a result of continued deposition of regional sediments within the Log Pond areas.

Localized erosional areas were noted along the inshore margin of the cap/habitat surface immediately adjacent to relatively steep riprap embankments. These findings are consistent with the expected redistribution and equilibration of the new sediment surface predicted during Remedial Design (Anchor 2000). The areal extent of shoreline erosion expanded somewhat from the Year 1 monitoring, and typically varied between 0.5 and 2.0 feet. Localized areas of erosion previously identified in the center of the cap/habitat surface during Year 1 monitoring now exhibit no discernable change from the baseline post-construction data, indicating sediment redistribution in the center between Years 1 and 2.

Based on the October 2002 bathymetric survey, the majority of the former Log Pond sediment surface is presently covered by more than 3 feet of cap/habitat restoration material within 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 is up to 10 feet thick within the interior of the project area (Figure 5).

The Year 2 bathymetric survey data collected at the Log Pond verify that the majority of capping materials placed at the Log Pond have not been eroded significantly by vessel propeller wash or storm wave forces. Moreover, the Year 2 thickness of the entire Log Pond cap/habitat is consistent with objectives set forth in the Agreed Order and associated remedial design (Anchor 2000). Periodic disturbances of the cap/habitat 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 5 and 10, as set forth in the OMMP.

In part to further stabilize the existing embankment and minimize future erosion, G-P is currently evaluating an integrated shoreline stabilization/habitat enhancement for appropriate sections of the Log Pond. These enhancements, which might include further development of existing habitat functions within the Log Pond by softening the existing shoreline, will be developed in coordination with the cleanup/redevelopment study of the adjacent former Chlor-Alkali Facility uplands, currently being performed under a separate Agreed Order between G-P and Ecology (see Section 4).

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 conditions.

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 soil and 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 2001 implementation 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 developed.

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 2 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.

Well point samples collected during Year 1 monitoring were similar to or lower than pre-construction baseline concentrations (Anchor 2001b). Year 1 water quality monitoring data collected at the Log Pond indicated compliance of seepage discharges with State Surface Water Quality Standards and also verified 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 Year 2 well point monitoring.

4.1 Well Point Sampling Activities

Water quality monitoring was conducted on May 15, 2002, at two 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 1. 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 A.

The 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 just before and after low tide (WP-1 and WP-2, respectively), in order to characterize minimum tidal dilution conditions. Tide levels were –1.7 feet and –1.9 feet mean lower low water (MLLW) at WP-1 and WP-2, respectively, at the time of sampling. 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).

Sample collection necessitated two minor deviations from the OMMP:

- Well point station WP-2 was sampled in the same location as sampled in Year 1 (2001). This location is approximately 100 feet north of the location proposed in the OMMP. This adjustment was necessary because the original site did not exhibit discernable seepage. In Years 1 and 2, the WP-2 sample location was positioned within a visible seep, and is more representative of local discharges.

- As in Year 1, a hand-auger and sand pack were not needed for the installation of well points during Year 2 monitoring. Site conditions were suitable for direct installation of the well points. That is, the well points were pushed in by hand. Turbidity measurements indicated that water of suitably low turbidity (less than 50 nephelometric turbidity units) was withdrawn from the well points within a minute of the start of sampling/pumping activities.

4.2 Field Quality Assurance Sampling

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 (0.0015 ug/L) detected in the filter blank.

4.3 Well Point Chemical Analyses

Two well point samples, one each from WP-1 and WP-2, were submitted to Frontier Geosciences, Inc., for low-level total and dissolved mercury and total suspended solids 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; however, total suspended solid results are considered estimates because the holding time was exceeded by two days. Laboratory and data validation reports for well point chemical determinations are presented in Appendices B and C, respectively.

4.4 Well Point Water Quality Results and Discussion

As discussed in the Engineering Design Report (Anchor 2000), dissolved mercury concentrations are more representative of mercury available for transport than total mercury concentrations. Year 2 dissolved mercury concentrations at WP-1 and WP-2 were 0.0721 ug/L and undetected at 0.0026 ug/L, respectively (Table 2). The Year 2 dissolved mercury concentrations at both stations were well below the acute (1.8 ug/L) water quality standards for mercury; however, the chronic water quality standard for mercury (0.025 ug/L) was exceeded at station WP-1. In Year 1, dissolved mercury concentrations at WP-1 and WP-2 were 0.0059 ug/L and 0.0074 ug/L, respectively (Anchor 2001b). Dissolved mercury concentrations at WP-1 increased from Year 1 to Year 2, but decreased at WP-2.

Total mercury concentrations detected at stations WP-1 and WP-2 were 0.1550 ug/L and 0.0313 ug/L, respectively. In Year 1, total mercury concentrations at WP-1 and WP-2 were 0.0579 ug/L and 0.0304 ug/L, respectively (Anchor 2001b). Thus, total mercury concentrations at WP-1 increased from Year 1 to Year 2, but remained relatively constant and low at station WP-2.

Although mercury concentrations detected at WP-1 and WP-2 remain 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 screening-level tidal dilution modeling and tidal series monitoring performed at other similar shoreline sites within the Whatcom Waterway area (Anchor and Aspect 2001; ReTec 2001; Anchor 2002), 48-hour tidally-averaged seepage concentrations are expected to be at least six times lower than peak (i.e., low tide) seep discharge concentrations. Based on this comparison, compliance with water quality and sediment protection criteria set forth in the Engineering Design Report is indicated. However, as discussed above, G-P is currently evaluating further upland and shoreline remediation actions, along with concurrent habitat restoration actions within the Log Pond shoreline area (e.g., near riprap and bulkhead structures) as part of the ongoing RI/FS of the former G-P Chlor-Alkali Facility. These pending future actions will provide for further source controls and additional protection of the Log Pond shoreline area.

As set forth in the OMMP, well point monitoring will continue during Years 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 set forth in the OMMP, sampling of surface sediments at four Whatcom Waterway RI/FS locations and in two shoreline seepage zones (near WP-1 and WP-2) are used to determine compliance with SMS criteria. 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 centimeters (cm) of sediment (Anchor and Hart Crowser 2000). 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).

Year 1 sediment chemistry sampling verified that surface sediment chemical concentrations were well below SQS chemical criteria immediately following construction of the Log Pond cap/habitat restoration action. These data also indicated that the capping method successfully minimized mixing of underlying contaminated sediments into the bottom of the clean cap, and verified that chemicals were not migrating vertically into the cap/habitat layer. As set forth in the OMMP, no subsurface sediment sampling was necessary during the Year 2 monitoring.

This section discusses the collection activities, sample analyses, data quality assessment, and results associated with the Year 2 sediment samples collected as part of the OMMP. Sample collection logs for surface 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 locations within the G-P Log Pond on May 15, 2002, in accordance with the OMMP. Surface sediment sampling locations are depicted in Figure 6 and station coordinates are provided in Table 1.

5.2 Field Quality Assurance Sampling

One equipment rinsate blank and one field blank were submitted to the laboratory with the surface 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 sample jar. The field blank was collected by pouring distilled water directly from its container into an appropriate sample jar. The rinsate and field blanks were analyzed for total mercury and extractable organic compounds. No compounds or analytes were detected in the equipment rinsate or field blanks; however, the equipment rinsate blank data were qualified as undetected with estimated reporting limits due to the extraction holding time having been exceeded (see Data Validation Report in Appendix C).

5.3 Surface Sediment Chemical/Physical Analyses

Surface 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 C of this report.

5.4 Sediment Quality Results and 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 3.

Total mercury and miscellaneous extractable organic chemical concentrations in all surface sediment samples collected within the cap/habitat layer were well below SQS chemical criteria. Consistent with the Year 1 monitoring results, no extractable organic chemicals were detected in the Year 2 surface sediment monitoring samples. Between Year 1 and Year 2, mercury concentrations increased marginally at five of the six surface sediment stations, consistent with the deposition of regional sediments (with slightly higher mercury concentrations) on the Log Pond surface (see Anchor 2000). However, mercury concentrations remain well below the SQS chemical criterion on the Log Pond surface.

As set forth in the OMMP, surface sediment monitoring within the Log Pond will continue during Years 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, verified by the results of both the Year 1 and Year 2 sediment monitoring.

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

Although the MTCA process does not require evaluation of this habitat restoration action, biological monitoring has been incorporated in the OMMP because of the integrated nature of the project. 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. Year 2 biological monitoring was performed in accordance with the OMMP.

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 were below conservative benchmark concentrations calculated to protect tribal fishers and sensitive wildlife that may consume relatively large amounts of seafood.

6.1 Epibenthic and Benthic 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 E.

6.1.1 Epibenthic and Benthic Sampling Activities

Biological sampling included collection of triplicate epibenthic and benthic samples at three stations within the Log Pond (SS-74, SS-75, and SS-76; Figure 6), and two comparable reference stations in Chuckanut Bay (Bingham et al. 2002, attached as Appendix E). 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 and benthic sampling was conducted almost exactly one year after the Year 1 data were collected and therefore data can be directly compared between years without confounding seasonal effects. Year 2 epibenthic sampling occurred on May 14 and June 24, 2002. Benthic sampling was conducted on June 24, 2002.

6.1.2 Epibenthic and Benthic 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., nematodes, annelids, molluscs, crustaceans, and echinoderms) 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. A p-value of 0.05 was used to evaluate statistical significance in all analyses.

6.1.3 Epibenthic and Benthic Re-colonization Results

No significant differences in either epibenthic or benthic biomass were observed between the Log Pond and the Chuckanut Bay reference area sites. However, a comparison of benthic biomass between stations revealed significantly higher biomass at Log Pond station SS-75 than all other sampling stations. A similar examination of epibenthic biomass data was not significant, although the data suggest that there may be a difference among Log Pond stations as SS-75 had higher biomass than the other two stations.

The examination of epibenthic community composition showed no clear site difference in the number of species between the Log Pond and Chuckanut Bay reference area samples, as many of the same species occurred at both sites. The data indicate significant increases in the number of species between the May and June sampling at both sites. Although these increases were observed at each station, the change in number of species between May and June was found to be significantly higher at the Chuckanut Bay reference area than the Log Pond.

In benthic sampling, there were no significant differences in the number of species between the Log Pond and Chuckanut Bay reference area. There were significant differences in diversity and evenness between sites, as both were slightly higher in the Chuckanut Bay reference area.

Cluster analysis results revealed that the structure of the epibenthic community was similar between the Log Pond and Chuckanut Bay. However, the epibenthic community at Log Pond station SS-76 appeared to be an outlier with exceptionally high numbers of nematodes and harpacticoid copepods. The structure of the benthic community was significantly different between the Log Pond and Chuckanut Bay reference area. The most striking pattern was the separation of SS-75 from all other stations due to the exceptionally high abundance of a polychaete (*Owenia fusiformis*) at the station. Observed differences between the Log Pond and Chuckanut Bay benthic communities were driven by differing abundances of polychaetes, crustaceans, and gastropods.

As described in more detail in Appendix E, the Year 2 benthic and epibenthic sampling data document the continuing development of a healthy invertebrate community within the Log Pond, consistent with early colonization documented during the Year 1 monitoring (Anchor 2001b). In accordance with the OMMP, benthic and epibenthic sampling will continue during Years 5 and 10 to provide information on long-term colonization of the macroinvertebrate communities in this area.

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 Dungeness crab tissue mercury bioaccumulation sampling was conducted on July 22, 2002, at three locations (Stations SS-74, SS-75, and SS-76) within the Log Pond and two Chuckanut Bay reference stations in accordance with the OMMP. However, even after repeated attempts, no juvenile Dungeness crabs were retrieved in samplers deployed at the Chuckanut Bay reference area sampling. Following consultation with Pete Adolphson of Ecology and Mike MacKay of the Lummi Nation Natural Resources Department, alternate reference stations were established in west Bellingham Bay near Portage Island. These stations were sampled on August 21, 2002, resulting in the collection of three reference samples, which were then submitted to the testing laboratory. G-P Log Pond juvenile crab sampling locations are depicted in Figure 6 and station coordinates are provided in Table 1. Reference area locations are shown on Figure 1.

Sample collection and processing procedures for the juvenile crab sampling did not deviate from the OMMP except for the change in reference area location discussed above and the availability of three replicate samples from one reference station rather than two.

6.2.2 Juvenile Crab Sample Analysis

Three juvenile crab replicate samples from each of the three Log Pond sampling stations and the Portage Island reference area were submitted to Frontier Geosciences, Inc. for the analysis of total mercury. Each replicate was comprised of two to three juvenile crabs. 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, except for the matrix duplicate relative percent difference for sample Ref-1 which was elevated at approximately 54 percent. The difference between the native sample and the sample duplicate is greater than can be explained by analytical variability and may indicate insufficient homogenization of the sample. Nevertheless, all data for this project are considered acceptable for use. The laboratory report for juvenile crab tissue bioaccumulation is provided in Appendix F.

6.2.3 Juvenile Crab Results

Juvenile Dungeness crabs ranging in carapace width (straight line distance across the carapace including the spines) from 60 to 83 millimeters (mm) were collected from the Portage Island reference area. Comparably-sized juvenile Dungeness crabs ranging in carapace width from 52 to 78 mm were collected from the Log Pond.

Whole-body total mercury concentrations in juvenile crab tissues (including carapace) collected from the Portage Island reference area ranged from approximately 0.02 to 0.31 milligrams per kilogram (mg/kg; wet weight basis; Table 4). By comparison, Year 2 whole-body total mercury concentrations measured in individual juvenile crab tissues collected from the Log Pond (two to three composited individuals) were at the low end of the reference area range, varying from approximately 0.01 to 0.03 mg/kg, averaging 0.020 mg/kg throughout the Log Pond area (Table 4). The average whole-body total mercury concentrations in juvenile crab tissues detected in Year 2 were also similar to pre-construction baseline levels (0.019 mg/kg) and levels measured during the Year 1 sampling (0.023 mg/kg). Juvenile Dungeness crab whole-body total mercury concentrations remain 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).

The relatively low concentrations of mercury detected in juvenile Dungeness crab whole-body tissue, relative to both regional reference values and risk-based benchmarks, further demonstrate the protectiveness of the cap in controlling bioaccumulation exposures and restoration of aquatic habitat. As set forth in the OMMP, bioaccumulation sampling will continue during Years 5 and 10, to document the continued effectiveness of the action.

6.3 Fish Utilization

Using methods described in the OMMP, juvenile salmonid utilization of the Log Pond was evaluated during the spring outmigration period. Scientific collection permits from the National Marine Fisheries Service (NMFS permit 1319), U.S. Fish and Wildlife Service (USFWS permit TE040557-0), and the Washington Department of Fish and Wildlife (WDFW permit 02-202) were obtained for this investigation.

6.3.1 Fish Sampling Activities

Beach seine sampling was conducted to investigate fish utilization of the Log Pond. Sampling was conducted at three stations within the Log Pond and two comparable reference stations in Chuckanut Bay. The Chuckanut Bay reference stations were near those used for the epibenthic and benthic sampling activities. Beach seine sampling was conducted May 22, June 26, and July 18 to monitor utilization during the juvenile salmonid outmigration period. Sampling was conducted during rising and high tide slack conditions.

6.3.2 Fish Sampling Analysis

Beach seine catches were identified to species and enumerated. Juvenile salmonids captured in the beach seine were identified to species, enumerated, and measured for forklength. Other fishes were identified to a practical taxonomic level and enumerated. All fish were released back into the water at their point of capture. Note that visual identification of juvenile salmonids to species can often be uncertain due to morphological changes that occur during transition to the estuary and initial nearshore rearing. Key features used to identify salmonids in freshwater become less apparent during this transitional phase, and ocean phase distinguishing features are also not well established. In particular, juvenile chinook and coho salmon can be difficult to distinguish.

6.3.3 Fish Sampling Results

Five salmonid species (chinook, coho, chum, pink, and steelhead) were collected in the Log Pond during the first sampling event in May (Table 5). All five species were found at more than one station at the site. Coho and pink salmon were the most numerous salmonids in the May Log Pond sampling with 71 and 41 captured, respectively. Sixteen chinook salmon were captured in May. All three of the “forage fish” species were collected in the Log Pond also. Pacific herring, surf smelt, and sand lance are denoted by NMFS and WDFW as forage fish due to their importance in the diet of salmonids.

Few salmonids were captured in the Log Pond during June and July. In June, five chinook and three coho salmon were captured in the Log Pond.

Catches in the Chuckanut Bay reference stations were slightly lower than those in the Log Pond, but exhibited a similar pattern between sampling periods. In May, salmonid catches and species diversity was highest. Catches and the number of species decreased as spring and summer progressed.

The Year 2 monitoring documented utilization of the Log Pond by juvenile salmonids during their spring outmigration. In combination with the healthy invertebrate community shown in the epibenthic and benthic sampling (see Section 6.1), these results indicate that the Log Pond provides relatively high functioning habitat along the migration corridor of Bellingham Bay.

As set forth in the OMMP, juvenile salmonid utilization of the Log Pond will continue in Years 5 and 10, to document the continued effectiveness of the restoration action. After the 5-year and 10-year monitoring periods, 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.

6.4 Eelgrass Colonization

To document initial colonization of the Log Pond cap/habitat restoration surface by native eelgrass (*Zostera marina*), a reconnaissance survey was performed of the shoreline during low tide conditions on July 22, 2002. Water visibility was relatively clear during this period, and the tide receded to –1.9 feet MLLW during a morning low tide event. The survey covered approximately three-quarters of the Log Pond shoreline. GPS locations were noted where eelgrass colonization was observed.

Eleven very small patches (between two and ten shoots) of *Z. marina* were identified, as well as 27 isolated shoots. The eelgrass was found scattered along much of the shoreline surveyed (Figure 6). No non-native eelgrass (*Z. japonica*) was observed in the Log Pond.

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, 2001a. 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, 2001b. Year 1 Monitoring Report – Interim Remedial Action Log Pond Cleanup/Habitat Restoration Project. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. December 2001.

Anchor, 2002. Preliminary Design Submittal, Holly Street Landfill Cleanup, Redevelopment, and Habitat Restoration Project. Draft Report prepared for City of Bellingham by Anchor Environmental, L.L.C, Seattle, WA. December 2002.

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.

Bingham, B. L., B. Clothier, and R. Mathews, 2001. The Log Pond Restoration Project: Structure and Function of the Benthic Community – Year 1 Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Huxley College of the Environment, Western Washington University, Bellingham, Washington. November 2001.

Bingham, B. L., B. Clothier, and R. Mathews, 2002. The Log Pond Restoration Project: Structure and Function of the Benthic Community – Year 2 Report. Prepared for Georgia Pacific West, Inc., Bellingham, Washington. Huxley College of the Environment, Western Washington University, Bellingham, Washington. November 2002.

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
Sampling Station Coordinates (Actuals)

Station ID	Latitude	Longitude
Well Points		
WP-1	48 44.7512	122 29.4727
WP-2	48 44.8108	120 29.4043
Surface Sediments		
SS-40	48 44.7918	122 29.5147
SS-75	48 44.8147	122 29.4588
SS-76	48 44.8677	122 29.3763
SS-301	48 44.7950	122 29.4492
WP-1[a]	48 44.7333	122 29.4666
WP-2	48 44.8105	122 29.3957
Crab Tissue		
SS-74	48 44.7660	122 29.4750
SS-75	48 44.8160	122 29.4400
SS-76	48 44.8670	122 29.3810
Reference Stations[b]	48 43.5900	122 37.7034

Notes:

Station coordinates are reported in NAD 83 north zone.

a) Station coordinates for this station are estimated.

b) Crabs were collected from four traps deployed in the general location of the station coordinates provided.

Table 2
Well Point Water Quality Chemistry Data

				WP-1		WP-2	
	Chemical Criteria			Year 1 (2001)	Year 2 (2002)	Year 1 (2001)	Year 2 (2002)
Parameter	Units	Chronic	Acute				
Field Measurements							
Turbidity	NTU	na	na	5	3	2	4
Conductivity	uS/cm @ 25C	na	na	46,300	41,800	23,800	20,400
Temperature	Deg C	na	na	11.9	15.9	12.4	15.1
pH	pH units	na	na	7.1	7.1	7.6	7.5
Redox	mV	na	na	-146	-138	-151	-95.0
Dissolved oxygen	mg/L	na	na	0.2	0.4	0.4	3.3
Lab Measurements							
Total susp. solids	mg/L	na	na		14.5 J		18.2 J
Mercury - dissolved	ug/L	0.025	1.8	0.0059	0.0721	0.0074	0.0026 U
Mercury - total	ug/L	0.025	1.8	0.0579	0.1550	0.0304	0.0313

Notes:

na - not applicable.

J indicates an estimated concentration.

U indicates undetected at detection limit shown.

