The Liberty Development 2001 Sediment Quality Study provides an understanding of selected physical and chemical parameters of sediment anticipated to be excavated and used as fill or disposed of via ocean dumping. Key findings from this study include:

Surface and Subsurface Sediment (Chemistry) Quality

- All CoC concentrations in surface and subsurface sediment samples were less than the regulatory screening levels presented in the *Dredged Material Evaluation Framework, Lower Columbia River Management Area* (November 1998).
- The range of values for sediment chemistry and physical properties corresponded with findings from regional sediment studies and other sediment sample studies conducted to support the Liberty Development.
- Concentrations of CoCs were similar to sediment chemistry concentrations described in regional and previous studies as representing natural background concentrations
- There was a positive linear correlation between the fine-grained sediment fraction and heavy metal concentrations from surface and subsurface sediments. This study concludes that there is no evidence of contaminant input from industrial or human-use activities.
- Most PAH analytes were not present in measurable quantities. Estimated (J) values near the MDLs were reported for select compounds detected but not present at concentrations above the method reporting limits.

Grain-size Distribution

- Coarser-grained sediments were predominantly restricted to the shallow waters adjacent to the grounded ice zone and finer-grained sediments dominated the grain-size distribution for samples collected in northern end of the alternative pipeline routes. This trend toward increasing percent fines with distance offshore is consistent with earlier geotechnical investigations (Duane Miller and Associates 1997, 1998).
- Based on spatial analysis, the percent fines are relatively consistent between the three transects (52-63%). Earlier analyses using soil classification correlations with the average percent fine-grained sediment fraction produced results similar to those found in this report.
- Additional sampling would probably not result in an overall change in the estimated volume of fine-grained (silt and clay) sediments in the proposed excavated material.

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Appendix A
Work Plan
Liberty Development 2001
Sediment Quality Study

WORK PLAN

LIBERTY DEVELOPMENT 2001 SEDIMENT QUALITY STUDY

Prepared for

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900 East Benson Blvd.
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March 9, 2001

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74-00000034.00 Task 10000

TABLE OF CONTENTS

List of Acronyms iii

Section 1 Introduction 1-1

Section 2 Background Information 2-1

2.1 Site History 2-1
2.2 Previous Investigations 2-2
2.2.1 Geophysical Hazard Surveys 2-2
2.2.2 Geotechnical Investigations 2-2
2.2.3 Sediment Quality and Geochemistry Studies 2-3
2.3 Current Site Uses 2-5
2.4 Potential Sources of Contamination 2-5

Section 3 Objectives 2-6

Section 4 Program Design 4-1

4.1 Regulatory Sediment Quality Ranking 4-1
4.2 Sampling Design and Locations 4-2
4.2.1 Grain-Size Sampling 4-2
4.2.2 Trench Excavation Sediment Quality Sampling 4-3
4.2.3 Surface Sediment Quality Sampling 4-5
4.2.4 Chemicals of Concern for Subsurface Sediments 4-5
4.2.5 Chemicals of Concern for Surface Sediments 4-7

Section 5 Field Methods 5-1

5.1 Navigation and Sample Positions 5-1
5.2 Sampling Methods 5-1
5.3 Sample Collection & Handling Procedures 5-1
5.3.1 Sampling Scheme 5-2
5.3.2 General Sample Collection Procedures 5-3
5.3.3 Volatiles and Sulfides Sub-Sampling Procedures 5-3
5.3.4 Compositing Procedures 5-3
5.3.5 Field Decontamination Procedures 5-4
5.3.6 Field Quality Control (QC) 5-4
5.3.7 Sample Containers and Labels Procedures 5-5
5.3.8 Sample Transport and Chain-of-Custody Procedures 5-6
5.4 Field Documentation 5-8

Section 6 Field Schedule 6-1

Section 7 References 7-1

TABLE OF CONTENTS

List of Tables

Table 2-1 Heavy Metal Concentrations for Sediments 2-4

Table 4-1 Management Area Ranking Definitions (Corps 1998) 4-1

Table 4-2 Estimated Pipeline Trench Dimensions (MMS 2001) 4-2

Table 4-3 Grain-Size Samples and Borings Planned along a Pipeline Route 4-3

Table 4-4 Minimum Number of Sediment Quality Borings along a Pipeline Route 4-5

Table 4-5 Proposed Chemical and Physical Analyses for Subsurface Sediments 4-6

Table 4-6 Proposed Chemical and Physical Analyses for Surface Sediments 4-7

Table 5-1 Sample and Field QC Design – Subsurface Sediment Quality Samples 5-2

Table 5-2 Sample and Field QC Design – Surface Sediment Quality Samples 5-2

Table 5-3 Holding Times and Minimum Container Sizes for Physical and Chemical Analyses 5-7

List of Figures

Figure 1-1 Liberty Development Project Proposed Facilities 1-2

Figure 1-2 Pipeline Routes and Production Islands Evaluated in the Liberty Development EIS 1-3

Figure 2-1 Offshore pipeline route cross section (from island to Boring D-11) 2-6

Figure 2-2 Offshore pipeline route cross section (from Boring D-12 to shore) 2-7

Figure 4-1 Proposed Sediment Grain-Size Sample Bore Holes 4-9

Figure 4-2 Proposed Excavation Sediment Quality Sample Bore Holes 4-10

Figure 4-3 Proposed Excavation Sediment Quality Sample Bore Holes 4-11

LIST OF ACRONYMS

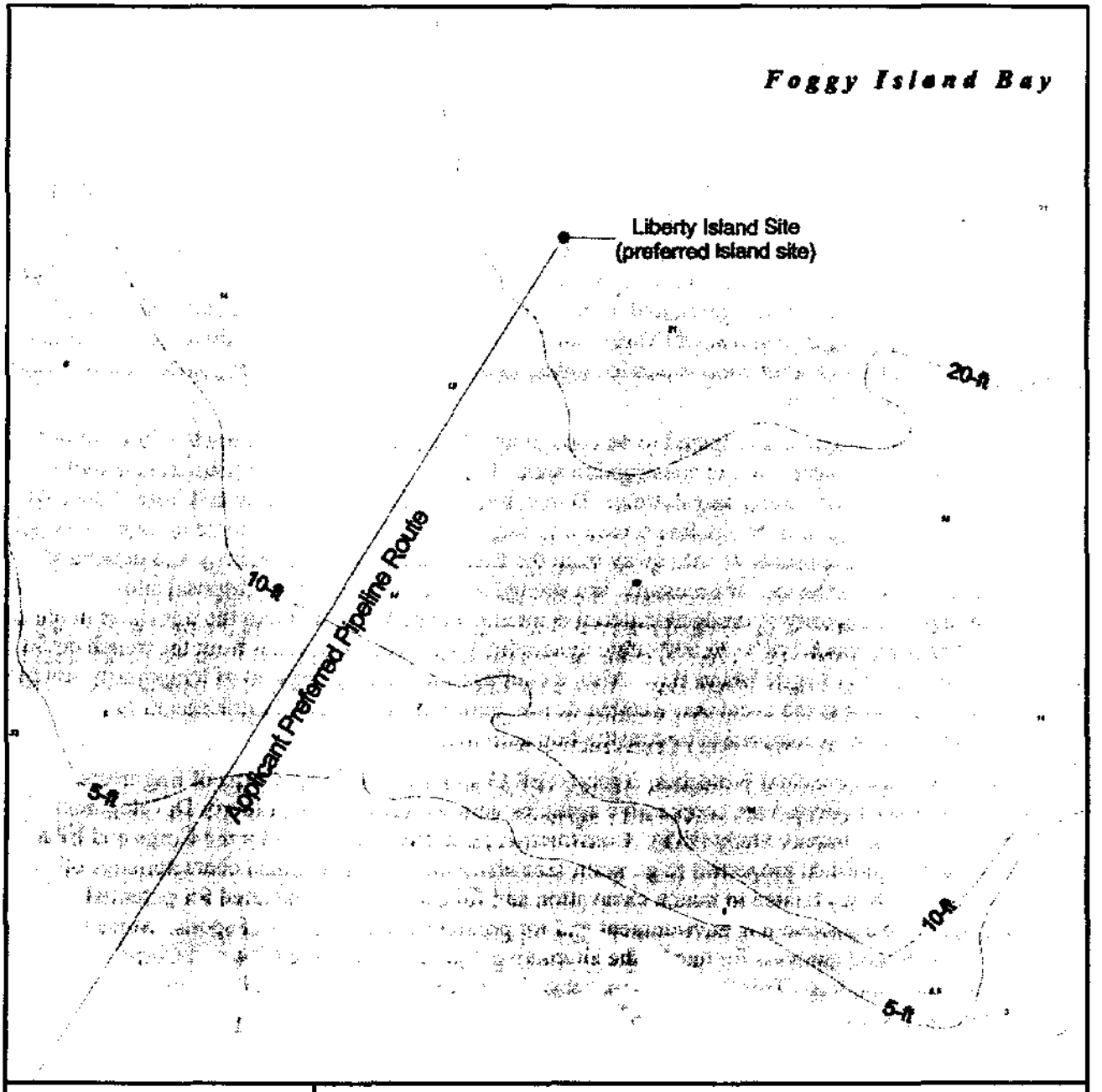
BPXA	BP Exploration (Alaska), Inc.
CORPS	U.S. Army Corps of Engineers
CVAA	Cold vapor atomic absorption
EPA	Environmental Protection Agency
EIS	Environmental Impact Study
GPS	Global Positioning System
HPAH	High Molecular Weight Polyaromatic Hydrocarbons
LPAH	Low Molecular Weight Polyaromatic Hydrocarbons
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
MMS	U.S. Minerals Management Service
MDRD	Minimum detectable relative difference
MS/DS	Matrix Spike/Duplicate Spike
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
OCS	OUTER CONTINENTAL SHELF
PAH	Polyaromatic Hydrocarbons
ppb	parts per billion
ppm	parts per million
PSDDA	Puget Sound Dredged Disposal Analysis Program
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QC	quality control
Rollagons	Arctic off-road vehicles
RPD	relative percent difference
SVOCs	semi-volatile organic compounds
TSS	total suspended sediments
USCS	Unified Soil Classification System
VOCs	volatile organic compounds

BP Exploration (Alaska) Inc. (BPXA) plans to develop the Liberty oil field in the Beaufort Sea for production and transport of sales-quality oil to the Trans-Alaska Pipeline system. The field will be developed from a gravel island to be constructed on the Federal Outer Continental Shelf (OCS) in Foggy Island Bay (Figure 1-1). The Liberty oil field development will include a subsea pipeline construction from the proposed island (Liberty Island) to a land-based connection with the Badami Sales Oil Pipeline.

The U.S. Minerals Management Service (MMS) is currently conducting an environmental evaluation of the Liberty Development based on the National Environmental Policy Act of 1969 (NEPA). The evaluation is presented in the *Liberty Development and Production Plan Draft Environmental Impact Statement* (MMS 2001). This document includes evaluations of multiple pipeline routes and production island locations, including the applicant's proposed Liberty Island route (Figure 1-2).

The pipeline system is anticipated to be constructed during the winter. Ice roads will be built to allow equipment access to the construction area. The proposed pipeline construction activity sequence is: 1) ice cutting and slotting, 2) trenching, 3) pipeline assembly and installation, 4) trench backfilling, and 5) pipeline pressure testing. During construction, some dredged material will be stored temporarily at sites away from the trench due to loading capacity and deflection characteristics of the ice. If necessary, the storage sites also will serve as disposal sites. Although the majority of dredged material is intended to be backfilled into the trench, as much as 110,000 cubic yards (yd^3) (76,500 cubic meters [m^3]) of dredged material from the trench could be disposed of in Foggy Island Bay. Also, a contingency plan for disposal of temporarily stored spoil is required in the event that weather or ice conditions necessitate abandonment of operations prior to completion of construction activities.

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers, Alaska District (Corps) are cooperative agencies with the MMS on the Liberty Development Environmental Impact Study (EIS). Construction permits administered by the Corps and EPA require that physical properties (e.g., grain-size distribution) and chemical characteristics of sediment samples related to trench excavation and fill activities be evaluated for potential impacts to the surrounding environment and for possible ocean disposal of spoils. Since there are no sediment analyses for one of the alternative pipeline routes, the EPA and Corps requested additional sampling. This document presents the sampling and analysis plan to evaluate the sediments anticipated to be excavated for the three routes evaluated in the EIS and used as fill or disposed of via ocean dumping.



Legend

- Production Island (proposed alternative)
- Proposed Pipeline Route

bp

Liberty Development Project
Proposed Facilities

NORTH

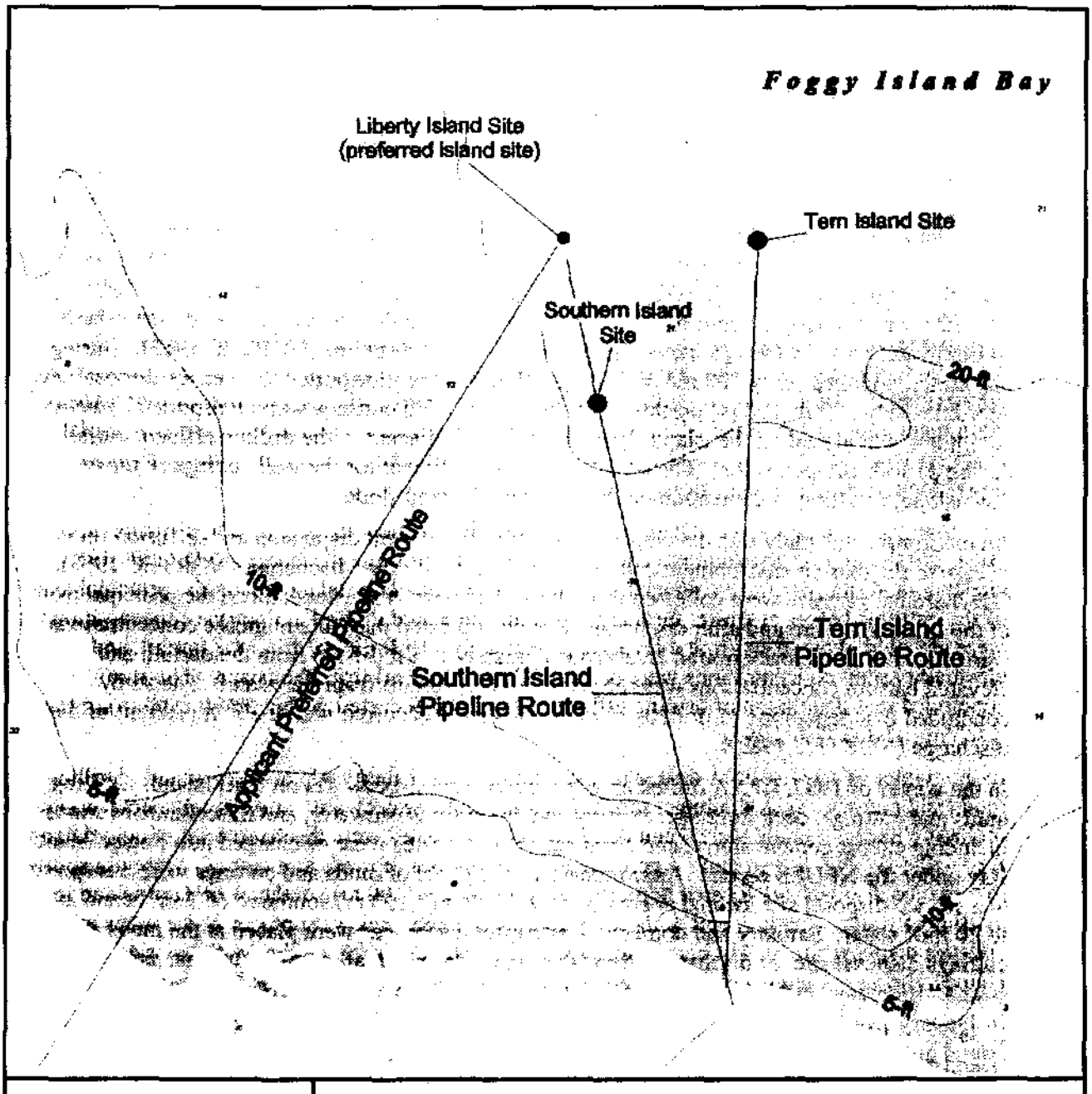
1 0 1 2 3

Miles

Figure 1-1

URS Anchorage, Alaska

anc1\\shared\projects\2000\7400000034.00LibSedQual\GIS\SiteMap2001.wor



Legend

- Production Island (proposed alternative)
- Proposed Pipeline Route

bp

Pipeline Routes and Production Islands Evaluated in the Liberty Development EIS

NORTH

1 0 1 2 3

Miles

Figure 1-2

URS Anchorage, Alaska

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2.1 SITE HISTORY

In the winter of 1982, Shell Oil Company constructed Tern Island at the mouth of Foggy Island Bay to support exploratory drilling. Wastewater discharge permits under the National Pollutant Discharge Elimination System (NPDES) allowed for the discharge of drilling muds, cuttings, and fluids onto the surrounding sea ice during winter and direct discharge into Beaufort Sea waters during the summer open-water season. Drilling muds used at the site in the early 1980s are classified as potassium chloride (KC/Polymer) muds. A total of 2,800 barrels (bbl) of drilling effluents was discharged between June and August 1982 on the northwest side of Tern Island, approximately 50 feet (ft) (15 meters [m]) from the island shoreline (NORTEC 1983). During the winter, approximately 700 bbl of drilling effluents were transported to a sea ice disposal area approximately 500 ft (150 m) northwest of the island. Well cuttings were transported by heavy equipment and placed on the island slope immediately adjacent to the drilling effluent outfall during periods of open water. The island slope was sufficient for the well cuttings to move downslope, resulting in deposition on the submerged island slope.

An environmental study was developed to quantify the effluent dispersion and diffusion upon release to the marine environment and to assess the fate of these discharges (NORTEC 1983). Geochemical samples were collected from the seabed near Tern Island, along the principal axis of the currents before and after discharge. Results indicated that oil and grease concentrations were elevated above background levels approximately 115 ft (35 m) from the outfall, and elevated barium concentrations were observed 330 ft (100 m) from the island. The study concluded that deposition of drilling effluents may have occurred within 330 ft (100 m) of the discharge (NORTEC 1983).

In the winter of 1997, BPXA drilled an exploration well (Liberty #1) on Tern Island. Drilling muds and cuttings, deck drainage, sanitary and domestic wastewater, and miscellaneous wastes including excess cement slurry, and desalination unit wastes were discharged into Foggy Island Bay under the NPDES permit. Approximately 16,200 bbl of muds and cuttings were transported to a sea ice disposal site located approximately 7,000 ft (2,100 m) southeast of Tern Island in 18 to 20 ft of water. Sanitary and domestic wastewater discharges were placed at the muds and cuttings disposal site, or discharged through a line with an outfall on the southeast side of Tern Island. Bioassays indicated that the drilling fluid was nontoxic (AMBAR Technical Labs 1997).

In January 1997, during ice road construction, a truck broke through the ice southwest of Tern Island and spilled approximately 10 gallons of diesel and 0.5 gallons of hydraulic fluid into the open water. All of the spilled material was later recovered and properly disposed of.

It is unlikely that the sediments along or near the applicant's preferred or alternative pipeline routes have been disturbed by past activities. Past activities occurred east and north of the pipeline route, were of limited duration, and resulted in minimal discharge of drilling muds and cuttings. Geophysical surveys conducted throughout the Liberty Development Project area did not identify any anthropogenic (i.e., man-made) structures or observable effects from human-use activities.

2.2 PREVIOUS INVESTIGATIONS

Two geotechnical investigations (Duane Miller & Associates 1997, 1998), one sediment quality study (Montgomery Watson 1998), and two geophysical hazard surveys (Watson Co. 1998a, 1998b, 1998c) provide a comprehensive understanding of the sediments encountered along the applicant's proposed pipeline route and production island location. No evidence of any anthropogenic features or disturbance was found by these studies. Following is a summary of our current understanding of the site.

2.2.1 Geophysical Hazard Surveys

High-resolution geophysical data were collected in the summer of 1997 to identify geological hazards and man-made materials that could affect or alter the design of the proposed Liberty Development (Watson Company 1998a). This was a comprehensive survey, which included geophysical data from high-resolution multi-channel seismic systems, digital side-scan sonar, and a sub-bottom profiler. No man-made structures or evidence of human-use activities were identified.

Watson described the seafloor as gently undulating, although a northwest-southeast ridge with 3 to 6 ft (1 to 2 m) of relief was delineated west of the applicant's preferred gravel island. Interpretations of side-scan sonar records indicated seafloor sediments with greater than 25 percent boulders and cobbles are situated west and northwest of the proposed gravel island. Watson noted that the seafloor areas, characterized by boulders and cobbles, are considered to be lag deposits of Pleistocene origin and were formed by the erosion of the Flaxman marine units of the Gubik Formation. These lag deposits are exposed on the seafloor where Holocene (recent) sediments are absent (Watson Company 1998a).

Analysis of geophysical records determined that approximately 75 percent of the 1997 survey area consists of Holocene fine-grained materials characterized by low reflectivity with few boulders (Watson Company 1998a). Watson states that the Holocene sediments are relatively thin, less than 8.5 ft (2.6 m), with distributions characterized as small patchy accumulations of soft mud. While the deposits are considered to be marine sediments, the source may be fine-grained silts and clays discharged from the Sagavanirktok River (Watson Company 1998a).

2.2.2 Geotechnical Investigations

Duane Miller & Associates conducted geotechnical exploration surveys in 1997 and 1998 along possible pipeline alignments, including the selected route. The 1998 survey, which included 18 borings along the pipeline route, yielded the following information.

Seafloor sediments at the island location can be divided into three primary horizons: the upper Holocene non-plastic silt; the intermediate Pleistocene clayey silt; and the underlying granular sand and gravel (Duane Miller & Associates 1998). No frozen soils were encountered at any location along the offshore pipeline route. Soft silts were documented from the seafloor (0 ft) to a depth of 4 to 6 ft. The underlying stiff clayey silt horizon reached depths between 18 to 21.5 ft. This stratigraphy corresponds with the relatively flat seafloor with depths averaging 22 ft (Figure 2-1).

The seafloor rises gently from the 22-ft isobath to the 15-ft isobath where the sediments typically consists of sand, silty sand with some soft silt, and many pockets and layers of peaty soil. One 4.5-ft thick shoal consisting of uniform fine-grained, clean sand was identified in 15 ft (4.6 m) of water.

The sediments found in water depths between the 15-ft and 7-ft isobaths are silty sands interbedded with medium stiff silt to the maximum pipe burial depth of 10 ft. Stiff silt underlain by sandy gravel are found below the silty sands.

Between the 7-ft and 4-ft isobaths, the dominant material is silty sand with thin interbeds of silt and thin organic rich layers. The underlying gravelly sand is shallower than the pipeline depth at Boring D-16 (Figure 2-2).

Sediments from water depths less than 4 ft and extending to the shoreline consist of thin surface layers of sand and soft silt with the underlying sand and gravel at shallow depths 5 to 6 ft. Frozen ice bound sediments were observed up to 230 ft from shore.

2.2.3 Sediment Quality and Geochemistry Studies

Numerous sediment samples from Foggy Island Bay have been analyzed to quantify natural background concentrations of selected heavy metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and petroleum hydrocarbons (NORTEC 1983; Montgomery Watson 1997, 1998). Prior to 1982, no petroleum exploration occurred within Foggy Island Bay. Accordingly, the samples collected by NORTEC in 1983, prior to drilling of the first well in Foggy Island Bay (Shell Oil Tern #1) served to establish the natural background concentrations.

Barium concentrations for five samples collected at one location prior to 1982 drilling activities ranged from 210 to 9,040 mg/kg. Further analyses indicated that the seafloor sediments in the Beaufort Sea are heterogeneous with a patchy nature; that is, it is not uncommon to find large variations in sediment grain-size and trace metal concentrations among samples taken at the same location (NORTEC 1983). The natural variability in these sediments is reflected in lead concentrations found in sediments collected in the western half of Foggy Island Bay during evaluation of several proposed pipeline routes associated with the Liberty Development (Montgomery Watson 1997).

Table 2-1 is a statistical summary of selected heavy metal concentrations for sediments collected throughout the Beaufort Sea and samples specific to Foggy Island Bay. Within Foggy Island Bay, arsenic, chromium, and mercury exhibit consistent concentrations, while barium and lead tend to be variable. On average, metal concentrations from the pipeline route studies (Montgomery Watson 1997, 1998) are lower than results from the study conducted prior to exploratory drilling in 1982 (NORTEC 1983). Also, most of the heavy metal results from samples collected from Foggy Island Bay are within the range of concentrations found throughout the Beaufort Sea. The only exception is chromium, of which Foggy Island Bay sediments contained a maximum concentration of 34 mg/kg (Montgomery Watson 1997).

In 1998, Montgomery Watson collected samples at three depths below the seafloor to describe the sediment chemistry along the selected pipeline route. All heavy metals and VOCs, were uniformly below the screening levels set forth by the Puget Sound Dredged Disposal Analysis, which was developed for dredging operations by EPA Region X (Seattle), USACOE,

Table 2-1. Heavy Metal Concentrations for Sediments

Investigation	Location	Arsenic (mg/kg)	Barium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)
1982 Tern Island (NORTEC 1983) [1]	Foggy Island Bay	no analysis	30 minimum **121** (537[†]) average 360 (9040[†]) maximum	13 minimum **19** average 27 maximum	12 minimum **16** average 20 maximum	no analysis
Proposed Liberty Pipeline Routes (Montgomery Watson 1997)	Foggy Island Bay	3 minimum **5.5** average 11.4 maximum	29 minimum **67.5** average 194 maximum	7.2 minimum **18.5** average 34 maximum	2.79 minimum **10.1** average 67.8 maximum	[‡] all sample results were deemed invalid by the laboratory since the relative percent difference (RPD) for duplicate analyses exceeded acceptance limits.
Selected Liberty Pipeline Route (Montgomery Watson 1998)	Foggy Island Bay (pipeline route)	3.3 minimum **5.5** average 11.2 maximum	23 minimum **45** average 86 maximum	5.4 minimum **12.2** average 27 maximum	2.2 minimum **5.4** average 13.9 maximum	No Detect minimum **0.035** average 0.085 maximum
Northstar Development Pilot Offshore Trenching Program (Montgomery Watson 1996)	Offshore of Stump Island (Site C)	5.0 minimum **7.1** average 16 maximum	46 minimum **63** average 122 maximum	10 minimum **16.6** average 21 maximum	No Detect minimum 23 maximum	Not detected
Beaufort Sea Planning Area Oil & Gas Lease Sale 144 (MMS 1996) [2]	Beaufort Sea	no analysis	185 minimum 745 maximum	17 minimum 19 maximum	3.9 minimum 20 maximum	0.02 minimum 0.09 maximum

[1] Samples collected prior to exploratory drilling.
[2] Regional summary

and the Washington State Department of Natural Resources and Ecology. One sample collected approximately 9 ft below the seafloor contained 4-Methylphenol (p-Cresol), a SVOC, at a concentration that was above the minimum screening level. However, this sample was collected approximately 600 m northwest of the proposed gravel island, and outside the proposed pipeline trench.

Analyses of samples collected throughout the western portion of Foggy Island Bay in 1997 demonstrated a positive linear correlation between chromium and lead concentrations. Also, barium and arsenic levels increased proportionally with increasing chromium concentrations. Similarly, the relationship of these metals to grain-size reflects a positive linear trend. The samples collected represent undisturbed subsurface strata, and thus, the positive linear relationships found between the metals and similar relationships between metals and grain-size describe naturally existing baseline conditions. It was interesting to note that sediment chemistry analysis did not delineate any differentiation between Holocene and Pleistocene sediments.

It is reasonable to conclude that the pipeline trench sediments do not contain measurable concentrations of pollutants related to industrial and other human-use activities because:

- There were no artificial bathymetric features or other anthropogenic structures observed along or adjacent to the pipeline route
- The concentrations of selected heavy metals and hydrocarbons collected in the western portion of Foggy Island Bay (along the proposed and alternative Liberty Development pipeline routes) are similar to sediment chemistry concentrations described in regional and pre-industrial activity studies as representing natural background concentrations
- The strong positive linear correlation between the fine-grained sediment fraction and heavy metal concentration from undisturbed subsurface strata is evidence that there is no observable input from industrial or human-use activities. If pollutants were introduced into the environment, there would not be a linear correlation between the concentration of metals or polyaromatic hydrocarbons (PAH) with physical properties such as grain-size distribution (e.g., percent fines).

2.3 CURRENT SITE USES

Access to Foggy Island Bay is limited to marine vessels during the brief summer open-water season and tundra travel vehicles during the winter. During autumn freeze-up and spring ice breakup there is virtually no surface accessibility. Foggy Island Bay is used occasionally by the local native population for subsistence hunting and fishing. There are no industrial or military activities operating anywhere near the bay, with the exception of occasional geophysical exploration surveys.

2.4 POTENTIAL SOURCES OF CONTAMINATION

With the exception of drillings muds and cuttings discharged immediately adjacent to Tern Island during exploration drilling in the early 1980s and 1997, there are no other known potential sources of contamination. Prevailing currents produce a net westward drift, placing the Prudhoe Bay coastal oil production facilities downcurrent of Foggy Island Bay.

Figure 2-1. Offshore pipeline route cross section (from island to Boring D-11).