Table 3
Surface Sediment Chemistry Data

	SMS Criteria		SS-301		SS-40		SS-75		SS-76		WP-1		WP-2	
Parameter	**SQS**	**CSL**	**Year 1 (2001)**	**Year 2 (2002)**	**Year 1 (2001)**	**Year 2 (2002)**	**Year 1 (2001)**	**Year 2 (2002)**	**Year 1 (2001)**	**Year 2 (2002)**	**Year 1 (2001)**	**Year 2 (2002)**	**Year 1 (2001)**	**Year 2 (2002)**
Conventionals (%)														
Total Organic Carbon	--	--	1.9	1.5	1.6	1.6	1	2.1	3.1	0.65	0.13	0.24	1.9	0.2
Total solids	--	--	53.6	55	68.4	69.6	72.4	63.5	56.6	75.3	83.6	77.3	66.1	84.7
Grain Size (%)														
Gravel	--	--	0	1.3	0.3	2.9	0.4	0.4	1.6	0.2	5.1	2.1	1.2	6.8
Sand	--	--	8.5	13.4	84.1	49.1	92.8	55.9	61.4	92.9	94.2	94.9	55.7	91.6
Silt	--	--	76	70.7	11.1	27.2	4.4	27	29.1	4.6	0.7	2	35.7	1.4
Clay	--	--	15.5	14.6	3.8	20.7	2.4	16.7	7.9	2.1	0.0	1	7.4	0.2
Fines	--	--	91.5	85.3	15.6	47.9	6.8	43.7	37	6.7	0.7	3	43.1	1.6
Metals (mg/kg dry wt)														
Mercury	0.41	0.59	0.11	0.25	0.12	0.26	0.07 U	0.15	0.13	0.05 U	0.05 U	0.08	0.07 U	0.15
SVOCs (ug/kg dry wt)														
2,4-Dimethylphenol	420	1200	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	19 U
2-Methylphenol	63	63	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	19 U
4-Methylphenol	670	670	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	19 U
Benzoic acid	29	29	190 U	200 U	190 U	200 U	190 U	200 U	190 U	200 U	190 U	200 U	190 U	190 U
Benzyl alcohol	360	690	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	19 U
Pentachlorophenol	57	73	95 U	99 U	97 U	98 U	94 U	98 U	96 U	98 U	96 U	98 U	95 U	96 U
Phenol	650	650	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	20 U	19 U	19 U

Notes:

U: Not detected

SQS: Exceedances are shaded

CSL: Exceedances are shaded and underlined

Table 4
Juvenile Dungeness Crab Tissue Bioaccumulation Data

Station	Sample Number	Year 1 (2001) Total Mercury (mg/kg; wet wt)	Year 2 (2002) Total Mercury (mg/kg; wet wt)	Year 1 (2001) Juvenile Crab Carapace Widths (mm)	Year 2 (2002) Juvenile Crab Carapace Widths (mm)
SS-74	SS-74A	0.0207	0.0289	59, 60, 63	57, 64, 68
	SS-74B	0.0487	0.0216	53, 58, 59	54, 60, 62
	SS-74C	0.0176	0.0187	55, 68	54, 58, 65
SS-75	SS-75A	0.0171	0.0234	56, 67	65, 78
	SS-75B	0.0237	0.0285	62, 73	54, 65
	SS-75C	0.0150	0.0215	58, 68	55, 57
SS-76	SS-76A	0.0258	0.0143	59, 68	53, 68
	SS-76B	0.0167	0.0152	56, 66	65, 71
	SS-76C	0.0237	0.00954	67, 68	52, 68
Reference[a]	Ref-1	---	0.0365	---	60, 71
	Ref-2	---	0.0199	---	83
	Ref-3	---	0.308	---	83, 83
Average Total Mercury Concentration in Log Pond Stations		**0.0232**	**0.0202**		

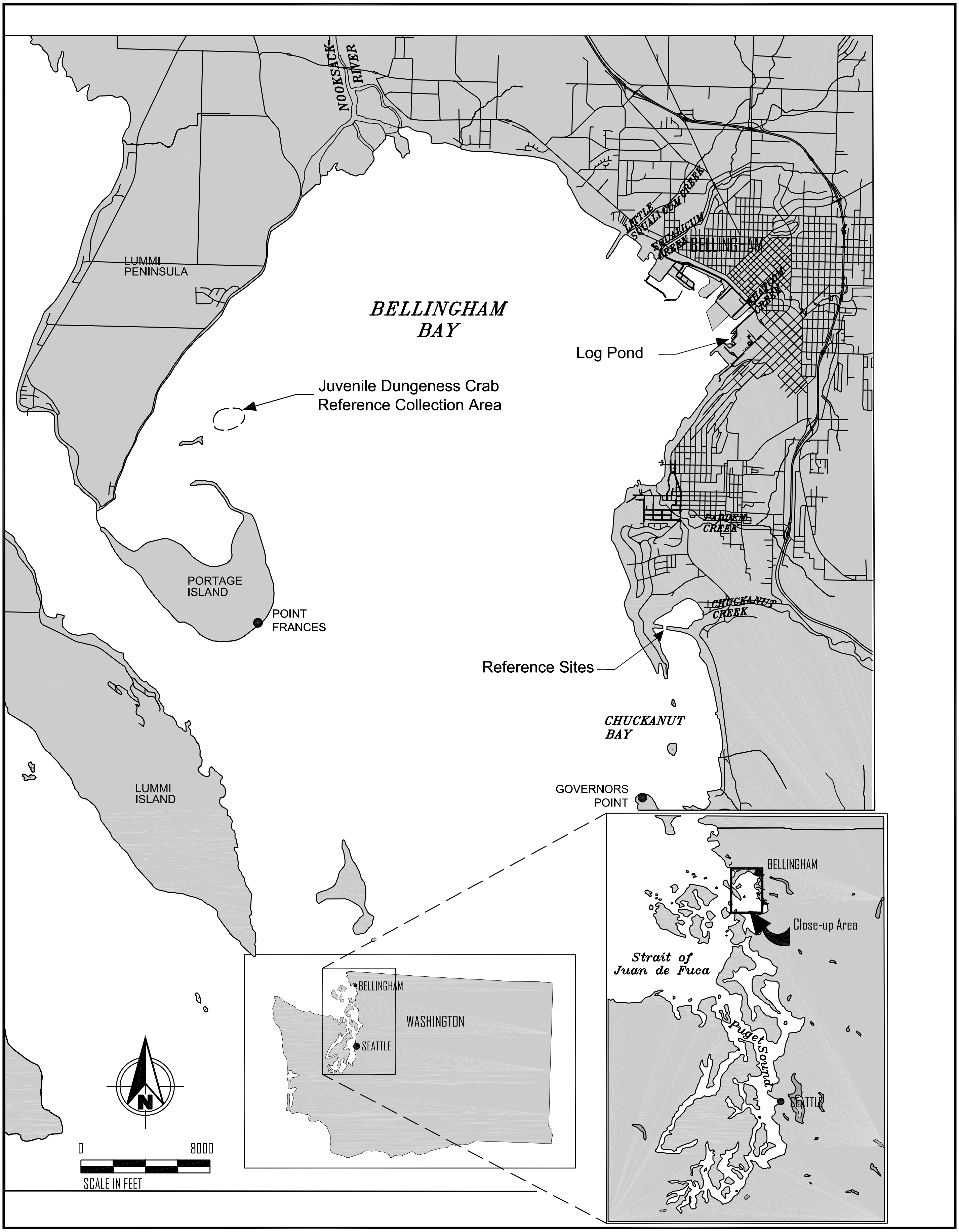
Notes:

Mercury concentrations have been blank corrected.

a) Attempts to collect juvenile Dungeness crab in the Chuckanut Bay reference stations were unsuccessful in Year 1 and Year 2. Based on input from Ecology and the Lummi Nation, a reference area near Portage Island in western Bellingham Bay was sampled in 2002 following attempts in Chuckanut Bay.

Table 5
Beach Seine Catches

		May 22, 2002					June 26, 2002					July 18, 2002				
	Station	**BS1**	**BS2**	**BS4**	**Ref 1**	**Ref 2**	**BS2**	**BS3**	**BS4**	**Ref 1**	**Ref 2**	**BS1**	**BS2**	**BS3**	**R1**	**R2**
Salmonids	Chinook salmon		6	10	7	2			5		1				1	
	Chum salmon	5	2		50	5										
	Coho salmon	32	26	13	4				3		2					
	Pink salmon	35	4	2	13											
	Steelhead		4	1												
	Unidentified Trout		1													
Other fish	Pacific herring	2														
	Surf smelt		4	10			1									
	Sand lance			1	1						2					
	Shiner perch	79	111	5	9	21	1	1	3	1	72	2		32	8	80
	Perch (unid.)									1						
	Sculpin	21	1	3	5	15	39	2		1	3	12	5	1		54
	Starry flounder	7		3			82	3	7			24	8	2		
	Threespine stickleback		1		2	1							8		9	
	Pipefish			1	5					4	1			1		
Total Salmonid Catch		72	42	26	74	7	0	0	8	0	3	0	0	0	1	0
Total Catch		181	160	48	96	44	123	6	18	7	81	38	21	36	18	134



Dec 03, 2002 10:51am rchao I:\CAD\Jobs\000030-GP Log Pond\02003001-Year2\GP-02003001-02.dwg Figure 1

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ENVIRONMENTAL, L.L.C.

Figure 1
Vicinity Map

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Dec 03, 2002 10:55am rchao

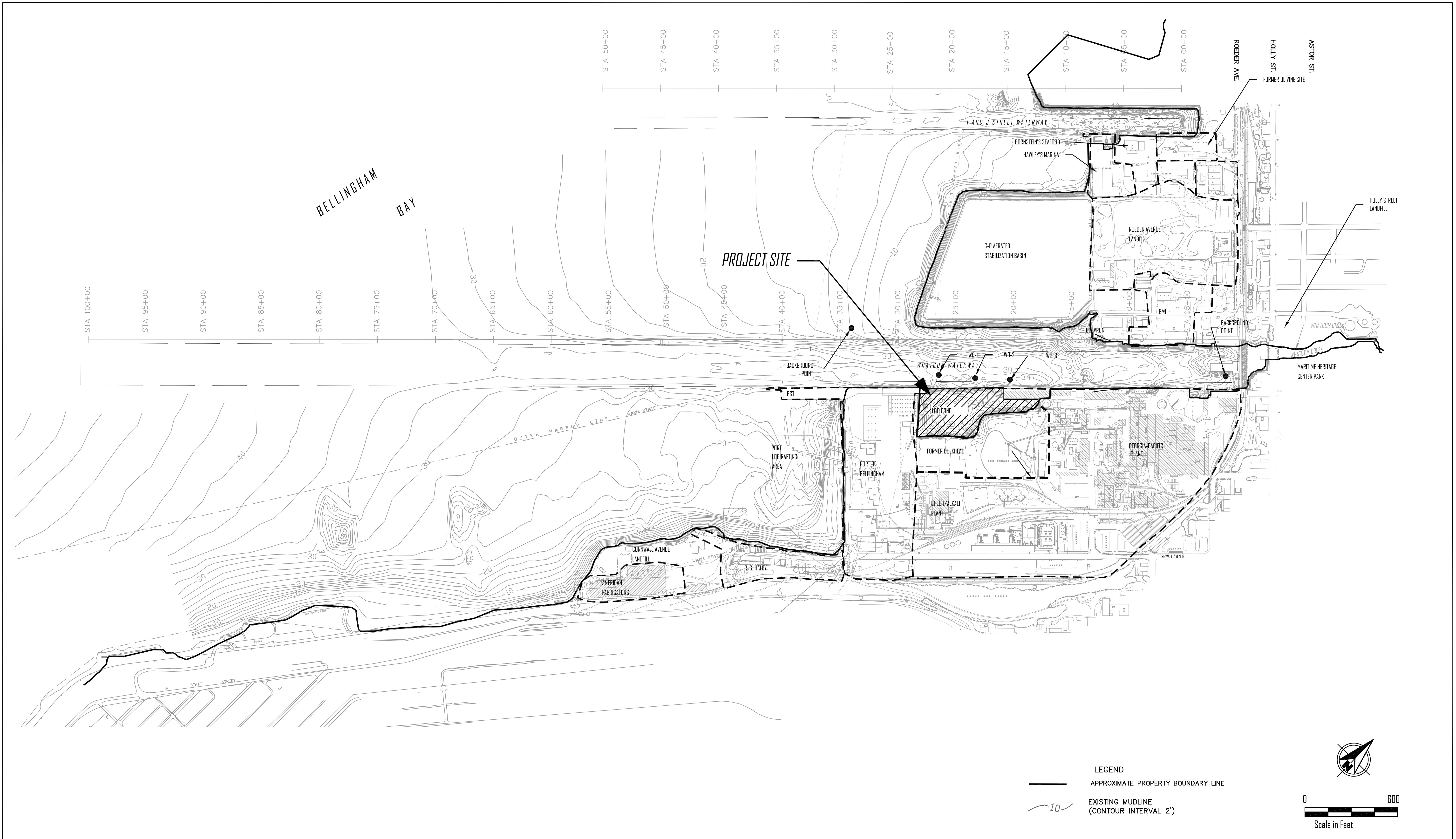

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Figure 2
Log Pond Project Area
Log Pond Cleanup and Habitat Restoration

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Dec 03, 2002 11:03am rchao

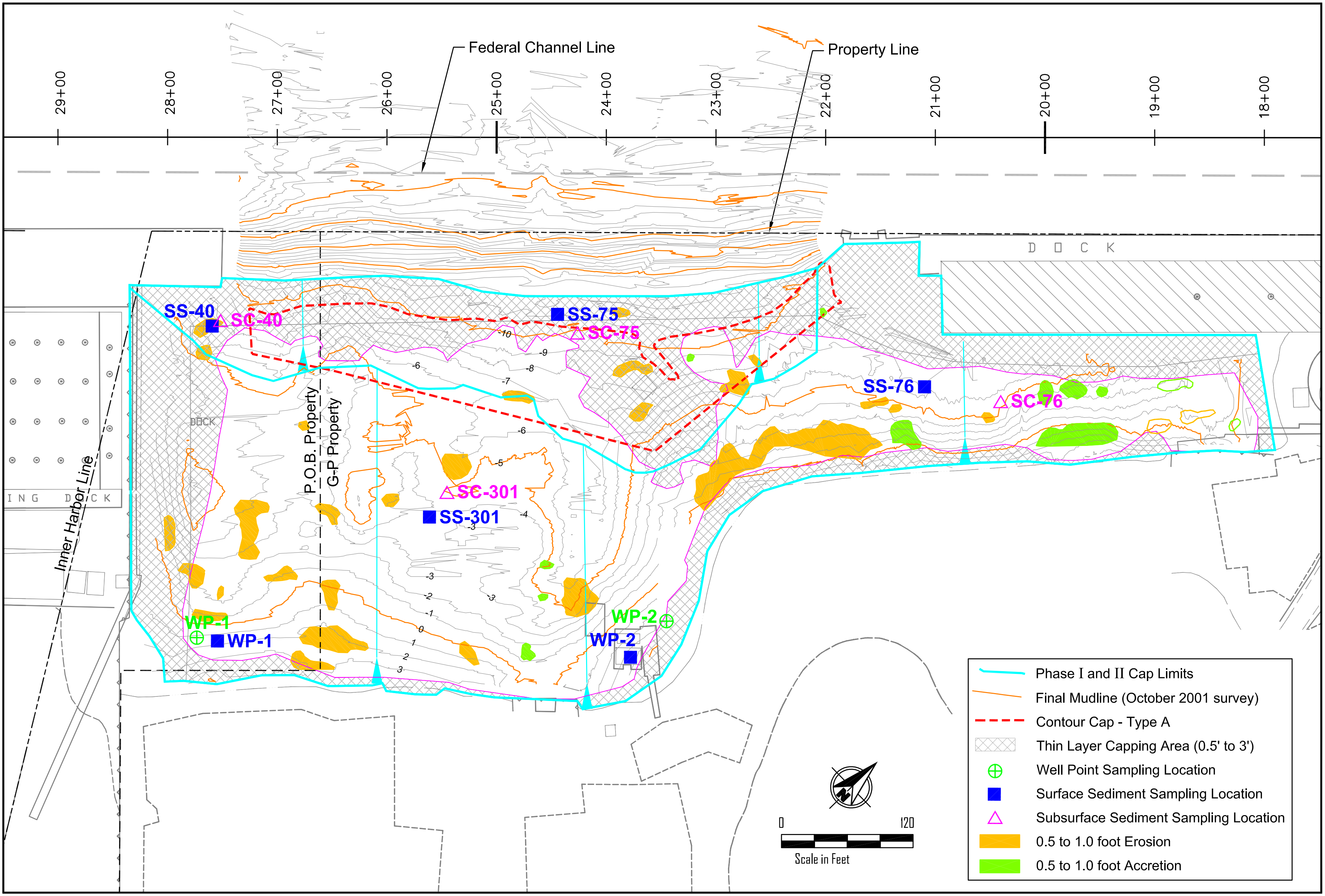

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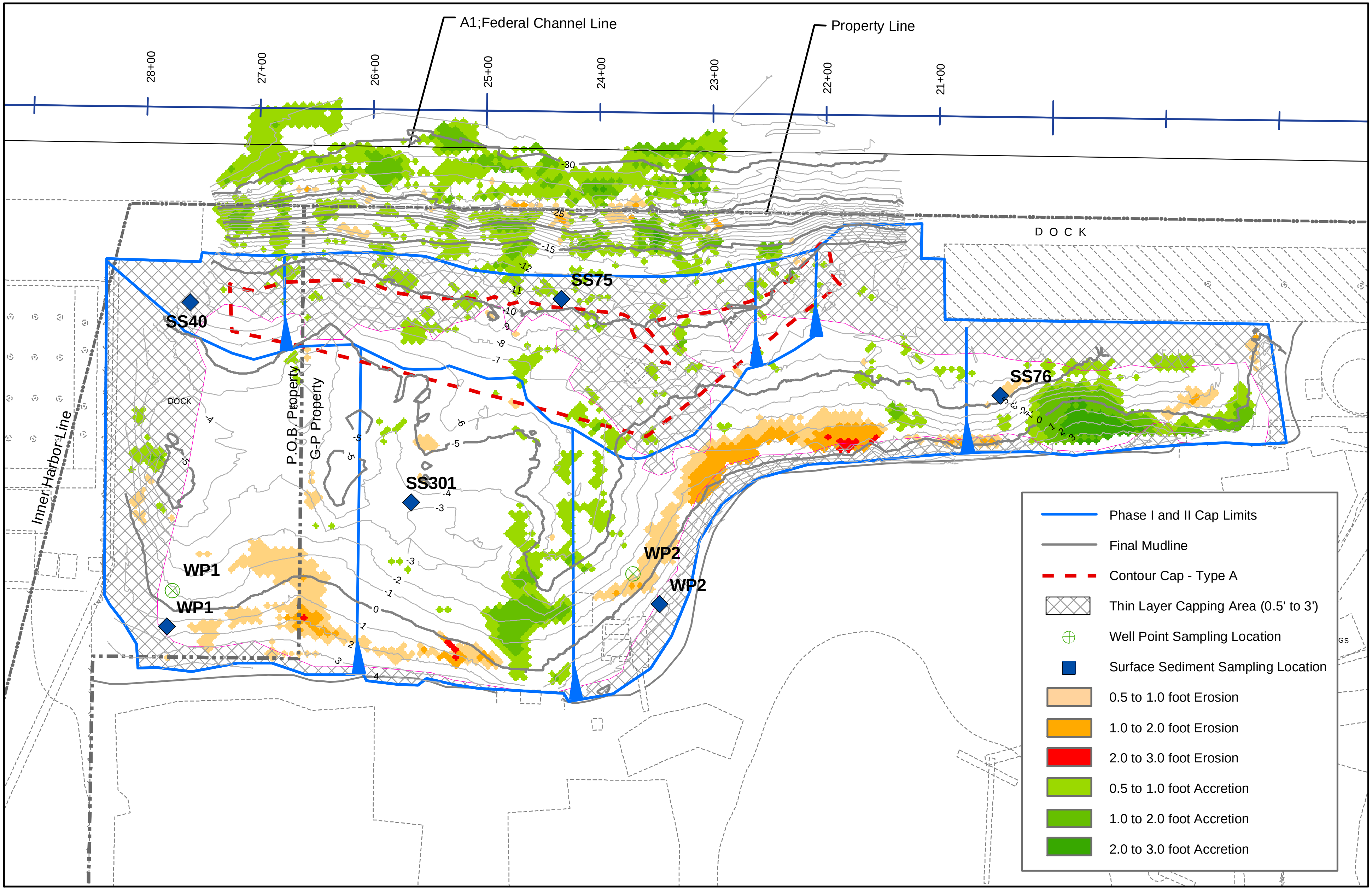
Figure 3
Change in Log Pond Surface
7 Months after Construction - October 2001



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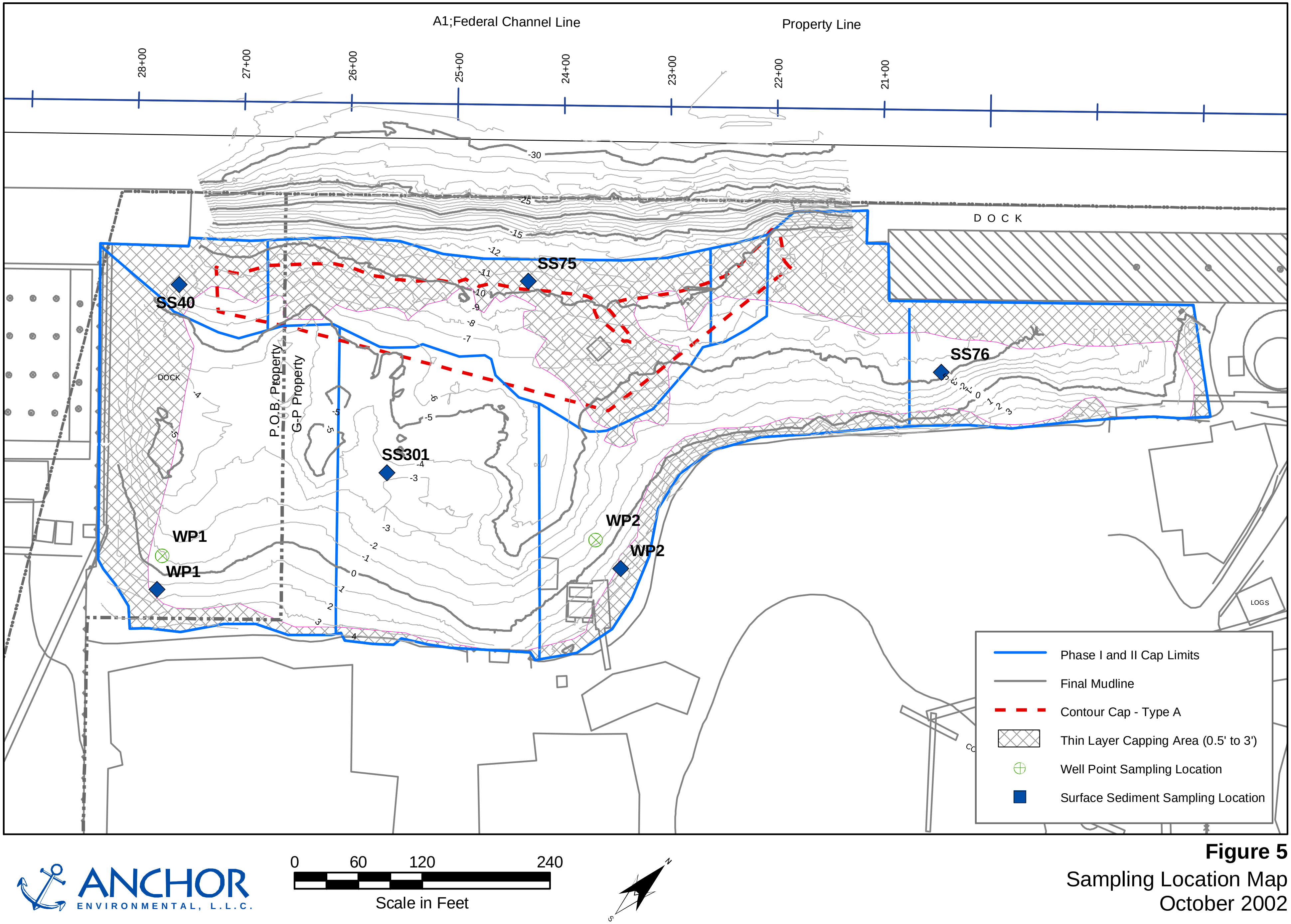
0 60 120 240
Scale in Feet

N
S

Figure 4
Change in Log Pond Surface
19 Months after Construction - October 2002



GP-02003001-02.mxd RC 11/26/02

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Figure 5
Sampling Location Map
October 2002

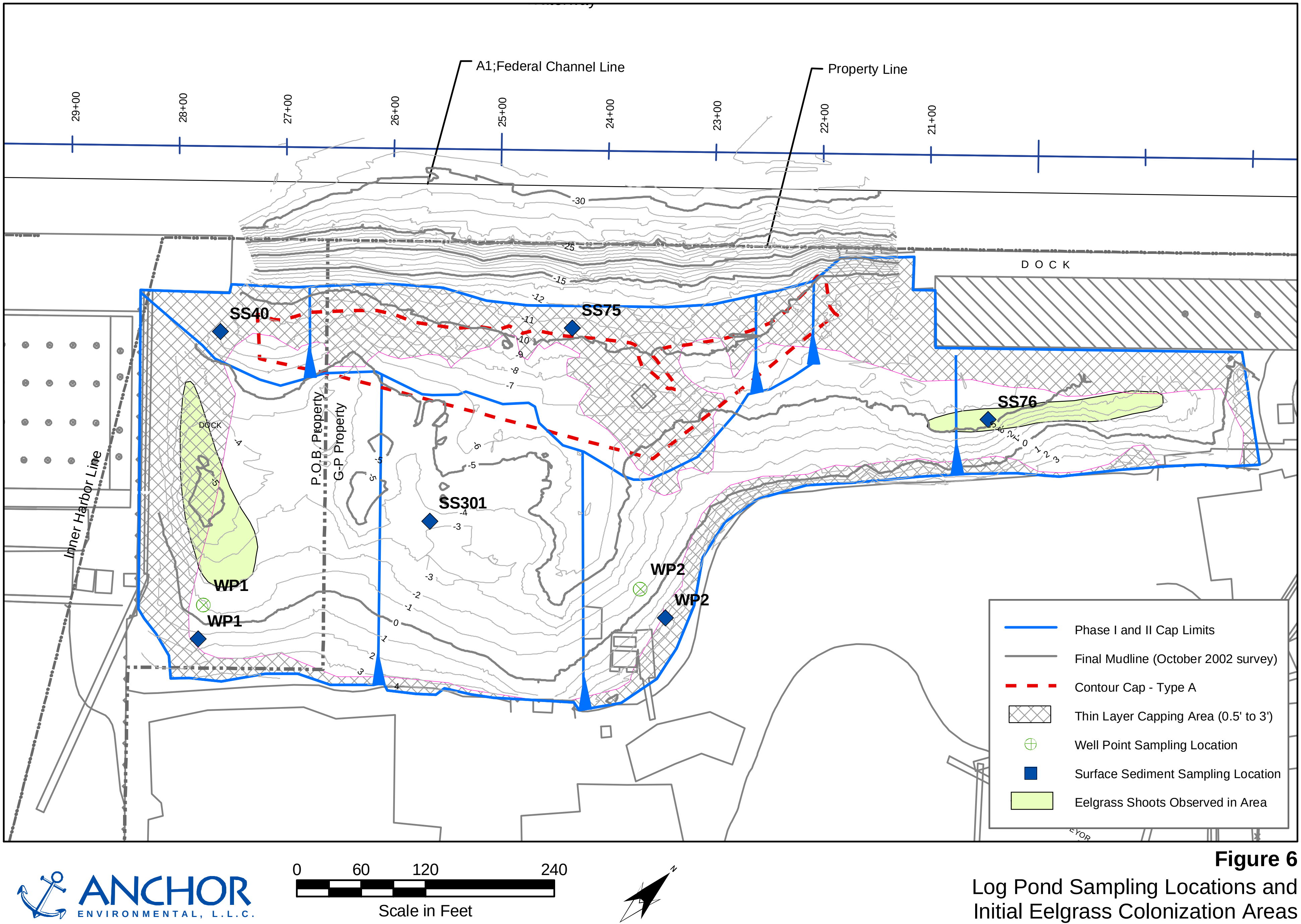

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Figure 6
Log Pond Sampling Locations and
Initial Eelgrass Colonization Areas
October 2002

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1411 4th Avenue, Suite 1210
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287-9131
www.anchorenv.com

Water Collection Form: Water Quality Monitoring

Station ID: WP-1
Date 5/15/02
Time 1150-1300hrs
Project Name: GP Log Pond
Project Number Year 2 Cap Monitoring
Coordinates UTM NAD83 meters Zone 10
Lat/[✓ Northing] 5399329
Long/[✓ Easting] 537403
Weather Observations: pt. cloudy

Time of Well Point Intstallation 1150 hrs
Flowrate 1 liter per 4 min 40 sec

Param. ---Unit--- Time	Temp. °C	D.O. mg/L	pH	Redox mV	Turb. NTU	Cond. mS/cm	Salinity ppt	TDS
1230	16.45	2.42	6.08	-9	700	40.2	26.3	
1237	16.27	0.55	7.05	-91	7.1	41.6	26.5	
1243	15.87	0.42	7.12	-138	3.0	41.8	26.7	
after sampling 1302	15.83	1.46	7.22	-107	0.3	42.6	27.2	

Evidence of floating or suspended materials: no
Evidence of oil/hydrocarbon sheen: no
Discoloration and Turbidity:

Odor [✓ none], slight, moderate, strong
H_2S, petroleum, septic

Comments: field measurements taken using a Horiba U-22TG multiparameter water quality monitoring system, U-20 series

Recorded by: Paul Schlenger

ANCHOR
ENVIRONMENTAL, L.L.C.

1411 4th Avenue, Suite 1210
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287-9131
www.anchorenv.com

Water Collection Form: Water Quality Monitoring

Station ID: WP-2

Date 5/15/02

Time 1330-1430

Project Name: GP Log Pond

Project Number Year 2 Cap Monitoring

Coordinates UTM, NAD83 meters, Zone 10

Lat/[✓ Northing]: 5399440

Long/[✓ Easting]: 537486

Weather Observations: pt. cloudy

Time of Well Point Intstallation 1330

Flowrate 1 liter in 5 min 50 sec

Param. ---Unit--- Time	Temp.	D.O.	pH	Redox	Turb.	Cond.	Salinity	TDS
	°C	mg/L		mV	NTU	mS/cm	ppt	
1356	14.57	2.28	7.37	-41	48.6	21.9	13.1	
1403	14.74	3.08	7.42	-82	12.8	21.0	12.5	
1410	15.05	3.33	7.46	-95	4.0	20.4	12.1	
after sampling 1431	15.22	4.84	7.57	-51	8.2	19.3	11.5	

Evidence of floating or suspended materials: no

Evidence of oil/hydrocarbon sheen: no

Discoloration and Turbidity:

Odor [✓ none], slight, moderate, strong
H$_2$S, petroleum, septic

Comments: TSS bottle AL-D-2522

Recorded by: Paul Schlenger

Frontier Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

June 12, 2002

Paul Schlenger
Anchor Environmental
1411 4th Avenue, Suite 1210
Seattle, WA 98101

Re: G-P Log Pond year 2 Cap Monitoring

Dear Mr. Schlenger,

Following is a high QA report for total mercury and total suspended solids in water samples collected for the GP Log Pond Project May 15, 2002. Samples were analyzed using high level (CLP-style) QA determination. Please feel free to contact me should you have any questions or concerns regarding this report.

Best Wishes,

Lucas Hawkins

Lucas Hawkins
Project Manager

206 622 6960
fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

Total Hg Total Suspended Solids in Water
Anchor Environmental - GP Log Pond Year 2 Cap Monitoring

TABLE OF CONTENTS

Total Mercury in Water-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Total mercury analyzed: May 28, 2002 (THG11-020528-1)
Total suspended solids analyzed: May 24, 2002 (TSS-020524-1)

Sample Identification	**Date Collected**	**Total Hg, ng/L***	**TSS mg/L**
WP-1D	5/15/2002	72.1	N/R
WP-1T	5/15/2002	155	N/R
WP-1	5/15/2002	N/R	14.5
WP-2D	5/15/2002	2.59	N/R
WP-2T	5/15/2002	31.3	N/R
WP-2	5/15/2002	N/R	18.2
FD-99	5/15/2002	1.52	N/R

*Blank and dilution corrected

N/R-Analysis not requested

Total Mercury in Water-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Total mercury analyzed: May 28, 2002 (THG11-020528-1)
Total suspended solids analyzed: May 24, 2002 (TSS-020524-1)

Sample Identification	**Date Collected**	**Total Hg, ng/L**	**TSS mg/L**
Method blanks			
Blank-1		0.05	0.143
Blank-2		0.05	0.286
Blank-3		0.03	0.286
Mean		**0.04**	**0.24**
Estimated MDL		**0.03**	**0.25**
Method MDL		**0.20**	**0.5**
Standard Reference Materials			
NIST 1641d		1,478	
recovery		**93.0%**	
reference value		1,590	

Total Mercury in Water-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Total mercury analyzed: May 28, 2002 (THG11-020528-1)
Total suspended solids analyzed: May 24, 2002 (TSS-020524-1)

Sample Identification	Date Collected	Total Hg, ng/L*	TSS mg/L
Analytical Replicates			
WP-1T	5/15/2002	154.6	14.5
WP-1T MD	5/15/2002	151.4	15.0
Mean		**153.0**	**14.8**
RPD		**2.1%**	**3.4%**

*Blank and dilution corrected

Total Mercury in Water-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
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phone: (206) 622-6960 fax: (206) 622-6870

Total mercury analyzed: May 28, 2002 (THG11-020528-1)
Total suspended solids analyzed: May 24, 2002 (TSS-020524-1)

Sample Identification	Date Collected	Total Hg, ng/L*	TSS mg/L
Matrix spikes			
WP-1T MS	5/15/2002	559.8	
spiking level		408.2	
net		406.7	
recovery		**99.6%**	
WP-1T MSD	5/15/2002	553.3	
spiking level		408.2	
net		400.2	
recovery		**98.0%**	

*Blank and dilution corrected

Total Hg Total Suspended Solids in Water
Anchor Environmental - GP Log Pond Year 2 Cap Monitoring

June 12, 2002

Frontier Geosciences Inc.
414 Pontius North
Seattle, WA 98109

1. Scope of Work

Seven (7) water samples were submitted for total mercury and total suspended solids analysis May 16, 2002. Samples were analyzed using high level (CLP-style) QA determination.

2. Sample Receipt

A total of 7 water samples were received for total mercury and total suspended solids analysis May 16, 2002. All samples listed on the chain of custody were accounted for and received in good condition. Following receipt, the water samples designated for total mercury analysis were preserved with 1-2% (v/v) 0.2N BrCl depending on a visual inspection of sample turbidity. The samples were then placed in secure storage until sample analysis could occur. Samples designated for total suspended solids analysis were placed directly into refrigerated storage until sample preparation could occur.

3. Analysis

General. All samples were received and logged in according to FGS protocols on the day of receipt. All samples identified on chain of custody forms were received in good condition. Samples were processed using ultra-clean sample handling techniques in a laboratory known to be low in atmospheric Hg. Reagents, gases, and DI water are all reagent or ultra-pure grade, and are analyzed prior to use for Hg to ensure negligible blanks. All Hg analyses were performed using cold vapor atomic fluorescence spectrometry (CVAFS) detection (Bloom and Fitzgerald, 1988), with dual pen chart recorders or integrators as output devices. Total Hg (THg) standards are prepared by direct dilution of NIST certified NBS-3133 10.00 mg/ml Hg standard solution, and concentrations are independently verified by the analysis of NIST-1641d (certified water CRM; 1,590 ± 18 μg/L THg).

All daily analytical runs for mercury were begun with a 5-point standard curve, spanning two orders of magnitude, with additional standards run every 10 samples. The daily standard curve was calculated using the initial standards (blank corrected) of the day, using linear regression, forced through zero (Excel 97). All raw data and calculations have been supplied with this data package. Calculations were made using Excel spreadsheets, which illustrate each step.

For each sample set (or 20 samples), at least one matrix replicate, two matrix spikes, and at least two method blanks were co-processed, and analyzed exactly as the ordinary samples.

Total Suspended Solids.

Samples were prepared for total suspended solids in accordance with Frontier SOP FGS-016. After shaking the sample vigorously to assure homogenization, a known aliquot of sample was processed through a pre-weighed 0.45-μm polycarbonate membrane filter. The filters were dried in an oven at 55 °C for at least 12 hours, allowed to return to room temperature and weighed. Net total suspended solids concentrations were calculated using the following equation where $\mathbf{F_S}$ is the weight of the oven-dried filter and sample, $\mathbf{F_I}$ is the initial weight of the filter, and **V** is the volume of sampled passed through the filter.

$$\mathbf{(F_S - F_I)/V}$$

Total Hg analysis.

For water samples, 0.2 N BrCl in 11.6 N HCl was added to the sample in the original bottle at a level of 1-2 ml per 100 ml of sample. The samples were then allowed to digest overnight at room temperature according to the protocols listed in FGS-012.

Digests were analyzed for total Hg in accordance with the Frontier SOP FGS-069. Aliquots of each digest were reduced in pre-purged DDW, first with NH_2OH to destroy free halogens, and then to Hg^0 with $SnCl_2$. The Hg^0 is then purged onto gold traps as a pre-concentration step. The Hg contained on the gold traps was then analyzed by thermal desorption into a cold vapor atomic fluorescence detector (CVAFS), using the dual amalgamation technique. Peak areas are accessed either by integrator or dual-pen strip chart recorder, and recorded on bench sheets in peak area or peak height units to the nearest 0.2 unit. Net THg concentrations were calculated according to the following formula, where **PH** is the chart recorder peak area or height, **bb** is the mean bubbler blank, **V** is the digest volume, **B** is the mean BrCl method blank (ng/L), **x** is the BrCl preservation level (1 for 1% BrCl, 2 for 2% BrCl, etc.), **S** is the calibration curve slope in units/ng, for the set of samples, and FD is the dilution correction factor, calculated:

$$[THg]\ (ng/L) = \frac{\underline{\mathbf{([(PH\text{-}bb/S)/(V)] - Bx)}}}{F_D}$$

Net total Hg results are corrected for the dilution resulting from the addition of BrCl. For samples preserved with 3% BrCl, F_D is approximately equal to 0.97.

4. Analytical Issues

No analytical problems were associated with the analysis of these samples. All QC samples were well within Frontier QC acceptance guidelines.

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Environmental Research & Specialty Analytical Laboratory
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Chain-of-Custody Record & Laboratory Analysis Request

Date: May 16, 02 Page: 1 of 1

Client Company: Anchor Environmental
Address: 1411 4th Ave, Suite 1210
Seattle, WA 98101
CONTACT: Paul Schlenger
Phone: 206-287-9130 Fax: 206-287-9131
Email: pschlenger@anchorenv.com
Project Name: GP Log Pond Year 2 Cap Monitoring
Contract/PO #:

Frontier Project Manager: Lucas Hawkins
Guaranteed Turnaround Time: 28 day
Confirmation of Sample Arrival at Frontier: ☐ YES ☐ NO
Quality Assurance Level: ☐ Standard ☑ High
Disposal*: ☑ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.
**Please discuss this with the Frontier Project Manager.
Carrier Information: FED EX ☐ UPS ☐ Other ☒ Personally delivered
Tracking #

Engraved Bottle ID	Sample ID	Matrix¹	# Bottles	Date/Time Sampled		Collected by	Preservation	Analysis Required/Comments
	WP-1D	BW	1	5/15/02	1258	PS	on ice	dissolved Hg ★
	WP-1T	BW	1	5/15/02	1248	PS		total Hg
AL-D-2526	WP-1	BW	1	5/15/02	1255	PS		total susp. solids
A	WP-2D	BW	1	5/15/02	1425	PS		dissolved Hg ★
	WP-2T	BW	1	5/15/02	1413	PS		total Hg
AL-D-2522	WP-2	BW	1	5/15/02	1417	PS		total susp. solids
	FD-99	BW	1	5/15/02	0940	PS		dissolved Hg ★

Sample Receipt
C.O.C. Seal Intact? ☐ YES ☐ NO ☒ N/A
Cooler Temperature: 3.4 °C
Comments:

VTSR: 11:30

¹Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by: Ryan Barth	Relinquished by:
Print name: Ryan Barth	Print name:
Company: Anchor	Company:
Date: 5/16/02 Time: 11:30	Date: Time:
Received by:	Received by:
Print name: Christabel Fowler	Print name: [illegible] Getzer
Company: FGS	Company: FGS
Date: 5.16.02 Time: 1130	Date: 5/16/02 Time: 12:30

★ Note: dissolved Hg samples have already been filtered using a 0.45 micron membrane filter

FRONTIER GEOSCIENCES
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Total Suspended Solids Dataset Cover Page

Dataset ID: TSS020524-1

Analyst: CW Christy

Data Analysis: CW Christy

Client/Project Name*
Anchor 5/16/02 and [redacted]
*Clients with name in **bold High QA**

Analytical Issues/explanations:

QUALITY ASSURANCE
PEER-REVIEWED
INITIALS: ja 05-29-02

Preparation Date: May 24, 2002 **Batch #:** 1 **Analyst:** CW Christy

Project(s): Anchor 5/16/02 and ENSR 5/23/02

Pan ID		Sample ID	Original Filter Wt (mg)	Volume Filtered(L)	Filter Wt Dry(mg	TSS (mg/L)	Notes	
1		PBW 1	15.1	0.700	15.2	0.143		
2		PBW 2	15.2	0.700	15.4	0.286		
3		PBW 3	15.0	0.700	15.2	0.286		
4	Anchor (5/16)	WP-1	15.1	0.200	18.0	14.500		
5	Anchor (5/16)	WP-1 (MD)	15.2	0.200	18.2	15.000	14.75	Mean
6	[redacted]	AL-D-2221	15.1	0.200	16.3	6.000	3.39	%RPD
7	Anchor (5/16)	WP-2	15.0	0.400	22.3	18.250		

Preparation Date: 5-24-02
Batch #: 1
Analyst: AN Ohrly

Project(s): Anchor (5-16-02) [redacted]

Pan ID	Sample ID	Original Filter Wt (mg)	Volume Filtered(L)	Filter Wt Dry(mg	TSS (mg/L)	Notes	
1	PBW 1	15.1	700 mL	15.2	#DIV/0!		
2	PBW 2	15.2	700	15.4	#DIV/0!		
3	PBW 3	15.0	700	15.2	#DIV/0!		
4	Anchor516 WP-1	15.1	200	18.0	#DIV/0!		
5	L MD	15.2	200	18.2	#DIV/0!		
6 8	Anchor 516 WP-2	15.1	5.24.02 ~~400~~ 200	16.3	#DIV/0!	#DIV/0!	Mean
7 7	[redacted] AL-D-2221	15.0	~~200~~ 400	22.3	#DIV/0!	#DIV/0!	%RPD
8					#DIV/0!		
9					#DIV/0!		
10					#DIV/0!	#DIV/0!	Mean
11					#DIV/0!	#DIV/0!	%RPD
12					#DIV/0!		
13					#DIV/0!		
14					#DIV/0!	#DIV/0!	Mean
15					#DIV/0!	#DIV/0!	%RPD
16					#DIV/0!		
17					#DIV/0!		
18					#DIV/0!		
19					#DIV/0!		
20		5.24.02			#DIV/0!	#DIV/0!	Mean
21					#DIV/0!	#DIV/0!	%RPD
22					#DIV/0!		
23					#DIV/0!		
24					#DIV/0!	#DIV/0!	Mean
25					#DIV/0!	#DIV/0!	%RPD
26					#DIV/0!		
27					#DIV/0!		
28					#DIV/0!	#DIV/0!	Mean
29					#DIV/0!	#DIV/0!	%RPD
30					#DIV/0!		
31					#DIV/0!		
32					#DIV/0!		

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Dataset Cover Page

Dataset ID: THG11-020528-1

Analyst: Holsman

Data Analysis: Holsman

Client/Project Name*
[redacted] **Anchor (5/16/02)**
[redacted]
*Clients with name in **bold** are **High QA**

Analytical Issues/explanations:

All results are bubbler blank corrected, except for samples with ID #'s of: ICB, CCB, or BB.

Samples Q10003 and Q10004FD2 were farther apart than would be expected of field duplicates. Both were rerun to confirm the results, and the PM was notified of the discrepancy (see runs #16-17, 21-22, 49).