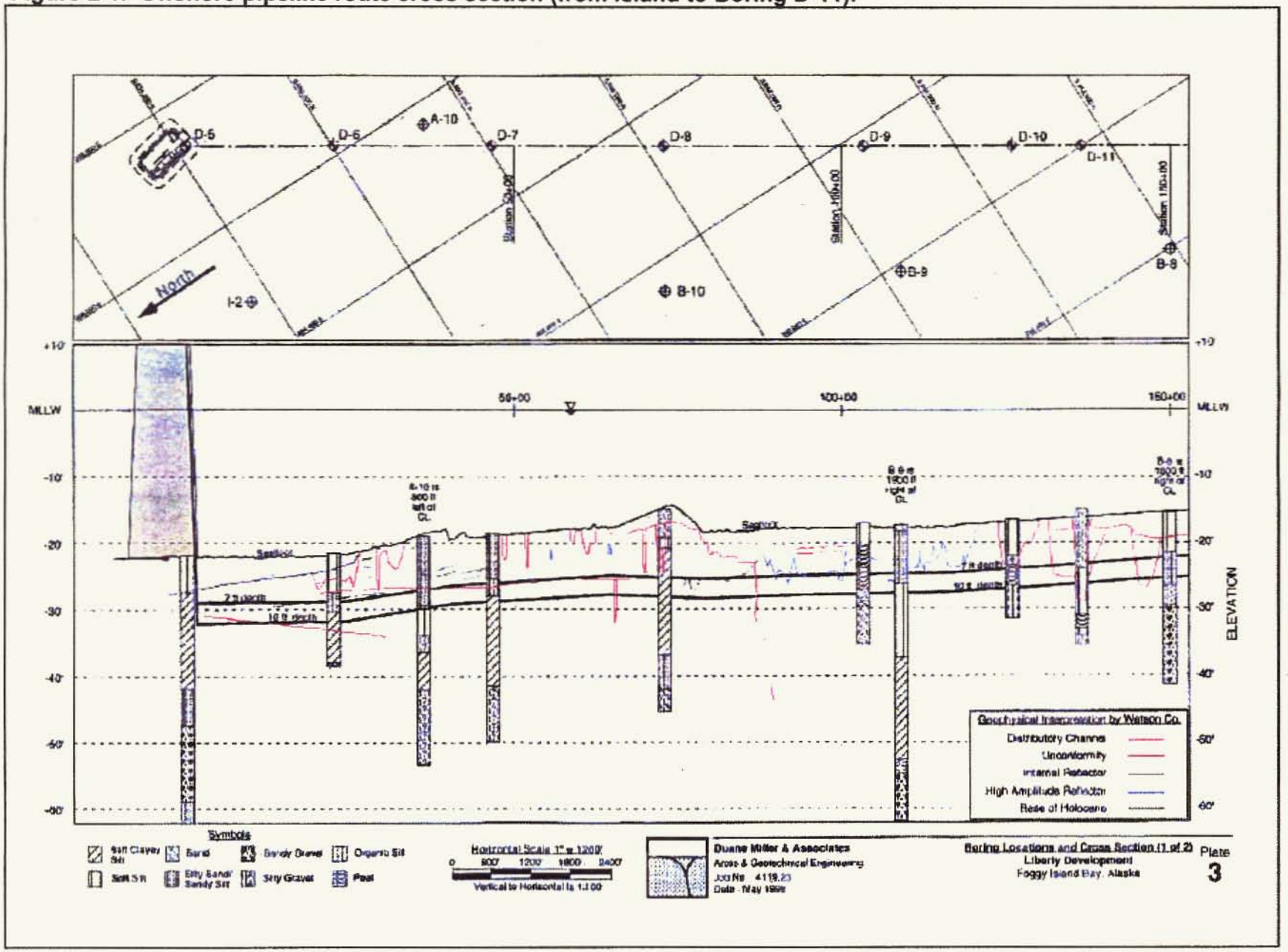
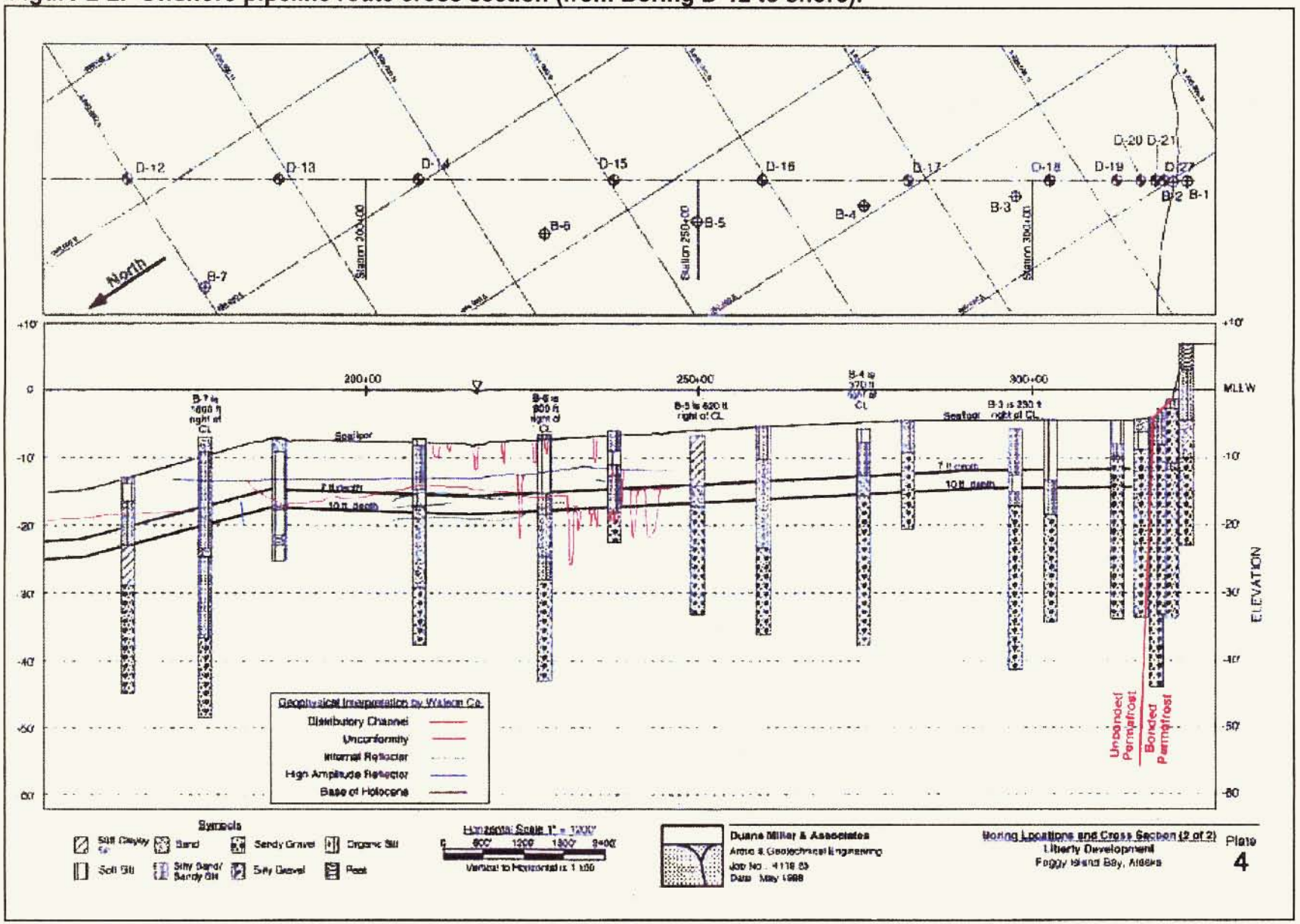


Figure 2-2. Offshore pipeline route cross section (from Boring D-12 to shore).



The sediment sampling program is part of a baseline data collection survey to support permit activities associated with the Liberty Development. The goal of the sediment chemistry sampling plan is to describe the natural concentrations and variability of selected physical and chemical parameters of sediment anticipated to be excavated and used as fill or disposed of via ocean dumping.

This sampling program has three objectives, which are based on the Corps and EPA requirements:

- Collect representative samples of the proposed excavated material to ascertain the grain-size distribution, including silt and clay sized particles to support a modeling effort that will be used to predict suspended sediment transport associated with pipeline construction
- Collect representative sediment quality samples of the proposed excavated material to determine if any of the chemicals-of-concern (CoCs) identified by the EPA exceed regulatory screening levels as presented in the *Dredged Material Evaluation Framework, Lower Columbia River Management Area* (November 1998)
- Collect sediment quality samples from the seafloor (i.e., surficial samples) to determine whether a larger group of CoCs identified by the EPA exceeds regulatory screening levels as presented in *Dredged Material Evaluation Framework, Lower Columbia River Management Area* (November 1998).

4.1 REGULATORY SEDIMENT QUALITY RANKING

The EPA and Corps have not promulgated guidance for environmental evaluation of dredging activities specific to Alaska. However, such guidance does exist for the Lower Columbia River and other Pacific Northwest estuaries in the form of the *Dredged Material Evaluation Framework, Lower Columbia River Management Area* (November 1998). In this document, the EPA, Corps, and State participants developed a ranking scheme that classifies proposed dredged materials as a function of known chemical and physical properties (Table 4-1). EPA Region X directed that these classifications be used for the design of this sampling program.

Table 4-1 Management Area Ranking Definitions (Corps 1998)

Ranking	Parameters
Exclusionary	Available data indicate coarse-grained sediment with at least 80% sand retained in a No. 230 sieve and a total volatile solids content of less than 5.0 percent. Locations sufficiently removed from potential sources of sediment contamination based on historical information and/or best professional judgement. Typical locations include the mouth and mainstream channel of the Lower Columbia River.
Low	Available data indicate low concentrations of CoCs and/or no significant response in biological tests. Locations with higher percentage of finer-grained sediments and organic material but few sources of potential contamination. Typical locations include adjacent entrance channels, rural marinas, navigable side sloughs, and small community berthing facilities.
Low-Moderate	Available data indicate a "low" rank may be warranted but data are not sufficient to validate the ranking.
Moderate	Available data indicate moderate concentrations of CoCs in sediments in a range known to cause adverse response in biological tests. Locations where sediments are subject to several sources of contamination, or where existing or historical use of the site has the potential to cause sediment contamination. Typical locations include urban marinas, fueling and ship berthing facilities, areas downstream of major sewer or stormwater outfalls, and medium-sized urban areas with limited shoreline industrial development.
High	Available data indicates high concentrations of CoCs in sediments and/or significant adverse responses in at least one of the last two cycles of biological tests. Locations where sediments are subject to numerous sources of sediment contamination, including industrial runoff and outfalls, or where existing or historical use of the site has the potential to cause sediment contamination. Typical locations include large urban areas and shoreline areas with major industrial development.

Application of these ranking definitions to the sediments proposed for excavation along any of the alternative pipeline routes shows them to have a low ranking. The low rank is based on available sediment chemistry data collected by Montgomery Watson (1998) which indicated low concentrations of CoCs for samples collected along two of the alternative pipeline routes. The study encountered only naturally occurring fine-grained sediments, with no indication of anthropogenic disturbance.

The estimated excavation volumes for each of the pipeline alternatives are summarized in Table 4-2 as presented in MMS 2001.

Table 4-2 Estimated Pipeline Trench Dimensions (MMS 2001)

Pipeline Trench Design Parameters	Preferred Pipeline Route (Shallow Burial)	Preferred Pipeline Route (Deeper Burial)	Southern Island Alternate Route	Tern Island Alternate Route
Average Trench Depth	10.5 ft	15 ft	10.5 ft	10.5 ft
Trench Depth Range	8-12 ft	15 ft	8-12 ft	8-12 ft
Trench Width Range	61-132 ft	120-152 ft	61-132 ft	61-132 ft
Trench Length	32,400 ft	32,400 ft	22,276 ft	29,140 ft
Quantity of Trench Dredge/Excavation Material	724,000 cubic yards (cy)	1,438,560 cy	652,800 cy	557,300 cy
Quantity of Trench Backfill Material	724,000 cy	1,438,560 cy	652,800 cy	557,300 cy
Minimum Burial Depth	7 ft	11 ft	7 ft	7 ft
Surface Area Disturbed by Trench	59 acres	81 acres	37 acres	59 acres

4.2 SAMPLING DESIGN AND LOCATIONS

4.2.1 Grain-Size Sampling

Representative samples of proposed excavated material will be collected to ascertain the sediment grain-size distribution. This sampling will be conducted based on the Corp prescriptive requirement to estimate the total suspended sediments (TSS) associated with construction activities. The resulting grain-size distributions will be used in the modeling effort to predict suspended sediment associated with the planned pipeline construction.

The grain-size sampling plan is to collect borehole sediments along each alternative pipeline route (Figure 4-1). The sampling will be performed only within the floating land-fast ice areas (no grounded ice areas) using a ½-mile spacing interval between boreholes, where the land-fast ice is greater than 6.5 ft. Table 4-3 summarizes the number of samples to be collected along each pipeline route.

Four samples will be collected in each borehole along the preferred pipeline route. The sample depths will be selected based on changes in sediment grain-size. If changes are not visually evident, then samples will be collected at equal intervals from the mud line to a depth of 15 ft below the seafloor. If material is recovered successfully from all boreholes, 104 samples will be collected for grain-size analysis (Table 4-3).

Table 4-3 Grain-Size Samples and Borings Planned along a Pipeline Route

Pipeline Routes	Total Borings Per Route	Total Samples Per Route
Preferred Pipeline Route	9	36
Southern Island Alternative Route	8	32
Tern Island Alternative Route	9	36
Total Borings and Samples	*26*	*104*

As noted previously, the sampling design for grain-size distribution is prescriptive; however, to assure that sufficient samples are collected, statistical performance standards can be determined using existing grain-size data sets from Foggy Island Bay. These grain-size data sets are used as the basis to determine the number of samples required for the trench excavation sediment quality sampling. As noted in the following section, only 16 samples are required per route.

4.2.2 Trench Excavation Sediment Quality Sampling

In 1992 the EPA developed sampling design guidelines based on statistical methods summarized by Gilbert (1987) and presented in a structured manner that allows investigators to design robust sampling programs. Both Gilbert (1987) and EPA (1992) provide a descriptive review of various sampling designs and their applicability for estimating chemical distributions and trends. The objective of this sampling program is to determine if the concentrations for the CoCs exceed regulatory screening levels issued in the *Dredged Material Evaluation Framework, Lower Columbia River Management Area* (EPA 1998). The baseline study should delineate the representative concentrations for each chemical-of-concern along each alternative pipeline route presented in the Liberty Development draft EIS (MMS 2001). Based on the EPA 1992 guidance, this study will use the classical stratified systematic sampling design because it is appropriate for use in sampling any medium to define the representative concentration values over a site.

The 1992 EPA guidance document developed standardized tables to quantify the statistical performance of a sampling program, in terms of:

- *Confidence Level*: The confidence level is 100 minus a, where a is the percent probability of taking action when no action is required (i.e., false positive result–a is the probability of a type I error)
- *Power*: Power is 100 minus ß, where ß is the percent probability of not taking action when action is required (i.e., false negative result–ß is the probability of a type II error)

- *Minimum detectable relative difference (MDRD)*: MDRD is the percent difference required between site and background concentration levels before the difference can be detected statistically.

Baseline sampling design strategy is presented in the 1992 EPA guidance, with an example that uses the standardized tables to quantify statistical performance of the sampling program. These tables presume that the investigator can estimate the coefficient of variance. Visual grain-size descriptions from existing geotechnical bore logs were used to estimate the coefficient of variance. Bore logs noted that on average three strata were encountered within the proposed excavation depth (0 to 15 ft below the seafloor) in each borehole. If it is assumed that similar strata found at similar depths are not continuous between adjacent boreholes–a very conservative assumption that will increase the minimum number of samples required–then 70 discrete sediments were delineated along the applicant's preferred route. The resulting coefficient of variance is approximately 30 percent. Following the example found in EPA (1992) for baseline samples, and based on these visual grain-size descriptions, the following can be determined:

- Coefficient of Variance is 30 percent
- False positive error is 20 percent (i.e., the confidence level is 80 percent)
- False negative error is 5 percent (i.e., the power is 95 percent)
- MDRD is 20 percent
- The resulting minimum number of samples required is 15.

A simplification of an example presented in Gilbert (1987) was used to determine the number of samples needed from each borehole to have the necessary confidence to describe stratified sediments. The number of borehole samples is determined to be the sum of the mean and variance, where the sample population is the number of strata encountered in boreholes along the preferred pipeline route. As noted below, four samples are the minimum number to be collected within a borehole.

Vertical Sample Number	=	mean + variance
	=	3 + 0.86
	=	3.86
	~	4 samples

The sampling design assumes that the sampling program will encounter, on average, three strata per borehole. So, as stated above, the minimum number of samples required to be collected along a given pipeline route is 15, and the minimum number of samples to be collected within each borehole is 4. Therefore, the minimum number of boreholes required along each alternative pipeline route is four (i.e., 4 samples/borehole x 4 boreholes = 16 samples).

Subsurface sediment quality samples representing the proposed excavated material will be collected along the three alternative pipeline routes. These samples will be analyzed to determine if any of the CoCs identified by the EPA exceed regulatory screening levels.

Based on the statistical performance standards, a minimum of 15 samples will be collected to describe sediments from the seafloor along the preferred pipeline route. Four samples will be

collected in each borehole based on changes in sediment grain size, or if changes are not visually evident, then at equal spacing from the mud line to a depth of 15 ft below the seafloor.

The sediment quality sampling plan is to collect sediments from a minimum of 4 boreholes situated along the preferred pipeline route, from four boreholes along the Southern Island alternative, and from 3 boreholes along the Tern Island route, for a total of 12 boreholes (Figure 4-2). Only three boreholes are identified along the Tern Island route, since the shoreward sample from the Southern Island route is located very near the Tern Island route. If material is recovered successfully from all boreholes, a total of 44 samples will be collected. Table 4-4 presents the minimum number of sediment quality borings planned for each pipeline route.

Table 4-4 Minimum Number of Sediment Quality Borings along a Pipeline Route

Pipeline Routes	Total Borings Per Route	Total Samples Per Route
Preferred Pipeline Route	4	16
Southern Island Alternative Route	4	16
Tern Island Alternative Route	3	12
Total Borings	*11*	*44*

4.2.3 Surface Sediment Quality Sampling

Seafloor sediment quality samples will be collected to determine if a larger group of CoCs identified by the EPA exceed regulatory screening levels, and if future sediment quality sampling within the Beaufort Sea warrant expanding the list of CoCs. The sampling design is based on the opportunity to collect a small data set without incurring significant costs, since the samples will be taken in conjunction with the trench excavation sediment quality sampling, and it is expected that the concentrations for the expanded CoCs are well below the regulatory screening levels.

Sediment samples will be collected from four seafloor locations, three sites located along the preferred pipeline route. A fourth site, a background or reference sample will be collected immediately seaward of the Sagavanirktok River delta in the western part of Foggy Island Bay (Figure 4-3). Each sample will be collected from the mud line to approximately 6 inches below the surface. If shallow seafloor sediments are recovered successfully from the subsurface boring effort, those samples will be collected as representative seafloor surface sediments.

4.2.4 Chemicals of Concern for Subsurface Sediments

Table 4-5 presents a complete list of the chemical and physical parameters to be measured from the borehole sampling effort to characterize the proposed excavation material. A minimum of 5 replicate samples will be collected at the 11 boreholes. Additional samples will be collected at selected boreholes to address quality control and quality assurance (QA/QC) protocols as noted in Section 5.

Table 4-5 Proposed Chemical and Physical Analyses for Subsurface Sediments

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)
CONVENTIONALS:			
Total Solids (%)	NA	160.3M	0.1
Total Volatile Solids(%)	NA	160.4M	0.1
Total Organic Carbon (%)	NA	ASTMD4129M	0.1
Total Sulfides (mg/kg)	NA	SW9030	1
Ammonia (mg/kg)	NA	Plumb 1981	1
Grain Size (%)	NA	ASTM 2422 (Pipette)	NA
METALS (ppm):			
Antimony	SW3050	SW6020	0.05
Arsenic	SW3050	SW6020	0.1
Barium	SW3050	SW6020	0.1
Cadmium	SW3050	SW6020	0.05
Calcium	SW3050	SW6010B	2.0
Chromium	SW3050	SW6020	0.1
Copper	SW3050	SW6020	0.05
Iron	SW3050	SW6010B	2.0
Lead	SW3050	SW6020	0.05
Manganese	SW3050	SW6020	.1
Mercury	NA	SW7471	0.01
Nickel	SW3050	SW6020	0.05
Silver	SW3050	SW6020	0.05
Zinc	SW3050	SW6020	0.05
ORGANICS (ppb):			
LPAH			
Naphthalene	SW3550	SW8270SIM	5
Acenaphthylene	SW3550	SW8270SIM	5
Acenaphthene	SW3550	SW8270SIM	5
Fluorene	SW3550	SW8270SIM	5
Phenanthrene	SW3550	SW8270SIM	5
Anthracene	SW3550	SW8270SIM	5
2-Methylnaphthalene	SW3550	SW8270SIM	5
Total LPAH	—	—	—
HPAH			
Fluoranthene	SW3550	SW8270SIM	5
Pyrene	SW3550	SW8270SIM	5
Benzo(a)anthracene	SW3550	SW8270SIM	5
Chrysene	SW3550	SW8270SIM	5
Benzofluoranthenes	SW3550	SW8270SIM	5
Benzo(a)pyrene	SW3550	SW8270SIM	5
Indeno(1,2,3-c,d)pyrene	SW3550	SW8270SIM	5
Dibenzo(a,h)anthracene	SW3550	SW8270SIM	5
Benzo(g,h,i)perylene	SW3550	SW8270SIM	5
Total HPAH	—	—	—

[1]Cold vapor atomic absorption (CVAA)

4.2.5 Chemicals of Concern for Surface Sediments

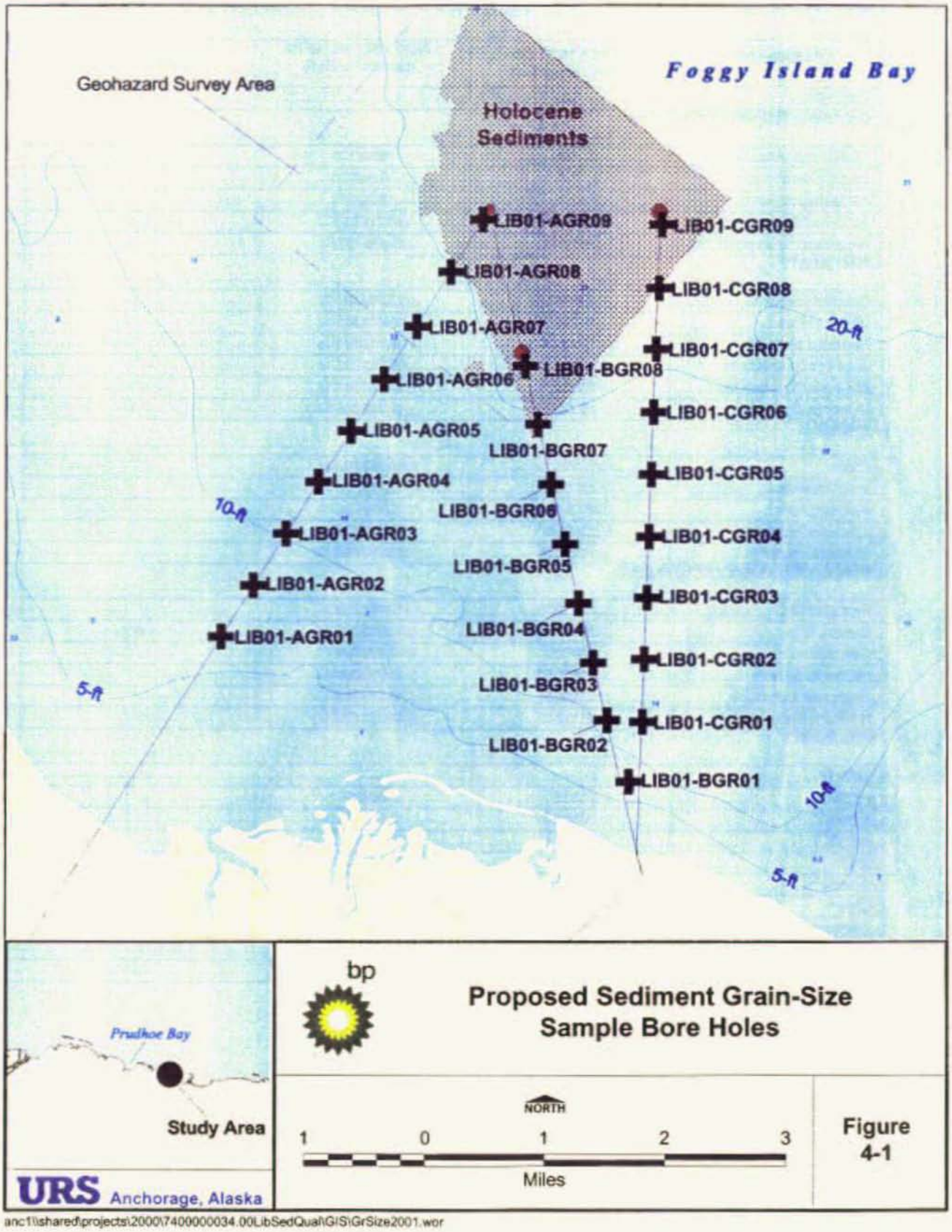
Table 4-6 presents a complete list of the chemical and physical parameters to be measured from the surface sediment sampling effort. If sufficient sediment is collected, additional QA/QC samples will be collected including replicate, split, matrix spike, and matrix spike duplicate samples.

Table 4-6 Proposed Chemic and Physical Analyses for Surface Sediments

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)
CONVENTIONALS:			
Total Solids (%)	NA	160.3M	0.1
Total Volatile Solids(%)	NA	160.4M	0.1
Total Organic Carbon (%)	NA	ASTMD4129M	0.1
Total Sulfides (mg/kg)	NA	SW9030	1
Ammonia (mg/kg)	NA	Plumb 1981	1
Grain Size (%)	NA	ASTM 2422 (Pipette)	NA
METALS (ppm):			
Antimony	SW3050	SW6020	0.05
Arsenic	SW3050	SW6020	0.1
Barium	SW3050	SW6020	0.1
Cadmium	SW3050	SW6020	0.05
Calcium	SW3050	SW6010B	2.0
Chromium	SW3050	SW6020	0.1
Copper	SW3050	SW6020	0.05
Iron	SW3050	SW6010B	2.0
Lead	SW3050	SW6020	0.05
Manganese	SW3050	SW6020	.1
Mercury	NA	SW7471	0.01
Nickel	SW3050	SW6020	0.05
Silver	SW3050	SW6020	0.05
Zinc	SW3050	SW6020	0.05
ORGANICS (ppb):			
LPAH			
Naphthalene	SW3550	SW8270SIM	5
Acenaphthylene	SW3550	SW8270SIM	5
Acenaphthene	SW3550	SW8270SIM	5
Fluorene	SW3550	SW8270SIM	5
Phenanthrene	SW3550	SW8270SIM	5
Anthracene	SW3550	SW8270SIM	5
2-Methylnaphthalene	SW3550	SW8270SIM	5
Total LPAH	—	—	—
HPAH			
Fluoranthene	SW3550	SW8270SIM	5
Pyrene	SW3550	SW8270SIM	5
Benzo(a)anthracene	SW3550	SW8270SIM	5
Chrysene	SW3550	SW8270SIM	5
Benzofluoranthenes	SW3550	SW8270SIM	5
Benzo(a)pyrene	SW3550	SW8270SIM	5
Indeno(1,2,3-c,d)pyrene	SW3550	SW8270SIM	5
Dibenzo(a,h)anthracene	SW3550	SW8270SIM	5
Benzo(g,h,i)perylene	SW3550	SW8270SIM	5

PARAMETER	PREP METHOD (recommended)	ANALYSIS METHOD (recommended)	SEDIMENT MDL (1)
Total HPAH	—	—	—
CHLORINATED HYDROCARBONS			
1,3-Dichlorobenzene	NA	SW8260	1
1,4-Dichlorobenzene	NA	SW8260	1
1,2-Dichlorobenzene	NA	SW8260	1
1,2,4-Trichlorobenzene	SW3550	SW8270SIM	5
Hexachlorobenzene (HCB)	SW3550	SW8270SIM	5
PHTHALATES			
Dimethyl phthalate	SW3550	SW8270SIM	5
Diethyl phthalate	SW3550	SW8270SIM	5
Di-n-butyl phthalate	SW3550	SW8270SIM	5
Butyl benzyl phthalate	SW3550	SW8270SIM	5
Bis(2-ethylhexyl)phthalate	SW3550	SW8270SIM	10
Di-n-octyl phthalate	SW3550	SW8270SIM	5
PHENOLS			
Phenol	SW3550	SW8270SIM	20
2 Methylphenol	SW3550	SW8270SIM	6
4 Methylphenol	SW3550	SW8270SIM	20
2,4-Dimethylphenol	SW3550	SW8270SIM	6
Pentachlorophenol	SW3550	SW8270SIM	50
MISCELLANEOUS EXTRACTABLES			
Benzyl alcohol	SW3550	SW8270SIM	6
Benzoic acid	SW3550	SW8270SIM	100
Dibenzofuran	SW3550	SW8270SIM	10
Hexachloroethane	SW3550	SW8270SIM	10
Hexachlorobutadiene	SW3550	SW8270SIM	10
N-Nitrosodiphenylamine	SW3550	SW8270SIM	10
PESTICIDES			
Total DDT	—	—	—
p,p'-DDE	SW3540	SW8081	1
p,p'-DDD	SW3540	SW8081	1
p,p'-DDT	SW3540	SW8081	1
Aldrin	SW3540	SW8081	1
Chlordane	SW3540	SW8081	1
Dieldrin	SW3540	SW8081	1
Heptachlor	SW3540	SW8081	1
Lindane	SW3540	SW8081	1
Total PCBs *	SW3540	SW8082	67

* Total PCBs BT value in ppm carbon-normalized.



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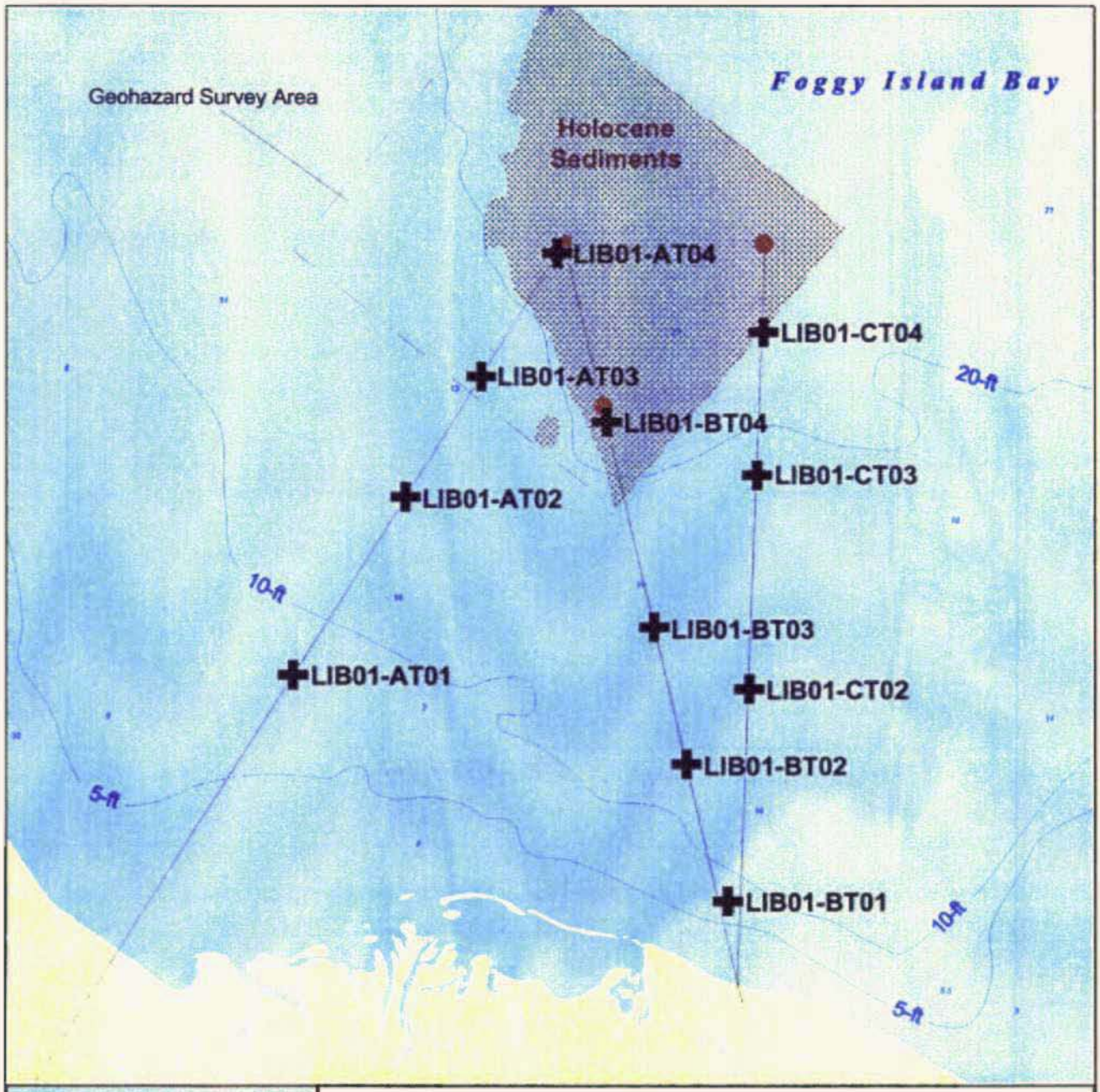

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Proposed Excavation Sediment Quality Sample Bore Holes

NORTH

1 0 1 2 3

Miles

Figure 4-2

URS Anchorage, Alaska

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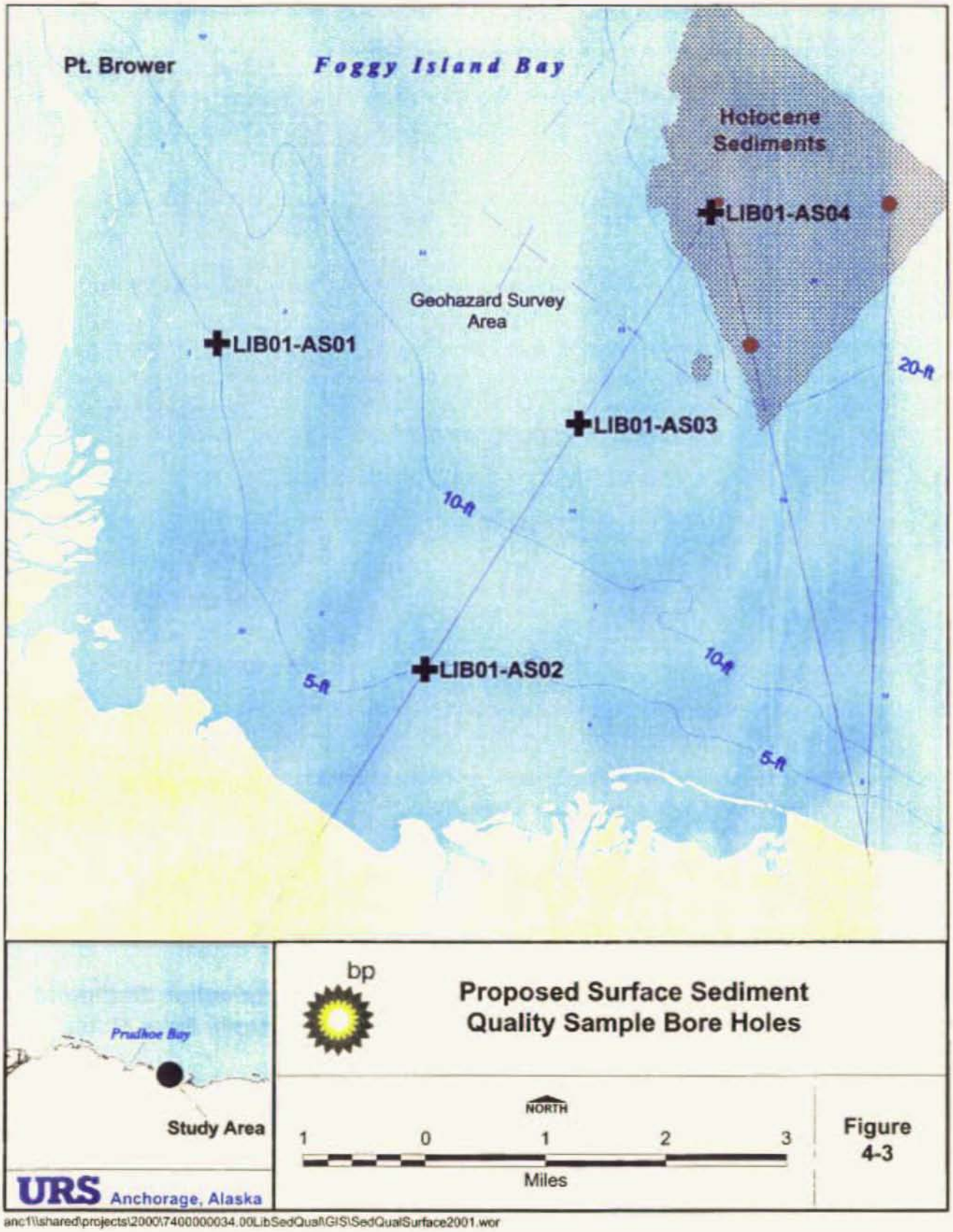

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5.1 NAVIGATION AND SAMPLE POSITIONS

A specialized arctic off-road vehicle (rollagon) equipped with an autonomous global positioning system (GPS) receiver will be used to navigate across unmarked off-road areas and will be the primary method to survey borehole positions. Horizontal positions will be based on the North American Datum of 1927 (NAD27), using either State Plane Coordinate System (in feet) or latitude/longitude coordinates. The position accuracy is anticipated to be approximately ±30 m.

5.2 SAMPLING METHODS

A drill rig and working deck will be mounted on a sled and enclosed in a fabric structure for towing by a rollagon to sampling locations. Various coring methods are currently under consideration, including a continuous coring option that would use Lexan liners up to 5 ft long. If the continuous coring method is ineffective or inefficient, hollow-stem auger and split-spoon sampling will be considered.

Multiple boreholes may be necessary to collect adequate sediment volume for the required analysis at a specific location. It is envisioned that an initial boring will be completed to 15 ft below the seafloor to provide a visual field description of the soils based on the Unified Soil Classification System (USCS). Grain-size samples will be collected from this boring. A second borehole will be completed approximately 5 to 10 ft away from the initial borehole, along the trench line, for collection of sediment quality samples. It is hoped that continuous cores, at up to 5-ft intervals, will be recovered to a depth of 15 ft below the seafloor. In the event that continuous coring is not effective, split spoon samples will be collected. All of the cores will be capped, labeled, wrapped, and secured in the field. The cores will be allowed to freeze in ambient conditions and stored outside of the enclosed sled.

Because the interior of the sled contains lubricants and is warmed by propane heaters, there is a possibility that contamination of sediment quality samples could occur if the cores are sub-sampled in the field. Consequently, sediment quality sub-sampling will be deferred until it can be conducted in a controlled environment. Arrangements will be made to conduct the sub-sampling under laboratory conditions, probably at the Endicott Development. After the cores thaw, the core will be removed from the liner. If sufficient sediment is recovered, sub-samples will be collected from material that was not in direct contact with the liner or within 1 inch from either end of the core.

5.3 SAMPLE COLLECTION & HANDLING PROCEDURES

The following descriptions and procedures are based on guidance derived and adapted for use in the Beaufort Sea, Alaska from the following:

Dredged Material Evaluation Framework: Lower Columbia River Management Area (Corps et al 1998)

Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound (PSEP 1997)

Dredged Material Evaluation and Disposal Procedures – A Users Manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program (Corps et al 1998)

5.3.1 Sampling Scheme

This is a baseline data collection survey in an area with no known industrial or military activities that could be considered sources of pollution. The goal of the sediment chemistry sampling portion of this study is to describe the natural concentrations and variability of selected physical and chemical parameters within the study area.

Original, field replicate, and split samples will be collected as part of this sampling program. Tables 5-1 and 5-2 summarize the types of samples and field quality control (QC) samples and blanks to be collected for the subsurface and surface sediment quality sampling effort.

Table 5-1 Sample and Field QC Design – Subsurface Sediment Quality Samples

Sample/Blank Type	Study Total	Preferred Pipeline Route	Southern Island Alternate Route	Tern Island Alternate Route
Samples	44	16	16	12
Field Replicates (initial analysis)	4	2	1	1
Field Split (Duplicate) Sample	4	2	1	2
Matrix Spike/Matrix Spike Duplicate	2	1	1	0
Field Blank	4	1	0	0
Rinsate Blank	4	1	1	0
Total Samples	62	23	20	15

Table 5-2 Sample and Field QC Design – Surface Sediment Quality Samples

Sample/Blank Type	Study Total	Preferred Pipeline Route	Background Location
Samples	4	3	1
Field Replicates (initial analysis)	1	1	0
Field Split (Duplicate) Sample	1	1	0
Matrix Spike/Matrix Spike Duplicate	1	1	0
Field Blank	1	1	0
Rinsate Blank	1	1	0
Reference Sample	1	0	1
Total Samples	10	8	2

5.3.2 General Sample Collection Procedures

To minimize the potential for cross-contamination, all samples will be collected using disposable or decontaminated tools. Sampling tools may include, but are not limited to, split spoons, mixing spoons, bowls, and trays. Disposal gloves appropriate for the site contaminants will be worn and changed between sample intervals. Samples will be placed in containers in the order of volatilization sensitivity as outlined in the following table.

Standard Order of Preferred Sample Collection for Typical Baseline Studies

Order	Analyte to be Sampled
1	Volatile organics
2	Total organic halogens, total organic carbon, and total phenols
3	Extractable organics (e.g., semi-volatiles, pesticides, herbicides)
4	Anions, cations (e.g., CN^-, SO_4^{2-}, Cl^-, NO_3^{2-}, and NH_4^{2+})
5	Metals (total and dissolved)
6	Radionuclides

5.3.3 Volatiles and Sulfides Sub-Sampling Procedures

Samples collected for volatile analysis will be undisturbed. The sample material for volatile organic or sulfide compound analysis will be collected first from the soil core; no mixing will be performed. One 2-ounce unpreserved container with septa will be completely filled with sample sediment for volatiles. No headspace should be allowed to remain in the container. Jars should be filled as tightly as possible, eliminating obvious air pockets. Threads on the sample container and lid will be wiped clean prior to closure to prevent leakage. For sulfides sampling, sediment will be placed in a 2-ounce sampling container preserved with zinc acetate.

The volatiles and sulfides sampling containers will be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the logbook. The sulfides sampling jars will indicate that zinc acetate has been added as a preservative. The sample containers will be refrigerated or stored on ice or blue ice until delivered to the analytical laboratory.

5.3.4 Compositing Procedures

Following the collection of soil samples for volatile analysis, the remaining portion of the sample will be transferred to a large container (i.e., a decontaminated stainless steel mixing bowl) for homogenization before being placed into remaining sample jars for extractable organics, metals, and conventionals analyses. Sample material will be thoroughly homogenized prior to splitting into separate sample containers.

After compositing is performed, sediment will be placed in one 8-ounce unpreserved container for extractable organic analysis. One 16-ounce unpreserved sample container will be filled with sediment for metals and conventional analyses. Both containers will be completely filled to the top with sediment, and will be labeled with the project name, sample/composite identification,

type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the logbook. The sample containers will be refrigerated or stored on ice or blue ice until delivered to the analytical laboratory.

5.3.5 Field Decontamination Procedures

Field decontamination of sediment sampling equipment and associated utensils will be conducted between sampling intervals. The following sequence of wash and rinses will be used to decontaminate sampling equipment prior to use and between samples.

- Wash with sodium triphosphate or Alconox® solution
- Rinse twice with potable water
- Rinse with de-ionized water
- Air dry in a hydrocarbon-free environment.

5.3.6 Field Quality Control (QC)

The following describes the field QC blanks and samples associated with this project.

Container Blank: A container blank will be prepared at the analytical laboratory by filling one of the sample containers with analyte-free water or organic solvent. The blank will be retained at the laboratory and analyzed along with samples collected in the same batch of containers. Container blank results will be used to evaluate any contamination present in the sample containers.

Field Blank: A field blank is a sample of analyte-free water that is supplied by the laboratory. The field blank will be generated by opening the analyte-free water container at the sampling location and transferring an aliquot to another laboratory-supplied container. The field blank will be analyzed for PAH and metal analytes for which associated samples are being analyzed. Field blank results will be used to measure and document any possible on-site contamination.

Preservation Blank: A preservation blank is a sample of analyte-free water that contains the same preservative used for associated samples and will be analyzed for the same parameters. Analysis of the preservation blank will be used to measure and document any contamination present in the preservative.

Rinsate (Equipment) Blank: A rinsate blank is a sample of analyte-free water that has been used to rinse sampling equipment after prescribed decontamination. The analyte-free water will be supplied by the laboratory. The rinsate blank will be analyzed for PAH and metal analytes for which the samples are being analyzed. Analysis of the rinsate blank will be used to measure and document the effectiveness of field decontamination of sampling equipment and possible carry-over of contamination to samples collected after the rinsate blank.

Temperature Blank: A temperature blank is a plastic container of water that is kept in the sample cooler with analytical samples between sub-sample collection and delivery. The temperature of this water will be measured and recorded when samples are received at the analytical laboratory. Measurement of the temperature blank will be used to indicate whether proper sample temperature was maintained between sample collection and delivery to the analytical laboratory.

Field Split (Duplicate) Sample: A field split sample consists of an actual sample for which twice as much volume as necessary to fill the sample containers has been collected. Aliquots of this sample will be equally distributed in two sets of sample containers. This division results in two (theoretically) equivalent samples collected from one sampling location. The field split sample will be analyzed for the same set of analytes for which the original sample is being analyzed.

Field Replicate Sample: A field replicate consists of additional samples grab(s) that will be collected using the same sampling methods used to obtain the first sample. Two field replicates and a spare replicate samples will be collected at the same sampling station and as soon after the original sample as possible. The field replicate samples will be analyzed for the same set of analytes as the original sample. Analysis of the field replicate is used to measure and document the repeatability of field sampling methods as well as the heterogeneity of the sample matrix. Statistical analysis of numerical analytical results (mean and standard deviation) of the original sample and multiple replicates may also be performed to calculate the likely range of analyte concentrations at a given sampling location.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample: A matrix spike is a solution of the target analytes at known concentrations that is spiked into a field sample before sample preparation and analysis. Two aliquots of the sample are spiked for the duplicate analysis. The results of the duplicate spiked samples are used to measure the percent recovery of each spiked compound and compare the recovery between samples, which provides estimates of the accuracy and precision of the method. The frequency for the MS/MSD analysis is five percent of samples analyzed for each method where spikes are performed (i.e., one MS/MSD per analytical batch of 20 samples).

Background/Reference Sample: Typically, a background sample is collected from an area outside, but near to, the area of suspected contamination. Since there has been no industrial or military activity to contaminate the sediments to be collected from the designated sample stations, analytical results from these samples will be considered to reference or baseline samples.

5.3.7 Sample Containers and Labels Procedures

Soil samples will be collected in pre-cleaned glass and/or plastic containers provided by the analytical laboratory. The containers will have screw-type lids to assure adequate sealing of the bottles. The lids will include Teflon® inserts to prevent sample reaction with the lid and to improve the quality of the seal. Table 5.2 summarizes the amount of sediment and types of containers required for different types of analyses. If the same laboratory is to perform a number of the analyses, it is not necessary for each type of analysis to have a separate sediment sample jar. Two or more sediment sub-samples from the same station may be combined in a single sample jar as long as the required container types are the same and the sample preservation methods and maximum holding times are compatible. Table 5.2 identifies which sub-samples are appropriate to combine in the same jar.

Self-adhesive labels will be attached to the outside of all sediment sample containers. The following information will be provided on each sample label in waterproof ink:

- A unique sample number which includes the station identification
- Sampling date and time

- Sampling personnel
- Preservative (if appropriate).

5.3.8 Sample Transport and Chain-of-Custody Procedures

Sample transport and chain-of-custody procedures will include the following guidelines:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24
- Individual sample containers will be packed to prevent breakage and transported in a sealed ice chest or other suitable container
- Ice will be placed in separate plastic bags and sealed, or blue ice used to maintain an ambient sample temperature of approximately 4°C until delivery to the analytical laboratory
- Each cooler or container containing sediment samples for analysis will be shipped to the laboratory within 24 hours of being sealed
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office name and address) to enable positive identification
- Upon transfer of sample possession to the analytical laboratory, the chain-of-custody form will be signed by the persons transferring custody of the sample containers. The shipping container seal will be broken and the condition of the samples will be recorded by the receiver
- Chain-of-custody forms will be used internally in the lab to track sample handling and final disposition.

Table 5-3 Holding Times and Minimum Container Sizes for Physical and Chemical Analyses

Sample Type	Holding Time	Minimum Sample Size[b]	Container Size	Preservative
Physical/Chemical Analyses[a]				
Grain Size	6 months	100-200 g (75-150ml)	16 oz wide-mouth glass jar	None
Total Solids	14 days	125 g (100 ml)		
Total Volatile Solids	14 days	125 g (100 ml)		
Total Organic Carbon	14 days	125 g (100 ml)		
Ammonia	7 days/extraction 28 days/analyze	25 g (20 ml)		
Metals (except mercury)	6 months (28 days)	125 g (100 ml)		
Total Sulfides	7 days	50 g (40 ml)	2 oz wide-mouth glass jar	Zinc Acetate
Volatile Organic Compounds	14 days	50 g (40 ml)	2 oz wide-mouth jar with septa[c]	None
Semivolatile organic compounds	14 days	150 g (120 ml)	8 oz wide-mouth jar[d]	None
Pesticides	14 days	150 g (120 ml)		
Polynuclear aromatic hydrocarbons	14 days	150 g (120 ml)		
Archive Sample	6 months	300 g (250 ml)	8 oz wide-mouth jar[e]	None

[a] During transport to the analytical laboratory, samples will be stored on ice. The archived samples will be frozen immediately upon receipt at the laboratory.

[b] Recommended field sample sizes (wet weight basis) for one laboratory analysis. If additional laboratory analyses are required (e.g., laboratory replicates, allowance for having to repeat an analysis), the field sample size should be increased accordingly. For some chemical analyses, smaller sample sizes may be used if comparable sensitivity can be obtained by adjusting instrumentation, extract volume, or other factors of the analysis.

[c] No headspace or air pockets should remain.

[d] Container to be filled to the top.

[e] Sample to be frozen at the laboratory. Freezing sample extends hold time for SVOCs, pesticides, and PCBs to 6 months.

5.4 FIELD DOCUMENTATION

The following descriptions and procedures are based on guidance derived and adapted for use in the Beaufort Sea, Alaska from the following:

Dredged Material Evaluation Framework: Lower Columbia River Management Area (Corps et al 1998)

Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound (PSEP 1997)

Dredged Material Evaluation and Disposal Procedures – A Users Manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program (Corps et al 1998)

This section provides guidance for documenting sampling and data gathering activities. The documentation of field activities provides important project information and data that can act as support to data generated by laboratory analyses. Project data validation may require reporting field data to verify sample identification, sampling locations, correct sampling techniques. It may also be necessary to validate results of field analyses and measurements.

Field Notes: Field notes will be maintained for all field activities, whether the collection of samples or the gathering of environmental data. Field notes will be kept on water-resistant paper and all field documentation will be recorded in indelible black ink and errors will be crossed out with a single line, initialed and dated by the data recorder. Information recorded in field notes include, but not be limited to:

- Name of recorder
- Sample and station number
- Data or sample station locator information
- Sample elevation (water depth of the sampler bottle)
- Date and time of sample or data collection (all times should be recorded for multiple sampler deployments)
- Ambient weather conditions such as air temperature, cloud cover, and precipitation
- Sample elevation (water depth above the surface of the sediment)
- Sampling interval (i.e., 0 to 10 cm)
- Positioning information required to calculate the location of the station
- Physical characteristics such as gross particle size distribution, debris, odor or evidence of contamination such as a visible sheen or discoloration
- Record of splits, duplicates and sub-samples taken

Other information that may be recorded in field notes includes sampling methods and any deviations from established sampling protocols. Additional anecdotal information pertaining to observations of unusual sampling events or circumstances may be recorded in field notes. A field book should be unique to the project or, at the very least, to a class of field events, such as marine sediment sampling. It is also advisable to keep record of all personnel involved in each sampling event, including the time each individual boarded and departed the research vessel.

The field sampling program is dependent on the ability to deploy rollagons onto the floating landfast sea ice and grounded sea ice within Foggy Island Bay. Thin ice and/or open water conditions could delay or prohibit sampling this winter. However, typical sea ice conditions allow heavy equipment deployment on or about February 1, lasting for approximately 90 days. It is hoped that sampling can begin as soon as practical after the sea ice conditions permit operations.

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Montgomery Watson. 1997. Liberty Island Route Water/Sediment Sampling. Prepared for BP Exploration (Alaska). April 1997.

Montgomery Watson. 1998. Liberty Island Route Water/Sediment Sampling Revised and Corrected Final Data Report. Prepared for BP Exploration (Alaska). August 1998.

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U.S. Environmental Protection Agency. 1992. Guidance for Data Usability in Risk Assessment (Part A).

U.S. Environmental Protection Agency, Region 10. 1997. Puget Sound Estuary Program (PSEP). Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound, Sampling Chapter. April 1997.

U.S. Environmental Protection Agency, Region 10. 1997. Puget Sound Estuary Program (PSEP). Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples, Organics Chapter. April 1997.

U.S. Environmental Protection Agency, Region 10. 1996. Puget Sound Estuary Program (PSEP). Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. March 1986.

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U.S. Mineral Management Service, Alaska, OCS Region. 2001. Liberty Development and Production Plan, Volume II. Draft Environmental Impact Statement. January 2001.

Watson Company 1998a. Liberty High Resolution Geophysical Survey Foggy Island Bay in Stefansson Sound, Alaska. Prepared for BP Exploration (Alaska), Inc. Final Report Volume 1, February 1998.

Watson Company 1998b. Liberty Pipeline Route Survey Foggy Island Bay in Stefansson Sound, Alaska. Prepared for BP Exploration (Alaska), Inc. Final Report Volume 1, April 1998.

Watson Company 1998c. Liberty High Resolution Geophysical Survey Foggy Island Bay in Stefansson Sound, Alaska. Prepared for BP Exploration (Alaska), Inc. Addendum to Final Report, November 1998.

Appendix B

Health, Safety, And Environmental Interface Document

HEALTH, SAFETY AND ENVIRONMENTAL (HSE) INTERFACE DOCUMENT

CONTRACTOR: URS Corporation CONTRACT# 1017

WORK SCOPE:

BP Exploration (Alaska) Inc., (BPXA) plans to develop the Liberty oil field in the Beaufort Sea for production and transport of oil to the Trans-Alaska Pipeline system. The field will be developed from a gravel island to be constructed in Foggy Island Bay. The Liberty oil field development will include a sub-sea pipeline construction from the proposed island to a land-based connection with the Badami pipeline.

An environmental evaluation of the Liberty Development is being conducted and includes the evaluations of multiple pipeline routes and production island locations. The construction permits require that physical properties and chemical characteristics of sediment samples related to trench excavation and fill activities be evaluated for potential impacts to the surrounding environment. Since there are no sediment analyses for one of the alternative pipeline routes, additional sampling is required and will be performed as part of this environmental baseline study work scope.

Based on the need to perform sediment sampling in support of construction permits for the proposed Liberty development, additional investigative coring and sampling will be performed in April 2001 along the three proposed pipeline trench routes. The drilling and sampling work will be performed in order to collect sufficient environmental baseline physical (i.e., grain size) and chemical surface and subsurface seafloor sediment data to support the NEPA evaluation and permit applications for the proposed Liberty Development.

TRANSPORATION AND COMMUNICATIONS:

Transportation of field crews and equipment to the various sites will occur via truck along the road system, and via Rolligon beyond the road system. A valid driver's license will be required for truck operation, and Rolligon operations will be conducted by authorized crew members only.

SITE SPECIFIC HEALTH AND SAFETY INFORMATION:

Safety Management Standards (SMSs) for hazards anticipated during this field program are included as Attachment A. The SMSs included in Attachment A are as follows:

- Emergency Action Plan (SMS #3)
- Drilling Safety Guidelines (SMS #056)
- Hand Tools and Portable Equipment (SMS #16)
- Hazardous Waste Operations (SMS #17)
- Heavy Equipment Operations (SMS #19)
- Medical Screening and Surveillance (SMS #24)
- Noise and Hearing Conservation (SMS #26)
- Personal Protective Equipment (SMS #29)
- Remote Travel Health and Safety (SMS #36)
- Subcontractor Health and Safety Requirements (SMS #46)
- Work Over Water (SMS #27)

All field personnel will carefully read and understand this Health and Safety Plan. In addition, the on-site team leader will conduct daily field safety briefings before personnel travel out to the work sites. The meetings will discuss safety concerns and mitigation measures concerning the project. Up-to-date observations of weather, wind chill, and wildlife presence will be discussed among the field team leader and field crew personnel.

Chemical Hazards

The potential chemical hazards associated with this project are minimal. The sediment core samples to be collected during drilling are not likely to be contaminated with diesel, weathered crude oil, or other components of drilling waste. However, there may be an odor of diesel or other hydrocarbons within the enclosed sled work area as a result of drilling activities. Where fumes are strongly evident, where air circulation is not sufficient, or where employees feel uncomfortable with the potential exposure, air monitoring using a Photo-ionization detector (PID) will be conducted (see below). If air monitoring results or physical symptoms (such as headace or nauseau) indicate strong odors are present in the breathing zone, engineering controls (open door to ventilate work area, don respirators) will be put into place. Dermal exposure to contaminated core materials will be minimized through the use of gloves. Eating and drinking will not be allowed during sampling activities.

Physical Hazards

The physical hazards associated with the project scope include working around heavy equipment, being struck by a vehicle or equipment, hypothermia and frostbite associated with cold weather exposure, encounters with wildlife, and slips and falls.

Heavy Equipment and Other Vehicles. Field personnel assigned to this project will not be operating heavy equipment (drill rig). However, a portion of the sampling will take place alongside the drill rig in an enclosed Panacheck sled; therefore the following requirements for rig-based personnel must be met:

- Personnel must wear steel-toed boots and hard hats when working within the Panacheck sled.

- Sampling personnel will stay outside the work zone of the drill rig. If it is necessary for samplers to approach the rig, they must wait until the rig operators have given signal that it is appropriate to approach the rig.

- Ground personnel shall never walk or position themselves between a fixed object and running equipment or between two running pieces of equipment.

Hypothermia and Cold Injuries. Operating Procedure HS-202 (Attachment B) details the symptoms of, treatment for, and how to avoid cold injuries such as frostbite and hypothermia. To avoid cold injuries during sampling activities, workers will wear approved arctic gear including pac boots and mitts. Should the beginning signs of either hypothermia or frost bite be observed, the affected worker will immediately proceed to the vehicle to warm up. Indication of adverse effects includes, but is not limited to:

- Uncontrolled shivering
- Slurring of speech
- Loss of motor skills
- Burning or tingling extremities (frostnip or frostbite).

Should symptoms become significant, the sample team will return to the vehicle and work will be stopped. The affected personnel will be taken to the clinic for medical evaluation.

Encounters with Wildlife. Encounters with polar bears are a hazard for the location and time of year that field activities are planned. Heightened awareness for possible bear encounters will form the basis of personnel control and safety. During day-to-day activities, all personnel will be reminded to be constantly alert to polar bears in the nearby vicinity. Food and other items that might attract bears will be controlled and removed from the site at the end of each day's activities.

If a polar bear is seen or recent bear sign identified, team members will go directly to the vehicle and depart the location, leaving sampling equipment and other personal effects behind if necessary. Personnel will immediately notify the on-site team leader of the bear's location and direction of travel. They will also notify PBOC Security (659-5634) who will be responsible for further notification within BPXA. Work will not continue until an authorized polar bear hazer is on site. A polar bear guard will accompany sampling staff at all times.

Foxes, although not as immediately dangerous as polar bears, are of great concern due to rabies. Any physical contact, as well as the observation of sick animals must be reported to security personnel. If a fox (especially one suspected of having rabies) touches your clothing, do not touch that part of your clothing, as you could become contaminated yourself. Wildlife must not be harassed or harmed.

Slips and Falls. Most falls on the ice occur within 7 feet from exiting a vehicle. Caution should be used when walking on the ice; do not take cold strides and attempt to keep your centerline over your mid-stride. Do not attempt to change direction quickly. Wear ice cleats if necessary.

PERSONAL PROTECTIVE EQUIPMENT:

The initial level for all activities is **Level D.**

INITIAL PPE LEVELS

Activity	Level of Protection	Equipment Requirements
Collection of water and ice/soil core samples during drilling.	D	Arctic Gear consisting of down coveralls or parka and bibs with reflective tape, Arctic grade pac boots or bunny boots, safety glasses, hard hat, hard hat liner, and water resistant arctic mitts with polypropylene or silk liners. Safety goggles. Half or full face respirator with organic vapor cartridges if PID indicates action levels are met or if personnel are affected by diesel fumes. Hearing protection if warranted due to heavy equipment.

EXPOSURE MONITORING:

A PID will be used to monitor the breathing zone at locations as determined by the field team leader/site safety officer. Upgrade to level C will proceed as directed in the following table:

TOXICITY ACTION LEVELS
FUELS OTHER THAN GASOLINE, METHANOL AND JET B
(In PPM)

Instrument	Calibration Gas	Action Upgrade to Level C[2]	Evacuate
Photo-ionization meter (10.0 to 10.2 eV lamp)	HNU calibration gas or Benzene	20	100[2] 600[3]
Photo-ionization meter (10.0 to 10.2 eV lamp)	Isobutylene	35	200[2] 600[3]
Flame ionization meter (OVA-128)	Methane	100	300[2] 600[3]

[1]Sustained in the breathing zone for 1 minute.
[2]For workers wearing half-face respirators.
[3]For workers wearing full-face respirators.

EMERGENCY RESPONSE:

The purpose of this section is to provide guidance in preparing for contingency or emergency situations during field activities. Accidents can, and do, happen. However, with adequate planning and preparedness, resulting consequence can be minimized or prevented.

Emergency preparedness starts with advanced planning. It requires anticipation of potential problems or hazards. Proper emergency preparedness involves use of the project health and safety plan that may address emergency situations. It involves training, site orientation of personnel, medical information of personnel, and availability of emergency equipment and services.

Emergency Action Plan

This section describes the steps to be taken if an emergency occurs.

- Fire – Vehicles are equipped with fire extinguishers. Personnel should first notify someone else of the fire (radio for help) and then if they can fight the fire comfortably, do so. If not, personnel should make sure that they have arctic gear and move to a safe distance to wait for pick up. Do not attempt to walk for help, a burning vehicle draws a lot of attention and will be easily found. Communicate with rescuers using the radio or telephone.

- Medical – All vehicles are equipped with First Aid kits. If the injury requires further medical attention, call for help on the radio. EOA Medical Clinic (located at MCC) can be reached at 659-5239. If an injury occurs in the camp or hotel, go to the desk for assistance All injuries, no matter how small, must be reported for medical attention (see reporting procedures below).

- Environmental Spills – A positive impact on the environment is the goal of all BP EOA participants. A spill is any incident that releases a contaminant into the environment. Nothing may be poured on the tundra and all food and containers must be taken back to the camp area for disposal. If field personnel create or witness an emergency situation, Spill Response (659-5700) must be contacted. Spill Response will then contact the proper departments.

Emergency Equipment/First Aid

The emergency equipment to be located on site in the vehicle or Rolligon includes a first aid kit, air horn, emergency eyewash, an ABC-type fire extinguisher, potable water, anti-bacterial soap, and radio equipment.

Spill and Release Contingencies

If a small spill occurs, the release will be handled using on-site spill containment materials. The spill will be reported to the BPXA ACS Environmental Technician at 659-5800.

Incident Reporting and Investigation

Any work-related incident, accident, injury, illness, exposure, or property loss must be reported to URS and BPXA personnel following the procedures in SMS #049, Incident Injury Reporting (Attachment C), using the contact numbers provided below. The incident will also be reported to the project BP project contact (659-5999). Motor vehicle accidents must also be reported. An incident report form, attached to this plan, must also be filled out and forwarded to the local URS Health and Safety Manager, Ms. Sue Ban, (907) 261-6779. In addition, the incident will be reported to BP HSE Shared Resource through the BP site contact.

BPX CONTRACT ACCOUNTABLE MANAGER	CONTRACTOR'S ACCOUNTABLE MANAGER
DATE: _____	DATE: _____

CONTACT LIST

Medical Services	Onsite	PBU-EOA	Notes
Medical services	Onsite emergency care limited to First Aid.	PBOC Medical Clinic 659-5239	Emergency numbers are · PBU-EOA Emergency 659-5300 · PBU-EOA Security 659-5634
Environmental Services	Onsite	PBU-EOA	Notes
Routine environmental services including waste management advice, manifesting, fluid transfers, minor spill management.		Additional technical support available through SRT Env. /Waste Techs 659-5800.	Contractor expected to provide cleanup of minor spills. PBOC Env. Tech. will provide guidance on disposal of spill cleanup waste. HSE rep. site contact will provide field spill information to ACS Env. Tech. and to Compliance Advisor for agency reporting.
Emergency environmental services including large controlled or uncontrolled spills.		PBOC Emergency Spill Hotline 659-5700	
Emergency Response Services	Onsite	PBU-EOA	Notes
Fire/exposure protection	Incipient response	PBOC activated with BP resources deployed as needed	Emergency numbers are · PBU-EOA Emergency 659-5300 · PBU-EOA Security 659-5634
Rescue/extraction	Initial response as possible	Additional support as needed	Emergency numbers are · PBU-EOA Emergency 659-5300 · PBU-EOA Security 659-5634
HazMat response team	Initial response as possible	Additional support as needed	Emergency numbers are · PBU-EOA Emergency 659-5300 · EOA Spill Hotline 659-5700

ATTACHMENT A

SAFETY MANAGEMENT STANDARDS

ATTACHMENT B
OPERATING PROCEDURE HS-202
COLD STRESS

OPERATING PROCEDURE NO. HS-202

202.0 COLD STRESS

202.1 PURPOSE

The purpose of this Operating Procedure is to provide information on cold stress and the procedures for preventing and dealing with cold stress. Adverse climatic conditions are important considerations in planning and conducting site operations. Ambient temperature effects can include physical discomfort, reduced efficiency, personal injury, and increased accident probability.

202.2 TYPES OF COLD STRESS EFFECTS

202.2.1 Frostbite

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite can be categorized into:

- **Frost Nip or Initial Frostbite:** (1st degree frostbite) Characterized by blanching or whitening of skin.
- **Superficial Frostbite:** (2nd degree frostbite) Skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient. Blistering and peeling of the frozen skin will follow exposure.
- **Deep Frostbite:** (3rd degree frostbite) Tissues are cold, pale, and solid; extremely serious injury with possible amputation of affected area.

Frostbite can occur without hypothermia when the extremities do not receive sufficient heat. The toes, fingers, cheeks, and ears are the most commonly affected. Frostbite occurs when there is freezing of the fluids around the cells of the affected tissues. The first symptom of frostbite is an uncomfortable sensation of coldness, followed by numbness. There may be tingling, stinging, or cramping. Contact by the skin with tools or other metal objects below 20°F (-7°C) may result in contact frostbite.

The prevention of frostbite includes early recognition of problems, adequate protective clothing, recognizing the combination of wind and low temperature (see Table 202-1 Windchill Index), adequate fluids, work-rest regimens with heated rest areas, and use of controls such as wind-breaks and heaters.

The initial treatment for frostbite includes bringing the individual to a warm location, removal of clothing in the affected area, and placing the affected parts in warm (100-105°F) water. Do not massage or rub the frostbite area. After the initial treatment, wrap the affected area loosely in sterile gauze and seek medical attention.

202.2.2 Hypothermia

Hypothermia results when the body loses heat faster than it can be produced. When this situation first occurs, blood vessels in the skin constrict in an attempt to conserve vital internal heat. Hands and feet are first affected. If the body continues to lose heat, involuntary shivers begin. This is the body's way of attempting to produce more heat, and it is usually the first real warning sign of hypothermia. Further heat loss produces speech difficulty, confusion, loss of manual dexterity, collapse, and finally death. Wet clothes or immersion in cold water greatly increases the hypothermia risk. The progressive clinical presentation of hypothermia may be seen in Table 202-2.