QUALITY ASSURANCE
PEER-REVIEWED

INITIALS: JL 5-29-02

Frontier Geosciences

Analysis Datasheet for Total Mercury

FGS Dataset ID: THG11-020528-1

Date of Analysis: May 28,2002
Instrument #: CVAFS-11
Calibration #: 1

Analyst: Holsman
Project(s): [redacted], Anchor (5/16/02)

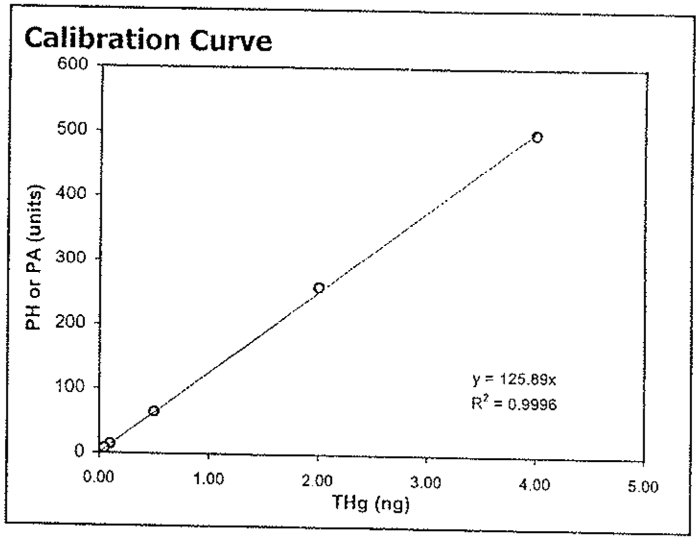
Calibration Statistics:

True Val	PH	PH-BB	Calc Values	
0.10 ng	14.00	13.48	0.107 ng	12.59
0.50 ng	65.10	64.58	0.513 ng	62.95
2.00 ng	260.00	259.48	2.061 ng	251.78
4.00 ng	500.00	499.48	3.968 ng	503.57
0.05 ng	7.60	7.08	0.056 ng	6.29

Slope: 125.9 units/ng
SE: ±4.00

R2: 0.9996
R: 0.9998
Obs: 5

Calibration Curve



Blanks:

PB#	Sample ID	n	Mean	Std Dev	
-	ICB				
-	CCB·				
-	BB	6	0.52 units	±0.21	Mean=0.041 ng/L ±0.017
1	PBW	3	0.041 ng/L	±0.009	
2					

Lab Control Samples:

Run#	Sample ID	Conc	Dil Factor	True Val	Rec	
06	ICV/NIST	1478403 ng/L	100000	1590000 ng/L	93.0%	**(NIST 1641d)**

Laboratory Standards

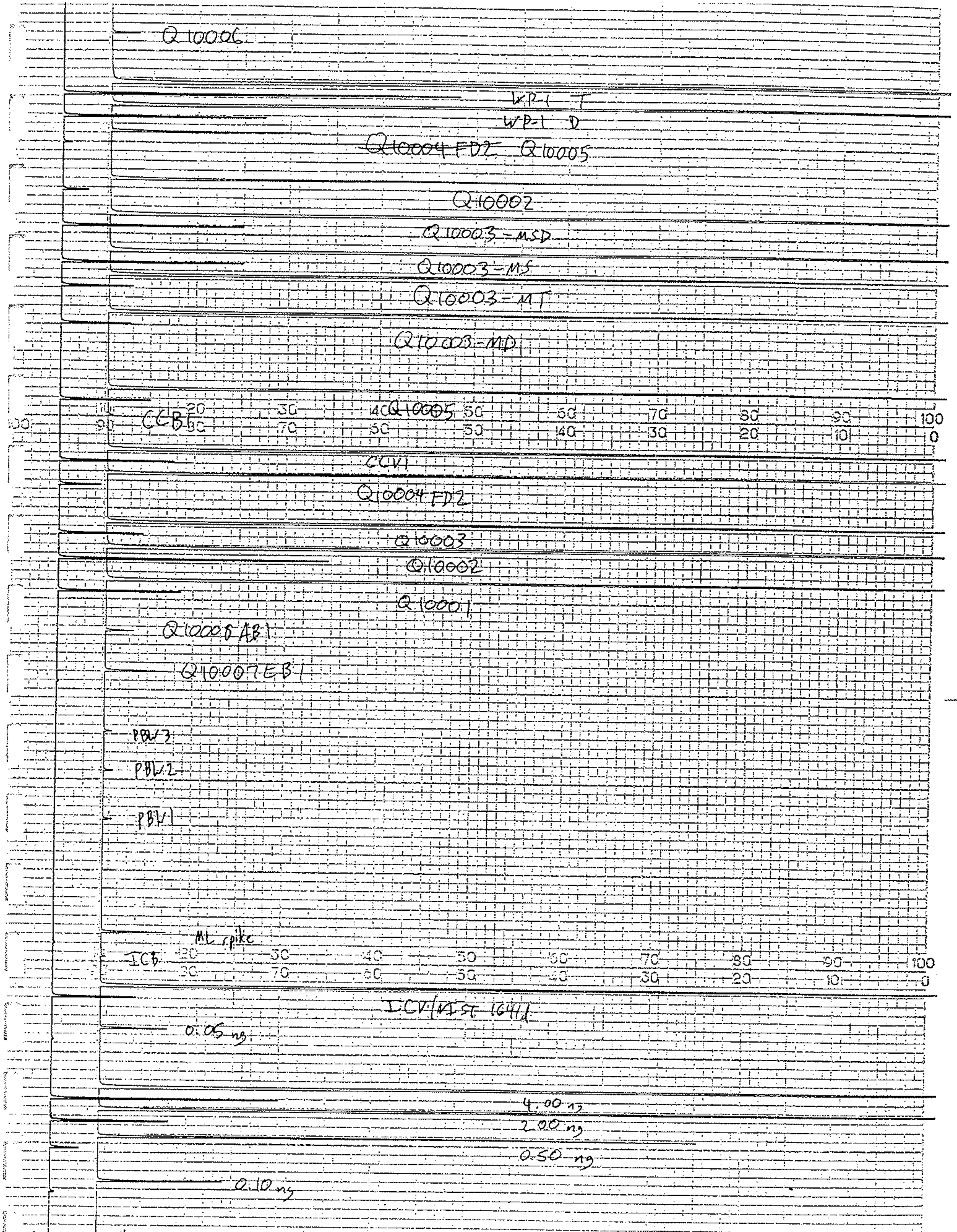
Type	Concentration	ID Number
Calibration	10 ng/mL	**Hg2-15-11**
ICV (NIST 1641d)	1.59 mg/L	**HG2-11-9**
ML, MS/MSD	10 ng/mL	**Hg2-15-11**

ML Spikes:

Matrix	Digestion	ML Conc. (ng/g or ng/L)	True Value (ng/g or ng/L)
Water	BrCl	0.495	0.5 ng/L

Data Set	Run	Tp	Bub	Sample ID	Aliquot Volume	PH	%BrCl (Waters)	THg per Aliquot	THg Conc (Gross)	PB #	THg Conc (Net)	Remarks
THG11-020528-1	01	1	1	0.10 ng (Calibration Std.)	100.00 mL	14.0		0.107 ng	1.071 ng/L		1.071 ng/L	
THG11-020528-1	02	2	2	0.50 ng	100.00 mL	65.1		0.513 ng	5.130 ng/L		5.130 ng/L	
THG11-020528-1	03	3	3	2.00 ng	100.00 mL	260.0		2.061 ng	20.612 ng/L		20.612 ng/L	
THG11-020528-1	04	4	4	4.00 ng	100.00 mL	500.0		3.968 ng	39.675 ng/L		39.675 ng/L	
THG11-020528-1	05	5	1	0.05 ng	100.00 mL	7.6		0.056 ng	0.563 ng/L		0.563 ng/L	
THG11-020528-1	06	6	2	ICV/NIST 1641d (15.9 ng/L)	100.00 mL	184.0	2%	1.457 ng	14.575 ng/L	1	14.784 ng/L	93.0 %Rec
THG11-020528-1	07	7	3	ICB/BB	100.00 mL	0.6		0.005 ng	0.048 ng/L		0.048 ng/L	
THG11-020528-1	08	8	4	ML spike	100.00 mL	7.2	1%	0.053 ng	0.531 ng/L	1	0.495 ng/L	
THG11-020528-1	09	9	1	PBW1	100.00 mL	1.1		0.005 ng	0.046 ng/L		0.046 ng/L	
THG11-020528-1	10	10	2	PBW2	100.00 mL	1.1		0.005 ng	0.046 ng/L		0.046 ng/L	
THG11-020528-1	11	1	3	PBW3	100.00 mL	0.9		0.003 ng	0.030 ng/L		0.030 ng/L	
THG11-020528-1	12	2	4	Q10007EB1	100.00 mL	6.9	1%	0.051 ng	0.507 ng/L		0.512 ng/L	[redacted]
THG11-020528-1	13	3	1	Q10008AB	100.00 mL	3.2	1%	0.021 ng	0.213 ng/L		0.215 ng/L	[redacted]
THG11-020528-1	14	4	2	Q10001	5.00 mL	272.0	3%	2.156 ng	431.294 ng/L		444.233 ng/L	
THG11-020528-1	15	5	3	***Q10002	100.00 mL	592.0	2%	4.698 ng	46.983 ng/L		47.923 ng/L	off curve; see #25 for rerun
THG11-020528-1	16	6	4	Q10003	5.00 mL	186.0	3%	1.473 ng	294.670 ng/L		303.510 ng/L	
THG11-020528-1	17	7	1	***Q10004FD2	5.00 mL	94.0	3%	0.743 ng	148.513 ng/L		152.968 ng/L	sizable difference between FD and original; see #49 for rerun
THG11-020528-1	18	8	2	CCV1 (2.00 ng)	100.00 mL	256.0		2.029 ng	20.294 ng/L		20.294 ng/L	101.5 %Rec
THG11-020528-1	19	9	3	CCB1	100.00 mL	0.6		0.005 ng	0.048 ng/L		0.048 ng/L	
THG11-020528-1	20	10	4	Q10005	50.00 mL	200.0	2%	1.585 ng	31.691 ng/L		32.325 ng/L	
THG11-020528-1	21	1	1	Q10003 - MD	5.00 mL	158.0	3%	1.251 ng	250.187 ng/L		257.693 ng/L	Average=274.1 ng/L for replicates
THG11-020528-1	22	2	2	Q10003 - MT	5.00 mL	160.0	3%	1.267 ng	253.365 ng/L		260.966 ng/L	9.3 %RSD
THG11-020528-1	23	3	3	Q10003 - MS +412.4 ng/L	5.00 mL	400.0	3%	3.173 ng	634.643 ng/L		653.682 ng/L	Net=379.626 ng/L 92.1 %Rec
THG11-020528-1	24	4	4	Q10003 - MSD +412.4 ng/L	5.00 mL	400.0	3%	3.173 ng	634.643 ng/L		653.682 ng/L	Net=379.626 ng/L 92.1 %Rec 0.0 RPD
THG11-020528-1	25	5	1	Q10002	10.00 mL	72.0	2%	0.568 ng	56.781 ng/L		57.917 ng/L	
THG11-020528-1	26	6	2	***Q10005	5.00 mL	22.8	3%	0.177 ng	35.401 ng/L		36.463 ng/L	confirmation of wrong sample
THG11-020528-1	27	7	3	WP-1 D	50.00 mL	446.0	2%	3.539 ng	70.772 ng/L	1	72.105 ng/L	**Anchor (5/16/02)**
THG11-020528-1	28	8	4	WP-1 T	50.00 mL	866.0	2%	6.875 ng	137.496 ng/L	1	140.164 ng/L	off curve; see #33 for rerun
THG11-020528-1	29	9	1	Q10006	0.20 mL	3.0	100%	0.020 ng	98.629 ng/L		197.258 ng/L	
THG11-020528-1	30	10	2	CCV2	100.00 mL	252.0		1.998 ng	19.976 ng/L		19.976 ng/L	99.9 %Rec
THG11-020528-1	31	1	3	CCB2	100.00 mL	0.7		0.006 ng	0.056 ng/L		0.056 ng/L	
THG11-020528-1	32	2	4	WP-2 D	50.00 mL	17.0	2%	0.131 ng	2.619 ng/L	1	2.589 ng/L	
THG11-020528-1	33	3	1	WP-1 T	5.00 mL	96.0	2%	0.758 ng	151.690 ng/L	1	154.642 ng/L	
THG11-020528-1	34	4	2	WP-1 T - MS +408.2 ng/L	5.00 mL	346.0	2%	2.744 ng	548.855 ng/L	1	559.750 ng/L	Net=406.728 ng/L 99.6 %Rec
THG11-020528-1	35	5	3	WP-1 T - MSD +408.2 ng/L	5.00 mL	342.0	2%	2.713 ng	542.500 ng/L	1	553.268 ng/L	Net=400.247 ng/L 98.1 %Rec 1.2 RPD
THG11-020528-1	36	6	4	WP-2 T	5.00 mL	19.9	2%	0.154 ng	30.793 ng/L	1	31.327 ng/L	
THG11-020528-1	37	7	1	WP-1 T - MD	5.00 mL	94.0	2%	0.743 ng	148.513 ng/L	1	151.401 ng/L	Mean=153.022 ng/L 2.1 RPD
THG11-020528-1	38	8	2	***FD-99	5.00 mL	2.2	2%	0.013 ng	2.674 ng/L	1	2.646 ng/L	rerun to improve signal (#48)
THG11-020528-1	39	9	3	***Q10005	5.00 mL	22.2	2%	0.172 ng	34.447 ng/L		35.136 ng/L	confirmation of wrong sample
THG11-020528-1	40	10	4	Q10006	5.00 mL	54.2	100%	0.426 ng	85.284 ng/L		170.569 ng/L	
THG11-020528-1	41	1	1	5/14 Eff	100.00 mL	40.6	1%	0.318 ng	3.184 ng/L	1	3.175 ng/L	[redacted]
THG11-020528-1	42	2	2	CCV3	100.00 mL	252.0		1.998 ng	19.976 ng/L		19.976 ng/L	99.9 %Rec
THG11-020528-1	43	3	3	CCB3	100.00 mL	0.7		0.006 ng	0.056 ng/L		0.056 ng/L	
THG11-020528-1	44	4	4	5/15 Eff	100.00 mL	44.3	1%	0.348 ng	3.478 ng/L	1	3.472 ng/L	[redacted]
THG11-020528-1	45	5	1	5/16 Eff	100.00 mL	38.6	1%	0.303 ng	3.025 ng/L	1	3.014 ng/L	[redacted]
THG11-020528-1	46	6	2	5/17 Eff	100.00 mL	38.0	1%	0.298 ng	2.977 ng/L	1	2.966 ng/L	[redacted]
THG11-020528-1	47	7	3	5/18 Eff	100.00 mL	36.8	1%	0.288 ng	2.882 ng/L	1	2.870 ng/L	[redacted]
THG11-020528-1	48	8	4	FD-99	100.00 mL	20.0	1%	0.155 ng	1.548 ng/L	1	1.522 ng/L	[redacted]

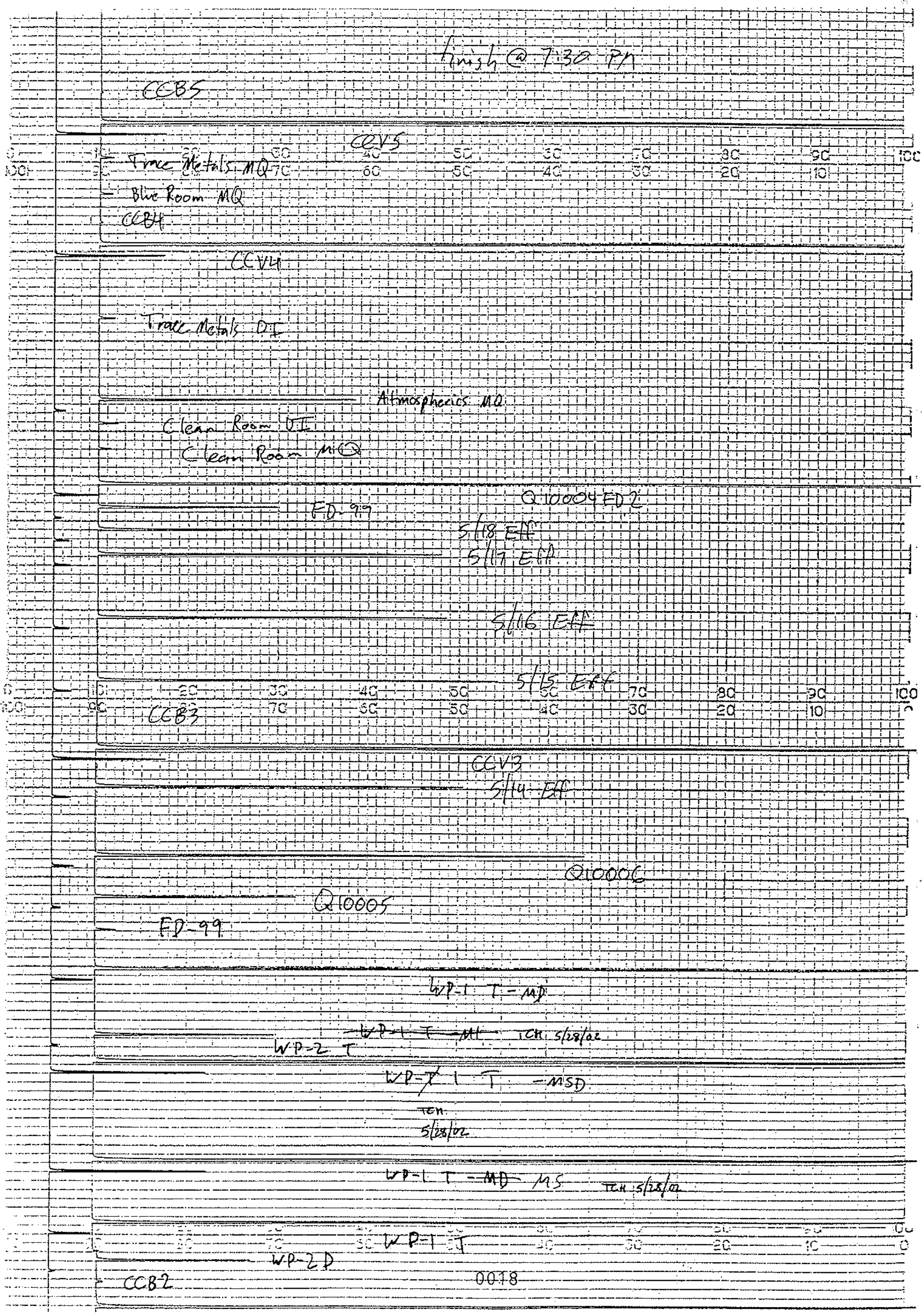
Data Set	Run	Tp	Bub	Sample ID	Aliquot Volume	PH	%BrCl (Waters)	THg per Aliquot	THg Conc (Gross)	PB #	THg Conc (Net)	Remarks
THG11-020528-1	49	9	1	Q10004FD2	5.00 mL	100.0	1%	0.790 ng	158.045 ng/L	1	159.584 ng/L	
THG11-020528-1	50	10	2	Clean Room MQ	125.00 mL	1.4	1%	0.007 ng	0.056 ng/L	1	0.016 ng/L	[redacted]
THG11-020528-1	51	1	3	Clean Room DI	125.00 mL	2.1	1%	0.013 ng	0.101 ng/L	1	0.061 ng/L	
THG11-020528-1	52	2	4	Atmospherics MQ	125.00 mL	28.4	1%	0.221 ng	1.772 ng/L	1	1.749 ng/L	high result; QA notified
THG11-020528-1	53	3	1	Trace Metals DI	125.00 mL	1.9	1%	0.011 ng	0.088 ng/L	1	0.048 ng/L	
THG11-020528-1	54	4	2	CCV4	100.00 mL	244.0		1.934 ng	19.341 ng/L		19.341 ng/L	96.7 %Rec
THG11-020528-1	55	5	3	CCB4	100.00 mL	0.3		0.002 ng	0.024 ng/L		0.024 ng/L	
THG11-020528-1	56	6	4	Blue Room MQ	125.00 mL	1.5	1%	0.008 ng	0.062 ng/L	1	0.022 ng/L	
THG11-020528-1	57	7	1	Trace Metals MQ	125.00 mL	1.6	1%	0.009 ng	0.069 ng/L	1	0.028 ng/L	
THG11-020528-1	58	8	2	CCV5	100.00 mL	246.0		1.950 ng	19.499 ng/L		19.499 ng/L	97.5 %Rec
THG11-020528-1	59	9	3	CCB5	100.00 mL	0.2		0.002 ng	0.016 ng/L		0.016 ng/L	



THg11-020528-1

start @ 8:45 AM
chart speed 1mm/min

Tobias C. Heleman



finish @ 7:30 PM

CCB5

CCV5

Trace Metals MQ

Blue Room MQ

CCB4

CCV4

Trace Metals DI

Atmospherics MQ

Clean Room DI

Clean Room MQ

Q10004 FD 2

FD-99

5/18 Eff

5/17 Eff

5/16 Eff

5/15 Eff

CCB3

CCV3

5/14 Eff

Q10006

Q10005

FD-99

WP-1 T-MD

~~WP-1 T-MI~~ TCH 5/28/02

WP-2 T

WP-~~2~~ 1 T -MSD

TCH 5/28/02

WP-1 T ~~-MD~~ MS TCH 5/28/02

WP-1 D

WP-2D

CCB2

0018

Data Validation and Data Quality Assessment Report

Log Pond Year 2 Cap Monitoring

Project Number: 020030-01

Prepared for:

Anchor Environmental, LLC
1411 4th Avenue
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Prepared by:

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July 17, 2002

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

1.0 Introduction

This report presents the EPA Level III validation of the sample analyses listed in Table 1. The well point water analyses were performed by Frontier Geosciences, Inc., located in Seattle, Washington. With the exception of grain size, the sediment 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, 1999). 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 from Functional Guidelines, the OMMP, the analytical methods, or the professional judgment of the validation chemist.

Sections 2 through 5 present the validation findings and Section 7 defines the data qualifiers. Section 6 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 reports and the Anchor data table.

Table 1
Sample Data Reviewed

Sample ID	Matrix	Laboratory Sample ID	SVOA	Mercury	Conventionals
WP-1D	Water	WP-1D		X	
WP-1T	Water	WP-1T		X	
WP-1	Water	WP-1			X
WP-2D	Water	WP-2D		X	
WP-2T	Water	WP-2T		X	
WP-2	Water	WP-2			X
FD-99	Water	FD-99		X	
SS-76	Sediment	EJ34A	X	X	X
SS-301	Sediment	EJ34B	X	X	X
SS-40	Sediment	EJ34C	X	X	X
SS-75	Sediment	EJ34D	X	X	X
WP-1	Sediment	EJ34E	X	X	X
WP-2	Sediment	EJ34F	X	X	X
AN-999	Water	EJ34G	X	X	
AN-998	Water	EJ34H	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 in sediment samples analyzed by Methods 7471A and 7470A (USEPA 1996); total and dissolved mercury in well point water samples analyzed by Method 1631 (USEPA 1999a)

Conventionals: Total solids by Method 160.3 (USEPA 1999a), total organic carbon by the Plumb Method (Plumb 1981), grain size by the PSEP Method (PSEP 1996), and total suspended solids by Method 2540-D (APHA 1998)

2.0 Review of Semivolatile Organics Analyses

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

Except as noted below, all samples were extracted and analyzed within the required holding times. Sample custody was maintained as required and the 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).

Sample AN-998 was re-extracted due to laboratory error. The re-extraction was preformed 1 day past the 14 day holding time. Since all the results of sample AN-998 are undetected, they have been qualified as estimated detection limit (UJ).

Sample ID	Analyte	Qualification	Quality Control Exceedance
AN-998	All	UJ	Extraction holding time exceeded

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

Calibration verifications were analyzed at the required frequency. The Functional Guidelines criteria of percent difference values less than or equal to 25 and relative response factors greater than 0.05 were met for all target compounds.

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 AN-999 and AN-998 were identified as field blanks. Target compounds were not detected above the reporting limits in either field blank.

2.6 Surrogate Analyses – Acceptable

Surrogate compounds were added to all samples, blanks, and QC samples as required. All recovery values are within the 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 the laboratory control sample demonstrates the analytical system is in-control.

2.8 Laboratory Control Sample Analyses – Acceptable

One laboratory control sample was reported with each analytical batch and all percent recovery values are within the OMMP criteria.

2.9 Standard Reference Material Analyses – Acceptable

The laboratory analyzed the Sequim Bay Fortified Reference Sediment as a standard reference material. 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

The OMMP target detection limits were met. The laboratory reporting limits are equal to or less than the target detection limits.

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 Review of Mercury in Sediment by Methods 7470A and 7471A

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

All samples were extracted and analyzed within the required holding times. Sample custody was maintained as required and the samples were received intact and were properly preserved. The data packages are complete and contain results for all samples and tests requested on the COC.

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. Mercury was not detected above the reporting limit.

3.4.2 Calibration Blanks

Calibration blanks were analyzed at the required frequency and mercury was not detected above the reporting limit.

3.4.3 Field Blanks

Samples AN-999 and AN-998 were identified as field blanks. Mercury was not detected above the reporting limit 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 the 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 Functional Guidelines criteria.

3.8 Standard Reference Material Analyses – Acceptable

Standard reference materials were analyzed with the sediment samples. All results are within the OMMP criteria.

3.9 Laboratory Reporting Limits – Acceptable

The OMMP target detection limits were met. The laboratory reporting limits are equal to or less than the target detection limits.

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 Review of Total and Dissolved Mercury in Water by Method 1631

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

All samples were extracted and analyzed within the required holding times. Sample custody was maintained as required and the samples were received intact and were properly preserved. The data package is complete and contains results for all samples and tests requested on the COC.