Prevention of hypothermia includes planning for outside work in winter conditions, particularly work over water. Planning will include adequate layers of clothing, training employees in recognizing hypothermia in themselves and others, recognition of the combination of wind and temperature (see Windchill Index in Table 202-1), use of controls such as wind-breaks and heaters, a work-rest schedule, and adequate fluid intake.

Fatal exposure to cold among workers has usually resulted from immersion in low temperature water. Water transmits body heat over 200 times faster than air. Wetsuits or drysuits are recommended for work over water with water temperatures below 45°F. Individuals who fall into cold water without wetsuits or drysuits may not be able to swim due to the rapid onset of hypothermia.

Prompt treatment of hypothermia is essential. Once the body temperature drops below 95°F, the loss of temperature control occurs, and the body can no longer rewarm itself. Initial treatment includes reducing heat loss by moving the individual out of the wind and cold, removal of wet clothing, applying external heat (such as a pre-warmed sleeping bag, electric blanket, or body-heat from other workers) and follow-up medical attention.

202.4 EXPOSURE LIMITS

The American Conference of Governmental Industrial Hygienists (ACGIH) has adopted Threshold Limit Values (TLVs) for cold stress. These limits set maximum work periods based on a combination of wind and temperature.

202.5 REFERENCES

American Conference of Governmental Industrial Hygienists, Documentation of Threshold Limit Values, 1984

EPA, Standard Operating Safety Guides, 1992, pages 95-100.

ATTACHMENT C

SAFETY MANAGEMENT STANDARD #049:
INCIDENT REPORTING

HSE "SHORT FORM" INTERFACE DOCUMENT

1. **CONTRACTOR: URS Corporation** 2. **CONTRACT #: 1917**

3. **WORK SCOPE** (materials & services, organization, personnel & supervision, location(s), customer(s), etc.):
The work performed by URS Corporation consists of drilling oversight and seafloor sediment sampling along three proposed pipeline trenches in Foggy Island Bay. The purpose of this task is to collect sufficient environmental baseline sediment data to support a NEPA evaluation and permit applications for the proposed construction of a gravel-filled island within Foggy Island Bay. The proposed island would serve as a production facility for the Liberty Development. The drilling and sampling work will be performed during the winter season on floating land-fast sea ice using a conventional drill rig and coring equipment.

The duration of the project is expected to be approximately 10 days. The URS field team will consist of four employees. The employees will have attended NSTC training prior to deployment. All field personnel will have full arctic gear and safety gear including: Arctic Parka, Arctic Bibs, Pack Boots or Bunny Boots, Mittens, Face Mask/Balaclava, Hard Hat Liner, Hard Hat, Respirator and Cartridges, Ski Goggles and Safety Glasses. The work will be conducted in April and May 2001.

4. **COMMUNICATION:**

BPXA: Tony Zamora	URS Corporation: Sharon Sullivan	BPXA: Dave Tomasko, Project Manager
(907) 564-5496	(907) 261-9745 or (907) 529-0642	(907) 564-5039

5. **SPECIFIC HSE HAZARDS:**
With the exception of drilling mud and cuttings discharged immediately adjacent to Tern Island during exploration drilling in the early 1980s and 1997, there are no other known chemical hazards within the study area ice, water, and sediments. Cold stress and cold injuries associated with working on the ice in the arctic during the winter. Physical hazards associated with working around heavy machinery. Hazards associated with encountering wild animals such as polar bears.

6. **ASSURANCE SYSTEMS:**
URS Corporation Health and Safety Program
Site Specific Health and Safety Plan (Attached)

7. **SIGNATURES:**
The contents of this document are the product of a desktop hazard assessment by management. The undersigned agree that to the best of their knowledge this document is an accurate depiction of the scope of work provided by the contractor, health, safety and environmental risks known about that work scope and management systems in place to mitigate risks. This document also identifies additional actions to further mitigate risks and the undersigned agree to review these and implement as appropriate.

BPX(A) Project Manager Date URS Health and Safety Officer Date

			Interfaces		
Category	**Hazard/Activity**	**Safeguards in Place to Manage the Hazard/Activity**	**Management System**	**Whose System**	**Responsible Person**
NORTH SLOPE SAFETY HAZARDS	1. Remote Camp hazards 2. Fire hazards 3. Cold Related Injuries 4. Foul Weather 5. Travel by Vehicle on Ice roads and trails on land-fast sea ice. 6. Noise exposure 7. Bear and other wildlife encounters 8. Working around heavy equipment.	1. North Slope Orientation Training (NSTC: Unescorted) for all field personnel. Site/Facility Orientation 2. Fire extinguishers available at camp and on vessels; training in use of extinguishers and evacuation procedures. 3. Use of appropriate cold-weather gear; training in signs of hypothermia and frostbite. Stop-work if symptoms present. 4. Stop work, follow evacuation procedures prescribed by Emergency Response Plan. 5. Radio, flares, signal horn and first aid kit carried on vehicle. 6. Hearing Conservation Program. Use of Ear Protection if warranted by noise levels. 7. Bear Training. Bear observation notification procedures. Bear guard available.	BPX(A) "Alaska Safety Handbook" within operated areas. Asset Policy, Recommended Practices, and SOPs Handbook: North Slope Field Guide for Visitors and Contractors Contractor's HSE Management System	BPX(A) within operated areas. Contractor	Contractor CAM responsible to ensure their personnel receive required orientation training and follow BPX(A) rules and procedures applicable to their work scope. Contractor CAM

Category	Hazard/Activity	Safeguards in Place to Manage the Hazard/Activity	Interfaces		
			Management System	Whose System	Responsible Person
NORTH SLOPE SAFETY HAZARDS (cont.)		8. Notify operators that team will be present. Stay out of the way of all heavy machinery. Maintain eye contact with operator when crossing the work area. Use of orange/ reflective clothing. Situational awareness.	Contractor's HSE Management System	Contractor	Contractor CAM
PERMIT AND PROCEDURE CONTROLLED HAZARDS	1. Work within BPX(A) operated areas 2. Flammable and Combustible Fluid Transfer(engine oils, gasoline)	1. North Slope Orientation Training for all personnel before initiating work. 2. Asset Fluid Transfer Procedure	BPX(A) "Alaska Safety Handbook" within operated areas. Asset Policy, Recommended Practices, and FOPs	BPX(A) within operated areas.	Contractor CAM responsible for ensuring personnel receive training and follow rules and procedures applicable to their activities.
ENVIRON-MENTAL IMPACT HAZARDS	1. Spills (fluid transfer, improper liner use etc.) 2. Wildlife Encounters 3. Waste Management and Disposal	1. Training on fluid transfer procedure (NS Orientation). 2. Personnel to avoid all contact with wildlife. 3. Contractor to minimize, segregate, containerize, and label solid waste, and ensure personnel are trained appropriately. All solid waste to be removed from site and properly disposed.	BPX(A) "Alaska Safety Handbook" within operated areas. Asset Policy, Recommended Practices, and FOPs	BPX(A)	Contractor CAM responsible for ensuring personnel receive training and follow rules and procedures applicable to their activities.

Category	Hazard/Activity	Safeguards in Place to Manage the Hazard/Activity	Interfaces		
			Management System	Whose System	Responsible Person
EMERGENCY AND MEDICAL	1. First Aid, Medical Treatment, Medevac	1. Contractor personnel to be First Aid/CPR trained. For serious accidents/illnesses, BPX(A)/AAI North Slope to provide medical stabilization or treatment and medevac to Anchorage (reimbursed by contractor).	BPX(A)	BPX(A)	
EMERGENCY AND MEDICAL (cont.)	2. Incident Reporting and Investigation a)Investigation of Incidents b)Emergency Response 3. Reporting HSE Data to CAM as required. 4. Return to work after illness/injury. 5. Fitness 6. OSHA Documentation	2. Report all incidents to Asset. Asset to investigate incidents per FOP (contractor to participate). BPX will report environmental incidents occurring on BPX operated areas. 3. Contract Language 4. Contractors Return to Work Policy. 5. Contractors Medical surveillance program. Medical monitoring, pre-job physicals, Doctor release. 6. OSHA 200 Log	Asset HSE Plan Asset Emergency Management Plan BPX Contingency Plans Contractor's HSE Management System	BPX(A) Contractor	Contractor CAM responsible for ensuring personnel receive training and follow rules and procedures applicable to their work Contractor CAM

Category	Hazard/Activity	Safeguards in Place to Manage the Hazard/Activity	Interfaces		
			Management System	Whose System	Responsible Person
MANAGEMENT SYSTEMS	1. Communications: points of contact with Asset 2. Competency (HSE and Work Program) 3. Roles and Responsibilities 4. Safety management 5. Fatigue 6. Drug and alcohol program	1. Site Specific HSE plan 2. Training Programs, Competency System, Performance Evaluations, Continuing Education 3. Job descriptions 4. Contractor Safety Management Policy and Procedures Manual 5. Budget 12 hour days 6. Contractor's program	Contractor defines points of contact within the Asset and AIC. Contractor's HSE Management System as provided Contractor	Contractor	Contractor CAM to ensure personnel receive site orientation and contact list
WORK PRACTICES AND CONTROLS	1. Work Programs and Procedures 2. Pre-work Risk Assessment 3. Management of Change (design, equipment, chemical, procedure) 4. Information/ Documentation	1. Written work procedures, standards, drawings 2. Contractors pre-work HSE plan 3. Contractors Management of Change procedure 4. Information reporting and documentation to management (daily, job, etc.)	Contractor BPXA CAM agree to all Contractor's HSE Management System Contract Language	Shared Contractor	CAM's agree to work scope and written work procedures before commencing work

Category	Hazard/Activity	Safeguards in Place to Manage the Hazard/Activity	Interfaces		
			Management System	Whose System	Responsible Person
CONTRACTOR SUPPLIED EQUIPMENT	1. Hand-tools 2. Trucks/Vehicles 3. Materials and Services in compliance with applicable industry standards and specifications. 4. Maintenance and operability of equipment	1. Inspection program. 2. Licenses, driver competency. 3. Inspection program, record keeping. 4. Inspection and records.	Contractors Work Plan Contractor's HSE Management System	Contractor	Contractor management to ensure personnel receive briefing on Safety Plan and Work Plan.

Appendix C
Field Activity Report

LIBERTY DEVELOPMENT 2001 SEDIMENT QUALITY STUDY:
Field Activity Report
June 14, 2001

Prepared by URS Corporation
for
BP Exploration (Alaska), Inc.

INTRODUCTION

BP Exploration (Alaska), Inc. (BPXA) applied for permit applications associated with the construction and operations of the Liberty Development–an offshore oil production facility located in Foggy Island Bay. Construction permits administered by the U.S. Army Corps of Engineers, Alaska District (Corps) and U.S. Environmental Protection Agency (EPA) require that physical properties (e.g., grain-size distribution) and chemical characteristics of sediment samples related to trench excavation and fill activities be evaluated for potential impacts to the surrounding environment and for possible ocean disposal of spoils. Samples were collected in 1997 and 1998; however, the EPA and Corps required additional sample collection to satisfy regulatory evaluations for the marine segments of the preferred and alternative pipeline routes.

BPXA secured the services of URS Corporation (URS) to design and conduct a marine sediment sampling study to support permitting activities associated with the Liberty Development. The goal of this study was to collect representative sediment chemistry and sediment physical properties (grain-size) samples along the preferred and alternative pipeline alignments within Foggy Island Bay (Figure 1). Field activities based on the approved *Liberty Development 2001 Sediment Quality Study Work Plan* developed by URS were conducted between April 25th and May 8th, 2001.

The field team successfully collected a representative sample set based on statistical performance criteria noted in the Work Plan. Approximately 94 percent of the sediment chemistry samples and 61 percent of the grain-size samples were collected. Sampling methods and other field protocols were completed as described in the Work Plan (URS 2001). This report serves to provide a summary of the field activities, including a description of other operations that affected the field program.

FIELD SAMPLING STRATEGY

The field program collected samples in the following order to assure that a representative sample set was collected to describe the sediment chemistry and grain-size distribution for all three pipeline alternatives:

1. Subsurface sediment chemistry and associated grain-size samples.
2. Surface sediment chemistry and associated grain-size samples.
3. Remaining grain-size samples.

The field team departed from the road that connects the Endicott Development with the Prudhoe Bay in-field road system and moved along the coast on the grounded sea ice until reaching the westernmost sample stations that coincide with Transect A, the applicant's preferred pipeline route (Figure 1). Subsurface chemistry and associated grain-size sampling commenced at the nearest station along Transect A and progressed toward the eastern side of the study area. Due to travel restrictions related to seal structures, the field team followed a path cleared by seal-sniffing dogs that corresponded with the three pipeline route alternatives. The only deviations from this route were detours up to 5-miles to avoid crossing geophone cables related with an ongoing seismic survey. As the field team reached the location of the proposed Liberty Island at the north end of Transect A, progress continued southeast along Transect B (South Island alternative). Upon completion of Transect B sampling, the field team sampled the adjacent station on Transect C (Tern Island alternative) and moved north toward the Tern Island shoal until all of the subsurface sediment and associated grain-size samples were collected.

Upon completion of the subsurface sediment chemistry and associated grain-size samples, the field team moved back to the west side of the study area to collect the surface sediment chemistry and grain-size samples. Once the background and three Transect A sediment chemistry and associated grain-size samples were collected, the field team started collecting the remaining grain-size samples, starting at the nearest station on Transect A and moved toward the north. Field sampling ceased prior to the collection of the remaining grain-size samples located along Transects B and C.

DAILY ACTIVITIES

The following table presents a daily summary of significant events and accomplishments related to field activities. Daily Field Activities Reports (Appendix A) were submitted by the field team and identifies the field personnel, contacts, sampling activities, significant events, and other accomplishments for a given day.

Table 1. Significant Field Events

Day	Planned Activities, Significant Field Events, and Accomplishments
April 25	***Planned Activities*** • Setup of field sampling equipment, mobilization of the CATCO rollagon and drilling sled. • All field personnel attended the Authorization to Proceed (ATP) meeting facilitated by Tony Zamora (BPXA). ***Significant Field Events*** • Bryan Trimm (URS) and Sharon Sullivan (URS) discussed the potential impact of tundra travel closure to the sampling effort. Bryan Trimm (URS) decided that if Sharon Sullivan (URS) determined that tundra travel was imminent, that sub-surface sediment samples and associated grain-size samples were top priority. Second priority samples were surface sediment chemistry and associated grain-size, with the remaining grain-size samples comprising the third tier of sampling. • At 4:30 PM, Tony Zamora (BPXA) informed Sharon Sullivan, the URS field manager, and the field party that the field program was placed on stand-by until BPXA determined that the appropriate field sampling permits and authorizations were in place.
April 26	***Planned Activities*** • Field preparation and mobilization continued from the following day. • Rollagon and drilling sled transferred to the first sample station (LIB01-AGR01) late in the afternoon. ***Significant Field Events*** • At 10:00 am, Tony Zamora (BPXA) authorized URS to proceed with the sampling program. • Additional protocols were implemented related to polar bear awareness and harassment prevention. • Due to time constraints related to tundra travel closure and inclement weather conditions, Sharon Sullivan (URS) declared that subsurface sediment chemistry and associated grain-size samples were priority and thus were to be the first samples collected. This prioritization strategy was implemented to collect the minimum number of samples based on the statistical performance criteria noted in the Work Plan. As time allowed, surface chemistry and associated grain-size samples were selected to be the second priority, with the remaining grain-size samples as the third priority. • LGL was requested to supply the seal structure GPS positions.
April 27	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect A (preferred pipeline route) ***Significant Field Events*** • Western GeCo, a seismic acquisition firm, deployed geophone cables in an orientation that increased the one-way travel time by 3 hours. • Multiple orange survey lath (stakes) installed by Western GeCo overlapped with the seal structure stakes installed by LGL, and the CATCO rollagon trail markers. Since the field team could not distinguish between Western GeCo and seal

Day	Planned Activities, Significant Field Events, and Accomplishments
	structure markers, all stakes were avoided, thus, slowing progress. • The presence of Western GeCo geophone cables prohibited CATCO from blazing trails that would have increased travel time throughout the study area. CATCO policy is not to cross deployed geophone cables. • BPXA Endicott personnel prohibited LGL from deploying the seal sniffing dogs (to identify seal structures) because LGL did not have a Letter of Authorization (LOA) from USFWS. • Bryan Trimm (URS) approved changes to sample station identifications along Transect C (Tern island route) so that the southernmost station was identified as LIB-CT01.
April 28	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect A (preferred pipeline route). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • LGL completed the seal structure survey, which identified 15 structures. • Travel restrictions as noted on April 27th associated with the geophysical survey continue to cause unforeseen delays.
April 29	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect A (preferred pipeline route). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Travel restrictions as noted on April 27th associated with the geophysical survey continue to cause unforeseen delays. • Low recovery at Station LIB01-AT03 required an offset of 10 feet core to collect sufficient sediment.
April 30	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect A (preferred pipeline route) and Transect B (South Island Alternative). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Travel restrictions as noted on April 27th associated with the geophysical survey continue to cause unforeseen delays. • Station LIB01-AT04 (co-located with LIB01-AGR09) required an offset of about 400 feet north along the transect to collect the samples due to the presence of a seal structure. • Sampler and rod were lost during the coring at LIB01-AT04. Drilling commenced after the sampling equipment was recovered and relocation of the drilling rig 10-feet from the original position.
May 1	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect B (South Island Alternative). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Deteriorating (nearly whiteout) weather conditions resulted in increased travel time. • Travel restrictions as noted on April 27th associated with the geophysical survey continue to cause unforeseen delays. • Heaving sands at LIB01-BGR05/BT03 resulted in poor recovery. Insufficient material was recovered at the 13-foot deep interval for sample analysis.
May 2	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect B

Day	Planned Activities, Significant Field Events, and Accomplishments
	(South Island Alternative). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Fog with drifting snow resulted in increased travel time. • Travel restrictions as noted on April 27th associated with the geophysical survey continue to cause unforeseen delays. • Heaving and completely saturated sands were encountered resulting in use of a split spoon sampler.
May 3	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect B (South Island Alternative) and Transect C (Tern Island Alternative). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Travel time was improved as Western GeCo departed area.
May 4	***Planned Activities*** • Sediment chemistry and associated grain-size sample collection along Transect C (Tern Island Alternative). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Completed subsurface sediment chemistry and associated grain-size sample collection effort.
May 5	***Planned Activities*** • Surface sediment chemistry and grain-size samples were collected along Transect A (preferred pipeline route). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Completed surface sediment chemistry and associated grain-size sample collection effort.
May 6	***Planned Activities*** • Grain-size samples were along Transect A (preferred pipeline route). • Sub-sampling of cores in controlled laboratory environment. ***Significant Field Events*** • Last day of drilling activities. • Completed grain-size sample collection effort along Transect A. • Remove markers identifying seal structures from area.
May 7	***Planned Activities*** • Complete sub-sampling cores. • Demobilize field equipment.
May 8	***Planned Activities*** • Demobilize field equipment. • Last shipment of samples forwarded to laboratory. • Remaining field personnel return to Anchorage.

Sample Coverage

Table 2 summarizes the number of planned versus actual samples collected for grain-size distribution, surface sediment chemistry, and subsurface sediment chemistry. Also, complete list of the samples by type are provided in Tables 3-5 along with associated maps presenting the sample locations (Figures 2-4).

Table 2. Comparison between the planned and actual number of samples collected

Sample Type	Sample Collection[†]		Percent Collected
	Planned	Actual	
Subsurface chemistry	54	51	94 percent[‡]
Surface chemistry	4	4	100 percent
Grain-size distribution	112	68	61 percent
Totals	170	123	72 percent

[†] Sample numbers include quality control (QC) samples.
[‡] Subsurface sediment sampling completed but heaving sands prevented collection at specific locations and depths.

Table 3. Subsurface chemistry sample stations

Sample Station	Transect	Latitude (NAD27 Decimal Degrees)	Longitude (NAD27 Decimal Degrees)
LIB01-CT04	C	70.269689	147.498355
LIB01-CT03	C	70.254608	147.5001609
LIB01-AT03	A	70.264822	147.6846120
LIB01-BT04	B	70.260126	147.5459550
LIB01-AT02	A	70.252080	147.6079420
LIB01-CT02	C	70.232102	147.5021930
LIB01-BT01	B	70.209745	147.5084140
LIB01-BT02	B	70.224120	147.5211500
LIB01-BT03	B	70.238567	147.5311260
LIB01-AT01	A	70.233249	147.6418600
LIB01-AT04	A	70.277790	147.5612560

Table 4. Surface chemistry sample stations

Sample Station	Transect	Latitude (NAD27 Decimal Degrees)	Longitude (NAD27 Decimal Degrees)
LIB01-AS01	None	70.261402	147.7361710
LIB01-AS02	A	70.222127	147.6618790
LIB01-AS03	A	70.252080	147.6079420
LIB01-AS04	A	70.277790	147.561256

Table 5. Grain-size distribution sample stations

Sample Station	Transect	Latitude (NAD27 Decimal Degrees)	Longitude (NAD27 Decimal Degrees)
LIB01-AS01	None	70.261402	147.736171
LIB01-AS02	A	70.222127	147.661879
LIB01-AGR01	A	70.227042	147.653133
LIB01-AGR02	A	70.233249	147.64188

Sample Station	Transect	Latitude (NAD27 Decimal Degrees)	Longitude (NAD27 Decimal Degrees)
LIB01-AGR03	A	70.239565	147.630578
LIB01-AGR04	A	70.245880	147.619263
LIB01-AGR05	A	70.252080	147.607942
LIB01-AS03	A	70.252080	147.607942
LIB01-AGR06	A	70.258394	147.596279
LIB01-AGR07	A	70.264822	147.584612
LIB01-AGR08	A	70.271478	147.572604
LIB01-AGR09	A	70.277790	147.561256
LIB01-AS04	A	70.277780	147.561256
LIB01-BGR01	B	70.209745	147.508414
LIB01-BGR02	B	70.217208	147.516118
LIB01-BGR03	B	70.224199	147.52115
LIB01-BGR04	B	70.231383	147.526304
LIB01-BGR05	B	70.238567	147.531126
LIB01-BGR06	B	70.245778	147.536283
LIB01-BGR07	B	70.253077	147.541113
LIB01-BGR08	B	70.260126	147.545955
LIB01-CGR01	C	70.217022	147.503657
LIB01-CGR02	C	70.224676	147.503095
LIB01-CGR03	C	70.232102	147.502193
LIB01-CGR04	C	70.239528	147.501627
LIB01-CGR05	C	70.247068	147.500726
LIB01-CGR06	C	70.254606	147.500161
LIB01-CGR07	C	70.262263	147.49926
LIB01-CGR08	C	70.269689	147.498355
LIB01-CGR09	C	70.277344	147.497453

APPENDIX A
URS Daily Field Activities Report
(April 25 to May 6, 2001)

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: WEDNESDAY, 25 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 25 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
URS personnel (Sharon, Claude, Dana, Tracy) *Duane Miller & Associates* staff (Walt Phillips), *Discovery Drilling* crew (*Ralph Newland, Greg Turner*), *CATCO* crew (*Bill Kuper, Dan Stewart*), *Mehrdad Nadem (BPXA)*, and *Rick English (BPXA)* attended an ATP meeting led by *Tony Zamora* (*BPXA*) at PBOC. At the conclusion of the ATP meeting, BPXA directed URS and the other contractors to stand by until a decision was made regarding whether to proceed without the LOA permit in hand. Contractors left meeting and prepared for field activities.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
LOA Permit may not be in hand until Monday 30 April, 2001.

ACTIVITIES TO BE PERFORMED:
Continue to prepare for field effort and await BP go/no go decision.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: THURSDAY, 26 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 26 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
Sharon, Claude, Dana, and Tracy continued to prepare for the field and packed sled with sampling equipment. *Discovery Drilling* crew prepared rig for field effort. *CATCO* operator was assigned to another project for the day. *BP* directed URS to go ahead and initiate the field program without LOA in hand using the following procedures: heightened awareness of bear presence (use of binoculars while traveling and working, multiple bear spotters in place while traveling, etc.) and bear harassment prevention (i.e., rig shutdown) in the event a bear was spotted. *CATCO* and *Discovery Drilling* crews brought the sled and rig to the first grain-size sampling station (LIB01-AGR01) late in the afternoon.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Need to obtain GPS coordinates for seal structures from *LGL* to avoid structures in the event stakes are not visible in poor weather conditions. Due to time constraints related to potential deteriorating weather conditions, priority sampling will be performed first to collect subsurface chemistry and associated grain-size sediment samples, then collect surface samples, then collect remainder of grain-size only samples.

ACTIVITIES TO BE PERFORMED:
Begin drilling program. Will start on station LIB01-AGR01 to run through grain size sampling procedures.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: FRIDAY, 27 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 27 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
Claude, Dana, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site from CATCO's base in Deadhorse to begin drilling and sampling. Sharon and Tracy prepped staging area for sampling and tracked down information including LGL seal structure coordinates, permit information, etc. *BP* faxed permits (including LOA e-mail authorization) to URS. Field crew drilled and sampled along Transect A (preferred route) at the following grain size sampling stations: LIB01-AGR01 and LIB01-AGR02. Sharon and Tracy met with LGL crew in the evening to obtain latest maps and coordinates of seal structures.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Travel to site took 3 hours to complete (one way) due to coastline trail (seal avoidance) and seismic line interference from Western GeCo. Multiple orange painted stakes present in area due to Western GeCo staking seismic locations, CATCO staking trail locations, and LGL staking seal locations. All stakes were avoided which increased travel time between stations. LGL caught up with rig and mentioned they were on second pass of transects. BPXA Endicott personnel would not allow LGL to start seal sniffing program because LGL did not have an LOA in place (2-day delay). Presence of Western GeCo seismic lines prevented CATCO from blazing trail ahead of time between stations to improve travel time with rig between stations. URS must fuel at Endicott, not PBOC, due to AFE Number. Fuelling at Endicott reduces effective sub-sampling time at field staging area (2 hour delay to travel to and from fueling station).

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Will collect chemistry core at Station LIB01-AT01. Plan to drive to Endicott Causeway to meet Rolligon to try and reduce travel time to site.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: SATURDAY, 28 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 28 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
Claude, Dana, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site from Endicott Causeway to begin drilling and sampling. Sharon and Tracy performed sub-sampling of grain-size sediments and established sample control procedures. Field crew drilled and sampled along Transect A (preferred route) at the following sampling stations: LIB01-AT01, LIB01-AT02, LIB01-AGR05. LGL completed seal structure searches and notified rig personnel when they were leaving the area. Sharon left the North Slope to return to town.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
15 seal structures were identified during LGL's searches. Travel continues to be slow to and from the site and between sampling stations due to coastline route and Western GeCo seismic lines.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Will continue to collect chemistry cores along Transect A.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: SUNDAY, 29 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 29 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
Claude, Dana, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to begin drilling and sampling. Tracy performed sub-sampling of grain-size and chemistry sediments and performed sample control tasks. Field crew drilled and sampled along Transect A (preferred route) at the following sampling stations: LIB01-AT03 and LIB01-AGR07.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Problems with recovery at Station LIB01-AT03 required additional step-out sampling to collect sufficient quantity of material for analysis. Travel time to the site from Endicott Causeway takes 1.5 hours one-way.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to complete chemistry cores along Transect A and begin drilling and sampling along Transect B.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: MONDAY, 30 APRIL 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 30 April 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
Claude, Dana, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. Tracy performed sub-sampling of grain-size and chemistry sediments, performed sample control tasks, and shipped samples to lab. Field crew moved to LIB01-AGR09 (co-located with LIB01-AT04) but original location was within 50 meters of seal structure (LIB10) so rig was moved 150 meters from seal structure (~400 feet from original location). Drilling was completed along Transect A (preferred route) and was initiated along Transect B at the following locations: LIB01-AGR09, LIB01-AT05, and LIB01-BGR08.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Began to drill analytical core at LIB01-AT04 then lost sampler and some rod in hole. Lost time to recover equipment. Rig was moved to an offset location and collected LIB01-AT04.

Western GeCo is still in the area but moving to the east. However, the jump off point at Endicott is still impacted by their seismic lines. As a result of the Western GeCo seismic lines, the rolligon cannot use drag pipe to improve trail so travel time between the sample stations cannot be improved.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to continue chemistry cores along Transect B and begin with collecting analytical core at LIB01-BT04, move to LIB01-BGR05/BT03 and collect grain-size and analytical samples. Sub-sampling will continue to be performed at the field staging area and samples will be shipped to the lab.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: TUESDAY, 01 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 01 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
C. Denver, D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. T. Lewis performed sub-sampling of grain-size and chemistry sediments, performed sample control tasks, and shipped samples to lab. Field crew moved to LIB01-BT04 and collected chemical cores, then moved to LIB01-BGR05/BT03 and collected grain size samples and chemical cores. Rig was moved to LIB01-BGR03/BT02 before departing the site.

Samples collected on 5/01/01: LIB01-BT04A, LIB01-BT04B, LIB01-BT04C, LIB01-BT04D, LIB01-BGR05A, LIB01-BGR05B, LIB01-BGR05C, LIB01-BGR05D, LIB01-BT03A, LIB01-BT03B, LIB01-BT03C.

Sampling Progress as of 5/01/01 (Day 5 of Drilling):

Sample Type	Planned Samples*	Samples Collected	Percent Complete
Subsurface Sediment	52	31	60%
Surface Sediment	6	0	0%
Grain Size	112	32	29%
Totals	170	63	37%

* Number of samples includes duplicate and replicate samples

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Heaving sands present at LIB01-BGR05/BT03. Sample recovery was difficult; crew switched over to split spoon sampler for grain size sampling to try and increase recovery. Switch over caused some delay. Recovery was still poor with

split spoon sampler so logging had to be performed from material in sampler shoe. Poor recovery also occurred during chemical coring. Not enough material was recovered for the deepest sample interval (13 feet) at LIB01-BT03 in order for a sample to be collected and submitted for analysis.

Western GeCo seismic lines continue to block access to transect paths via coastline route. Travel to site continues to be diverted around the lines which increases travel time.

Weather conditions are poor (near whiteout conditions) which increases travel time to and from the transects and between sampling stations.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to finish sampling subsurface sediments and associated grain size samples at Transect B.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: WEDNESDAY, 02 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 02 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
C. Denver, D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and CATCO crew traveled to the site to continue drilling and sampling. T. Lewis performed sub-sampling of grain-size and chemistry sediments, performed sample control tasks, and shipped samples to lab. Drill rig already set up on LIB01-BGR03/BT02. Field crew collected grain size samples and chemical cores at LIB01-BGR03/BT02, then moved to LIB01-BGR01/BT01 and collected grain size samples. Rig was moved to LIB01-BGR03/BT02 before departing the site.

Samples collected on 5/02/01: LIB01-BT02A, LIB01-BT02B*, LIB01-BT03A, LIB01-BT03B, LIB01-BGR01A, LIB01-BGR01B, LIB01-BGR01C, LIB01-BGR01D.

*No recovery for chemical analysis for LIB01-BT02C or LIB01-BT02D

Sampling Progress as of 5/02/01 (Day 6 of Drilling):

Sample Type	Planned Samples**	Samples Collected	Percent Complete
Subsurface Sediment	52	35	67%
Surface Sediment	6	0	0%
Grain Size	112	36	32%
Totals	170	71	42%

** Number of samples includes duplicate and replicate samples

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Heaving, fluid sands (completely saturated) present. At the 2- to 15-foot depth sediment is too fine for sand catcher, limited if any recovery. Multiple sampling methods used (split spoon sampler, 3-inch core barrel, 5-inch core barrel) to improve recovery with limited success.

Weather is pea soup fog with drifting snow – travel time to site from drop off point took 3 hours one-way.

Western GeCo seismic lines continue to block access to transect paths via coastline route. Travel to site continues to be diverted around the lines which increases travel time.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to start sampling subsurface sediments and associated grain size samples at Transect C.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: THURSDAY, 03 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 03 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
C. Denver, D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. T. Lewis performed sub-sampling of grain-size and chemistry sediments, performed sample control tasks, and shipped samples to lab. Drill rig already set up on LIB01-BT01. Field crew collected chemical cores at LIB01-BT01, moved to LIB01-CGR03/CT01 and collected grain size samples and chemical cores, then moved to LIB01-CGR06/CT02 and collected grain size samples.

Samples collected on 5/03/01:

LIB01-BT01A, LIB01-BT01B, LIB01-BT01C, LIB01-BT01D,
LIB01-CGR03A, LIB01-CGR03B, LIB01-CGR03C, LIB01-CGR03D,
LIB01-CT01A, LIB01-CT01B, LIB01-CT01C, LIB01-CT01D,
LIB01-CGR06A, LIB01-CGR06B, LIB01-CGR06C, LIB01-CGR06D.