4.2 Initial Calibration – Acceptable

Initial calibrations were analyzed as required and all quality control checks met the method requirements.

4.3 Continuing Calibration – Acceptable

Calibration verifications were analyzed at the required frequency and met all method requirements.

4.4 Blank Analysis – Acceptable with Qualifications

4.4.1 Method Blanks

Except as noted below, reagent, instrument (bubbler), and method blanks were analyzed at the required frequency. All blanks are acceptable and meet the method criteria.

Instrument (bubbler) blanks were not analyzed after every sample as required by Method 1631. Data qualifiers are not recommended because acceptable instrument blanks were analyzed after every QC sample, demonstrating that instrument carryover was minimal.

4.4.2 Field Blanks

Sample FD-99 was identified as a field filter blank. Dissolved mercury was detected in the field blank at 1.52 ng/L. Functional Guidelines prescribes three qualifications schemes for blank contamination, (1) associated sample concentrations greater than the action level (5 times the blank concentration) are not qualified, (2) associated sample concentrations less than the action level and greater than the reporting limit are qualified as undetected (U) at the reported value, and (3) associated sample concentrations less than the action level and less than the reporting limit are qualified as undetected (U) at the reporting limit. Only sample WP-2D contained levels that are greater than the reporting limit and less than the action level as shown below.

Sample ID	Analyte	Qualification	Quality Control Exceedance
WP-2D	Dissolved mercury	U at reported value	Result is greater than the reporting limit and less than 5 times the field blank level

4.5 Laboratory Control Sample Analyses – Acceptable

Laboratory control samples (quality control samples) were analyzed at the required frequency. The percent recovery values are acceptable.

4.6 Matrix Spike/Matrix Spike Duplicate Analyses – Acceptable

MS/MSD analyses were reported at the correct frequency and all percent recovery and RPD values are with the OMMP criteria.

Sample WP-1T was analyzed as the MS/MSD and sample duplicate with acceptable results.

4.7 Laboratory Reporting Limits – Acceptable with Discussion

The OMMP target detection limits were met. The laboratory reporting limits are equal to or less than the target detection limits.

The laboratory reported all sample results as total mercury, even though several samples were field filtered. The field filtered sample results represent dissolved mercury.

4.8 Field Duplicates

Field duplicates are not associated with this sample set.

4.9 Overall Assessment of Data Useability

The useability of the data is based on the EPA guidance documents noted previously. 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.

5.0 Review of Conventional Parameters

5.1 Custody, Preservation, Holding Times, and Completeness – Acceptable with Qualifications

Except as noted below, all samples were analyzed within the required holding times. Sample custody was maintained as required and the samples were received intact and were properly preserved. The data packages are complete and contain results for all samples and tests requested on the COC forms.

The total suspended solids analyses were preformed two days past the 7-day holding time established by the method. Frontier Geosciences were contacted and replied that their standard operating procedure allows for a 14-day holding time. The total suspended solids results have been qualified as estimated (J).

Sample ID	Analyte	Qualification	Quality Control Exceedance
WP-1 WP-2	Total suspended solids	J	Analysis holding time exceeded

5.2 Initial Calibration – Acceptable

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

5.3 Calibration Verifications – Acceptable

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

5.4 Blank Analyses – Acceptable

5.4.1 Method Blanks

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

5.4.2 Field Blanks

The field blanks were not analyzed for conventional parameters.

5.5 Duplicate Sample Analyses – Acceptable

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

5.6 Matrix Spike Analyses – Acceptable

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

5.7 Laboratory Control Sample Analyses – Acceptable

Laboratory control samples were analyzed at the required frequency. The percent recovery values are acceptable.

5.8 Standard Reference Material Analyses – Acceptable

Standard reference material results were reported for TOC. The recovery values are within the OMMP criteria.

5.9 Laboratory Reporting Limits – Acceptable

The OMMP target detection limits were met. The laboratory reporting limits are equal to or less than the target detection limits.

5.10 Field Duplicates

Field duplicates are not associated with this sample set.

5.11 Overall Assessment of Data Useability

The useability of the data is based on the EPA 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.

6.0 Assessment of Data Quality Objectives

6.1 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 meets the data quality objective of the OMMP. For the semivolatile organics, mercury (water and sediment), and the conventional parameters, the MS/MSD and laboratory duplicate RPD values are within the OMMP criteria. Field duplicates are not associated with this sample set.

6.2 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 semivolatile organics, mercury in sediment and conventional data 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 mercury in sediment data meets the data quality objective of the OMMP. The filter blank contained reportable levels of dissolved mercury. The impact of the field blank contamination has been minimized by the proper use of data qualifiers as prescribed by Functional Guidelines. Qualifying contaminates in the associated samples as undetected when their concentration is less than five times the blank concentration minimizes the possibility of false positive results. All matrix spike and laboratory control sample recovery values are acceptable and the method blanks are free of contamination.

6.3 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, with the exception of results from analyses that were performed past the holding time. Since the results of tests performed past the holding time may not be representative, they were qualified as estimated. The field blank contamination does not affect the representativeness of the data since the procedures in Functional Guidelines were followed to minimize the impact of the contamination. The remaining data are representative since the samples were analyzed within the required holding time, the samples were properly preserved and handled, and method blank contamination was not present.

6.4 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.

6.5 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%, because all of the samples were analyzed and all the results were determined to be valid.

7.0 Definition of Data Qualifiers

7.1 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.)

7.2 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 1999).

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.

8.0 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.

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association. 1998.

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.

[illegible] 1999. Contract Laboratory Program National Functional Guidelines for Organic Data Review. U.S. Environmental Protection Agency Office of Emergency and Remedial Response. EPA540/R-99/008. October 1999.

USEPA 1999a. *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
AN-998	Phenol	UJ	Extraction holding time exceeded
	Benzyl alcohol	UJ	
	2-methylphenol	UJ	
	4-methylphenol	UJ	
	2,4-dimethylphenol	UJ	
	Benzoic acid	UJ	
	Pentachlorophenol	UJ	
WP-2D	Dissolved mercury	U at reported value	Result is greater than the reporting limit and less than 5 times the field blank level
WP-1	Total suspended solids	J	Analysis holding time exceeded
WP-2		J	

Appendix A

Laboratory Communications
(1 page)

Kathy J. Gunderson
981 State Street
Raymond, WA 98577

Phone (360)942-3409
Fax (360)942-6060
E-mail kathyg@willapabay.org

COMMUNICATION RECORD

Date: 7·8·02
Time:
☑ Phone in
☐ Phone out
Person communicated with: M.B. Miller
Affiliation: Frontier Geosciences
Project: TSS Hold time
Subject: Anchor GP LP Round 2
By: Kathy J. Gunderson

Remarks:

Their SOP hold time is 14 days.

Lucas, PM, on vacation. He's unaware of SOW/QAPP.

fax# 206-622-6870

Action required:

fax SOW/QAPP page w/ hold time info

Action taken:

faxed 7·8·02

By: KJG

ANCHOR
ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** SS-40

Sampling Crew: Paul Schlenger (shore), Ryan Barth, Ariel Blanc (WWU)
Sampling Vessel: zodiac
Sampling Method: petite ponar
Subcontractor(s):
Station Coordinates: [✓ N] / Lat. 5399401
[✓ E] W / Long. 537350
Weather: pt. cloudy, mid 60's F
UTM Datum: [✓ NAD 83] / WGS 84
Zone: 10

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Number: 1
Water Depth:
Penetration/Sampled Depth:
Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:	Sediment Odor:	
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	

Comments: Rejected
6cm collected; target penetration depth not met

Grab Number: 2
Water Depth:
Penetration/Sampled Depth:
Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:	Sediment Odor:	
cobble	some pebbles	D.O.	[✓ none]	H2S
gravel	shell fragments	[✓ gray]	slight	Petroleum
[✓ sand] C M [✓ F]	live snail	black	moderate	other:
silt clay		[✓ brown]	strong	no sheen
organic matter		brown surface	overwhelming	

Comments: Rejected
- no winnowing
- ponar not deconned so station abandoned for decon
- return post decon

Grab Number: 1
Water Depth:
Penetration/Sampled Depth: 8/5 cm
Time: 1216
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:	Sediment Odor:	
cobble	covered by	D.O.	[✓ none]	H2S
gravel	fine brown mat	[✓ gray]	slight	Petroleum
[✓ sand] C [✓ M F]	with some	black	moderate	other:
silt clay	worms, shell	[✓ brown]	strong	
organic matter	fragments	[✓ brown surface]	overwhelming	

Comments:
- no winnowing
- overlying H_2O partially cloudy

collected at 5399400/537347

Grab Number: 2
Water Depth:
Penetration/Sampled Depth: 6/5 cm
Time: 1240
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:	Sediment Odor:	
cobble	covered by	D.O.	[✓ none]	H2S
gravel	fine brown mat	[✓ gray]	slight	Petroleum
[✓ sand] C [✓ M F]	with some worms,	black	moderate	other:
silt clay	shell fragments	[✓ brown]	strong	no sheen
organic matter		[✓ brown surface]	overwhelming	

Comments:
no winnowing
seagrass
collected for grainsize (last jar to fill)

Recorded by: Ryan Barth (copied by Paul Schlenger)

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** SS-75

Sampling Crew: PS RB AB
Sampling Vessel: zodiac Sampling Method: petite ponar
Subcontractor(s):
Station Coordinates: [✓ N] / Lat. 5399477
E / W / Long. 537419
UTM Datum: [✓ NAD 83] / WGS 84 Zone: 10
Weather:

RB 5/16/02

Sampling location NOT located exactly at this location. While in vicinity the GPS unit ran out of batteries so location estimated. Since 2 grabs were necessary to obtain sufficient volu[me] the second grab location was visually estimated in vicinity of first grab.

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Number: 1 Water Depth: Penetration/Sampled Depth: 6/5 cm Time: 1600
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:	Comments:
cobble	D.O.	[✓ none] H2S	not enough sediment to to fill grain size jar
gravel sea snail	gray	slight Petroleum	
[✓ sand] C [✓ M F] worms	black	moderate other:	
silt clay	[✓ brown] throughout	strong globules of sheen	
organic matter	brown surface	overwhelming	

Grab Numbers: 2-6 Water Depth: Penetration/Sampled Depth: Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:	Comments:
cobble	D.O.	none H2S	Rejected
gravel Lack of	gray Granular	slight Petroleum	
sand C M F sediment	black material	moderate other:	
silt clay	brown with crab	strong	
organic matter (2-4cm pene)	brown surface shells, legs	overwhelming	

Grab Number: 7 Water Depth: Penetration/Sampled Depth: 6/5 cm Time: 1630
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:	Comments:
cobble	D.O.	[✓ none] H2S	Grab had difficult time penetrating sediment surface
gravel	gray	slight Petroleum	
[✓ sand] [✓ C] M F	black very homogenous	moderate other:	
silt clay	[✓ brown]	strong No sheen	
[✓ organic matter] → crab leg	brown surface	overwhelming	

Grab Number: Water Depth: Penetration/Sampled 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: Ryan Barth (copied by Paul Schlenger)

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** SS-76

Sampling Crew: PS RB AB
Sampling Vessel: zodiac
Sampling Method: petite ponar
Subcontractor(s):
Station Coordinates: [✓ N] Lat. 5399545
[✓ E] W / Long. 537519
UTM Datum: [✓ NAD 83] / WGS 84
Zone: 10
Weather: pt. cloudy

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Numbers: 1 and 2 Water Depth: Penetration/Sampled Depth: Time:
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	none	H2S	Rejected
gravel	gray	slight	Petroleum	Poor penetration
sand C M F	black	moderate	other:	(3 cm)
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Grab Number: 3 Water Depth: Penetration/Sampled Depth: 6/5 cm Time: 1530
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

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

Grab Number: 4 Water Depth: Penetration/Sampled Depth: 8/5 cm Time: 1541
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:	Sediment Odor:		Comments:
cobble		D.O.	none	[✓ H2S]	· grain size only
gravel	very granular	gray	[✓ slight]	Petroleum	jar this grab
sand C M F		black	moderate	other:	needed for
silt clay		brown	strong	slight sheen	· Ponar jars difficult time
organic matter		[✓ brown surface] very thin	overwhelming		creating tight seal

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Grab Number: Water Depth: Penetration/Sampled 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: Ryan Barth (copied by Paul Schlenger)

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** SS-301

Sampling Crew: PS RB AB
Sampling Vessel: zodiac
Sampling Method: petite ponar
Subcontractor(s):
Station Coordinates: [✓ N] / S Lat. 5399410
[✓ E] / W / Long. 537431
UTM Datum: [✓ NAD 83] WGS 84 Zone: 10
Weather:

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Number: 1 Water Depth: Penetration/Sampled Depth: 9/5 cm Time: 1316
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble worms present	D.O.	[✓ none]	H2S	no winnowing
gravel shell fragments	[✓ gray]	slight	Petroleum	
[✓ sand] C M [✓ F]	[✓ black]	moderate	other:	
silt clay → surface covered	brown	strong	no sheen	
[✓ organic matter] by brown mat	[✓ brown surface]	overwhelming		

Grab Number: Water Depth: Penetration/Sampled 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: Water Depth: Penetration/Sampled 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: Water Depth: Penetration/Sampled 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: Ryan Barth (copied by Paul Schlenger)

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** WP-1

Sampling Crew: PS RB AB
Sampling Vessel: accessed from shore
Sampling Method: spoon grab
Subcontractor(s):
Station Coordinates: [✓ N] / Lat. 5399344
[✓ E] / W / Long. 537415
Weather: pt. cloudy
UTM Datum: [✓ NAD 83] WGS 84 Zone: 10

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Number: 1 Water Depth: Penetration/Sampled Depth: 12/12cm Time: 1125
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:	Sediment Color:	Sediment Odor:		Comments:
cobble	D.O.	[✓ none]	H2S	2 young of the year salmonids (~ 50-60 seen near station
gravel	[✓ gray]	slight	Petroleum	
[✓ sand] [✓ C] M [✓ F] some shell fragments	black Some red sand particles	moderate	other:	
silt clay	[✓ brown]	strong		
organic matter	brown surface	overwhelming		

Grab Number: Water Depth: Penetration/Sampled 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: Water Depth: Penetration/Sampled 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: Water Depth: Penetration/Sampled 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:

ANCHOR ENVIRONMENTAL, L.L.C.

Surface Sediment Field Sample Record

Collection Date: 5/15/02
Shipping Date: 5/16/02

Project Name: GP Log Pond **Project No:** Year 2 Cap Monitor **Station ID:** WP-2

Sampling Crew: PS RB AB
Sampling Vessel: accessed from shore
Sampling Method: spoon grab
Subcontractor(s):
Station Coordinates: [✓ N] / Lat. 5399423
[✓ E] / W / Long. 537498
Weather: pt. cloudy
UTM Datum: [✓ NAD 83] / WGS 84
Zone: 10

Sample Number:
Analysis: Metals / BNAs / VOCs / PCBs / Pest / Herb / TBTs / Diox-Furans
TS / Grain Size / TOC / TVS / Ammonia / Sulfides
(Circle Appropriate Analyses)

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

Grab Number: 1 Water Depth: ______ Penetration/Sampled Depth: 12/12cm Time: 1140
Bioassay / Chemistry (circle) AVS/SEM; Total Sulfides; VOC Sample (circle)

Sediment Type:		Sediment Color:		Sediment Odor:		Comments:
cobble		D.O.		[✓ none]	H2S	
gravel	some shell fragments	[✓ gray]	some red sand particles	slight	Petroleum	
[✓ sand] [✓ C] [✓ M] F		black		moderate	other:	
silt clay		[✓ brown]		strong		
organic matter		brown surface		overwhelming		

Grab Number: ______ Water Depth: ______ Penetration/Sampled 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: ______ Water Depth: ______ Penetration/Sampled 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: ______ Water Depth: ______ Penetration/Sampled 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: ______

Log Pond Restoration Project: Structure and Function of the Benthic Community – Year 2 report

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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 initial capping, which occurred in 2000, involved covering existing sediments with a thick layer of clean sediment followed by a thinner layer of native silt material. It was expected that the native silt would already contain local infaunal invertebrates and would provide good settlement habitat for larvae from other regional invertebrate species.

The Log Pond restoration plan requires assessment of the new habitat performance. While capping the sediments in the pond should improve sediment quality, it is important to demonstrate that a healthy, productive benthic community is developing in the restored site. 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).

Sampling done 5-6 months after installation of the cap revealed a developing invertebrate community in the Log Pond (Bingham et al., 2001). The Log Pond and the Chuckanut reference sites held similar numbers of species, had similar levels of diversity and evenness, and had similar levels of invertebrate biomass. While diversity/evenness indices and biomass measurements indicated that the communities at the two sites were similar, other analyses showed that the populations were not the same. In particular, cluster analyses clearly separated the two sites, indicating that the Chuckanut sites were much more similar to each other than they were to the Log Pond sites. The effect resulted from differences in the species that occurred in the two locations. For example, the Chuckanut sites were dominated by crustaceans while the Log Pond held a much higher proportion of polychaete annelids.

Given the patchiness of invertebrate recruitment in space and time, the differences we saw in these communities in our sampling may have simply resulted from the failure of settling larvae to reach the Log Pond within the first 5 months after capping. If this is the case, we might expect to see more convergence in the two sites after an additional year of recruitment has occurred. The goals of the present study were 1) to determine how the invertebrate community had changed over the 12 months since the first sampling and 2) to determine how closely the Log Pond community resembles the undisturbed community in the Chuckanut reference site a full 18 months after capping was done.

Materials and Methods

To ensure that data collected in Year 2 were comparable to those collected in the Year 1 sampling, we used the same collection methods (full details in Bingham et al., 2001).

Quantitative sampling of the epibenthos

The epibenthic community was sampled with an epibenthic suction pump as described by Simenstad et al. (1991). Three replicate 0.033 m^2 samples were taken at each of 3 fixed stations (SS74, SS75 and SS76) within the log pond (Fig. 1). These are the same locations that were sampled in the Year 1 work. We washed the samples through a 0.253-mm mesh sieve, preserved them in 10% buffered formalin and later transferred them to 70% ethanol.

For comparison with the Log Pond, samples were also taken at a reference site in the inner part of Chuckanut Bay (Fig. 1). Triplicate samples at stations CH1 and CH2 (the same stations sampled in the Year 1 study) were taken as described above. The Log Pond and Chuckanut sites were sampled on May 14 and again on June 24, 2002.

In the laboratory, all invertebrates were picked from the samples, sorted and identified to the lowest taxonomic level. To determine biomass composition of each sample, we separated the invertebrates into broad taxonomic groups (i.e., nematodes, annelids, mollusks, crustaceans and echinoderms). These grouped 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 total invertebrate biomass. Where the ANOVA 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 were not really there).

Quantitative sampling of benthic invertebrates

As in Year 1 (and the baseline sampling), we used a 0.023 m^2 petite ponar grab sampler (PSEP 1997a) to collect benthic invertebrates. On each sampling date, three replicate samples were taken at each station in the log pond (SC-74, SC-75, SC-76) and at the Chuckanut Bay reference stations (CH1, CH2). All ponar samples were collected on June 24, 2002.

The collected samples were washed through a 0.5-mm brass sieve 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 taxonomic groups, oven dried them at 60° C for 24 hours then weighed them to get a dry biomass measurement. A large proportion of the biomass in some samples was due to a single polychaete (*Owenia fusiformis*). This species lives in tubes it constructs of sand and mucous. Unfortunately, it was not possible to remove the worms from their tubes making it difficult to get an accurate measure of the actual biomass. To give us maximum flexibility for data analysis and presentation, we weighed the *O. fusiformis* separately from other polychaetes. To compare total invertebrate biomass in the Log Pond and Chuckanut sites, we summed total biomass (including *O. fusiformis*) at each station, log transformed the data (to homogenize the variances) and tested for site and station differences with a 2-way nested ANOVA (with station nested in site).

Community analyses

We ran cluster analyses to get a better idea of similarities between the invertebrate communities in 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 (which may indicate interactions among species or common responses to environmental characteristics).

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 epibenthic data (all stations in both May and June) and for the ponar data (all stations 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 24, 2002. The sediments were held in a -80° C freezer until they could be processed. At that time, the samples were 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.

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

Statistical analysis of epibenthic invertebrate biomass failed to show any significant differences between the Log Pond and Chuckanut reference communities (Table I). While none of the effects were significant, the power of this analysis was quite low, reflecting the low replication and imbalance in the design (i.e., 9 samples in the Log Pond and only 6 in the Chuckanut reference site). An examination of the data suggests that there may, in fact, be differences among the stations in the Log Pond (Fig. 2). The SS75 station (Fig. 1), in particular, stands out in both the May and June samples. This station is deeper than the other two Log Pond sites and appears, in the Year 2 sampling, to be distinctly different.

The biomass of benthic invertebrates in the ponar samples showed strong differences among stations (though there were no statistically significant site effects, Table II). Once again, the SS75 station stood out dramatically (Fig. 2). The dramatic difference in this site was partially due to the polychaete *Owenia fusiformis*, which was extremely abundant here. The organic dry weight of these samples was overestimated due to the inclusion of their sand tubes in the measurements. However, it is clear from Figure 2 that differences existed even when *O. fusiformis* weights were not included. The invertebrate community at Station SS75 was clearly different from any other station we sampled.

Figure 3 shows how different taxonomic groups contributed to the dry weight biomass of the Log Pond and Chuckanut samples. Several patterns are clear. The first is the shift in epibenthic community composition of samples taken only a month apart, particularly in the Log Pond site. In the May samples, the community (on a weight basis) was composed primarily of annelids. By June, the composition had shifted toward a community with a greater representation of nematodes and crustaceans. These changes were not as clear in the Chuckanut site where the May and June samples were quite similar.

Ponar samples showed differences in the benthic communities at the Log Pond and Chuckanut sites. The Log Pond appeared to hold a greater proportion of annelids while the Chuckanut sites had more molluscs.

Community indices

Epibenthic community

To further evaluate community composition, we examined total numbers of species, diversity and evenness in the epibenthic samples. Statistical analysis showed significant seasonal differences in the number of species with more species in June than in May (Table III, Fig. 4). There was also a significant Time*Site interaction (indicating that the change in number of species was greater at the Chuckanut site than it was in the Log Pond) and a significant Station effect (indicating differences between stations within each site). There was no clear site difference, suggesting that total number of species is similar in the Log Pond and Chuckanut sites. We could detect no significant temporal or spatial differences in diversity or evenness indices (Tables IV - V, Fig. 4). However, power for these analyses was again quite low.

Benthic community

In contrast to the epibenthic samples, ponar samples showed strong patterns in number of species, diversity and evenness. Number of species differed among stations within sites (Table VI, Fig. 5) but there were no differences between the Chuckanut and Log Pond sites. There were, however, site differences in diversity and evenness; both were slightly higher in the Chuckanut site than in the Log Pond (Tables VII - VIII, Fig. 5).

Cluster analyses

Cluster analysis of epibenthic samples showed a strong effect of date on community composition. The analysis produced 4 data clusters (Fig. 6). Cluster 1 was a peculiar outlier group consisting of one June stations in the Log Pond (SS76). Because this sample stood out so strongly from all other clusters, we removed it and reran the analysis. Removing the sample had no effect on the clustering of the remaining stations so we returned to the original analysis.

Cluster 2 was composed almost entirely of May samples. Clusters 3 and 4 consisted almost exclusively of June samples. The separation of these clusters was largely due to changes in abundance of foraminiferans, nematodes and several crustaceans (*Cumella vulgaris*, *Tisbe* sp., and *Harpacticus* sp.). The strong difference in Cluster 1 appears related to an unusually high number of nematodes and harpacticoid copepods there. It is not clear why this particular station on this date was so different. It is likely that, in our sampling, we simply landed on an unusual habitat patch.

There was no separation of the Log Pond and Chuckanut sites in the cluster analysis, indicating that the epibenthic communities in these sites were similar. This was verified by a chi-square association test in a k-means cluster analysis, which showed no Site contribution to separation of the clusters ($X^2_{8df} = 11.6$, $p = 0.17$).

In contrast to the epibenthic samples, ponar samples showed very strong clustering of sites. The most striking pattern was the clear separation of station SS75 in the Log Pond (Cluster 1, Fig. 6). Clusters 2 and 4 were composed entirely of Chuckanut sites. Cluster 3 contained the remaining Log Pond stations and two samples from Chuckanut station CH2 (Fig. 6). K-means cluster analysis verified the strong contribution of site to the clustering ($X^2_{4df} = 15.0$, $p = 0.004$).

Five species appeared to contribute most strongly to the separation of the ponar clusters. The polychaetes *Nephtys longosetosa*, *Owenia fusiformis*, and *Spirorbis* sp. were particularly important in separating out SS75 (all were much more abundant at SS75 than at any other station). Separation of the remaining clusters was strongly influenced by differing abundances of the crustacean *Cumella vulgaris* and the gastropod *Alvania carpenteri* (*C. vulgaris* was particularly abundant in the Chuckanut sites while *A. carpenteri* was abundant at SS75, SS76, and CH1).

Sediment characteristics

Sediments from both study sites were composed largely of sands in the 0.064 - 0.495 mm size fractions (Fig. 7). Kolmogorov-Smirnov analysis showed that the Log Pond sediments were coarser (i.e., had larger average grain sizes) than the Chuckanut sediments ($D = 0.37$, $p > 0.01$).

The organic content of sediments from all sites was less than 3% (Fig. 7). One-way ANOVA failed to detect significant differences between the study sites ($F_{0.05,1,3} = 0.47$, $p = 0.54$). However, power was very low (power = 0.08).

Discussion

Results of Year 2 sampling suggest that a diverse invertebrate community has established itself in the Log Pond site approximately 18 months after it was capped with clean sediment. We could detect no differences in epibenthic or benthic invertebrate biomass between the Log Pond and the Chuckanut Bay reference site. In addition, many of the same species occurred in both habitats (though there were slight differences in their biomass contribution to the invertebrate communities).

While these are good indications that a healthy community is being established in the Log Pond, there are still distinct differences between it and the Chuckanut site. For example, benthic invertebrate diversity and evenness were higher in the Chuckanut site than in the Log Pond. Furthermore, the actual structure of the community appeared to differ in these two sites. In particular, the Chuckanut site seemed to have a better representation of mollusks, while the Log Pond had a higher relative proportion of annelids.

An overriding feature that emerged several times in our analyses was the significant small-scale variability of the invertebrate community at both the Chuckanut and Log Pond locations; we frequently found significant "Station" differences in species abundances, biomass, and community indices. This suggests that the invertebrate communities are patchy in both of these environments. This could reflect small scale differences in sediment composition or in other features of the habitat. The variability could also represent biological features of the habitat. For example, there are many patches of eelgrass (primarily *Zostera marina*) in the Chuckanut site and smaller patches have recently appeared in the Log Pond (P. Schlenger, pers. comm.). If invertebrate communities are responding to such a mosaic of patches, it could well account for the variability we saw in our sampling.

While small-scale patchiness appears important in both sites, it was evident that the variability is greatest in the Log Pond. To determine whether the Log Pond community is converging on the "natural" state represented by the Chuckanut reference site, we performed cluster analyses. The clustering was based only on the species present and their relative abundances (without reference to sites). After the clustering was complete, we overlaid the sample station identifier and looked for patterns. If the habitats are converging, any clusters that formed should have included a random assortment of stations from both Chuckanut and the Log Pond. While this was clearly the case for most of the epibenthic samples (temporal effects were them most important factor controlling the formation of clusters), it was not true for the SS76 station, indicating habitat patchiness. The effect was even more dramatic in the ponar sampling. All clusters had a strong "site" component to them. The most striking effect was the distance of the SS75 samples from everything else in the analysis.

In addition to spatial variability, the Log Pond samples also showed greater temporal variability than the Chuckanut site. Both the invertebrate biomass and community composition seemed to change more between the May and June samples in the Log Pond than they did in the Chuckanut site. This spatial and temporal variability is not surprising given the relatively short time since the Log Pond habitat was created. It is probable that the Log Pond community will continue to change for some time as sediments stabilize, as species not currently represented in the site recruit from the plankton, and as species interactions are influenced by the return of predators (e.g., fish).

Comparison of Year 1 and Year 2 data provides additional information about the changing structure of the invertebrate community in the Log Pond and in the Chuckanut site. Overall examination of the data again suggests considerable temporal variability. The most striking feature was the difference in diversity between the Year 1 and Year 2 data, which occurred in both the Log Pond and Chuckanut sites (Fig 4). It is not clear what factors may have contributed to this difference.

Figure 2 suggests a clearer pattern in the overall invertebrate biomass. Dry weight biomass in both the Log Pond and Chuckanut sites was higher in the second year than in the first. The major difference in the two years appears to be the change in Log Pond Station SS75. We suggest that the enormous change there was due to either 1) the establishment of a new *O. fusiformis* population in the SS75 site or 2) a patchy distribution of *O. fusiformis* in the Log Pond with the sampler missing the patches in the first year but sampling a dense patch in the 2nd year.

Percent biomass measurements also show substantial differences from Year 1 to Year 2. Of particular interest is the great increase in mollusc biomass in the Log Pond benthic samples; molluscs were nearly absent in the Year 1 sampling at that site. Comparison of the Year 1 and Year 2 cluster analyses suggest that the Log Pond community has changed. In Year 1, much of the clustering of the benthic samples was driven by *Owenia fusiformis* and by the bivalve *Macoma nasuta* (both were much more abundant in the Chuckanut samples than in the Log Pond sites). That has clearly changed since 1) *M. nasuta* did not contribute to the clustering (indicating that its abundance has gone up in the Log Pond) and 2) *O. fusiformis* again contributes to the clustering, but it is in the other direction with much higher abundances in the Log Pond. This suggests that these species have established strong populations in the Log Pond. The Log Pond still has fewer bivalves in general, but the populations appear to be growing.

While there are clear differences between the invertebrate communities in the Log Pond and at the Chuckanut reference site, there is reason to believe that a healthy, functioning community has been established in the sediment cap. Both sites show considerable spatial and temporal variability in their invertebrate fauna. This is a natural characteristic of healthy invertebrate assemblages. The community fluctuations appear to be greater in the Log Pond than in the reference site. This would be expected in a habitat that has been recently disturbed. Over time, we would expect the fluctuations to become less pronounced as the community stabilizes with the addition of a full complement of invertebrate, and vertebrate, species.

Literature cited

Anchor Environmental, L.L.C. & Hart Crowser, Inc, 2000. Remedial Investigation/Feasibility Study, Whatcom Waterway Site, Bellingham, Washington, prepared for Georgia-Pacific West, Inc. July 25, 2000.

Bingham, B.L., B. Clothier and R. Matthews. 2001. The Log Pond Restoration Project: structure and function of the benthic community. Prepared for Georgia-Pacific West, Inc.

PSEP 1997a. 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.

Simenstad, C.S., C.D. Tanner, R.M. Thom and L.L. Conquest. 1991. Estuarine Habitat Assessment Protocol. Report prepared for U.S. Environmental Projection "Agency by Fisheries Research Institute and Center for Quantitative Science, University of Washington, Seattle, WA. EPA 910/9-91-037.

Table I. Analysis of variance for total dry biomass 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	1.84E-03	1	1.84E-03	1.93	0.25	0.16
Site	6.39E-03	1	6.39E-03	0.89	0.41	0.10
Time*Site	8.00E-04	1	8.00E-04	0.83	0.42	0.10
Station	2.13E-02	3	7.12E-03	7.46	0.06	0.53
Time*Station	2.86E-03	3	9.54E-04	0.74	0.53	0.18
Error	2.56E-02	20	1.28E-03			
Total	5.88E-02	29				

Table II. Analysis of variance table for dry biomass measurements of invertebrates collected with a ponar grab. Biomass data were log transformed to meet the assumption of equal variances.

Source	SS	df	MS	F	P	Power
Site	1.16	1	1.16	0.38	0.58	0.07
Station	9.15	3	3.05	39.57	< **0.01**	
Error	0.77	10	0.07			
Total	11.08	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	911.3	1	911.3	363.2	< **0.01**	
Site	174.0	1	174.0	0.9	0.40	0.10
Time*Site	233.4	1	233.4	93.0	< **0.01**	
Station	553.7	3	184.5	73.5	**<0.01**	
Time*Station	7.5	3	2.5	0.1	0.94	0.06
Error	410.6	20	20.5			
Total	2290.5	29				

Analysis of variance table for Shannon-Wiener (H') diversity indices calculated for epibenthic samples. The equal variance assumption was met for these data.

Source	SS	df	MS	F	p	Power
Time	0.18	1	0.18	1.48	0.30	0.14
Site	2.61	1	2.61	2.97	0.18	0.23
Time*Site	0.54	1	0.54	4.49	0.12	0.31
Station	2.63	3	0.87	7.19	0.07	0.52
Time*Station	0.36	3	0.12	0.84	0.48	0.19
Error	2.90	20	0.14			
Total	9.22	29				

Table V. Analysis of variance table for the Pielou's (J') evenness indices from epibenthic samples. Unequal variance problems could not be corrected by transformation. Since no results were significant, however, the consequences of this ANOVA violation are minor.

Source	SS	df	MS	F	p	Power
Time	0.089	1	0.089	2.80	0.19	0.22
Site	0.118	1	0.118	1.12	0.36	0.11
Time*Site	0.018	1	0.018	0.58	0.50	0.08
Station	0.313	3	0.104	3.28	0.17	0.28
Time*Station	0.095	3	0.003	1.89	0.16	0.41
Error	0.336	20	0.016			
Total	0.969	29				

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

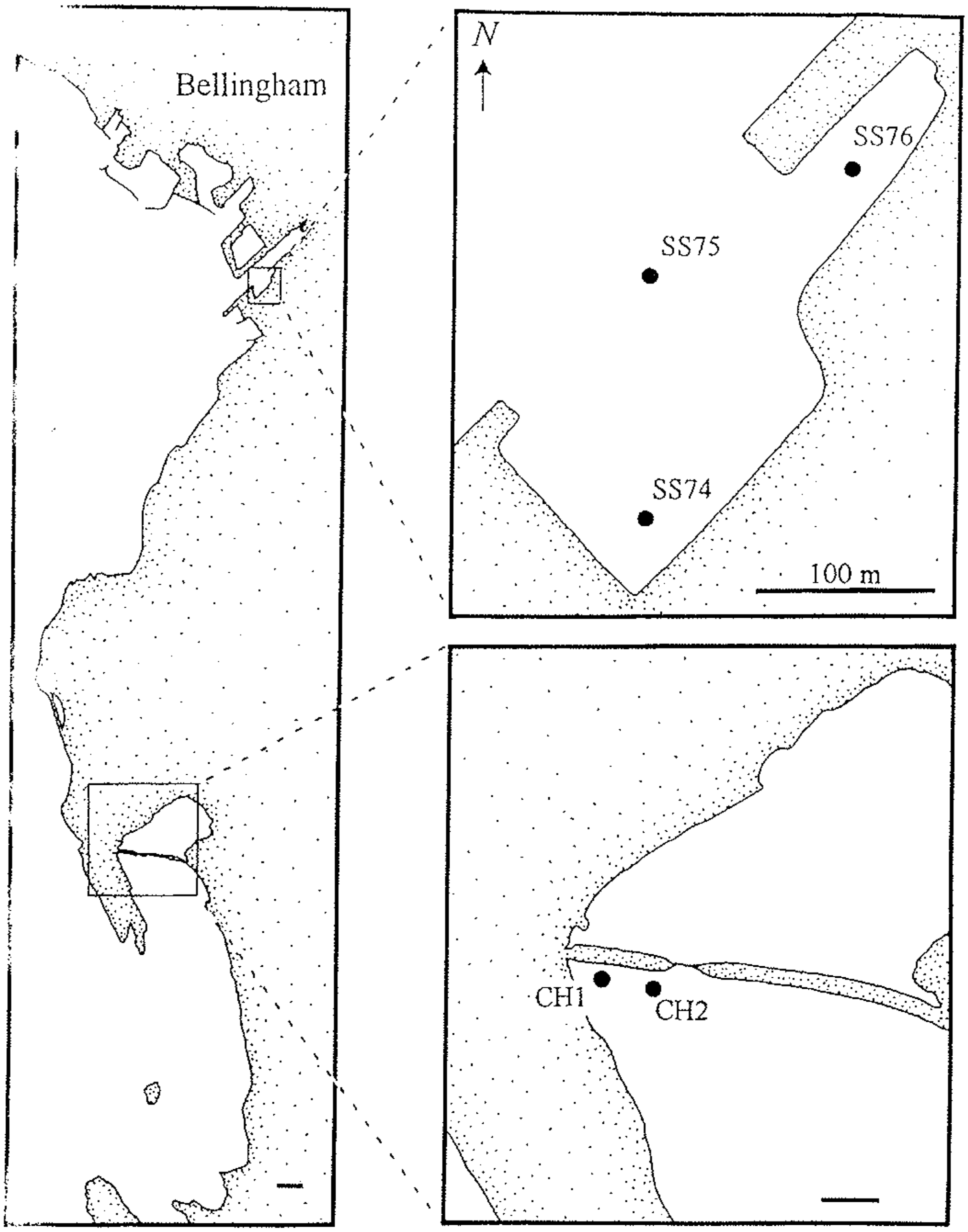
Source	SS	df	MS	F	P	Power
Site	1.11	1	1.11	0.01	0.94	0.05
Station	622.22	3	207.40	40.93	**< 0.01**	
Error	50.66	10	5.06			
Total	673.99	14				

Table VII. Analysis of variance table for the Shannon-Wiener (H') diversity indices calculated from ponar samples. Variances were homogeneous.

Source	SS	df	MS	F	P	Power
Site	0.83	1	0.83	9.09	**0.05**	
Station	0.27	3	0.09	0.54	0.66	0.12
Error	1.68	10	0.16			
Total	2.78	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 met.

Source	SS	df	MS	F	P	Power
Site	0.11	1	0.11	10.01	**0.05**	
Station	0.03	3	0.01	0.44	0.72	0.72
Error	0.24	10	0.02			
Total	0.38	14				



Fi[illegible] Study sites in the Log Pond and at the Chuckanut reference site. Scale bars on all figures represent 100 m.

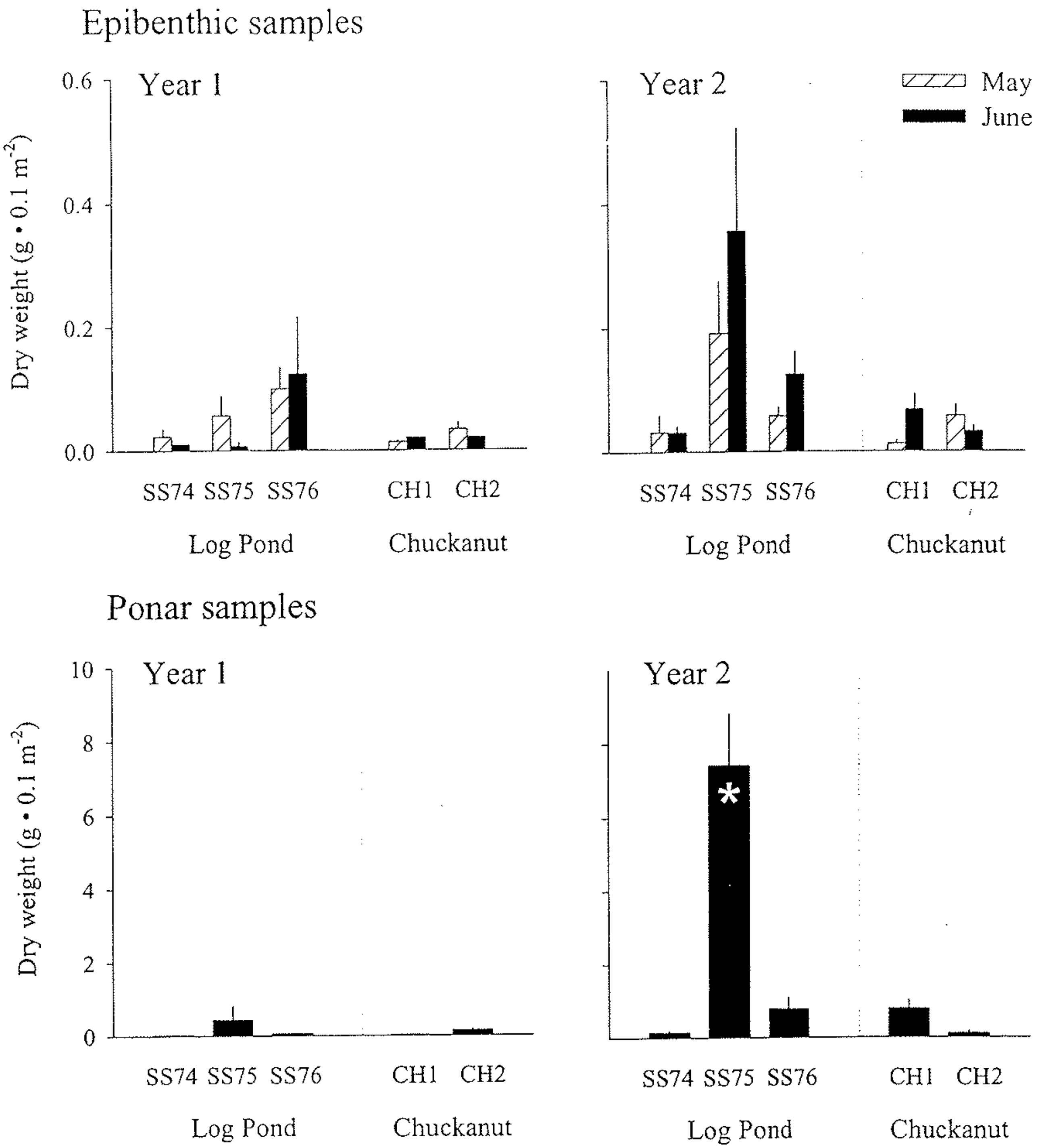


Figure 2. Total dry weights of all invertebrates picked from epibenthic and ponar samples. Standard errors are shown. Because weights of the polychaete *Owenia fusiformis* and its sand tubes were not included in the Year 1 ponar data, we also did not included them in the figure for the Year 2 data. The inclusion of those data would have had a major effect only on the height of the SS75 bar for Year 2 (indicated with an asterisk). The biomass volume of samples from that site (with *O. fusiformis* included) would have averaged 26.3 g • m^{-2}.

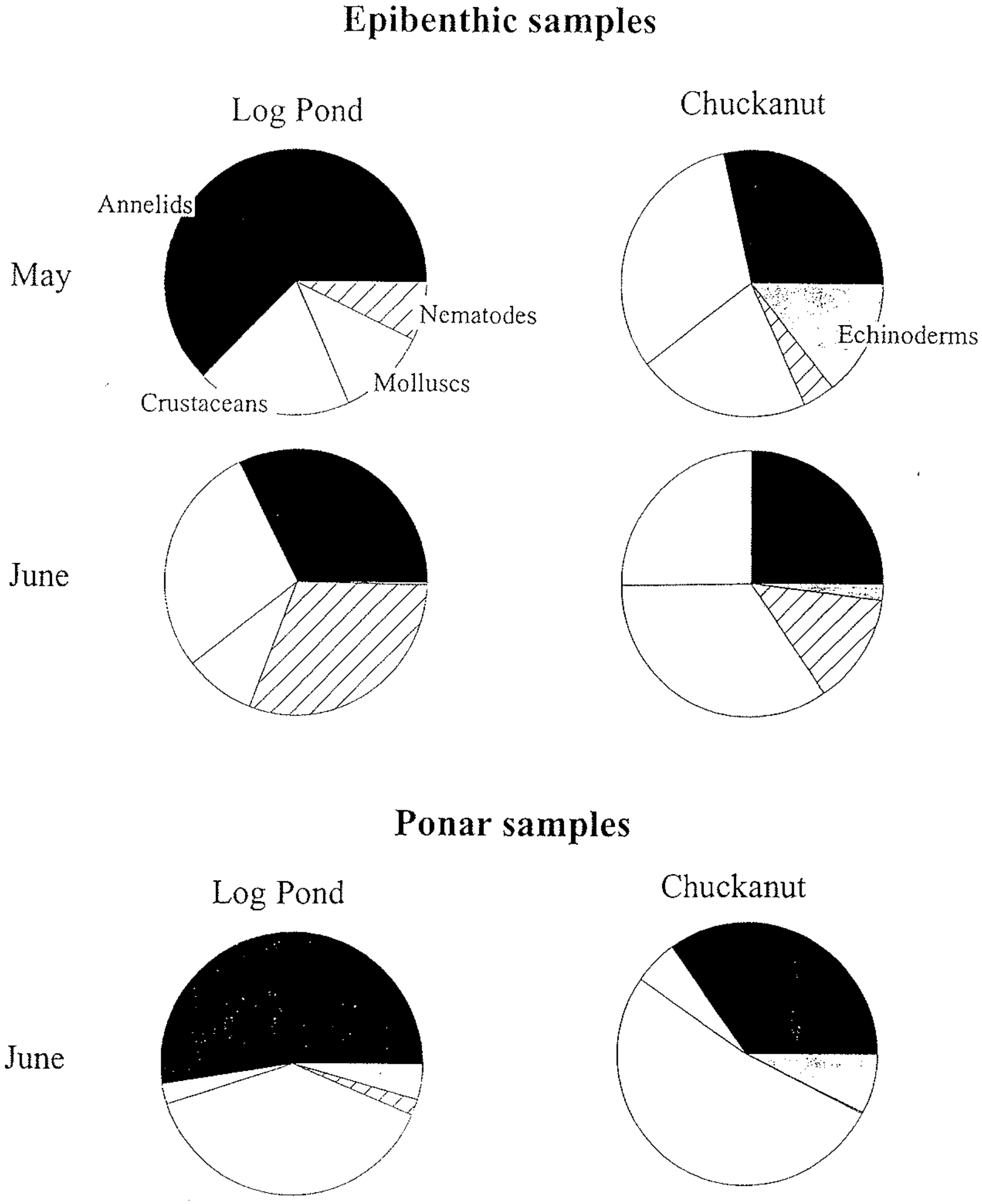


Figure 3. Dry weight composition of invertebrate samples from the Log Pond and Chuckanut study sites.