Sampling Progress as of 5/03/01 (Day 7 of Drilling):

Sample Type	Planned Samples*	Samples Collected	Percent Complete
Subsurface Sediment	52	43	83%
Surface Sediment	6	0	0%
Grain Size	112	44	39%
Totals	170	87	51%

* Number of samples includes duplicate and replicate samples

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:

- Flowing sands and irregular recovery hampered clear demarkation of lithologic boundaries in logging core.
- T. Lewis met with V. Pokryfki (EOA Health and Safety Specialist) and C. McNab (CATCO Rollagon Operator) to assist in ATP briefing of C. McNab who will begin work on the program on 5/4/01. Site specific and general safety issues were covered, including travel and wildlife issues.
- Crew worked an extended day (14-hour shift) to drill and sample an additional borehole.
- Western GeCo work in the vicinity of the Liberty project area was completed and crew and equipment left site on 5/3/01.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to finish subsurface sediment sampling and prep for surface sediment sampling.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: FRIDAY, 04 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 04 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
C. Denver, D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. T. Lewis performed sub-sampling of grain-size and chemistry sediments, performed sample control tasks, and shipped samples to lab. Drill rig already set up on LIB01-CGR06/CT02 on Transect C. Field crew collected chemical cores at LIB01-CT02, moved to LIB01-CGR08/CT03 and collected grain size samples, chemical cores, and additional samples for QC. After completing subsurface sampling, crew moved to Transect A and set rig up on a surface scrape sampling station then traveled back to PBOC.

Samples collected on 5/04/01:

LIB01-CT02A, LIB01-CT02B, LIB01-CT02C, LIB01-CT02D,
LIB01-CGR08A, LIB01-CGR08B, LIB01-CGR08C, LIB01-CGR08D,
LIB01-CT03A, LIB01-CT03B, LIB01-CT03C, LIB01-CT03D.

Sampling Progress as of 5/04/01 (Day 6 of Drilling):

Sample Type	Planned Samples*	Samples Collected	Percent Complete
Subsurface Sediment	52	51	98%**
Surface Sediment	6	0	0%
Grain Size	112	48	43%
Totals	170	89	58%

* Number of samples includes duplicate and replicate samples.
** Subsurface sediment sampling completed but some core recovery was not possible; therefore some planned samples could not be collected and submitted for analysis.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Completed priority subsurface sampling and associated grain size sampling.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to begin surface sediment sampling on Transect A.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: SATURDAY, 05 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 05 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
C. Denver, D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. T. Lewis performed sub-sampling of grain-size and chemistry sediment samples and performed sample control tasks. Field crew collected surface sediment scrapes at three stations along Transect A (LIB01-AS02 through LIB01-AS04) and at one background location (LIB01-AS01).

Samples collected on 5/05/01:

LIB01-AS01, LIB01-AS02, LIB01-AS03, and LIB01-AS04 (includes grain size samples).

Sampling Progress as of 5/05/01 (Day 9 of Drilling):

Sample Type	Planned Samples*	Samples Collected	Percent Complete
Subsurface Sediment	54	51	94%**
Surface Sediment	4	4	100%
Grain Size	112	52	46%
Totals	170	107	63%

* Number of samples includes duplicate and replicate samples. QC samples were redistributed to subsurface samples instead of surface samples due to anticipated material recovery problems with surface sediment sampling.
** Subsurface sediment sampling completed but some core recovery was not possible; therefore some planned samples could not be collected and submitted for analysis.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:

Completed surface sediment sampling and associated grain size sampling. Crew worked an extended day.

ACTIVITIES TO BE PERFORMED:
Continue drilling program. Plan to collect as many standalone grain size samples beginning with grain size sampling stations along Transect A.

URS DAILY FIELD ACTIVITIES REPORT

TO: TONY ZAMORA
FROM: CLAUDE DENVER
SUBJECT: LIBERTY SEDIMENT SAMPLING
DATE: SUNDAY, 06 MAY 2001
CC: SHARON SULLIVAN

This report documents activities performed by the URS field crew on 06 May 2001. Italicized names of field crew members indicate non-URS staff.

DAILY LOG:
D. Strength, *Duane Miller & Associates*, *Discovery Drilling*, and *CATCO* crew traveled to the site to continue drilling and sampling. C. Denver and T. Lewis performed sub-sampling of grain-size and chemistry sediment samples, performed sample control tasks, and shipped samples to laboratory for analysis. Field crew collected grain size samples along Transect A. URS personnel demobed equipment from rig at the end of the day. C. Denver traveled to Anchorage in the evening.

Samples collected on 5/06/01:

LIB01-AGR03A, LIB01- AGR03B, LIB01- AGR03C, LIB01- AGR03D, LIB01-AGR04A, LIB01- AGR04B, LIB01- AGR04C, LIB01- AGR04D, LIB01-AGR06A, LIB01- AGR06B, LIB01- AGR06C, LIB01- AGR06D, LIB01-AGR08A, LIB01- AGR08B, LIB01- AGR08C, LIB01- AGR08D.

Sampling Progress as of 5/06/01 (Day 10 of Drilling):

Sample Type	Planned Samples*	Samples Collected	Percent Complete
Subsurface Sediment	54	51	94%**
Surface Sediment	4	4	100%
Grain Size	112	68	61%
Totals	170	123	72%

* Number of samples includes duplicate and replicate samples. QC samples were redistributed to subsurface samples instead of surface samples due to anticipated material recovery problems with surface sediment sampling.
** Subsurface sediment sampling completed but some core recovery was not possible; therefore some planned samples could not be collected and submitted for analysis.

SIGNIFICANT FINDINGS AND ACTIVITIES PERFORMED:
Completed grain size sampling along Transect A. Drilling program has been terminated due to time constraints. All subsurface and surface sediment sampling was completed; however, some grain size sampling along Transect B and Transect C was not performed. In addition, all seal structure stakes have been removed from the area.

ACTIVITIES TO BE PERFORMED:
Plan to complete sub-sampling and sample control tasks, ship remaining samples to the laboratory for analysis, and begin demobing activities.

Appendix D
Grain-Size Soil Sampling Report

Duane Miller & Associates *Arctic & Geotechnical Engineering*
1041 East 76th Avenue, Unit A
Anchorage, AK 99518-3215
(907) 644-0510, Fax 644-0507

June 22, 2001

URS Corporation
3501 Denali Street, Ste. 101
Anchorage, AK 99503

Attention: Bryan Trimm

Subject: Liberty Development Project
Grain-size Soil Sampling Program-2001
Foggy Island Bay, Alaska
DM&A Job No. 4119.30

Between April 25, and May 6, 2001, Duane Miller & Associates provided support to a URS program designed to collect representative, near-surface samples from Foggy Island Bay in the vicinity of the proposed Liberty Project. The purpose of the soil sample collection program was to help document baseline conditions in the area prior to development of the Liberty Project. The role of Duane Miller & Associates was to supervise the drilling of shallow bore-holes, identify the soil types encountered and collect samples which are representative of the upper 15 feet of the sea-floor sediments.

The stated purpose for identifying soil types and collecting grain-size soil samples was to give URS field guidance in selecting intervals for chemical analyses. The "geotechnical" aspect of this program will also provide useful site-specific soils information to supplement existing information to be used in the design and construction of Liberty Island and the associated pipeline.

The Spring 2001 soil investigation was limited to three potential pipeline routes: "A"-line, the preferred route from the proposed Liberty Island Site southwest to the shore; "B"-line, the route from the Southern Island Alternative southward to the shore; and "C"-line, the route from the Tern Island location southwestward to the shore. Drilling and sampling was conducted only in unfrozen soils, from floating sea ice. Areas of bottom-fast ice, near shore, where seasonally frozen soils or permafrost might have been encountered, were avoided.

The crew arrived in Prudhoe Bay on the morning of April 25th and a project meeting was held that afternoon. Mr. Tony Zamora, BP Project Manager conducted the meeting with assistance from URS Project Manager Ms. Sharon Sullivan. Additionally, representatives from BP-Environmental, Duane Miller & Associates, Discovery Drilling and CATCO were in attendance. During the night of the 26th, the drill carrier was deployed to Foggy Island Bay on a Rolligon tractor-trailer and on the morning of the 27th fieldwork commenced.

A CME-75 drill specifically configured for soils exploration work was used to drill the test holes. The drill (Owned and operated by Discovery Drilling of Anchorage) was equipped to drill with an 8-inch O.D. continuous flight auger. The drill was mounted on an enclosed sled equipped with a generator and heater. An 8-bag Rolligon (RD-85), owned and operated by CATCO, was used to move the drill sled within the project area. The Rolligon also served as the onsite personnel carrier. The field crew consisted of two URS personnel (Mr. Claude Denver and Mr. Dana Strength), a Duane Miller & Associates geologist (Mr. Walter Phillips, P.G.), two drillers and a Rolligon Driver.

URS personnel working with the CATCO operator positioned the drill in the field at predetermined hole locations. "As drilled" grain-size hole locations (latitude and longitude), as determined using a hand held GPS unit, are shown on the field log of each hole. Schematic locations of each drill site sites are shown on Plate 1.

In all, 16 "grain-size" holes were drilled; nine along the preferred "A"-line alignment, four along the "B"-line and three along the "C"-line. The target depth of each hole was 15 feet below mud-line. As drilled depths varied from 13.5 to 17.5 feet.

As each hole was being drilled, Mr. Phillips recorded the thickness of sea ice, the ocean depth and the soil conditions encountered. Representative samples were collected as the holes were advanced. Initially, only four representative samples from each hole were to be collected but because of a desire by URS to specifically match chemical sample intervals with grain-size sample intervals, the sampling regime was changed to be much more inclusive. 157 individual grain size samples were collected as noted in the following table.

Test Hole Number	Test Hole Depth (ft)	Ice thickness (ft)	Water & Ice Depth (ft)	Grain-size Samples (#)	Date Sampled
AGR 01	16.0	5.0	6.0	10	27-Apr-01
AGR 02	16.0	5.5	7.0	10	27-Apr-01
AGR 03	15.0	4.5	12.0	14	06-May-01
AGR 04	15.0	5.0	14.5	10	06-May-01
AGR 05	13.5	4.8	16.5	6	28-Apr-01
AGR 06	15.0	5.0	17.5	12	06-May-01
AGR 07	16.0	4.8	17.0	8	29-Apr-01
AGR 08	15.0	4.5	20.0	14	06-May-01
AGR 09	16.0	5.0	21.0	14	30-Apr-01
BGR 01	15.5	5.0	6.5	4	02-May-01
BGR 03	17.5*	4.7	10.7	5	02-May-01
BGR 05	14.5	4.5	18.0	8	01-May-01
BGR 08	17.5**	5.0	19.5	14	30-Apr-01
CGR 03	14.5	4.0	17.0	7	03-May-01
CGR 06	16.0	4.0	19.0	7	03-May-01
CGR 08	14.5	4.5	21.5	14	04-May-01
				157	

* 13.5' to 17.5' from adjacent "TO" hole

** 15.0' to 17.5' from adjacent "TO" hole

Most of the grain-size samples were collected in an 18 -inch long by 3-inch ID tube inserted in the auger while drilling. This "auger coring" provided excellent recovery in fine grained and organic-rich soils. Auger core samples are designate as "Cc" on the drafted logs. In clean granular soils the auger core system was supplemented with drive samples. The drive samples were obtained in a 3-inch OD by 2.5-inch ID split barrel sampler driven into the ground with a 300-pound automatic drop hammer mounted on the CME-75. Blow counts for each 6-inch increment of the drive were recorded. Samples obtained by drive sampling are designated "Sh" on the drafted logs.

After an initial field evaluation, each grain-size sample was placed in a sealed container to prevent the loss of natural moisture. The hole number and depth of sample interval was shown on each sample container. Also the date and approximate time of sampling was noted. The samples were then packed in a container (without temperature control) for transport. The samples remained in the custody of Duane Miller & Associates until they were delivered to the URS field lab in Prudhoe Bay at the end of each shift. The samples and a copy of the field log of the corresponding borehole were then handed directly to the URS Field Laboratory Supervisor, Ms. Tracey Lewis.

After specific samples had been selected for grain size testing by URS, the remaining samples were reconveyed to Duane Miller and Associates. These remnant samples, sealed in Zip-Lock type bags and packed in plastic buckets, were then transported to the Duane Miller Soils Lab in Anchorage.

A graphic log of each boring is presented on Plates 2 through 17. The soils have been classified in accordance with the Unified Soil Classification System presented on Plate 18. The boring logs show the type of sampler used and, for drive samples, the blow counts required to drive the sampler the last 12 inches.

Columbia Analytical Services of Kelso, Washington provided testing services under contract to URS. Samples were analyzed for grain-size analysis and natural moisture content. Edited results of their testing are presented on the drafted logs and summarized on a hole-by-hole basis on Plates 18 through 34.

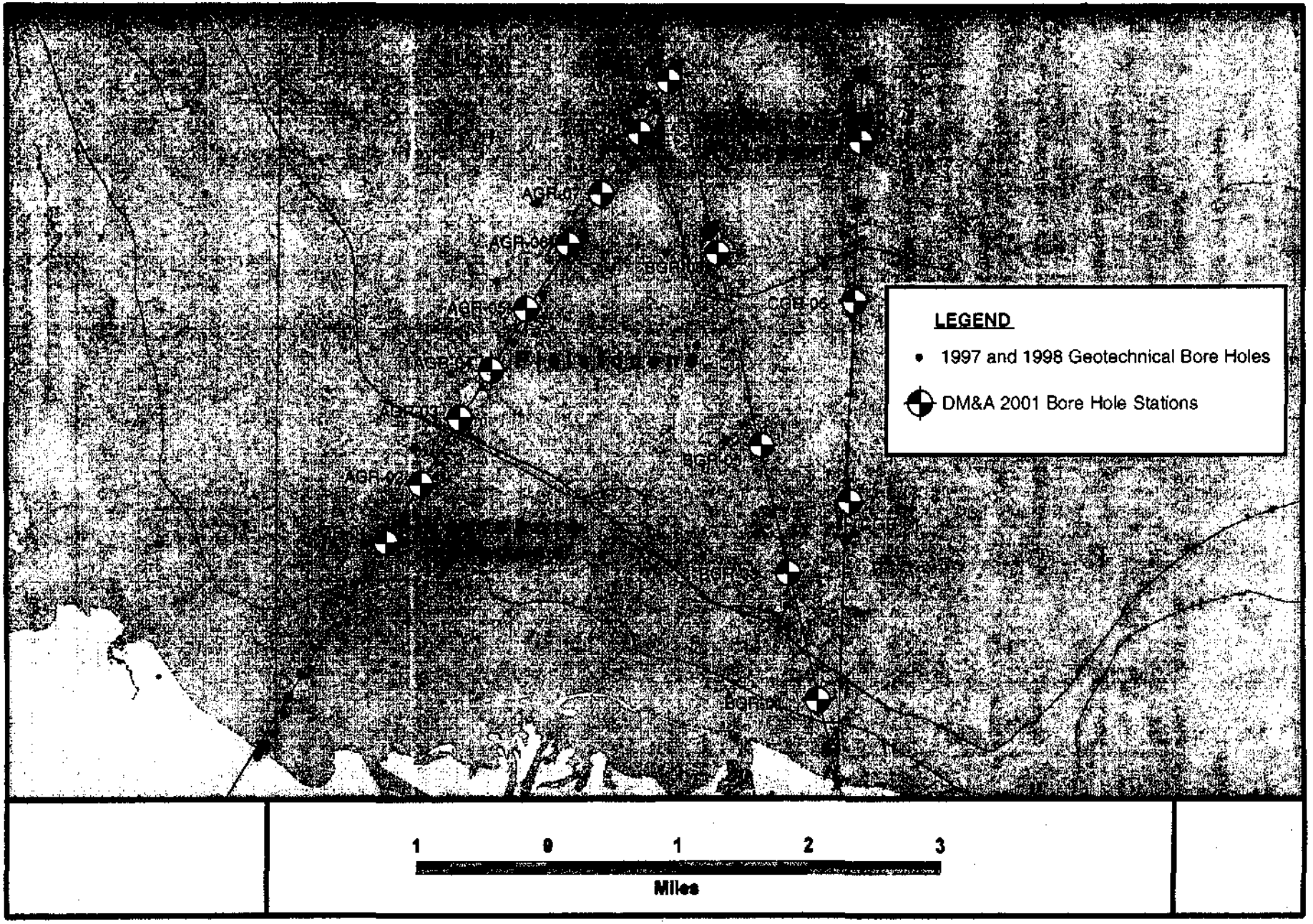
Soils encountered in the Liberty 2001 sampling program were consistent with those found in previous geotechnical studies in the area. Offshore, soft Holocene silt and organic silt generally overlies firmer Pleistocene deposits. Near shore, sandy zones are more prevalent and in some cases dominant.

Please call Duane Miller or me if you have questions regarding this submittal.

Very truly yours,

Walter T. Phillips, P.G.

Attachments:	Borehole Locations	Plate 1
	Borehole Logs	Plates 2 through 17
	Soil Classification & Key to Data	Plate 18
	Particle Size and Moisture Data	Plates 19 through 34



Duane Miller & Associates
Arctic & Geotechnical Engineering
Job No.: 4119.30
Date : June 2001

BORING LOCATIONS
Liberty Project
Foggy Island Bay, Alaska

Plate
1

DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-01

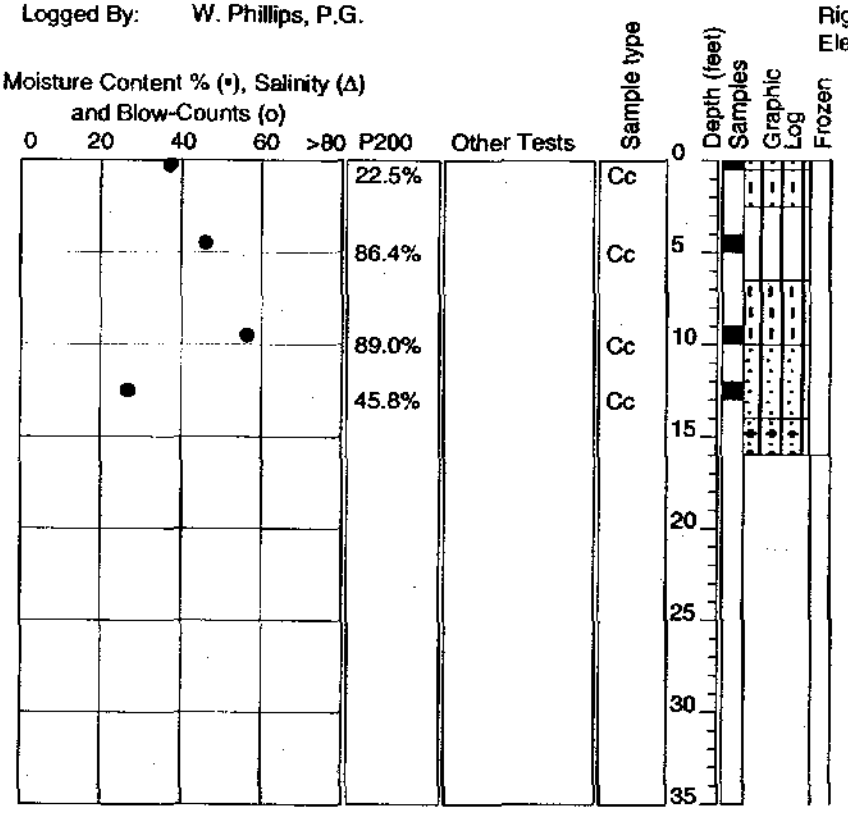
Date Drilled: April 27, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 6 ft

N 70° 13.615' W 147° 39.163'



Description

- SILTY SAND: (SM) Dark gray
- ORGANIC SILT: (OL) Dark gray with some amorphous peat (Pt)
- SILT: (ML) Gray, with thin interbedding of organic silt (OL) and amorphous peat (Pt)
- ORGANIC SILT: (OL) Dark gray to black with amorphous peat (Pt)
- SILTY SAND: (SM) Interbedded with fine sand (SP), dark peat (Pt) and organic silt (OL). Scattered pebbles and increased sand 11' -11.5'
- SILTY GRAVEL: (GM) Gray with 1/2" layers of sand and pebbley sand (SM)

DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-02

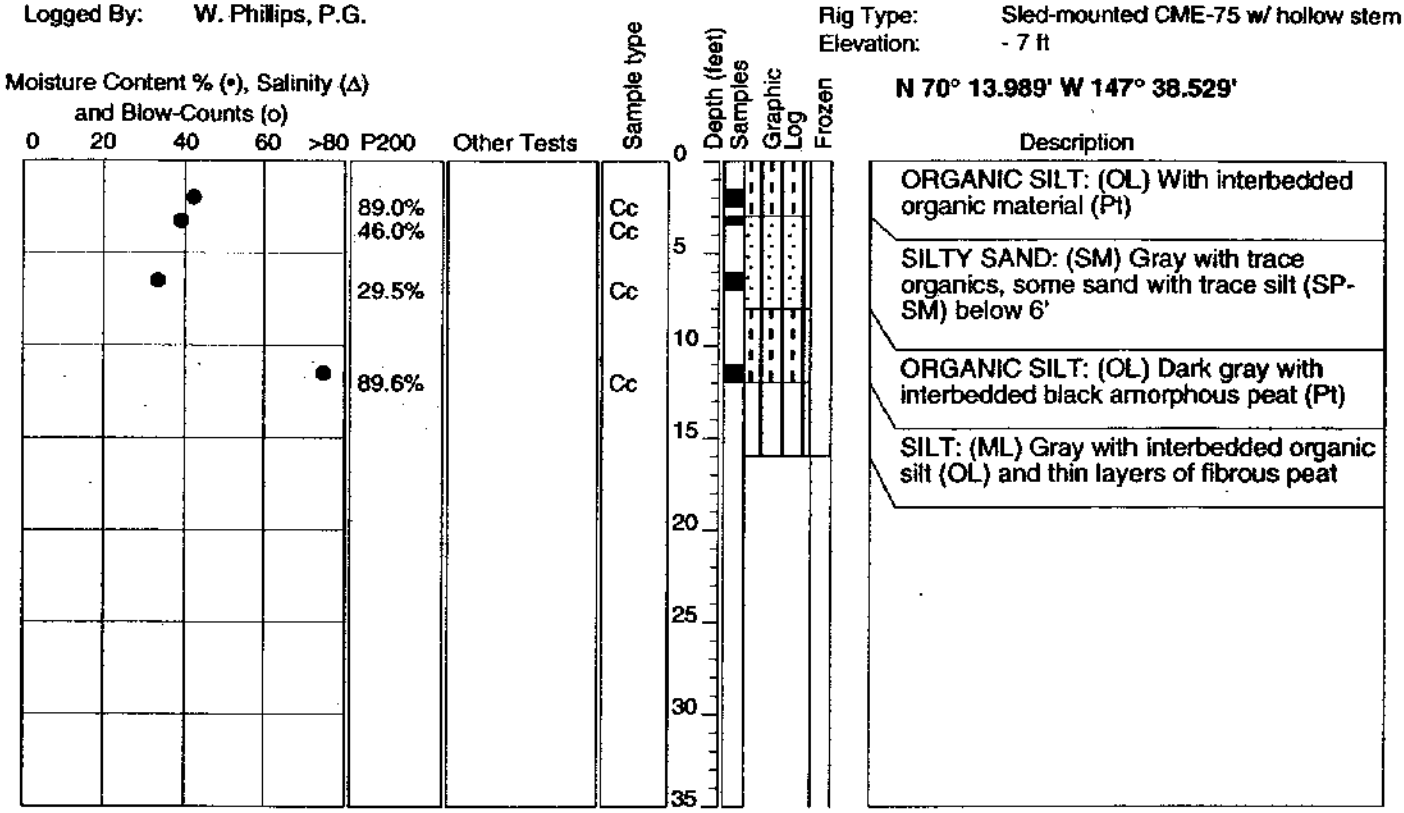
Date Drilled: April 27, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 7 ft

N 70° 13.989' W 147° 38.529'



Description

ORGANIC SILT: (OL) With interbedded organic material (Pt)

SILTY SAND: (SM) Gray with trace organics, some sand with trace silt (SP-SM) below 6'

ORGANIC SILT: (OL) Dark gray with interbedded black amorphous peat (Pt)

SILT: (ML) Gray with interbedded organic silt (OL) and thin layers of fibrous peat

DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-03

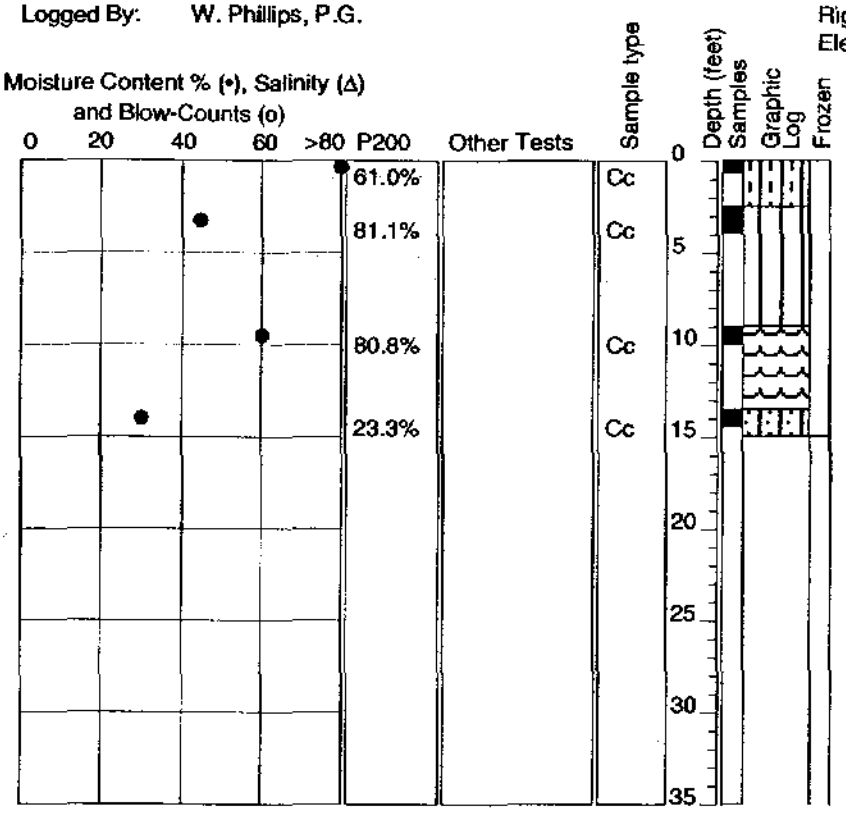
Date Drilled: May 6, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 12 ft

N 70° 14.376' W 147° 37.826'



Description
ORGANIC SILT: (OL) Dark gray
SILT: (ML) Gray with interbedded dark gray to black organic silt (OL) and thin streaks of organic material (Pt)
PEAT: (Pt) Gray-green amorphous peat with trace organic silt, zones of fibrous peat. Several layers of gray silt (ML) interbedded between 10.0' and 11.5'
SILTY SAND: (SM) Gray, with some gravel (pebbles), sand is fine to medium, pebbles < 1/2"

DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-04

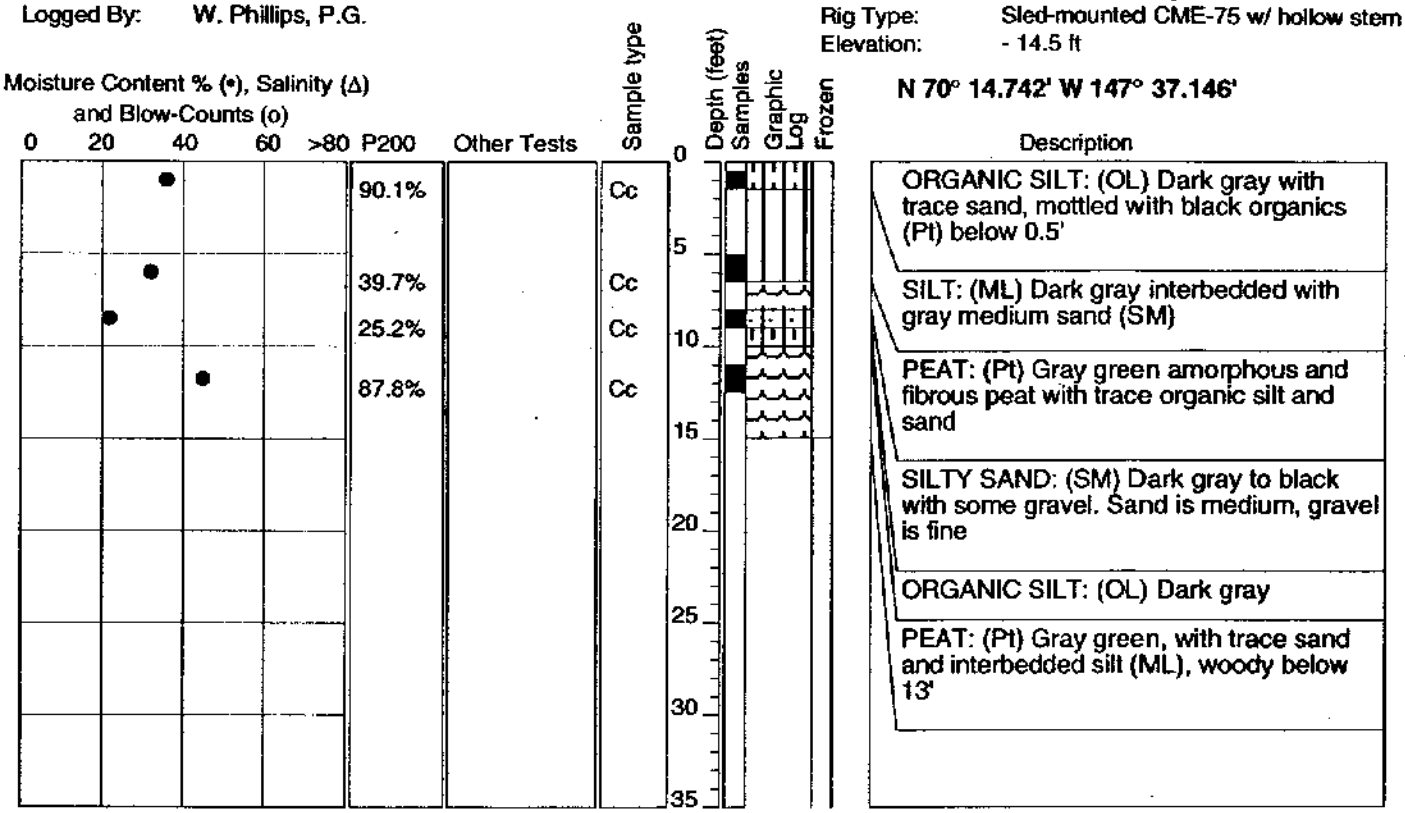
Date Drilled: May 6, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 14.5 ft

N 70° 14.742' W 147° 37.146'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-05

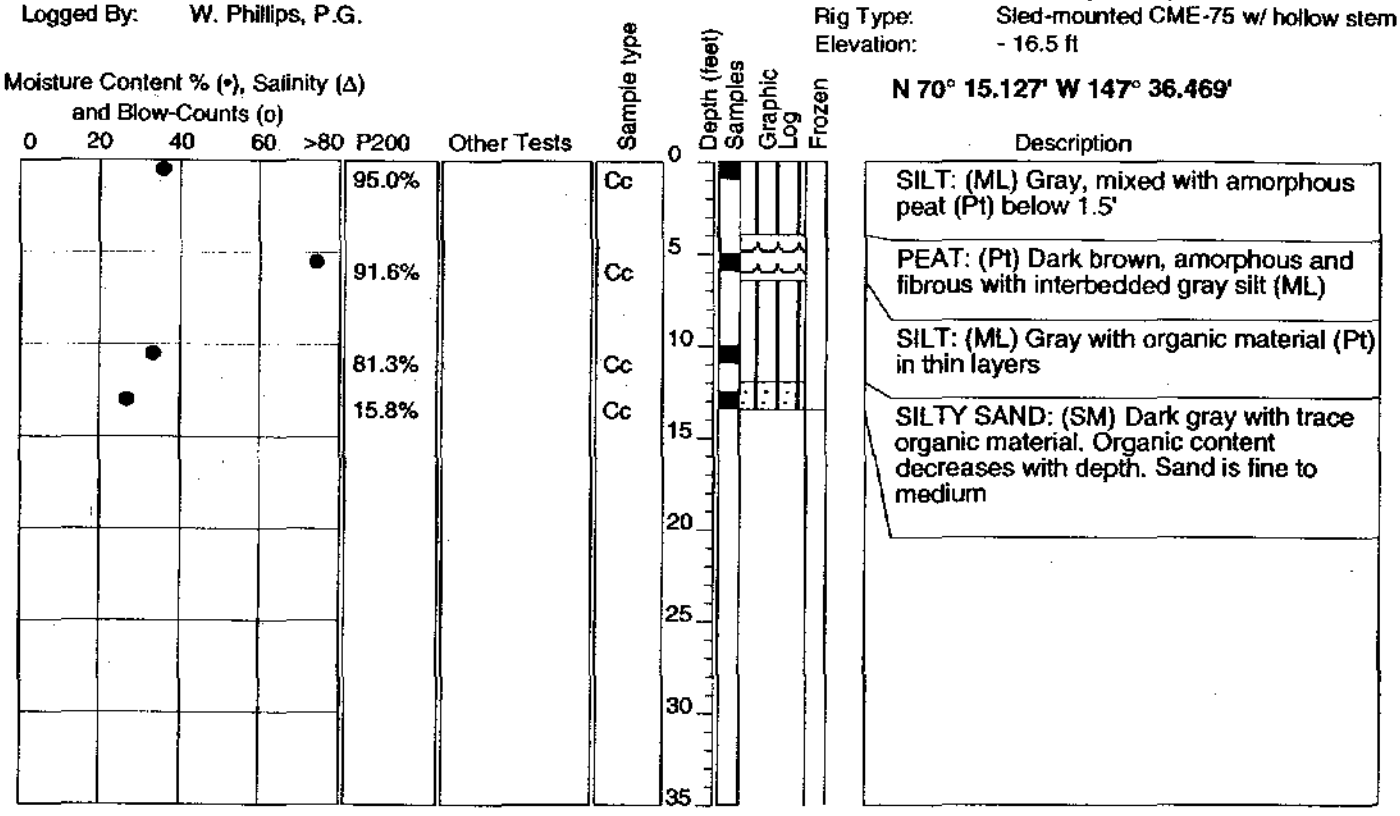
Date Drilled: April 28, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 16.5 ft

N 70° 15.127' W 147° 36.469'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

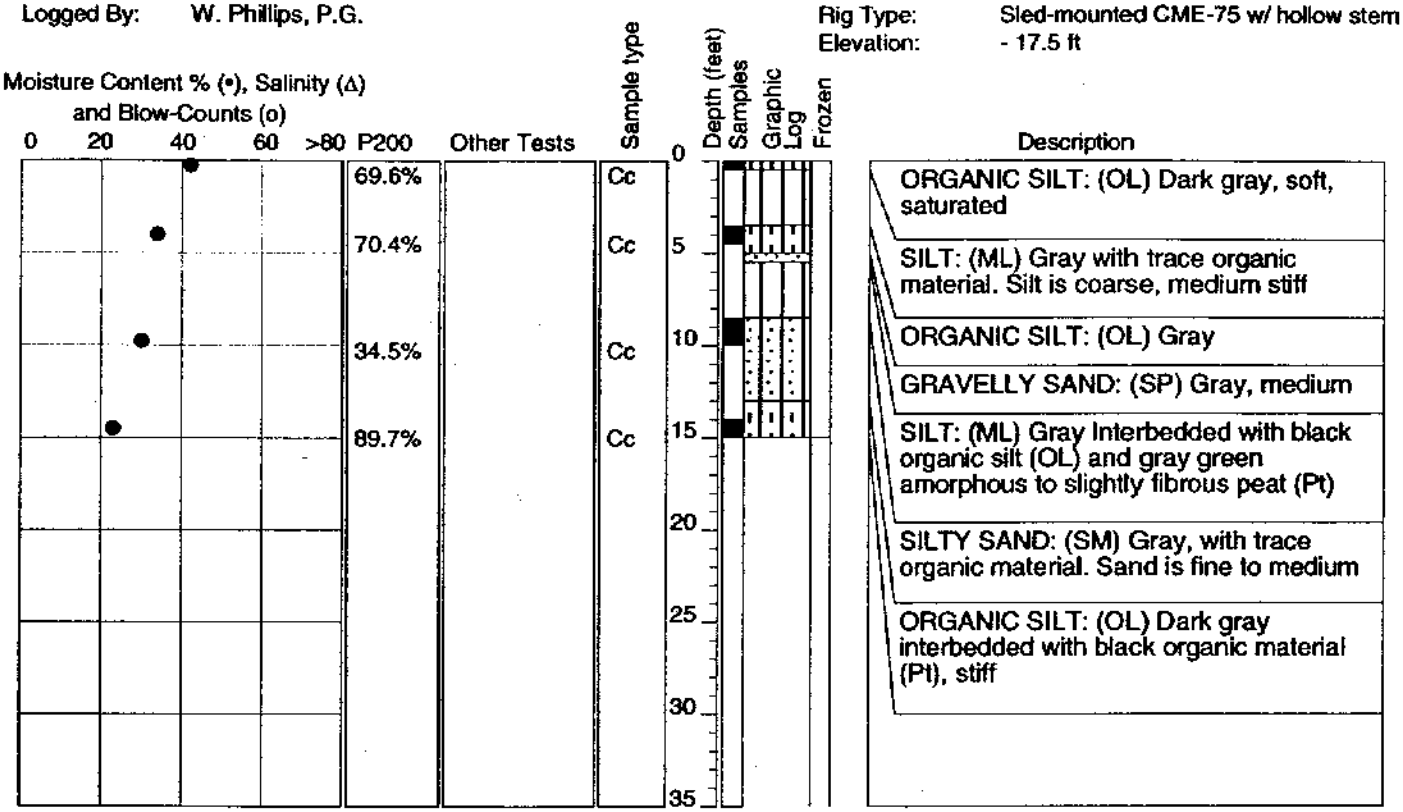
Log of HOLE : AGR-06

Date Drilled: May 6, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 17.5 ft



Description

- ORGANIC SILT: (OL) Dark gray, soft, saturated
- SILT: (ML) Gray with trace organic material. Silt is coarse, medium stiff
- ORGANIC SILT: (OL) Gray
- GRAVELLY SAND: (SP) Gray, medium
- SILT: (ML) Gray Interbedded with black organic silt (OL) and gray green amorphous to slightly fibrous peat (Pt)
- SILTY SAND: (SM) Gray, with trace organic material. Sand is fine to medium
- ORGANIC SILT: (OL) Dark gray interbedded with black organic material (Pt), stiff

DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-07

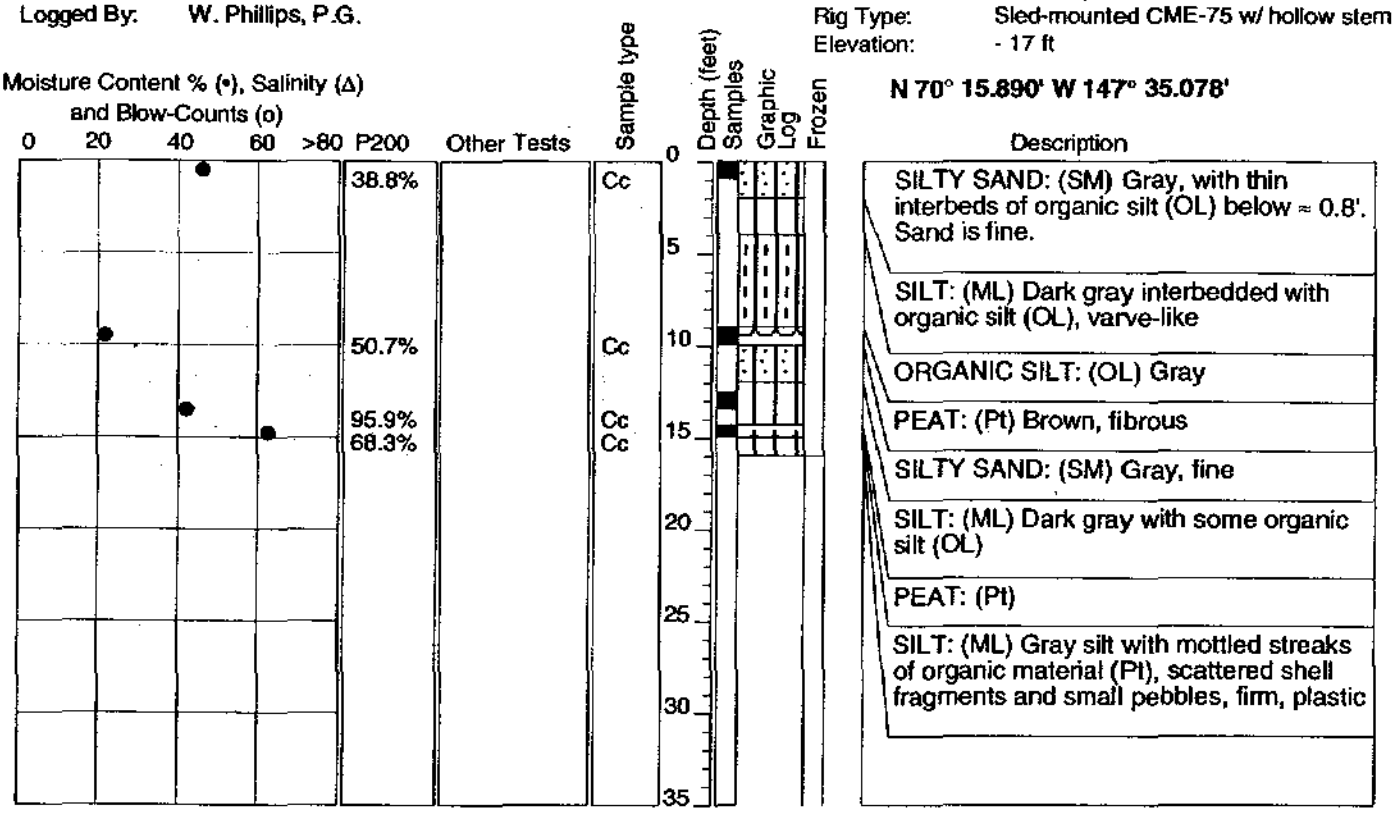
Date Drilled: April 29, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 17 ft

N 70° 15.890' W 147° 35.078'



DUANE MILLER & ASSOCIATES

Project: Liberty 2001

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-08

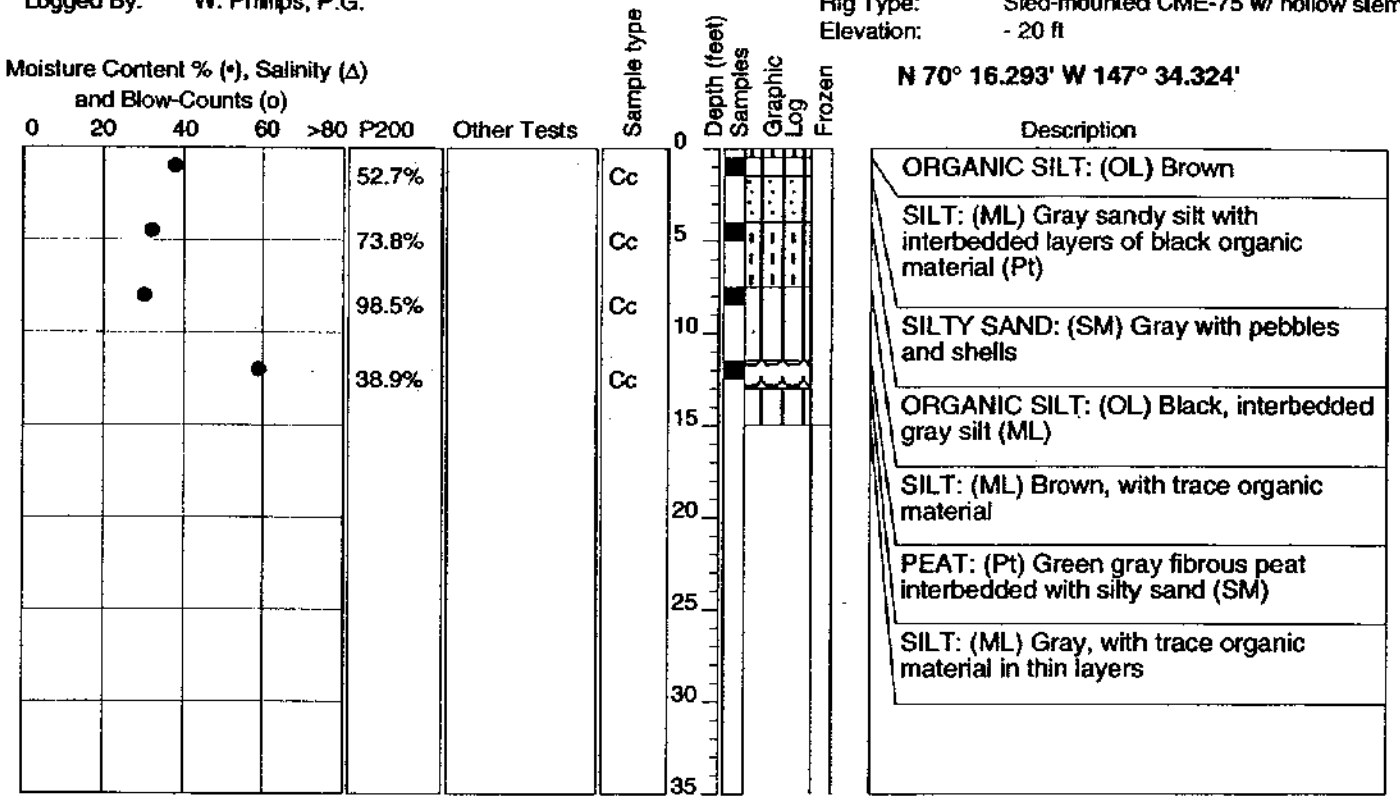
Date Drilled: May 6, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 20 ft

N 70° 16.293' W 147° 34.324'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : AGR-09

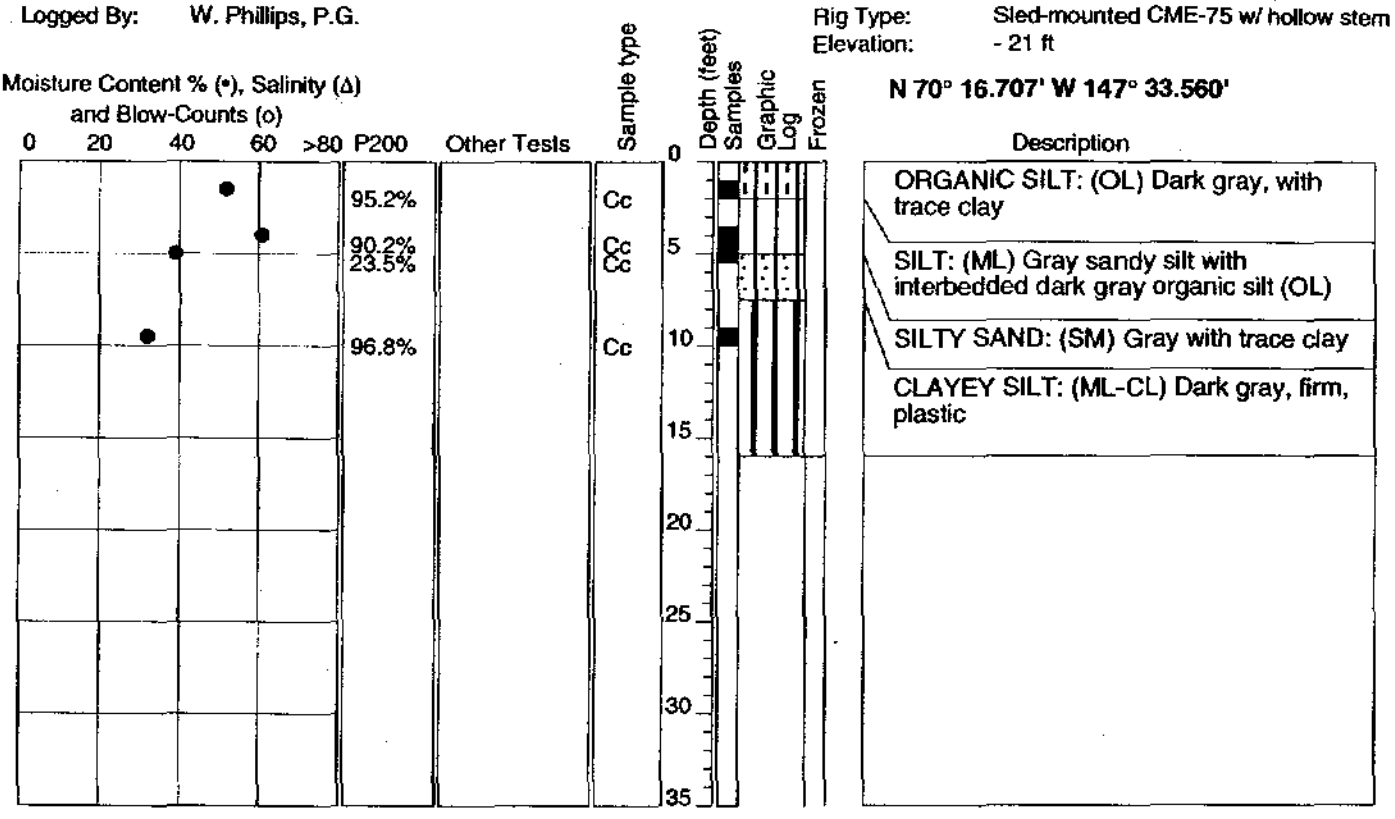
Date Drilled: April 30, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 21 ft

N 70° 16.707' W 147° 33.560'



DUANE MILLER & ASSOCIATES

Project: Liberty 2001

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : BGR-01

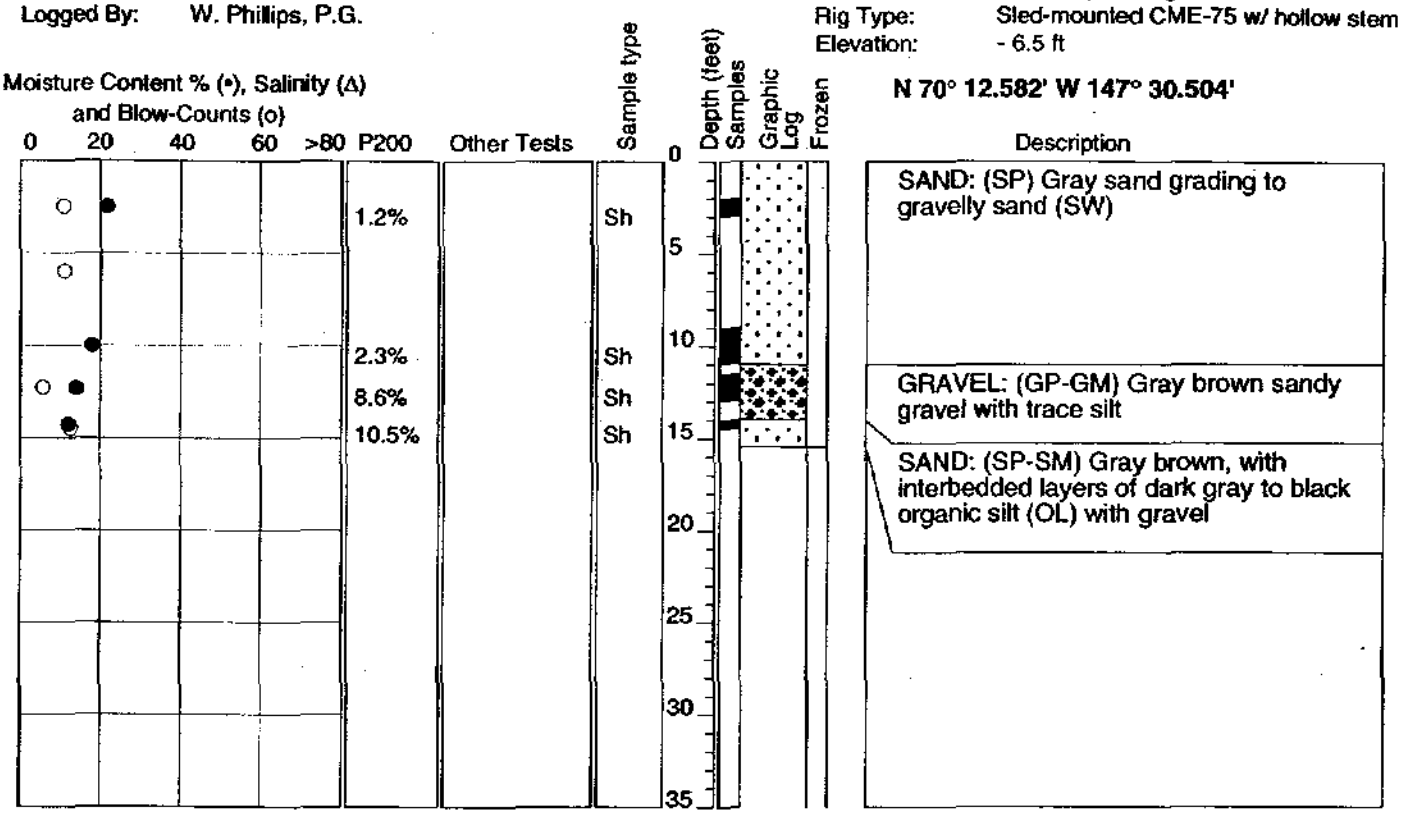
Date Drilled: May 2, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 6.5 ft

N 70° 12.582' W 147° 30.504'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : BGR-03

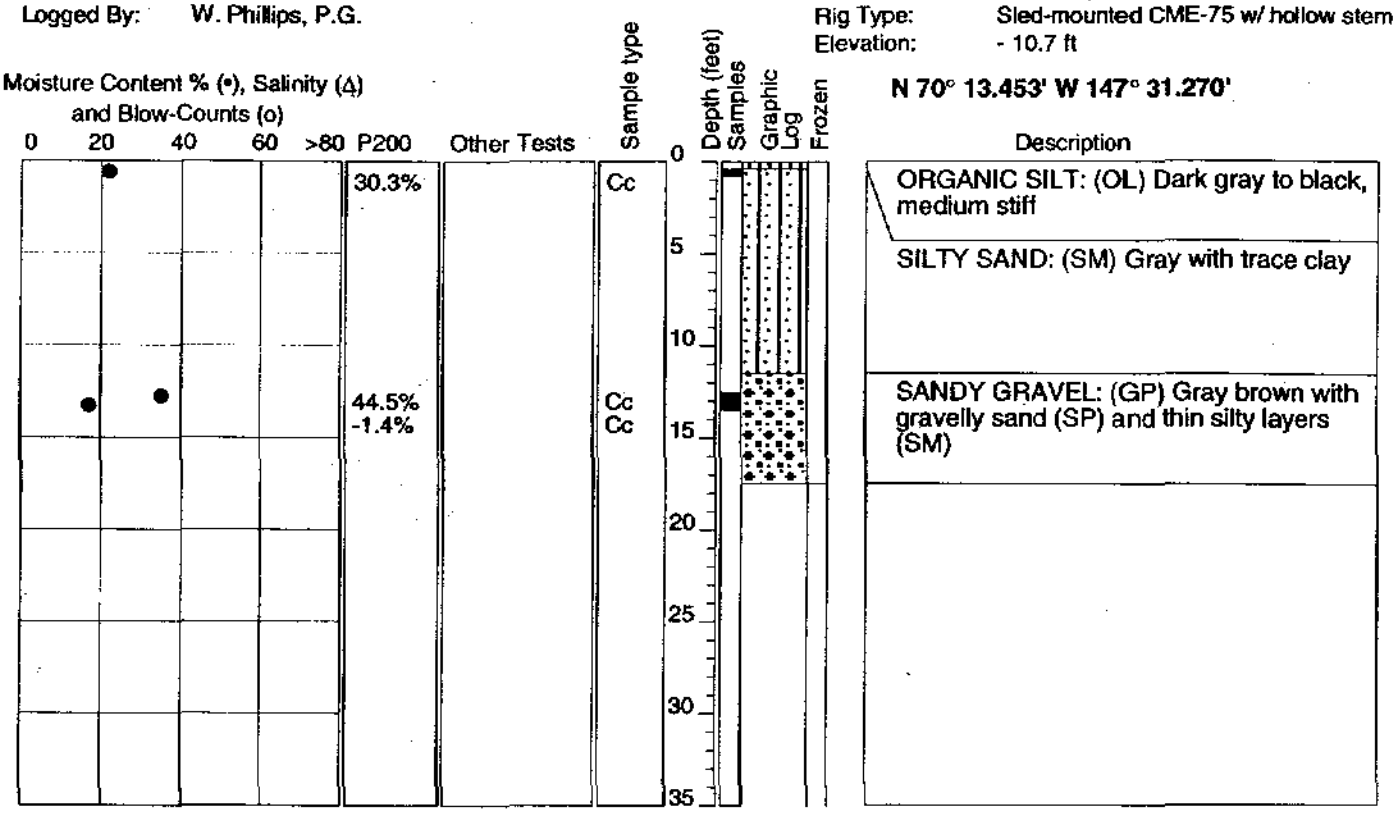
Date Drilled: May 2, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 10.7 ft

N 70° 13.453' W 147° 31.270'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : BGR-05

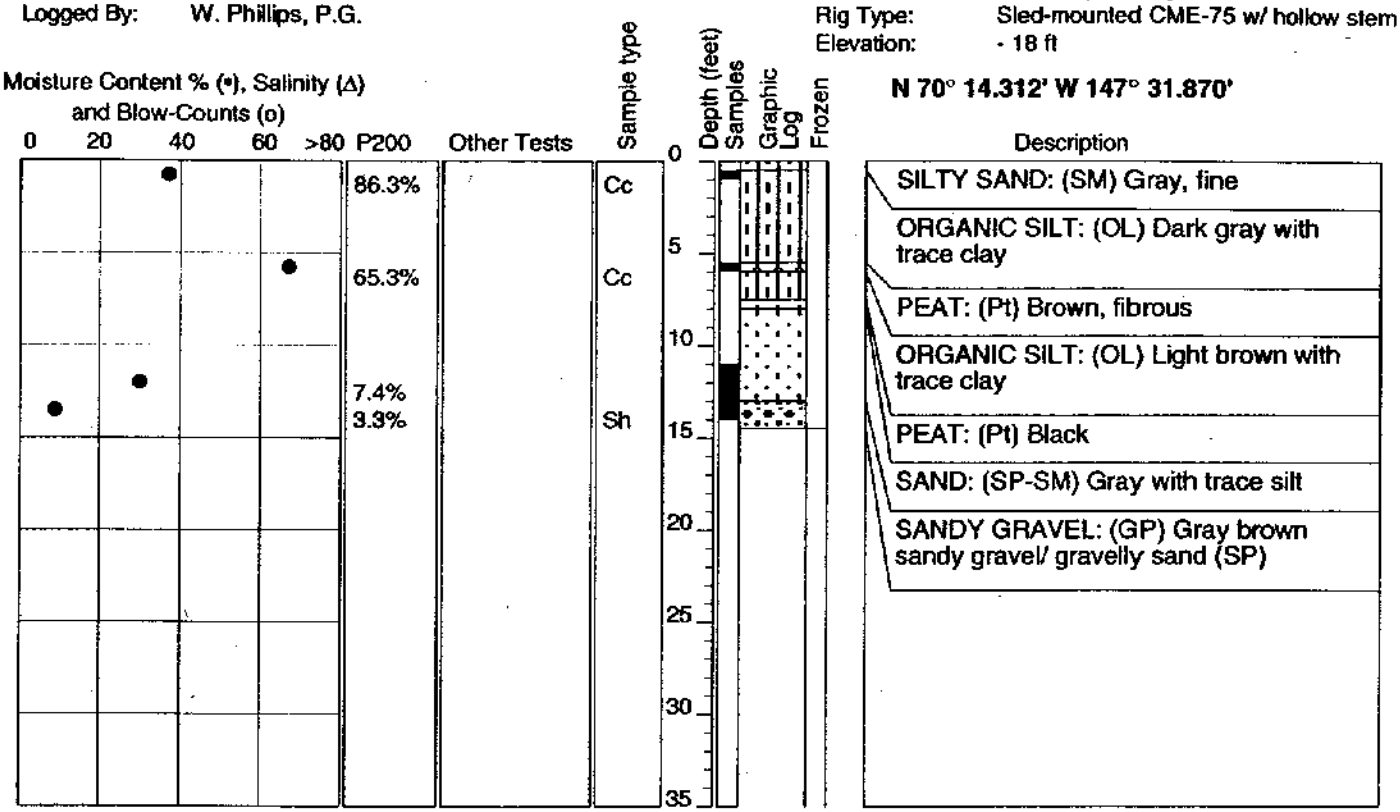
Date Drilled: May 1, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 18 ft

N 70° 14.312' W 147° 31.870'



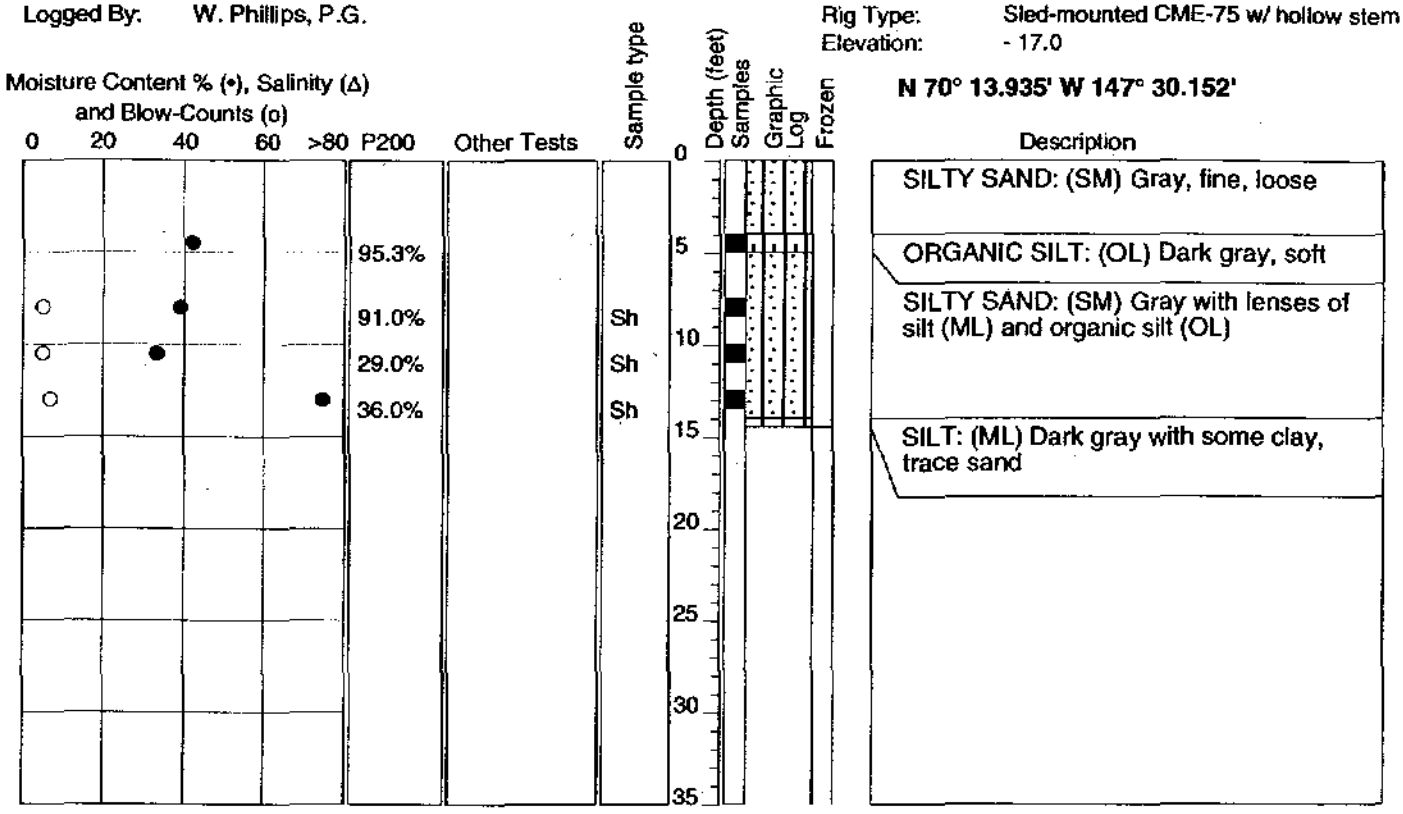
DUANE MILLER & ASSOCIATES

Project: Liberty 2001
DM&A Job No. :4119.30
Logged By: W. Phillips, P.G.

Log of HOLE : CGR-03

Date Drilled: May 3, 2001
Contractor: Discovery Drilling
Rig Type: Sled-mounted CME-75 w/ hollow stem
Elevation: - 17.0

N 70° 13.935' W 147° 30.152'



DUANE MILLER & ASSOCIATES

Project: Liberty 2001

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : CGR-06

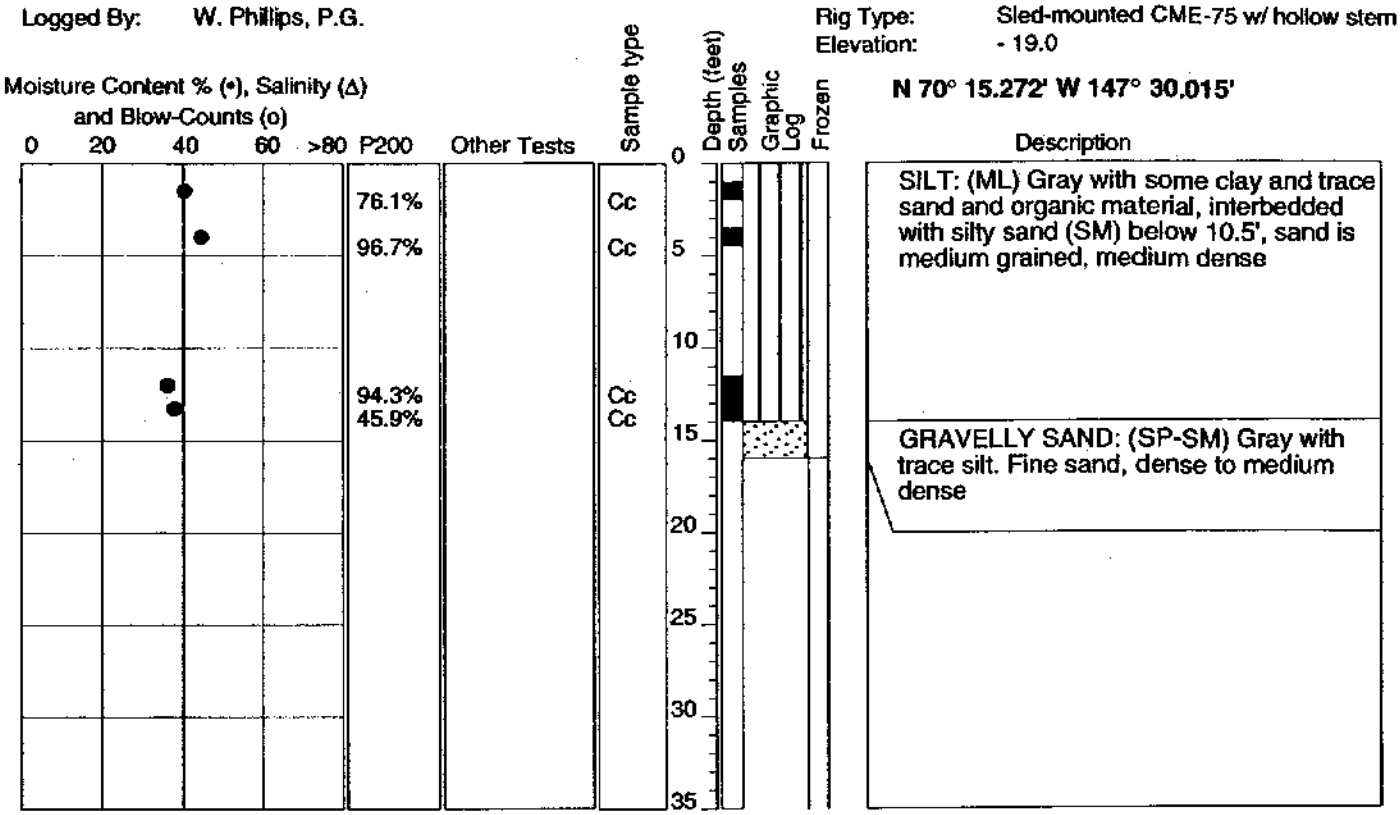
Date Drilled: May 3, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 19.0

N 70° 15.272' W 147° 30.015'



DUANE MILLER & ASSOCIATES

Project: **Liberty 2001**

DM&A Job No. :4119.30

Logged By: W. Phillips, P.G.

Log of HOLE : CGR-08

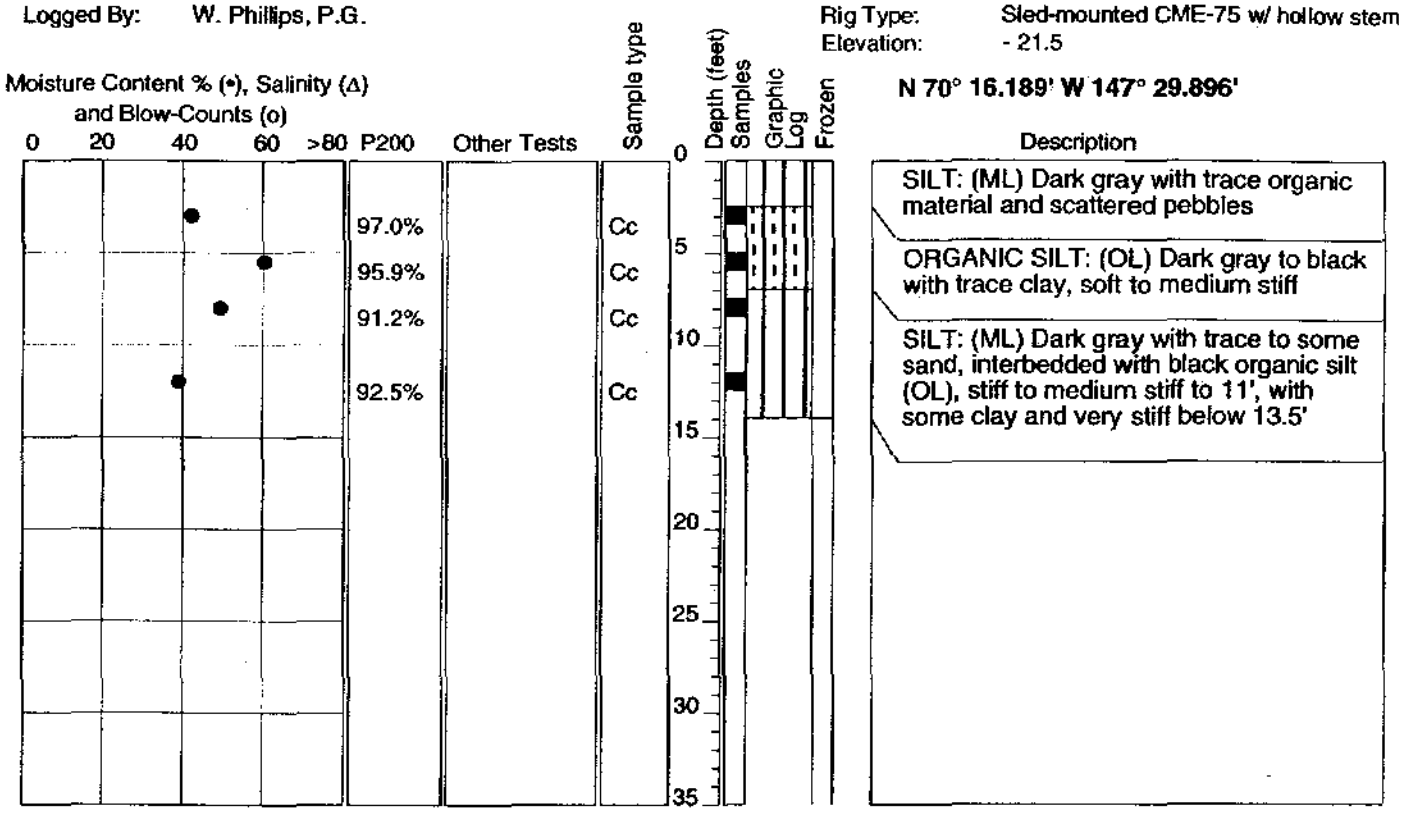
Date Drilled: May 4, 2001

Contractor: Discovery Drilling

Rig Type: Sled-mounted CME-75 w/ hollow stem

Elevation: - 21.5

N 70° 16.189' W 147° 29.896'

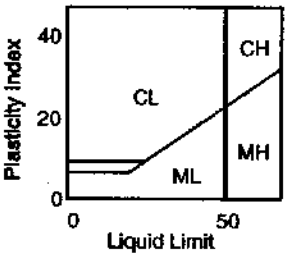


Description

SILT: (ML) Dark gray with trace organic material and scattered pebbles

ORGANIC SILT: (OL) Dark gray to black with trace clay, soft to medium stiff

SILT: (ML) Dark gray with trace to some sand, interbedded with black organic silt (OL), stiff to medium stiff to 11', with some clay and very stiff below 13.5'

MAJOR DIVISIONS			SYMBOL		TYPICAL NAMES
COARSE GRAINED SOILS >50% larger than #200 sieve, 75µm	GRAVELS More than half of the coarse fraction is larger than #4 sieve size, > 4.75 mm.	Clean gravels with little or no fines	GW		Well graded gravels, sandy gravel
			GP		Poorly graded gravels, sandy gravel
		Gravels with more than 12% fines	GM		Silty gravels, silt sand gravel mixtures
			GC		Clayey gravels, clay sand gravel mixtures
	SANDS More than half of the coarse fraction is smaller than #4 sieve size	Clean sands with little or no fines	SW		Well graded sand, gravelly sand
			SP		Poorly graded sands, gravelly sand
		Sands with more than 12% fines	SM		Silty sand, silt gravel sand mixtures
			SC		Clayey sand, clay gravel sand mixtures
FINE GRAINED SOILS >50% finer than #200 sieve, 75µm	Plasticity Chart 	SILTS and CLAYS Liquid limit less than 50	ML		Inorganic silt and very fine sand, rock flour
			CL		Inorganic clay, gravelly and sandy clay, silty clay
			OL		Organic silts and clay of low plasticity
		SILTS and CLAYS Liquid limit greater than 50	MH		Inorganic silt
			CH		Inorganic clay, fat clay
			OH		Organic silt and clay of high plasticity
HIGHLY ORGANIC SOILS			Pt		Peat and other highly organic soil

KEY TO TEST DATA

Dd = Dry Density (pcf)
TC = Thaw Consolidation
TCf = Thaw Consolidation (field)
LL = Liquid Limit
PL = Plastic Limit
PI = Plastic Index
SpG = Specific Gravity
SA = Sieve Analysis
MA = Sieve and Hydrometer Analysis
OLI = Organic Loss
TXUU = Unconsolidated Undrained Triaxial
TXCU = Consolidated Undrained Triaxial
TXCD = Consolidated Drained Triaxial
XXX (YYY)
XXX=$(\sigma 1-\sigma 3)/2$
YYY=$\sigma 3$

KEY TO SAMPLE TYPE

Ag = Auger grab
Ab = Auger bulk
Ac = Air chip
Cc = Auger Core
Ss = 1.4" ID split barrel w/ 140 lb. manual hammer
Sh = 2.5" ID split barrel w/ 340 lb. manual hammer
Sha= 2.5" ID split barrel w/ 340 lb. automatic hammer
Tw = Shelby tube

UNIFIED SOIL CLASSIFICATION SYSTEM

GROUP	ICE VISIBILITY	DESCRIPTION		SYMBOL	
N	Segregated ice not visible by eye	Poorly bonded or friable		Nf	
		Well bonded	No excess ice	Nb	Nbn
			Excess microscopic ice		Nbe
V	Segregated ice is visible by eye and is one inch or less in thickness	Individual ice crystals or inclusions		Vx	
		Ice coatings on particles		Vc	
		Random or irregularly oriented ice		Vr	
		Stratified or distinctly oriented ice		Vs	
ICE	Ice greater than one inch in thickness	Ice with soil inclusions		ICE + soil type	
		Ice without soil inclusions		ICE	

ICE CLASSIFICATION SYSTEM

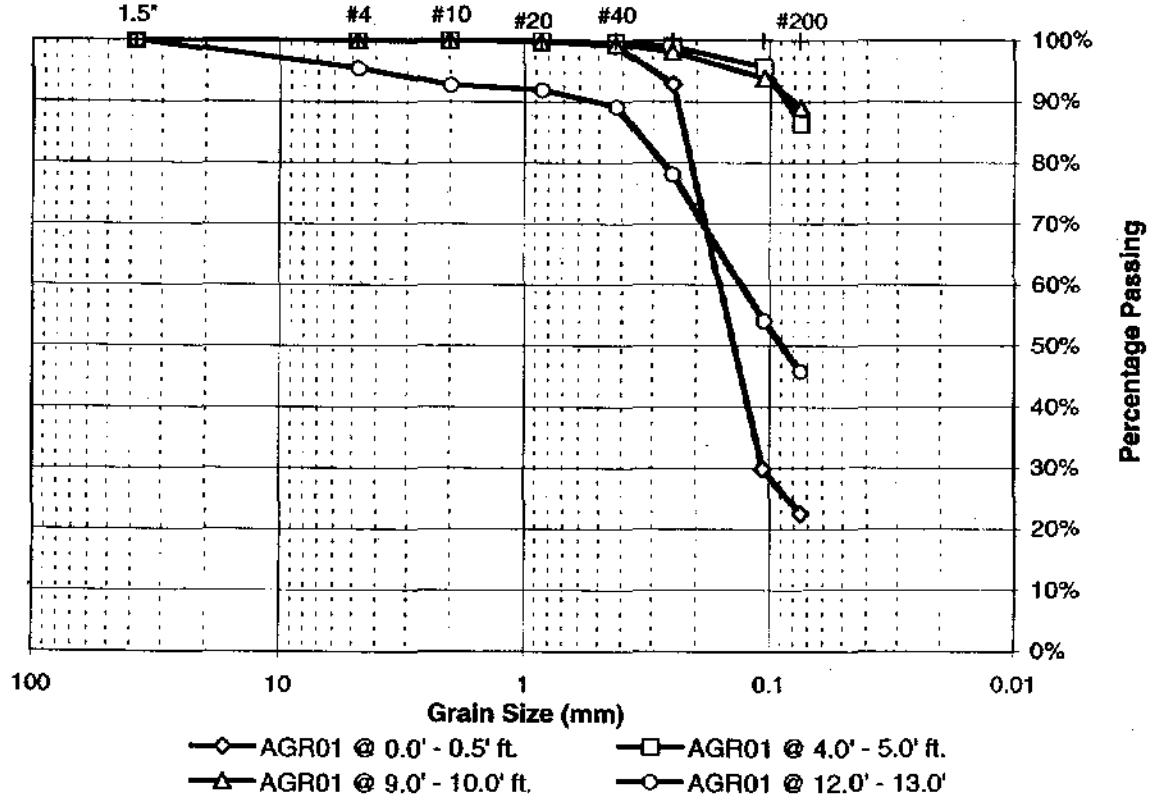
Duane Miller & Associates
Arctic & Geotechnical Engineering
Job No.: 4119.30
Date: June 2001

SOIL and ICE CLASSIFICATION and KEY TO DATA
Liberty Development
Foggy Island Bay, Alaska

Plate **18**

Boring =>	AGR01	AGR01	AGR01	AGR01
Sample Number =>	AGR01A	AGR01B	AGR01C	AGR01D
Depth =>	0.0' - 0.5'	4.0' - 5.0'	9.0' - 10.0'	12.0' - 13.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	95%
#10 =>	100%	100%	100%	93%
#20 =>	100%	100%	100%	92%
#40 =>	99%	100%	99%	89%
#60 =>	93%	99%	98%	78%
#140 =>	30%	96%	94%	54%
#200 =>	22.5%	86.4%	89.0%	45.8%
Wt Rcvd	50.1371	36.75	26.5311	30.6139
Wt Oven Dried	36.6502	25.1967	16.9534	24.0625
Moisture Content =>	36.8%	45.9%	56.5%	27.2%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>				0.089 mm
D60 size =>				0.131 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	5%
AASHTO Gravel (+#10) =	0.1%	0.0%	0.0%	7.3%
Sand percentage =	77.5%	13.6%	11.0%	49.7%
Fines percentage =	22.5%	86.4%	89.0%	45.8%
Unified Soil MLass Symbol =	**SM**	**ML**	**ML**	**SM**

U

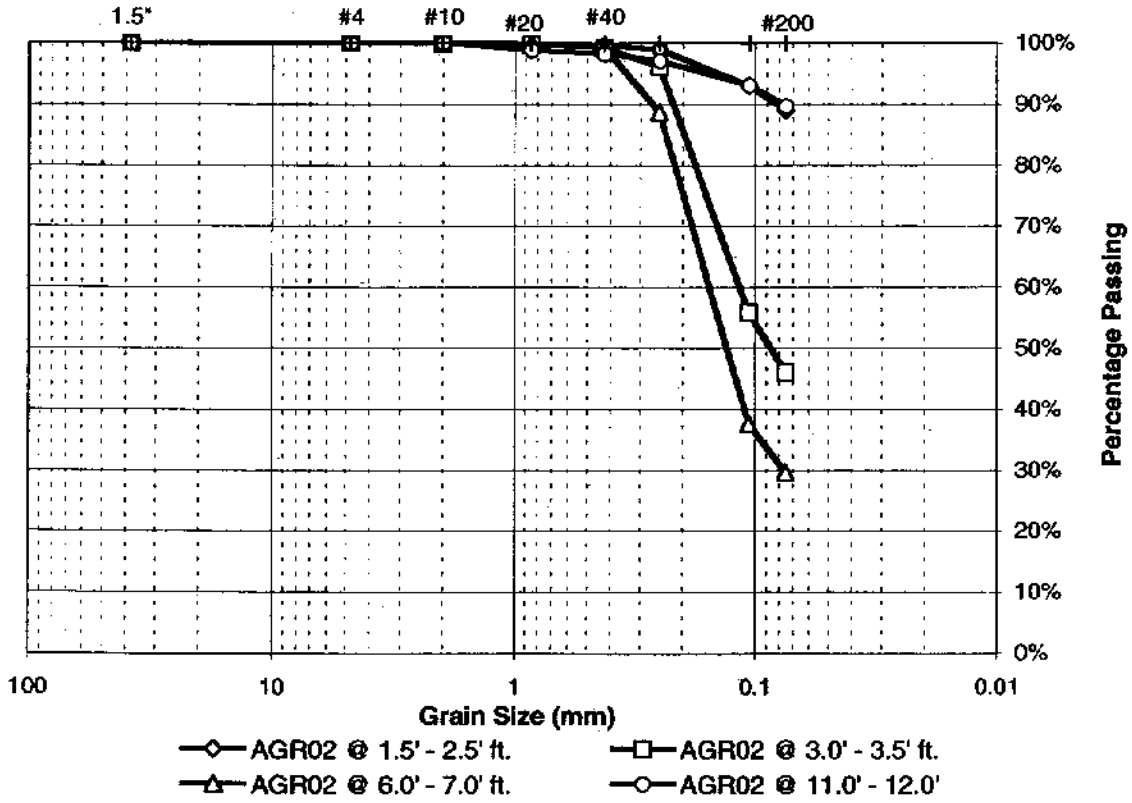


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
19

Boring =>	AGR02	AGR02	AGR02	AGR02
Sample Number =>	AGR02A	AGR02B	AGR02C	AGR02D
Depth =>	1.5' - 2.5'	3.0' - 3.5'	6.0' - 7.0'	11.0' - 12.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	100%
#20 =>	100%	100%	100%	99%
#40 =>	100%	99%	99%	98%
#60 =>	99%	96%	89%	97%
#140 =>	93%	56%	38%	93%
#200 =>	89.0%	46.0%	29.5%	89.6%
Wt Rcvd	28.5458	38.612	29.9706	25.4502
Wt Oven Dried	20.1248	27.8779	22.5079	14.5066
Moisture Content =>	41.8%	38.5%	33.2%	75.4%
Analysis of Data				
D10 size =>				
D30 size =>			0.077 mm	
D50 size =>		0.086 mm	0.131 mm	
D60 size =>		0.116 mm	0.155 mm	
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.1%	0.0%	0.0%
Sand percentage =	11.0%	54.0%	70.5%	10.4%
Fines percentage =	89.0%	46.0%	29.5%	89.6%
Unified Soil MLass Symbol =	**ML**	**SM**	**SM**	**ML**

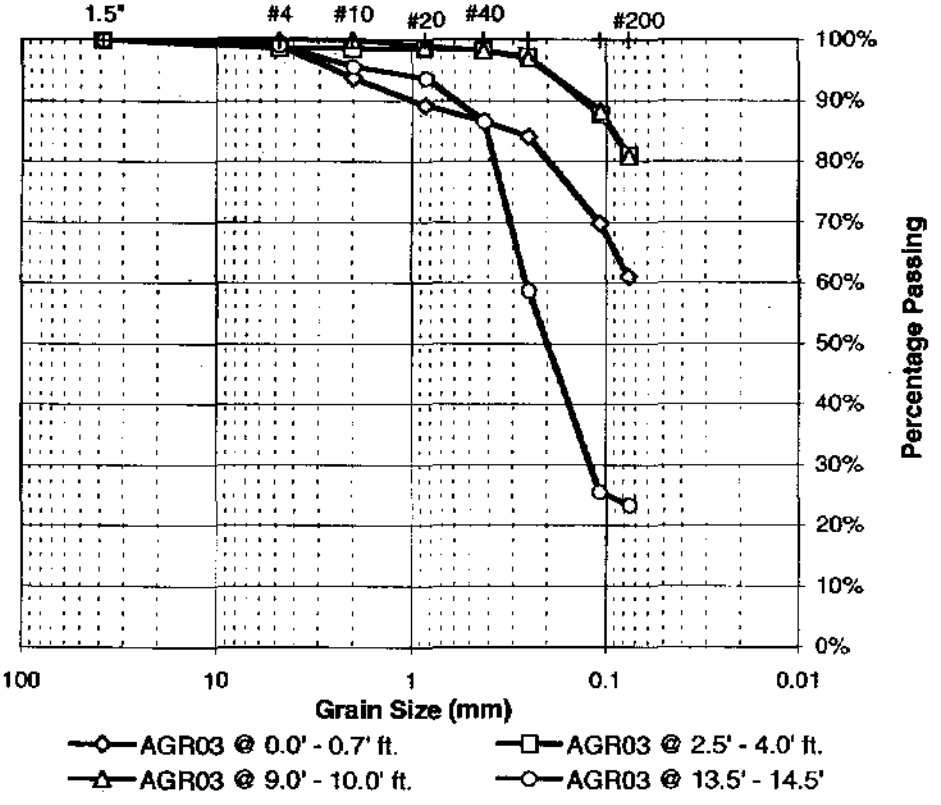


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
20

Boring =>	AGR03	AGR03	AGR03	AGR03
Sample Number =>	AGR03A	AGR03B	AGR03C	AGR03D
Depth =>	0.0' - 0.7'	2.5' - 4.0'	9.0' - 10.0'	13.5' - 14.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	99%	99%	100%	99%
#10 =>	94%	99%	100%	96%
#20 =>	89%	98%	99%	94%
#40 =>	87%	98%	98%	87%
#60 =>	84%	97%	97%	59%
#140 =>	70%	88%	88%	26%
#200 =>	61.0%	81.1%	80.8%	23.3%
Wt Rcvd	77.1085	32.2165	55.2914	79.3833
Wt Oven Dried	42.641	22.165	34.5018	61.1251
Moisture Content =>	80.8%	45.3%	60.3%	29.9%
Analysis of Data				
D10 size =>				
D30 size =>				0.119 mm
D50 size =>				0.200 mm
D60 size =>				0.256 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	1%	1%	0%	1%
AASHTO Gravel (+#10) =	6.3%	1.4%	0.0%	4.4%
Sand percentage =	38.1%	17.6%	19.2%	75.9%
Fines percentage =	61.0%	81.1%	80.8%	23.3%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**SM**

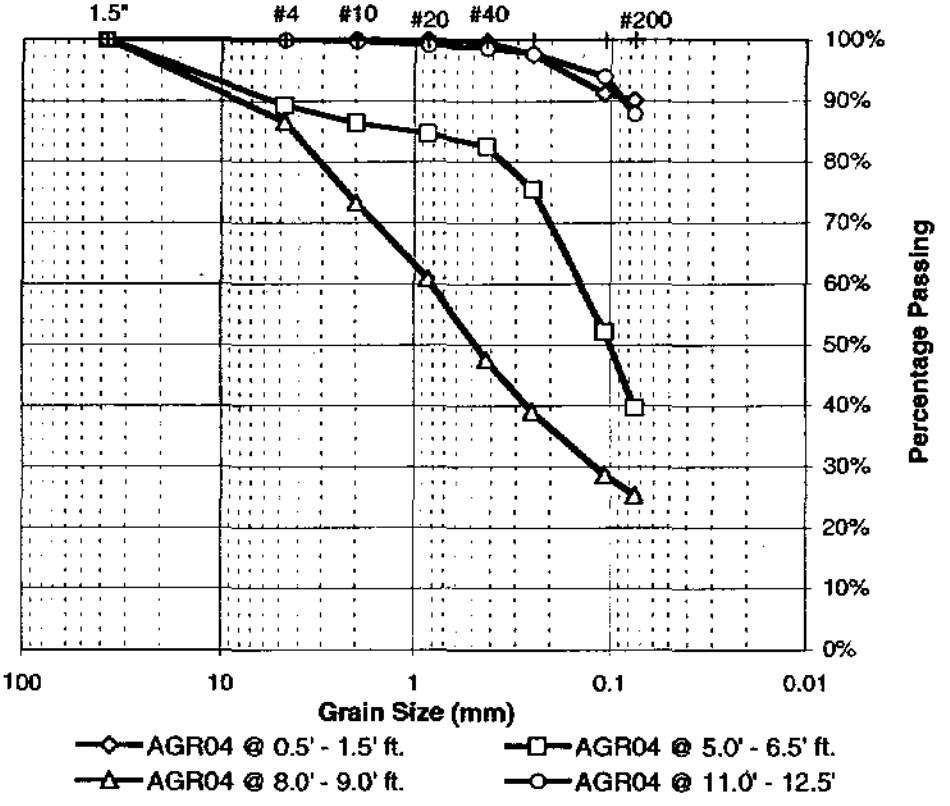


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
21

Boring =>	AGR04	AGR04	AGR04	AGR04
Sample Number =>	AGR04A	AGR04B	AGR04C	AGR04D
Depth =>	0.5' - 1.5'	5.0' - 6.5'	8.0' - 9.0'	11.0' - 12.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	89%	87%	100%
#10 =>	100%	86%	73%	100%
#20 =>	100%	85%	61%	99%
#40 =>	100%	83%	48%	99%
#60 =>	98%	76%	39%	98%
#140 =>	91%	52%	29%	94%
#200 =>	90.1%	39.7%	25.2%	87.8%
Wt Rcvd	36.3069	32.6201	49.1978	49.0218
Wt Oven Dried	26.7582	24.6934	40.3422	33.8741
Moisture Content =>	35.7%	32.1%	22.0%	44.7%
Analysis of Data				
D10 size =>				
D30 size =>			0.119 mm	
D50 size =>		0.100 mm	0.484 mm	
D60 size =>		0.141 mm	0.811 mm	
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	11%	13%	0%
AASHTO Gravel (+#10) =	0.0%	13.7%	26.7%	0.3%
Sand percentage =	9.9%	49.6%	61.4%	12.2%
Fines percentage =	90.1%	39.7%	25.2%	87.8%
Unified Soil MLass Symbol =	**ML**	**SM**	**SM**	**ML**



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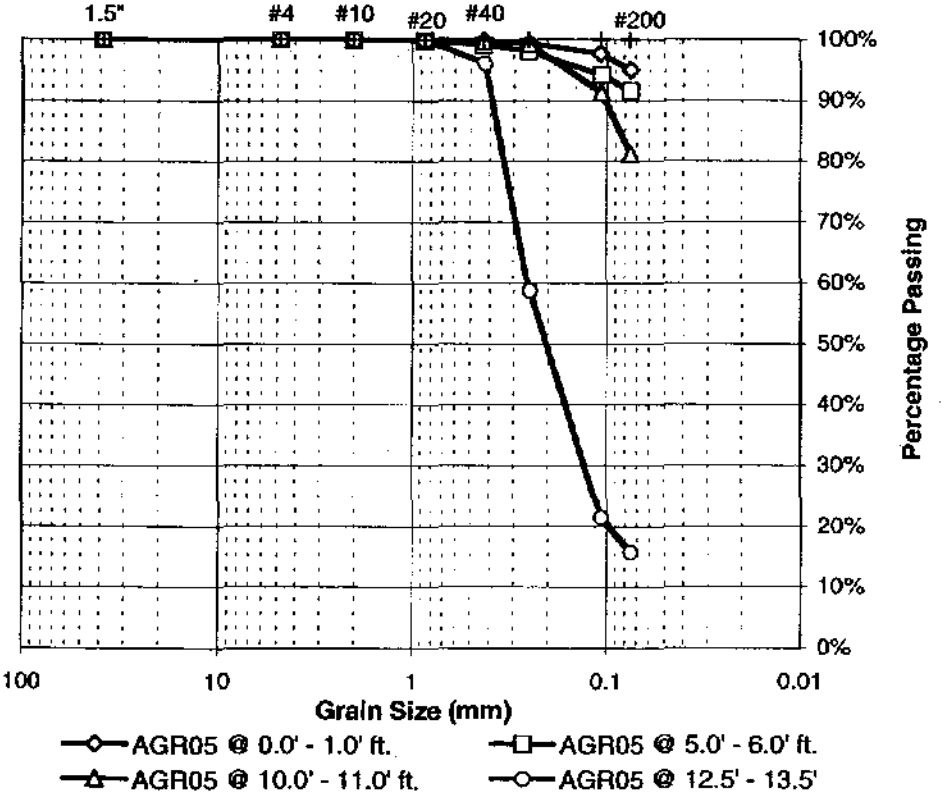
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
22

Boring =>	AGR05	AGR05	AGR05	AGR05
Sample Number =>	AGR05A	AGR05B	AGR05C	AGR05D
Depth =>	0.0' - 1.0'	5.0' - 6.0'	10.0' - 11.0'	12.5' - 13.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	100%
#20 =>	100%	100%	100%	100%
#40 =>	100%	99%	100%	96%
#60 =>	99%	98%	99%	59%
#140 =>	98%	94%	91%	21%
#200 =>	95.0%	91.6%	81.3%	15.8%
Wt Rcvd	36.3607	25.2745	30.3386	75.4575
Wt Oven Dried	26.7251	14.5076	22.7843	59.536
Moisture Content =>	36.1%	74.2%	33.2%	26.7%
Analysis of Data				
D10 size =>				
D30 size =>				0.129 mm
D50 size =>				0.204 mm
D60 size =>				0.254 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.0%	0.0%	0.0%
Sand percentage =	5.0%	8.4%	18.8%	84.3%
Fines percentage =	95.0%	91.6%	81.3%	15.8%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**SM**

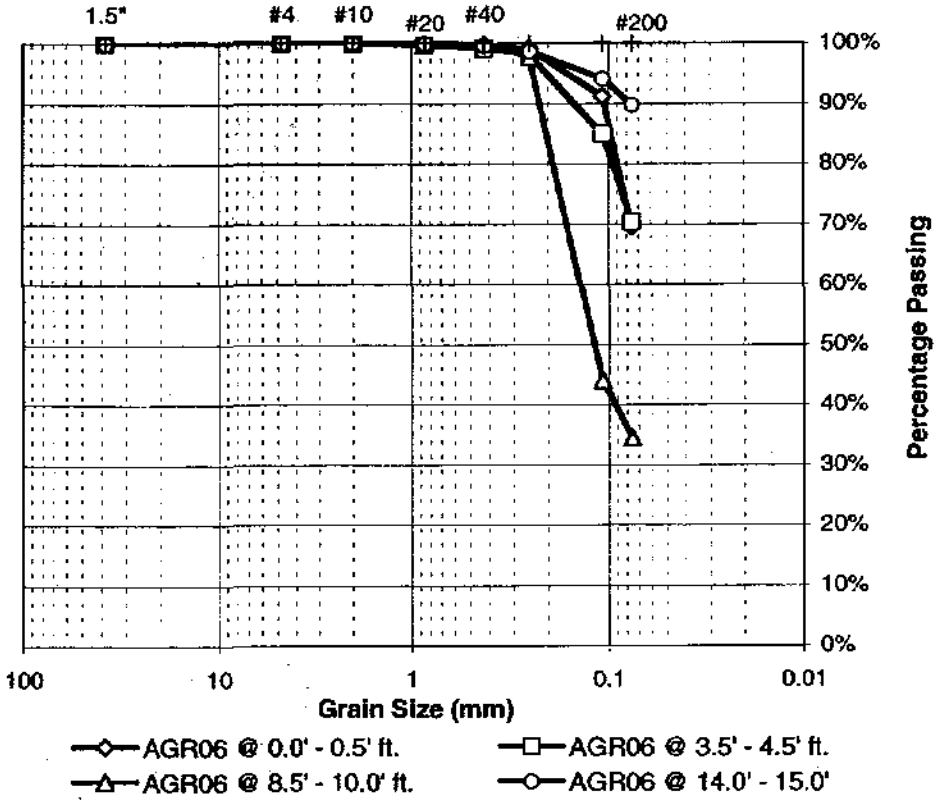


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
23

Boring =>	AGR06	AGR06	AGR06	AGR06
Sample Number =>	AGR06A	AGR06B	AGR06C	AGR06D
Depth =>	0.0' - 0.5'	3.5' - 4.5'	8.5' - 10.0'	14.0' - 15.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	100%
#20 =>	100%	100%	100%	100%
#40 =>	100%	99%	100%	100%
#60 =>	99%	98%	98%	99%
#140 =>	91%	85%	44%	94%
#200 =>	69.6%	70.4%	34.5%	89.7%
Wt Rcvd	36.5551	50.1497	49.7774	47.4901
Wt Oven Dried	25.6982	37.512	38.4282	38.467
Moisture Content =>	42.2%	33.7%	29.5%	23.5%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>			0.117 mm	
D60 size =>			0.137 mm	
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.0%	0.0%	0.0%
Sand percentage =	30.5%	29.7%	65.5%	10.3%
Fines percentage =	69.6%	70.4%	34.5%	89.7%
Unified Soil MLass Symbol =	ML	ML	SM	ML