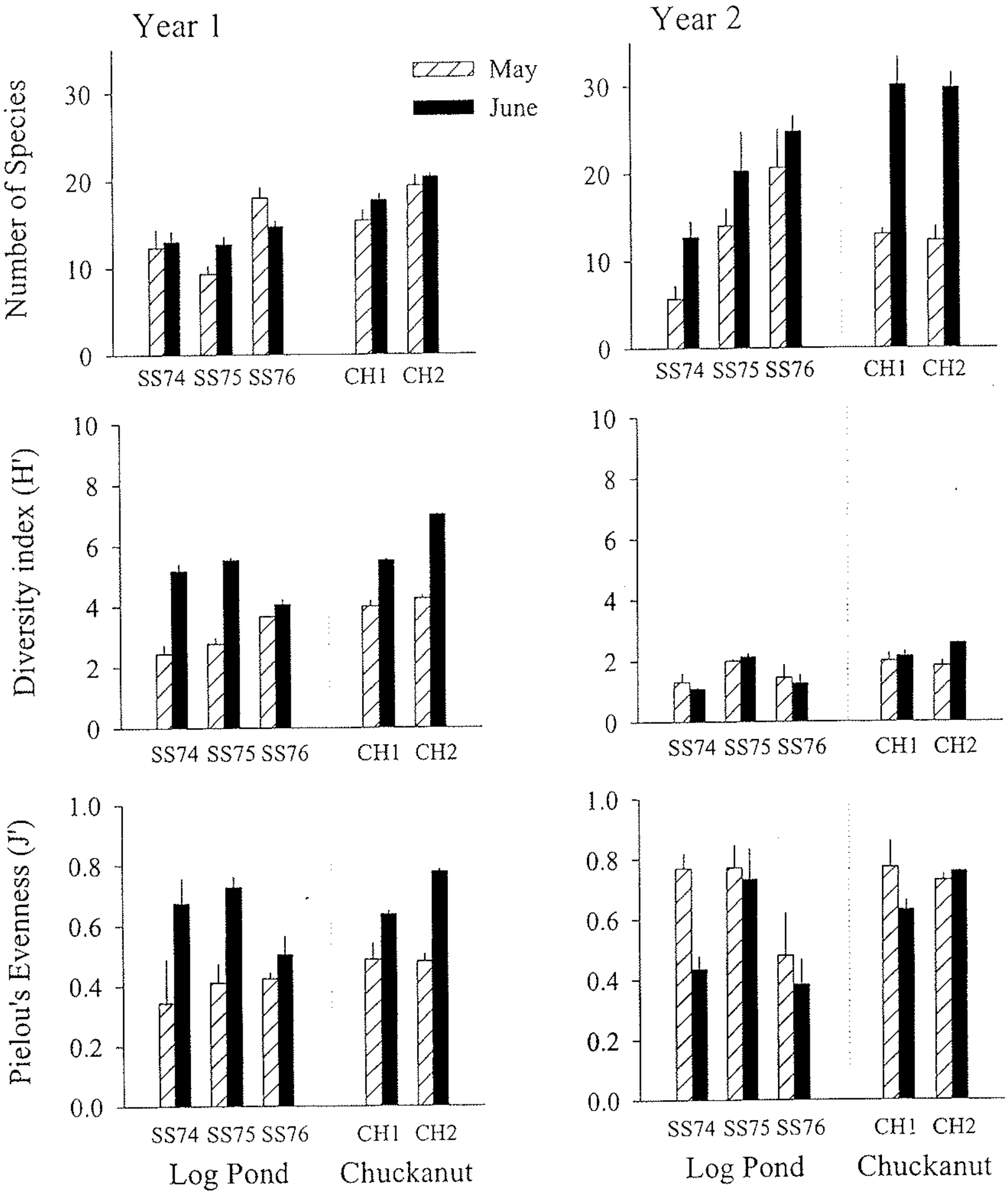


Figure 4. Community composition in epibenthic samples from the Log Pond and Chuckanut sites. Total number of species, the Shannon-Weiner diversity index (H') and Pielou's evenness index (J') are plotted. Standard errors are shown.

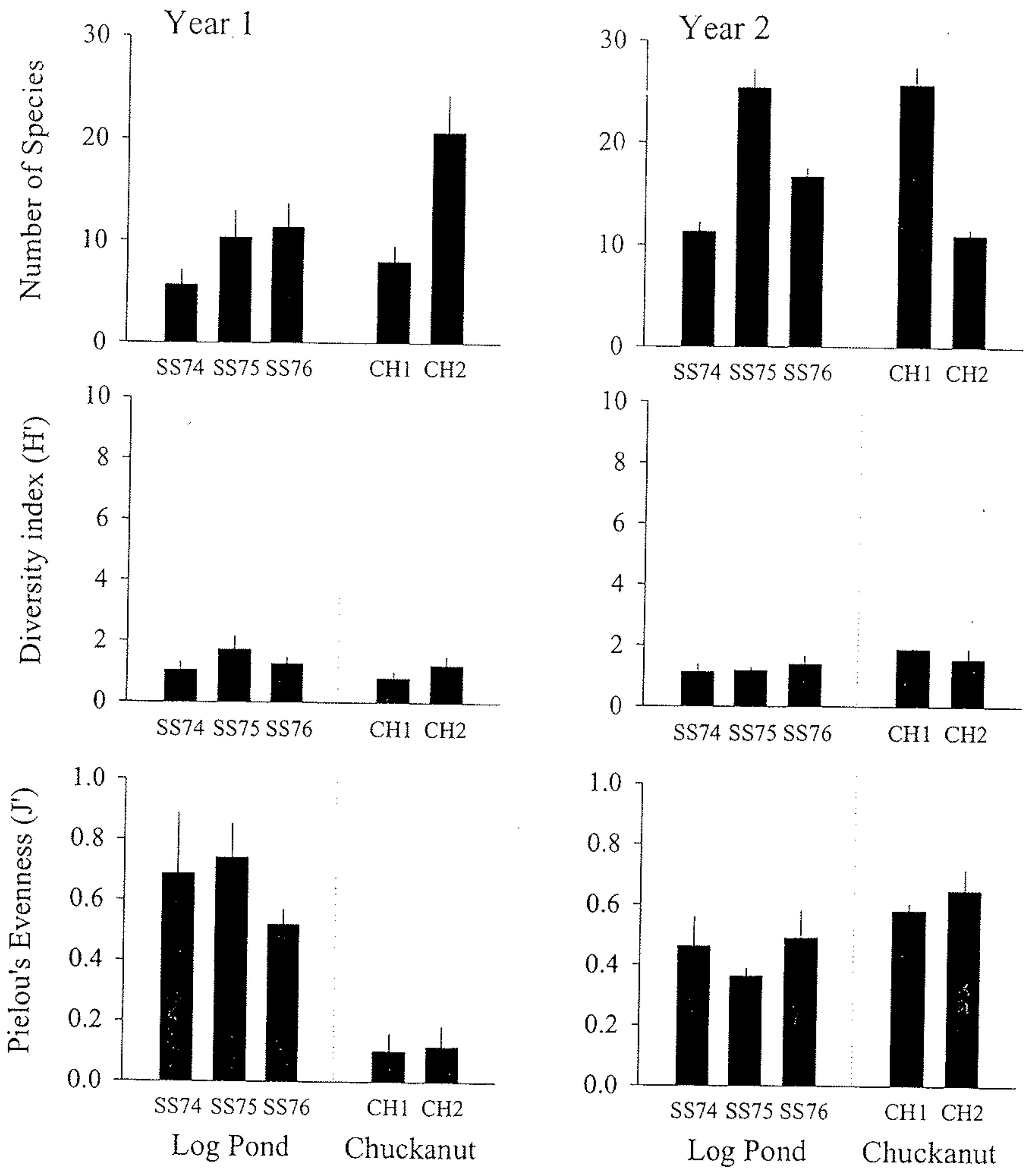
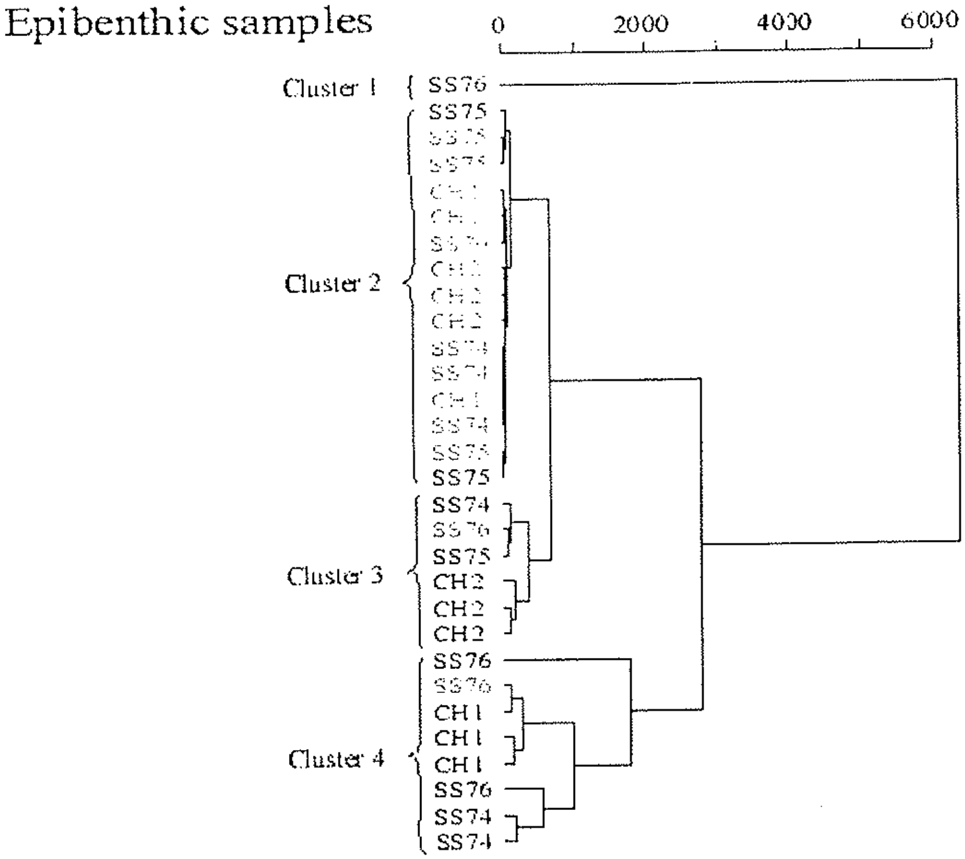


Figure 5. Community indices for ponar samples from the Log Pond and Chuckanut sites. Total number of species, the Shannon-Weiner diversity index (H') and Pielou's evenness index (J') are plotted. Standard errors are shown.



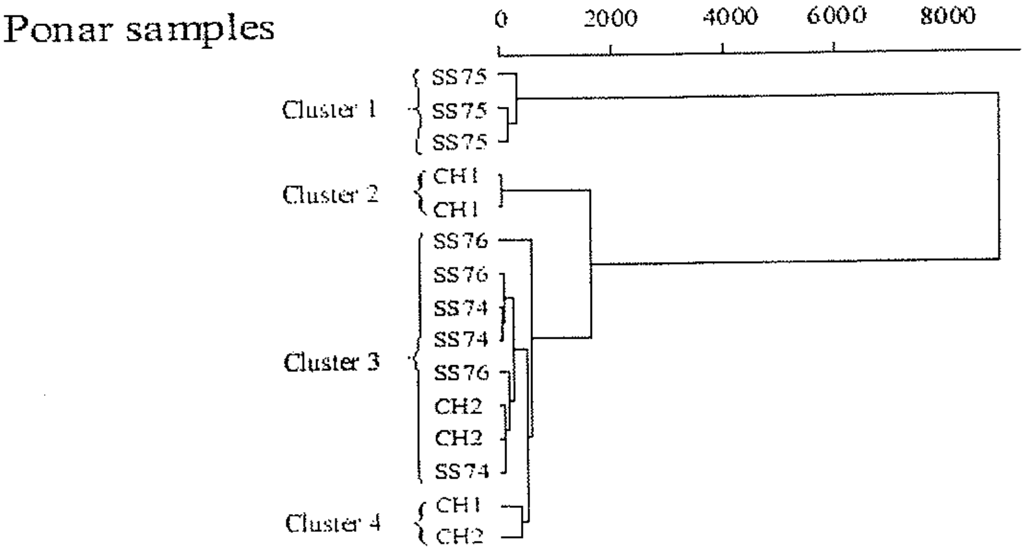


Figure 6. Cluster analysis for invertebrate samples with an epibenthic pump and with a ponar grab in the Georgia Pacific Log Pond and at a Chuckanut Bay reference site. Ward's cluster method with a Euclidean distance measurement was used for the analysis. Red text indicates that the samples were taken in May. The remaining samples were taken in June.

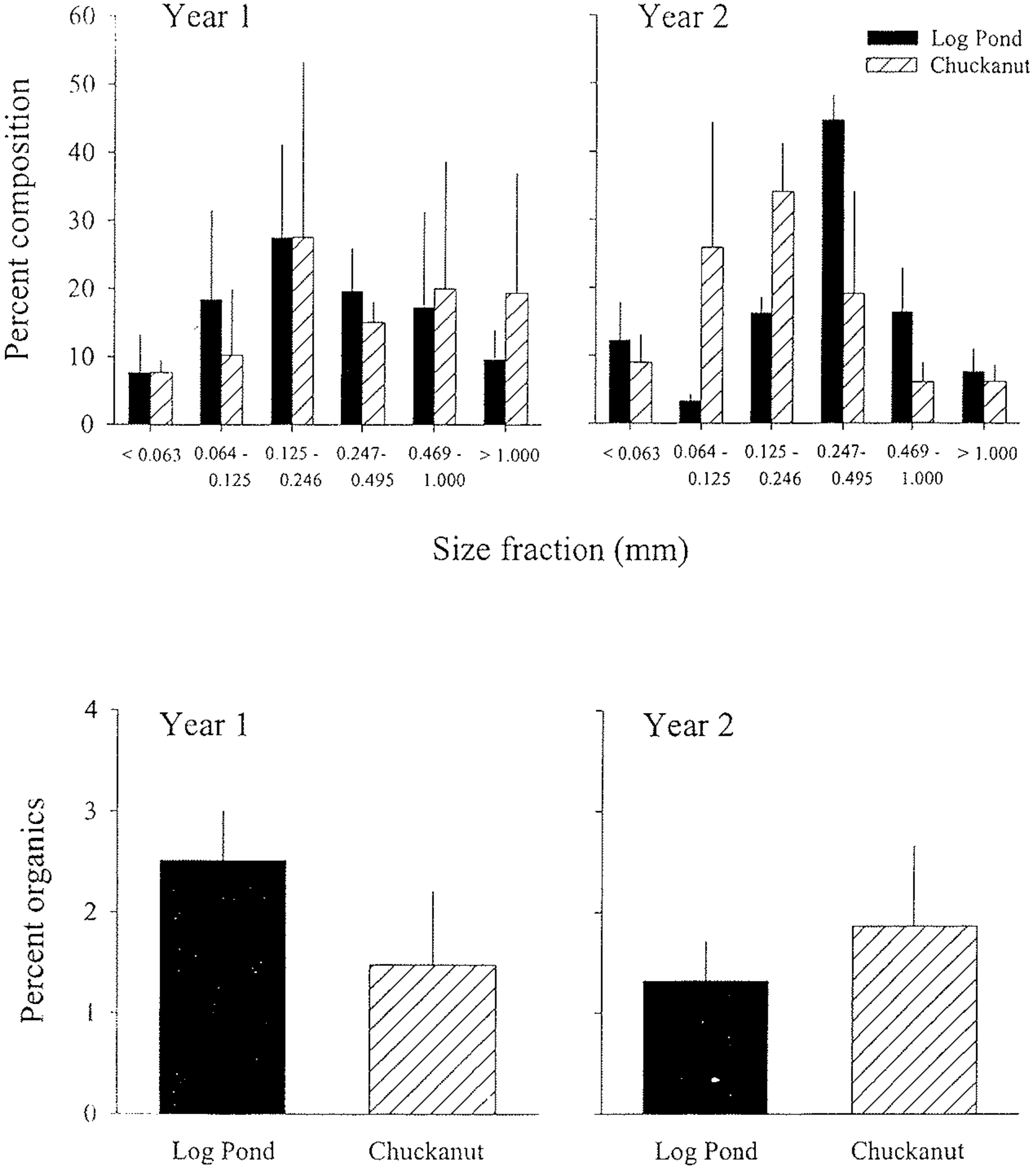


Figure 7. Sediment characteristics at the study sites. Grain-size distribution and percent organic content are plotted. Standard errors are shown.

Appendix 1.

Species Checklist for invertebrates collected in the Georgia Pacific Log Pond and in the Chuckanut Reference Site (Year 2).

- Phylum Sarcomastigophora
    - Class Granuloreticulosea
        - Order Foraminiferida
            - Unidentified foraminiferans
- Phylum Nematoda
    - Unidentified nematodes
- Phylum Cnidaria
    - Class Hydrozoa
        - Order Hydroida
            - Family Campanulariidae
                - *Obelia* sp.
- Phylum Kinorhyncha
    - Order Cyclorhagida
        - Family Centroderidae
            - *Kinorhynchus* sp.
- Phylum Annelida
    - Class Polychaeta
        - Order Capitellida
            - Family Capitellidae
                - *Capitella capitata* (Fabricius, 1780)
                - *Mediomastus* sp.
            - Family Maldanidae
                - Unknown species
        - Order Cirratulida
            - Family Cirratulidae
                - *Cirriformia cirratus* (Muller, 1776)
        - Order Cossurida
            - Family Cossuridae
                - *Cossura* sp.
        - Order Chaetopterida
            - Family Chaetopteridae
        - Order Eunicida
            - Family Lumbrineridae
                - *Lumbrineris* sp.
        - Order Flabelligerida
            - Family Flabelligeridae
                - *Pherusa* sp
        - Order Opheliida
            - Family Opheliidae
                - *Armandia brevis* (Moore, 1906)
        - Order Orbiniida
            - Family Orbiniidae
                - *Leitoscoloplos pugettensis* (Pettibone, 1957)
        - Order Oweniida
            - Family Oweniidae
                - *Owenia fusiformis* (Chiaje, 1841)
        - Order Phyllodocida
            - Family Goniadidae
                - *Glycinde polygnatha* (Hartman, 1950)
            - Family Hesionidae

- *Ophiodromus pugettensis* (Johnson, 1901)
- Family Nephtyidae
  - *Nephtys cornuta* (Berkley and Berkley, 1945)
  - *Nephtys longosetosa* (Ørsted, 1843)
- Family Nereidae
  - *Platynereis bicanaliculata* (Baird, 1863)
  - *Nereis vexillosa* (Grube, 1851)
- Family Pholoididae
  - *Pholoe* sp.
- Family Phyllodocidae
  - *Phyllodoce castanea* (Marenzeller, 1879)
- Family Polynoidae
  - *Harmothoe imbricata* (Linnaeus, 1766)
  - *Arctone* sp.
- Family Syllidae
  - *Exogone lourei* (Berkeley & Berkeley, 1938)
  - *Sphaerosyllis* sp.

- Order Sabellida
  - Family Spirobidae
    - *Spirobis* sp.
- Order Spionida
  - Family Spionidae
    - *Pygospio* sp.
    - *Prionospio jubata* (Blake)
    - *Sphiophanes* sp.
    - *Polydora* sp.
- Order Terebellida
  - Family Pectinariidae
    - *Pectinaria* sp.
  - Family Maldanidae
    - *Axiothella rubrocincta* (Johnson, 1901)

- Class Oligochaeta
  - Unidentified species

- Phylum Mollusca
  - Class Gastropoda
    - Subclass Opisthobranchia
      - Order Pyramidellacea
        - Family Cyclostremellidae
          - *Cyclostremella concordia* (Bartsch, 1920)
        - Family Pyramidellidae
          - *Odostomia* sp.
          - *Turbonilla* sp.
      - Order Cephalaspidea
        - Family Atyidae
          - *Haminaea vesicula* (Gould, 1855)
        - Family Cylichnidae
          - *Cylichna alba* (Carpenter, 1864)
      - Order Nudibrancia
        - Family Dendronotidae
          - *Dendronotus* sp.
    - Subclass Prosobranchia
      - Order Archaeogastropoda
        - Family Trochidae
          - *Margarites* sp.
        - Family Turbinidae

- *Astrea* sp.
- Order Mesogastropoda
  - Family Lacunidae
    - *Lacuna vincta* (Montagu, 1803)
  - Family Naticidae
    - *Polinices* sp.
    - Unknown sp. 1
  - Family Rissoidae
    - *Alvania carpenteri* (Weinkouff, 1885)
- Order Neogastropoda
  - Family Columbellidae
    - *Alia gausapata* (Carpenter, 1864)
  - Family Nassariidae
    - *Nassarius mendicus* (Gould, 1849)

- Class Bivalvia
  - Order Mytiloida
    - Family Mytilidae
      - *Mytilus* sp.
  - Order Veneroida
    - Superfamily Galeommatoidea
      - Family Cardiidae
        - *Clinocardium nuttallii* (Conrad, 1837)
        - *Nemocardium centifilosum* (Carpenter, 1864)
        - *Clinocardium* sp.
      - Family Lucinidae
        - *Parvilucina tenuisculpta* (Carpenter, 1864)
      - Family Montacutidae
        - *Rochefortia tumida* (Carpenter, 1864)
      - Family Tellinidae
        - *Macoma nasuta* (Conrad, 1837)
        - *Macoma* sp.
        - *Tellina bodegensis* (Hinds, 1845)
      - Family Veneridae
        - *Transennella tantilla* (Gould, 1852)
- Class Polyplacophora
  - Order Neoloricata
    - Family Leptochitonidae
      - *Leptochitona* sp.