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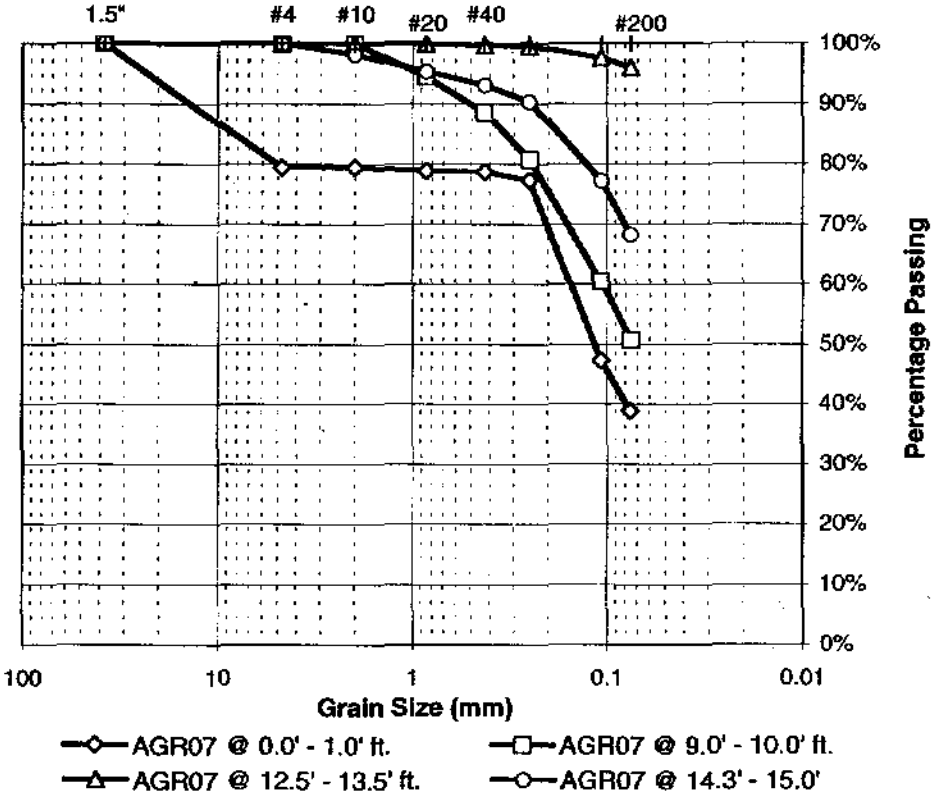
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
24

Boring =>	AGR07	AGR07	AGR07	AGR07
Sample Number =>	AGR07A	AGR07B	AGR07C	AGR07D
Depth =>	0.0' - 1.0'	9.0' - 10.0'	12.5' - 13.5'	14.3' - 15.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	79%	100%	100%	100%
#10 =>	79%	100%	100%	98%
#20 =>	79%	94%	100%	95%
#40 =>	79%	89%	100%	93%
#60 =>	77%	81%	99%	90%
#140 =>	47%	60%	98%	77%
#200 =>	38.8%	50.7%	95.9%	68.3%
Wt Rcvd	37.7227	37.7952	38.6373	44.0262
Wt Oven Dried	25.84	17.0078	27.2393	26.9881
Moisture Content =>	46.0%	122.2%	41.8%	63.1%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>	0.115 mm			
D60 size =>	0.153 mm	0.104 mm		
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	21%	0%	0%	0%
AASHTO Gravel (+#10) =	20.6%	0.0%	0.0%	1.8%
Sand percentage =	40.6%	49.3%	4.1%	31.8%
Fines percentage =	38.8%	50.7%	95.9%	68.3%
Unified Soil MLass Symbol =	**SM**	**ML**	**ML**	**ML**

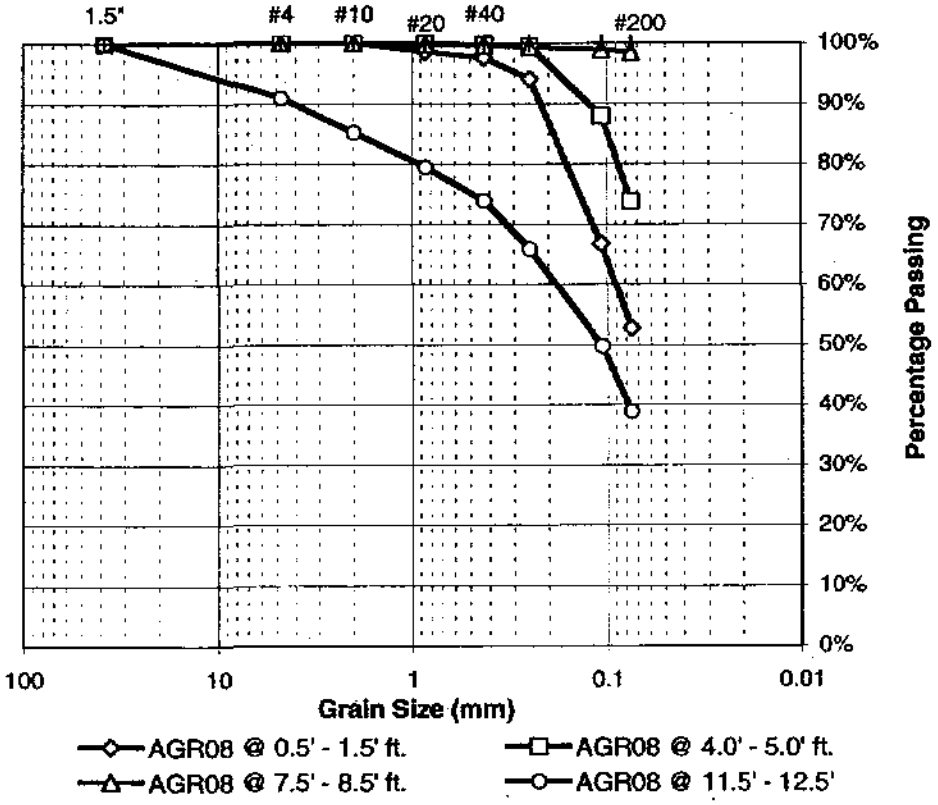


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
25

Boring =>	AGR08	AGR08	AGR08	AGR08
Sample Number =>	AGR08A	AGR08B	AGR08C	AGR08D
Depth =>	0.5' - 1.5'	4.0' - 5.0'	7.5' - 8.5'	11.5' - 12.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	91%
#10 =>	100%	100%	100%	85%
#20 =>	99%	100%	100%	80%
#40 =>	98%	100%	100%	74%
#60 =>	94%	99%	99%	66%
#140 =>	67%	88%	99%	50%
#200 =>	52.7%	73.8%	98.5%	38.9%
Wt Rcvd	47.3332	37.6902	20.6135	37.6417
Wt Oven Dried	34.3639	28.4561	15.8724	14.5297
Moisture Content =>	37.7%	32.5%	29.9%	159.1%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>				0.108 mm
D60 size =>	0.090 mm			0.183 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	9%
AASHTO Gravel (+#10) =	0.0%	0.0%	0.0%	14.7%
Sand percentage =	47.3%	26.2%	1.5%	52.1%
Fines percentage =	52.7%	73.8%	98.5%	38.9%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**SM**

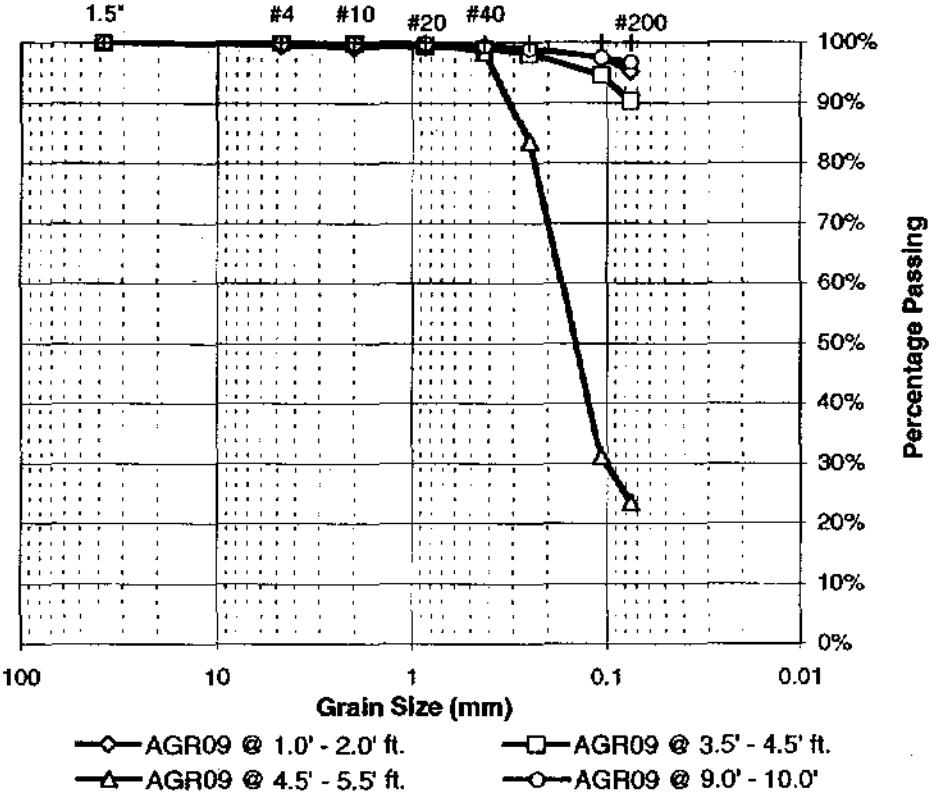


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
26

Boring =>	AGR09	AGR09	AGR09	AGR09
Sample Number =>	AGR09A	AGR09B	AGR09C	AGR09D
Depth =>	1.0' - 2.0'	3.5' - 4.5'	4.5' - 5.5'	9.0' - 10.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	99%	100%	100%	100%
#20 =>	99%	99%	100%	100%
#40 =>	99%	99%	98%	100%
#60 =>	99%	98%	84%	99%
#140 =>	98%	95%	31%	97%
#200 =>	95.2%	90.2%	23.5%	96.8%
Wt Rcvd	25.0089	26.0971	53.3723	26.2669
Wt Oven Dried	16.4559	16.2063	38.5348	19.8315
Moisture Content =>	52.0%	61.0%	38.5%	32.5%
Analysis of Data				
D10 size =>				
D30 size =>			0.101 mm	
D50 size =>			0.144 mm	
D60 size =>			0.170 mm	
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	1%	0%	0%	0%
AASHTO Gravel (+#10) =	0.8%	0.1%	0.1%	0.0%
Sand percentage =	4.3%	9.8%	76.5%	3.2%
Fines percentage =	95.2%	90.2%	23.5%	96.8%
Unified Soil MLass Symbol =	**ML**	**ML**	**SM**	**ML**

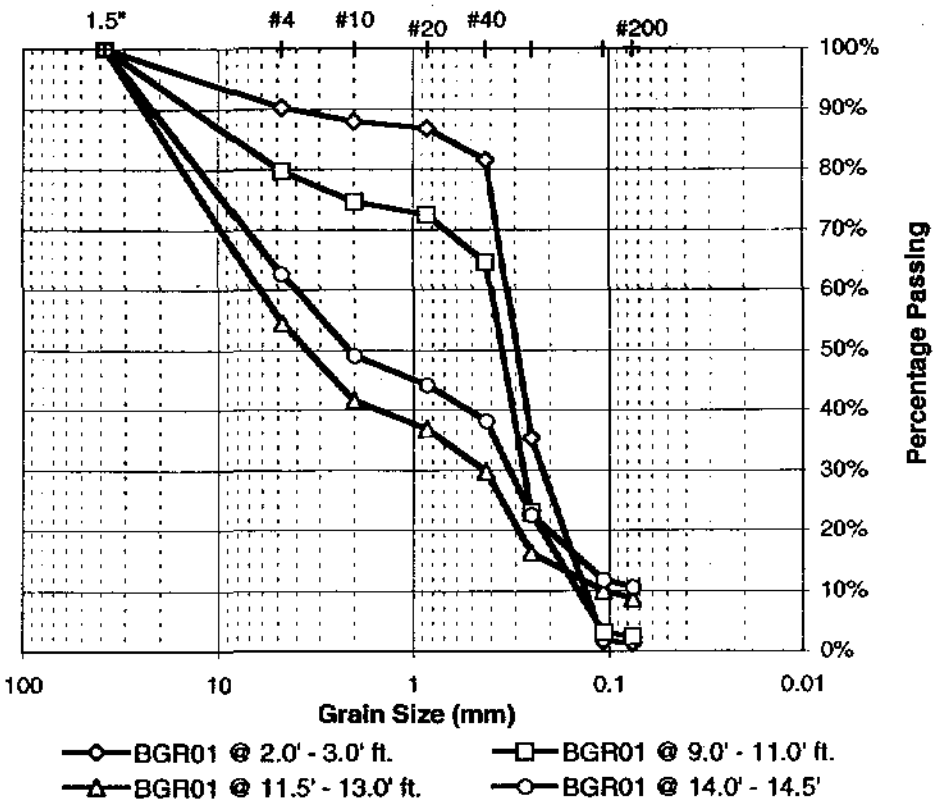


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
27

Boring =>	BGR01	BGR01	BGR01	BGR01
Sample Number =>	BGR01A	BGR01B	BGR01C	BGR01D
Depth =>	2.0' - 3.0'	9.0' - 11.0'	11.5' - 13.0'	14.0' - 14.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	90%	80%	54%	63%
#10 =>	88%	75%	42%	49%
#20 =>	87%	72%	37%	44%
#40 =>	82%	65%	30%	38%
#60 =>	35%	23%	16%	23%
#140 =>	2%	3%	10%	12%
#200 =>	1.2%	2.3%	8.6%	10.5%
Wt Rcvd	106.8232	103.4753	103.7884	100.319
Wt Oven Dried	87.595	88.0575	91.3338	89.8858
Moisture Content =>	22.0%	17.5%	13.6%	11.6%
Analysis of Data				
D10 size =>	0.131 mm	0.143 mm	0.107 mm	
D30 size =>	0.218 mm	0.274 mm	0.436 mm	0.322 mm
D50 size =>	0.296 mm	0.353 mm	3.536 mm	2.131 mm
D60 size =>	0.332 mm	0.401 mm	6.134 mm	4.026 mm
Coeff. of Uniformity, Cu =	2.53	2.80	57.47	
Coeff. of Curvature, Cc =	1.09	1.30	0.29	
Gravel (+#4) percentage =	10%	20%	46%	37%
AASHTO Gravel (+#10) =	12.1%	25.4%	58.5%	51.0%
Sand percentage =	89.1%	77.4%	45.8%	52.1%
Fines percentage =	1.2%	2.3%	8.6%	10.5%
Unified Soil MLass Symbol =	**SP**	**SP**	**SP-SM**	**SP-SM**

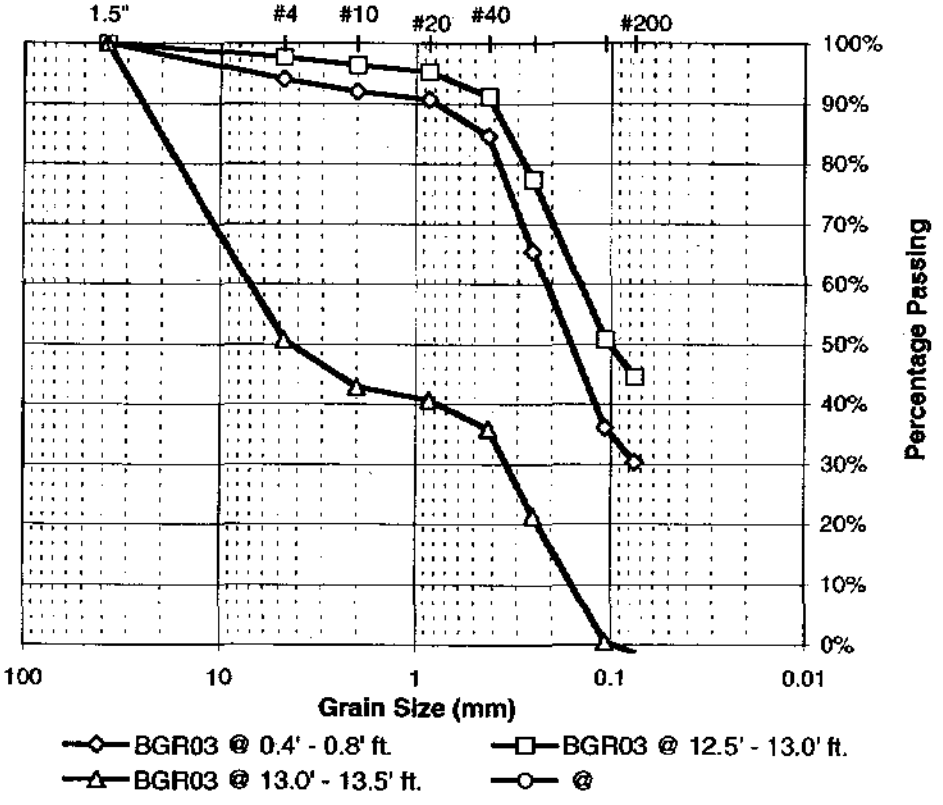


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
28

Boring =>	BGR03	BGR03	BGR03
Sample Number =>	BGR03A	BGR03B	BGR03C
Depth =>	0.4' - 0.8'	12.5' - 13.0'	13.0' - 13.5'
1 1/2" =>	100%	100%	100%
#4 =>	94%	98%	51%
#10 =>	92%	96%	43%
#20 =>	91%	95%	41%
#40 =>	85%	91%	36%
#60 =>	65%	77%	21%
#140 =>	36%	51%	0%
#200 =>	30.3%	44.5%	-1.4%
Wt Rcvd	48.6006	31.2386	82.547
Wt Oven Dried	39.9497	23.1478	70.7428
Moisture Content =>	21.7%	35.0%	16.7%
Analysis of Data			
D10 size =>			0.157 mm
D30 size =>			0.343 mm
D50 size =>	0.159 mm	0.102 mm	4.396 mm
D60 size =>	0.214 mm	0.143 mm	7.035 mm
Coeff. of Uniformity, Cu =			44.84
Coeff. of Curvature, Cc =			0.11
Gravel (+#4) percentage =	6%	2%	49%
AASHTO Gravel (+#10) =	8.0%	3.7%	57.1%
Sand percentage =	63.7%	53.2%	52.1%
Fines percentage =	30.3%	44.5%	-1.4%
Unified Soil MLass Symbol =	**SM**	**SM**	**SP**

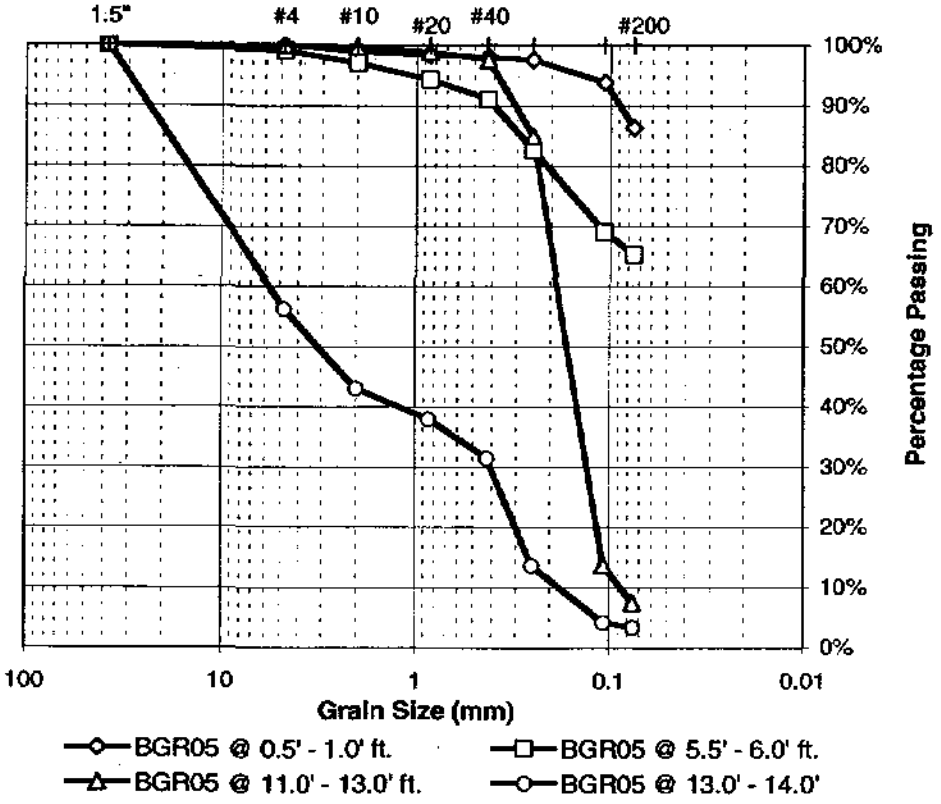


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
29

Boring =>	BGR05	BGR05	BGR05	BGR05
Sample Number =>	BGR05A	BGR05B	BGR05C	BGR05D
Depth =>	0.5' - 1.0'	5.5' - 6.0'	11.0' - 13.0'	13.0' - 14.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	99%	100%	56%
#10 =>	99%	97%	100%	43%
#20 =>	98%	94%	99%	38%
#40 =>	98%	91%	98%	32%
#60 =>	98%	83%	85%	14%
#140 =>	94%	69%	14%	4%
#200 =>	86.3%	65.3%	7.4%	3.3%
Wt Rcvd	37.7369	40.7818	60.5221	100.9106
Wt Oven Dried	27.5479	24.4691	46.602	92.535
Moisture Content =>	37.0%	66.7%	29.9%	9.1%
Analysis of Data				
D10 size =>			0.087 mm	0.180 mm
D30 size =>			0.129 mm	0.407 mm
D50 size =>			0.164 mm	3.164 mm
D60 size =>			0.185 mm	5.690 mm
Coeff. of Uniformity, Cu =			2.14	31.53
Coeff. of Curvature, Cc =			1.04	0.16
Gravel (+#4) percentage =	0%	1%	0%	44%
AASHTO Gravel (+#10) =	1.1%	2.9%	0.3%	57.0%
Sand percentage =	13.8%	33.8%	92.6%	52.9%
Fines percentage =	86.3%	65.3%	7.4%	3.3%
Unified Soil MLass Symbol =	ML	ML	SP-SM	SP

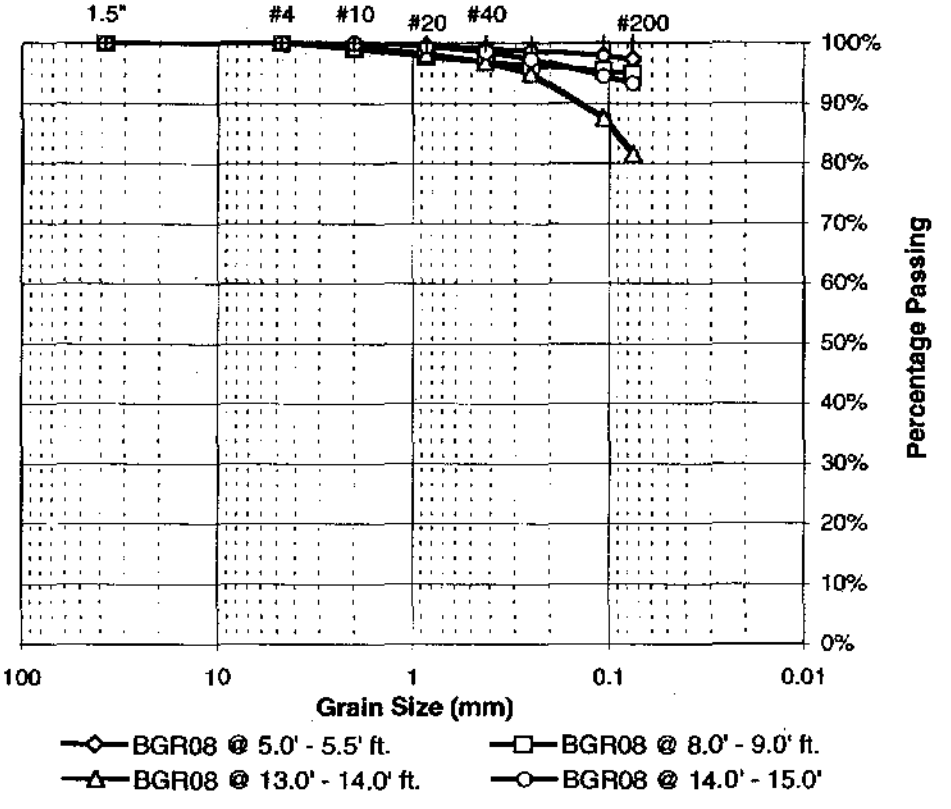


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
30

Boring =>	BGR08	BGR08	BGR08	BGR08
Sample Number =>	BGR08A	BGR08B	BGR08C	BGR08D
Depth =>	5.0' - 5.5'	8.0' - 9.0'	13.0' - 14.0'	14.0' - 15.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	99%	99%	100%
#20 =>	100%	98%	98%	99%
#40 =>	99%	97%	97%	99%
#60 =>	99%	96%	95%	97%
#140 =>	98%	95%	87%	95%
#200 =>	97.3%	94.8%	81.5%	93.3%
Wt Rcvd	24.8691	27.6801	26.9168	25.3288
Wt Oven Dried	17.5327	19.0439	14.9657	20.567
Moisture Content =>	41.8%	45.3%	79.9%	23.2%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>				
D60 size =>				
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.9%	0.7%	0.0%
Sand percentage =	2.7%	5.2%	18.5%	6.7%
Fines percentage =	97.3%	94.8%	81.5%	93.3%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**ML**

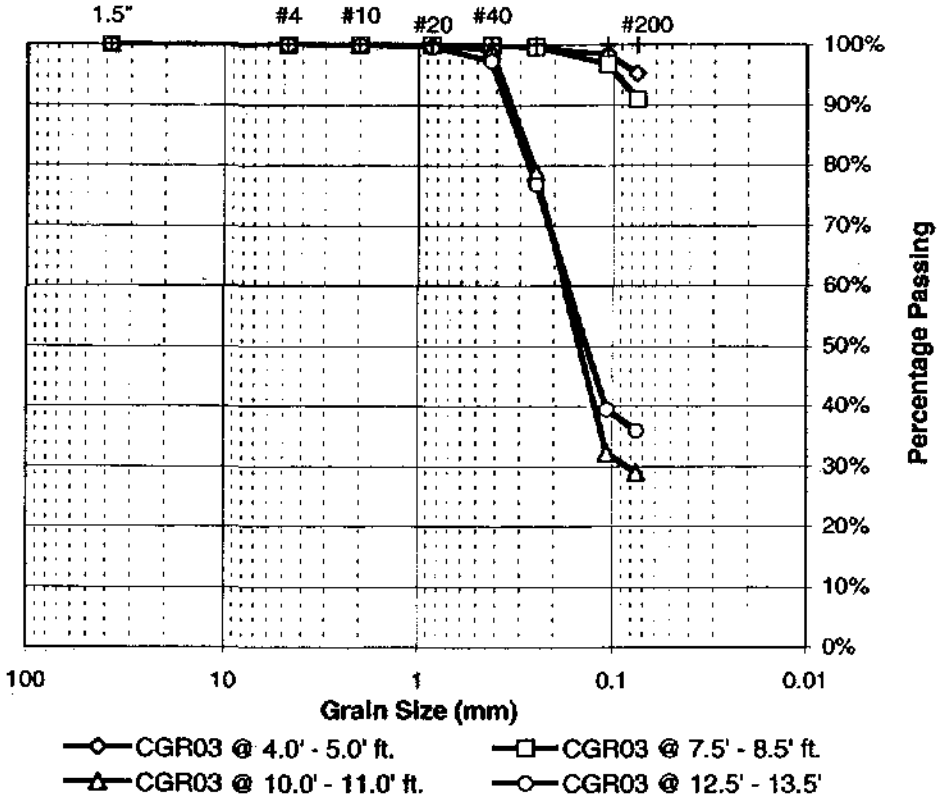


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
31

Boring =>	CGR03	CGR03	CGR03	CGR03
Sample Number =>	CGR03A	CGR03B	CGR03C	CGR03D
Depth =>	4.0' - 5.0'	7.5' - 8.5'	10.0' - 11.0'	12.5' - 13.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	100%
#20 =>	100%	100%	100%	100%
#40 =>	100%	100%	99%	97%
#60 =>	100%	100%	79%	77%
#140 =>	98%	97%	32%	40%
#200 =>	95.3%	91.0%	29.0%	36.0%
Wt Rcvd	28.5458	38.612	29.9706	25.4502
Wt Oven Dried	20.1248	27.8779	22.5079	14.5066
Moisture Content =>	41.8%	38.5%	33.2%	75.4%
Analysis of Data				
D10 size =>				
D30 size =>			0.084 mm	
D50 size =>			0.147 mm	0.135 mm
D60 size =>			0.177 mm	0.170 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.0%	0.0%	0.1%
Sand percentage =	4.7%	9.0%	71.0%	64.0%
Fines percentage =	95.3%	91.0%	29.0%	36.0%
Unified Soil MLass Symbol =	**ML**	**ML**	**SM**	**SM**

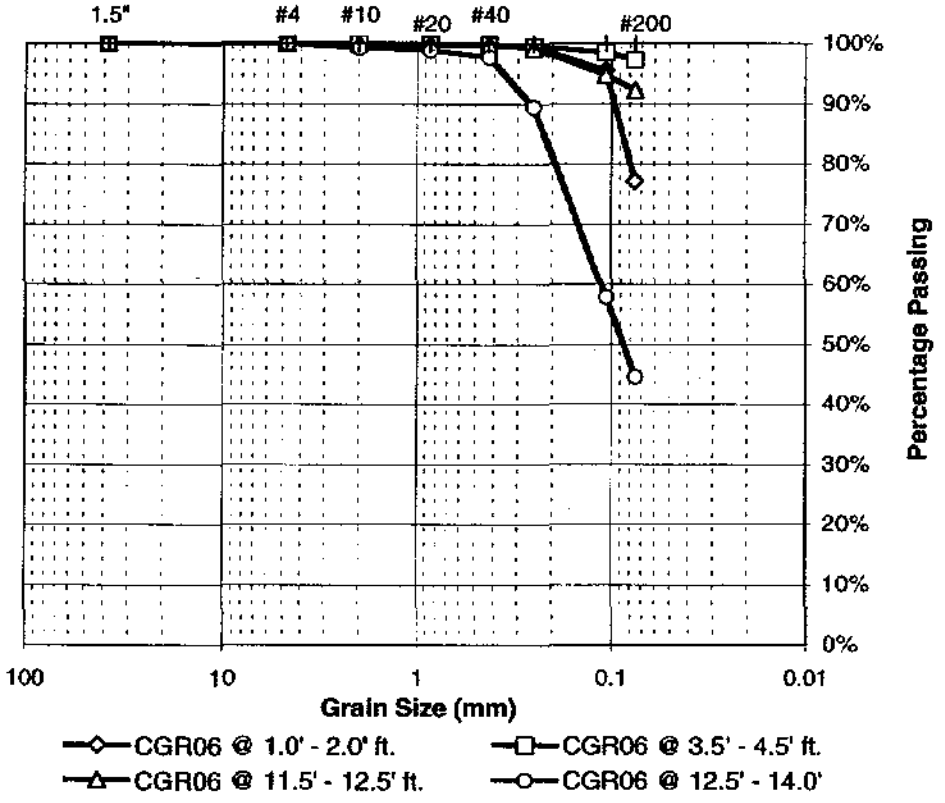


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
32

Boring =>	CGR06	CGR06	CGR06	CGR06
Sample Number =>	CGR06A	CGR06B	CGR06C	CGR06D
Depth =>	1.0' - 2.0'	3.5' - 4.5'	11.5' - 12.5'	12.5' - 14.0'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	99%
#20 =>	100%	100%	100%	99%
#40 =>	100%	100%	100%	98%
#60 =>	99%	99%	99%	89%
#140