- Phylum Arthropoda
  - Subphylum Crustacea
    - Class Branchiopoda
      - Order Cladocera
        - Family Podonidae
          - *Podon leuckarti* (G. O. Sars, 1862)
          - *Evadne* sp.
    - Class Ostracoda
      - Suborder Myodocopina
        - *Euphilormedes carcharodonta* (Smith, 1952)
      - Suborder Podocopida
        - Unidentified ostracod species 1
        - Unidentified ostracod species 2
        - Unidentified ostracod species 3
    - Class Cirripedia
      - *Balanus* sp.
      - Unidentified nauplius larvae

- Unidentified cyprid larvae
- Class Copepoda
  - Order Calanoida
    - Unidentified species
  - Order Harpacticoida
    - *Harpacticus* sp.
    - *Tisbe* sp.
    - *Ectinosoma melaniceps* (Boeck 1865)
    - *Orthopsyllus illgi*
    - *Nannopus palustris* (Brady, 1880)
- Class Malacostraca
  - Subclass Phyllocarida
    - Order Leptostraca
      - Family Nebaliidae
        - *Nebalia pugettensis* (Clark, 1932)
  - Subclass Peracarida
    - Order Cumacea
      - Family Leuconiidae
        - *Nippoleucon hinumensis* (Gamo, 1967)
      - Family Nannastacidae
        - *Cumella vulgaris* (Hart, 1930)
    - Order Tanaidacea
      - Family Paratanaidae
        - *Leptochelia dubia* (Kröyer,1842)
      - Family Tanaidae
        - *Sinelobus stanfordi* (Richardson, 1901)
  - Order Isopoda
    - Suborder Asellota
      - *Munna ubiquita* Menzies, 1952
  - Order Amphipoda
    - Superfamily Gammaroidea
      - Family Anisogammaridae
        - *Eogammarus* sp.
    - Superfamily Corophioidea
      - Family Corophiidae
        - *Corophium spinicorne* Stimpson, 1857
  - Order Decapoda
    - Infraorder Caridea
      - Family Hippolytidae
        - *Heptacarpus* sp.
    - Infraorder Anomura
      - Family Paguridae
        - *Pagurus* sp.
    - Infraorder Brachyura
      - Unidentified zoea larvae
      - Unidentified megalopa larvae
- Phylum Echinodermata
  - Class Ophiuroidea
    - Order Ophiuroidea
      - Family Amphiuridae
        - *Amphiodia occidentalis* (Lyman, 1860)
        - *Amphipholis* sp.
  - Class Holothuroidea
    - Order Dendrochirotida
      - Family Phyllophoridae
        - *Pentamera populifera* (Stimpson, 1864)

Phylum Chordata
  Subphylum Urochordata
    Order Doliolida
      Class Larvacea
        Oikopleura sp.

Appendix II. Organisms collected in May 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). Unknown specimens were generally juveniles too small to identify.

Annelida

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Arctonoe sp.	0	0	0	0	1
Armandia brevis	0	0	0	0	2
Axiothella rubrocincta	0	0	0	1	0
Capitella capitata	36	0	0	2	3
Exogone lourei	0	4	0	0	1
Glycinde polygnatha	0	0	0	0	1
Harmothoe imbricata	3	8	0	10	16
Mediomastus sp.	0	0	0	0	1
Nephtys longosetosa	5	5	0	5	8
Ophiodromus pugettensis	0	0	0	0	9
Owenia fusiformis	5	4	3	111	16
Pholoe sp.	0	0	0	1	0
Phyllodoce castanea	0	0	2	1	0
Prionospio jubata	1	1	0	0	0
Sphaerosyllis sp.	0	0	0	0	1
Spirorbis sp.	0	0	0	2	1
Unidentified oligochaete	0	0	3	1	9

Mollusca

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Alvania carpenteri	0	9	0	2	1
Clinocardium nuttallii	1	0	0	0	2
Cyclostremella concordia	0	0	0	3	0
Haminaea vesicula	0	0	0	0	1
Lacuna vincta	0	0	0	10	4
Macoma nasuta	0	1	0	36	1
Mytilus sp.	0	0	0	0	1
Nassarius mendicus	0	0	0	0	4
Odostomia sp.	0	2	0	0	0
Parvilucina tenuisculpta	0	2	0	0	4
Polinices sp.	0	0	0	0	15
Rochefortia tumida	16	66	0	5	84
Tellina bodegensis	1	0	0	12	14
Transennella tantilla	0	0	0	3	0
Unknown gastropod #1	0	0	0	0	3

Crustacea

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Balanus sp.	0	1	1	2	11
Corophium spinicorne	0	1	0	1	4
Cumella vulgaris	7	2	5	1	5
Ectinosoma melaniceps	1	0	3	1	0

Eogammarus sp.	24	10	1	0	2
Evadne sp.	0	10	0	0	0
Harpacticus sp.	15	0	2	0	34
Heptacarpus sp.	10	2	3	0	0
Leptochelia dubia	1	1	0	0	0
Munna ubiquita	0	3	0	4	0
Nannopus palustris	0	0	0	1	4
Nebalia pugettensis	0	3	0	0	0
Nippoleucon hinumensis	0	0	0	1	1
Pagurus sp.	1	0	0	0	0
Podon leuckarti	0	0	1	16	5
Tisbe sp.	0	2	0	1	2
Unidentified carangid copepod	1	1	0	0	3
Unidentified ostracod species 1	2	0	0	0	1
Unidentified cyprid larva	1	0	0	0	4
Unidentified zoeae larva	5	3	0	1	0

Miscellaneous

			Station		
	CH-1	CH-2	SS-74	SS-75	SS-76
Unidentified foraminiferans	13	18	0	0	441
Unidentified nematodes	105	35	29	24	843
Obelia medusa (Cnidaria)	0	0	0	1	0
Amphiodia occidentalis (Echinodermata)	1	0	0	0	0
Amphipholis sp. (Echinodermata)	2	9	0	5	1
Oikopleura sp. (Urochordata)	0	1	0	0	0

Appendix III. Organisms collected in June 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	6	15	0	2	1
Axiothella rubrocincta	0	0	0	0	2
Capitella capitata	2	0	3	22	0
Chaetopteridae (Family)	1	0	0	0	0
Exogone lourei	1	0	12	1	24
Glycinde polygnatha	7	0	0	0	9
Harmothoe imbricata	7	1	0	1	0
Leitoscoloplos pugettensis	0	0	3	0	0
Lumbrineris sp.	0	0	0	1	0
Mediomastus sp.	0	0	0	0	16
Nephtys cornuta	0	0	0	0	1
Nephtys longosetosa	10	1	0	0	48
Nereis vexillosa	0	0	1	1	0
Ophlodromus pugettensis	0	0	0	0	1
Owenia fusiformis	111	167	3	151	195
Pectinaria sp.	0	1	0	0	0
Pherusa sp.	0	0	0	3	0
Pholoe sp.	0	0	0	4	0
Platynereis bicanaliculata	0	1	0	0	0
Prionospio jubata	2	0	0	0	0
Polydora sp.	8	1	0	2	3
Spirorbis sp.	1	1	0	5	1
Unidentified oligochaete	2	6	84	5	16

Mollusca

			Station		
	CH-1	CH-2	SS-74	SS-75	SS-76
Alia gausapata	0	0	0	1	0
Alvania carpenteri	4	1	0	16	3
Clinocardium nuttallii	0	0	6	12	0
Clinocardium sp.	34	117	0	18	48
Dendronotus sp.	0	2	0	0	0
Lacuna vincta	1	29	0	0	0
Macoma nasuta	5	54	0	0	0
Macoma sp.	28	1	0	0	0
Mytilus sp.	0	1	0	2	0
Neocardium centifilosum	0	2	0	0	0
Parvilucina tenuisculpta	1	50	0	9	0
Polinices sp.	3	62	0	2	12
Rochefortia tumida	418	387	0	39	204
Tellina bodegensis	0	9	0	4	0
Unknown gastropod #2	4	0	0	7	8

Crustacea

			Station		
	CH-1	CH-2	SS-74	SS-75	SS-76
Balanus sp.	14	7	2	6	6
Corophium spinicornis	2	11	0	5	0
Cumella vulgaris	64	396	0	3	13
Ectinosoma melaniceps	25	1	2	0	146

Eogammarus sp.	23	162	0	0	0
Euphilomedes carcharodonta	2	0	0	0	0
Evadne sp.	1	17	0	0	0
Harpacticus sp.	367	676	1681	6	4737
Heptacarpus sp.	1	0	0	0	6
Leptochelia dubia	13	0	0	0	0
Munna ubiquita	19	0	0	5	0
Nannopus palustris	160	352	46	0	78
Nebalia pugettensis	5	0	0	1	0
Nippoleucon hinumensis	0	0	7	1	4
Orthopsyllus illogic	40	23	1	0	12
Podon leuckarti	147	139	33	6	13
Sinelobus stanfordi	1	0	0	0	2
Tisbe sp.	121	205	65	11	317
Unidentified carangid copepod	48	22	28	17	43
Unidentified ostracod species 1	0	40	0	0	0
Unidentified ostracod species 2	0	15	0	0	0
Unidentified ostracod species 3	131	0	0	0	0
Unidentified nauplius larva	30	7	0	0	1
Unidentified cyprid larva	37	20	4	5	135
Unidentified zoea larvae	5	4	2	0	7
Unidentified megalopa larva	0	0	1	0	0

Miscellaneous			**Station**		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Unidentified foraminiferans	1112	120	2	104	728
Unidentified nematodes	1180	273	1688	198	8787
Obelia medusa (Cnidaria)	0	1	0	0	0
Kinorhynchus sp. (Kinorhyncha)	0	0	0	0	2
Amphipholis sp. (Echinodermata)	2	0	0	2	0

Appendix IV. 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	18	5	2	0	1
Capitella capitata	7	0	47	16	22
Cirriformia cirratus	2	0	0	7	0
Chaetopteridae (Family)	2	0	0	0	0
Cossura sp.	0	0	0	15	0
Exogone lourei	0	0	1	0	0
Glycinde polygnatha	16	0	3	30	13
Harmothoe imbricata	0	0	0	13	0
Leitoscoloplos pugettensis	37	0	6	0	2
Maldanidae (Family)	0	0	0	0	3
Mediomastus sp.	1	2	0	25	0
Nephtys longosetosa	9	8	0	74	11
Owenia fusiformis	93	22	0	6227	125
Pectinaria sp.	1	0	0	8	0
Pholoe sp.	1	0	5	0	1
Phyllodoce sp.	0	0	9	0	0
Prinospio jubata	0	0	2	0	0
Pygospio sp.	6	0	2	0	5
Sphiophanes sp.	3	0	0	0	0
Spirorbis sp.	15	0	0	75	0

Mollusca

			Station		
	CH-1	**CH-2**	**SS-74**	**SS-75**	**SS-76**
Alia gausapata	3	0	0	0	0
Alvania carpenteri	90	0	2	540	107
Astrea sp.	0	1	0	0	0
Cylichna alba	1	1	0	33	0
Clinocardium nuttalli	69	313	1	0	4
Clinocardium sp.	13	0	0	0	0
Haminaea vesicula	1	0	1	0	5
Lacuna vincta	1	0	6	0	0
Leptochitona sp.	0	0	0	0	1
Macoma nasuta	2	4	7	0	2
Macoma sp.	0	0	0	0	6
Margarites sp.	3	0	0	0	0
Mytilus sp.	0	0	0	13	0
Nassarius mendicus	2	10	0	18	0
Naticidae (Family)	0	2	0	0	0
Neocardium centifilosum	0	0	0	1	0
Odostomia sp.	4	0	0	17	0
Parvilucina tenuisculpta	15	0	0	75	0
Rochefortia tumida	1409	62	7	182	25
Tellina bodegensis	57	0	15	91	14
Transennella tantilla	7	0	0	0	0
Turbonilla sp.	0	0	0	2	0
Unknown gastropod #1	0	0	0	1	1
Unknown gastropod #2	0	0	1	6	0

Crustaceana

			Station		
	CH-1	CH-2	SS-74	SS-75	SS-76
Balanus sp.	26	4	0	7	8
Corophium spinicorne	0	1	0	22	10
Cumella vulgaris	67	22	2	5	10
Eogammarus sp.	18	2	0	16	0
Euphilormedes carcharodonta	24	0	0	3	0
Heptacarpus sp.	0	0	1	0	0
Leptochelia dubia	62	1	0	6	0
Munna ubiquita	25	0	0	19	0
Nannopus palustris	0	0	8	0	0
Nebalia pugettensis	0	1	0	0	0
Nippoleucon hinumensis	3	0	1	0	7
Sinelobus stanfordi	0	0	0	9	0
Tisbe sp.	0	0	1	0	0
Unidentified calanoid copepod	0	0	0	4	0
Unidentified ostracod species 1	2	0	0	0	0
Unidentified cyprid larva					
Unidentified magalopa larva	0	0	0	1	0

Miscellaneous

			Station		
	CH-1	CH-2	SS-74	SS-75	SS-76
Unidentified foraminiferans	557	2	8	111	8
Unidentified nematodes	408	8	268	517	654
Obelia medusa (Cnidaria)	0	0	0	69	0
Amphiodia occidentalis (Enchinodermata)	0	0	0	0	0
Amphipholis sp. (Enchinodermata)	4	0	0	0	0
Pentamera populifera (Enchinodermata)	0	0	0	5	0
Oikopleura sp. (Chordata)	0	4	0	0	0

Frontier
Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

August 19, 2002

Paul Schlenger
Anchor Environmental
1411 4th Avenue, Suite 1210
Seattle, WA 98101

Re: Total Hg in Tissues: G-P Log Pond

Dear Mr. Schlenger,

Enclosed are results for total mercury in crab tissue samples collected on July 31, 2001. The samples were received in good condition on August 1, 2001. Following receipt, the samples were rinsed with reagent water to remove particulate matter from the exterior of the shells and immediately placed in frozen storage until sample preparation could take place.

Prior to digestion for total mercury, each sample was homogenized in an acid-cleaned blender. Approximately one half gram of each sample was digested with 10 ml of hot refluxing 70%HNO_3/30%H_2SO_4 for approximately two hours. The digests were then diluted to a final volume of 40 ml with a solution of 10% (v/v) 0.2N BrCl. Aliquots of each sample were analyzed by $SnCl_2$ reduction, dual gold amalgamation, and cold vapor atomic fluorescence (CVAFS) detection. No analytical difficulties were encountered. Please feel free to call me if you have any questions.

Best Wishes,

Lucas Hawkins

Lucas Hawkins
Project Manager

[illegible]
[illegible]
[illegible]
[illegible]

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 14, 2002 (THG12-020814-1)

Sample Identification	**Date Collected**	**Total Hg, ng/g***
SS-74A	7/22/2002	28.9
SS-74B	7/22/2002	21.6
SS-74C	7/22/2002	18.7
SS-75A	7/22/2002	23.4
SS-75B	7/22/2002	28.5
SS-75C	7/22/2002	21.5
SS-76A	7/22/2002	14.3
SS-76B	7/22/2002	15.2
SS-76C	7/22/2002	9.54

*Blank corrected

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 14, 2002 (THG12-020814-1)

Sample Identification	**Date Collected**	**Total Hg, ng/g**

Method blanks

Blank-1		0.26
Blank-2		0.15
Blank-3		0.15
Blank-4		0.19
Mean		**0.19**
Estimated MDL		**0.16**
Method MDL		**0.50**

Certified Reference Materials

DORM-2		3,662
recovery		**78.9%**
reference value		4,640

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 14, 2002 (THG12-020814-1)

Sample Identification	Date Collected	Total Hg, ng/g*

Analytical Replicates

SS-74A	7/22/2002	28.91
SS-74A MD	7/22/2002	27.60
Mean		**28.26**
RPD		**4.6%**

*Blank corrected

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Kim Magruder)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Suite B, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: August 14, 2002 (THG12-020814-1)

Sample Identification	**Date Collected**	**Total Hg, ng/g***
Matrix spikes		
SS-74A MS	7/22/2002	137.5
spiking level		115.8
net		109.2
recovery		**94.3%**
SS-74A MSD	7/22/2002	154.6
spiking level		125.1
net		126.4
recovery		**101.0%**

*Blank corrected

Chain of Custody Record & Laboratory Analysis Request

Page 1 of 1

Turnaround Requested:

Anchor Contact: Paul Schlenger

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

Lab Contact: Lucas Hawkins

Proj. Name: GP Log Pond

Lab: Frontier

Proj. Number: 02-0030-01

Address: 414 Pontius Ave N, Ste B.
Seattle 98109

Sampler: Paul Schlenger

Phone: 206-622-6960

Shipping Method: hand deliver

Fax: 206 622-6870

AirBill:

Analyses Requested

Sample ID	Sample Date	Sample Time	Sample Martix	# Containers	Total Hg-lowlevel FGS 011	method with initial rinsed	crabs								Notes/ Comments:
SS-74A	7/22/02	1715	Tissue	1											whole body
SS-74B		1715		1											
SS-74C		1715		1											
SS-75A		1335		1											
SS-75B		1335		1											
SS-75C		1335		1											
SS-76A		1345		1											
SS-76B		1730		1											
SS-76C		1730		1											

Relinquished: (Signature)	Relinquished: (Signature)	Relinquished: (Signature)	Special Instructions/Notes
Printed Name: Margaret McCauley	Printed Name:	Printed Name:	
Company: Anchor	Company:	Company:	
Date/Time: 7/23/2002 9:15 am	Date/Time:	Date/Time:	
Received By: A. Vandervort	Received By: A. Malaika Lafferty	Received By:	
Printed Name: A Vandervort	Printed Name: A. Malaika Lafferty	Printed Name:	
Company: FGS	Company: Frontier	Company:	# of Coolers: 1 | Cooler Temp(s): 0.0
Date/Time: 7/23/02 9:15	Date/Time: 7-23-02 0930	Date/Time:	COC Seals Intact? N/A | Bottles Intact? N/A

Frontier
Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N - Seattle WA 98109

September 18, 2002

Paul Schlenger
Anchor Environmental
1411 4th Avenue, Suite 1210
Seattle, WA 98101

Re: Total Hg in Tissues: G-P Log Pond Crabs

Dear Mr. Schlenger,

Enclosed are results for total mercury in 3 crab tissue samples collected on August 21, 2001. The samples were received in good condition on August 22, 2001. Following receipt, the samples were rinsed with reagent water to remove particulate matter from the exterior of the shells and immediately placed in frozen storage until sample preparation could take place.

Prior to digestion for total mercury, each sample was homogenized in an acid-cleaned blender. Approximately one half gram of each sample was digested with 10 ml of hot refluxing 70%HNO_3/30%H_2SO_4 for approximately two hours. The digests were then diluted to a final volume of 40 ml with a solution of 10% (v/v) 0.2N BrCl. Aliquots of each sample were analyzed by $SnCl_2$ reduction, dual gold amalgamation, and cold vapor atomic fluorescence (CVAFS) detection. No analytical difficulties were encountered, with one item to note.

- The matrix duplicate RPD for sample Ref-1 was elevated at 53.8%. The difference between the native sample and sample duplicate is greater than can be explained by analytical variability. A reanalysis of the matrix duplicate was performed yielding similar results. It is possible that the sample was insufficiently homogenized. Please note that the matrix spike and matrix spike duplicate were within control limits. Rehomogenization and reanalysis of the sample may be performed at the client's discretion.

Please feel free to call me if you have any questions.

Best Wishes,

Jennifer Cahn

Jennifer Cahn
Project Coordinator

206 622 6960
FAX 206 622 6870
E-mail: info@frontier.wa.com
www.frontiergeosciences.com

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Paul Schlenger)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: September 6, 2002 (THG8-020906-1)

Sample Identification	**Date Collected**	**Total Hg, ng/g***
Ref 1	8/21/2002	36.5
Ref 2	8/21/2002	19.9
Ref 3	8/21/2002	308

*Blank corrected

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Paul Schlenger)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: September 6, 2002 (THG8-020906-1)

Sample Identification	Date Collected	Total Hg, ng/g
Method blanks		
Blank-1		0.07
Blank-2		0.06
Blank-3		0.12
Blank-4		0.11
Mean		**0.09**
Estimated MDL		**0.09**
Reporting Limit		**0.45**
Certified Reference Materials		
TORT-2		214.6
recovery		**79.5%**
reference value		270.0

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Paul Schlenger)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: September 6, 2002 (THG8-020906-1)

Sample Identification	Date Collected	Total Hg, ng/g*
Analytical Replicates		
Ref 1	8/21/2002	36.48
Ref 1 MD	8/21/2002	21.01
Mean		**28.75**
RPD		**53.8%****

*Blank corrected

**RPD above acceptable limit of 25%. Please see case narrative.

Total Mercury in Tissues-GP Log Pond

(Anchor Environmental c/o Paul Schlenger)

analyzed by:
Frontier Geosciences, Inc.
414 Pontius Avenue North, Seattle, WA 98109
phone: (206) 622-6960 fax: (206) 622-6870

Samples analyzed: September 6, 2002 (THG8-020906-1)

Sample Identification	**Date Collected**	**Total Hg, ng/g***
Matrix spikes		
Ref 1 MS	8/21/2002	176.7
spiking level		161.4
net		140.2
recovery		**86.9%**
Ref 1 MSD	8/21/2002	178.6
spiking level		157.0
net		142.1
recovery		**90.5%**

*Blank corrected

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North • Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@FrontierGeosciences.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: August 22, 2002 Page: 1 of 1

Client Company: Anchor Environmental
Address: 1411 4th Ave Suite 1210
Seattle, WA 98101
CONTACT: Paul Schlenger
Phone: 206-287-9130 Fax: 206-287-9131
Email: pschlenger@anchorenv.com
Project Name: GP Log Pond
Contract/PO #:

Frontier Project Manager: Lucas Hawkins
Guaranteed Turnaround Time:
Confirmation of Sample Arrival at Frontier: ☐ YES ☐ NO
Quality Assurance Level: ☐ Standard ☐ High
Disposal*: ☐ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**

*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.
**Please discuss this with the Frontier Project Manager.

Carrier Information: FED EX ☐ UPS ☐ Other ☑
Tracking # Hand-delivered

Engraved Bottle ID	Sample ID	Matrix[1]	# Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
	Ref 1	AT	1	8/21/02 1830hrs	PS/EA	ice	low level whole body Mercu
	Ref 2	AT	1	8/21/02 1835hrs	PS/EA	ice	
	Ref 3	AT	1	8/21/02 1840hrs	PS/EA	ice	↓

Sample Receipt

C.O.C. Seal Intact? ☐ YES ☐ NO ☑ N/A
Cooler Temperature: N/A °C
Comments:
Please rinse crabs before processing

VTSR: 1050

[1] Matrix Codes:

- FW = fresh water (salinity < 0.5 ppth)
- BW = brackish water
- SW = seawater
- WW = wastewater
- SE = sediment
- SO = soil
- AT = animal tissue
- PT = plant tissue
- TR = trap
- PP = petroleum product
- OT = other

Relinquished by:
Print name: Paul Schlenger
Company: Anchor Env
Date: 8/22/02 Time: 1050

Received by:
Print name: Christabel Fowler
Company: FGS
Date: 8-22-02 Time: 1050

Relinquished by:
Print name:
Company:
Date: Time:

Received by:
Print name:
Company:
Date: Time: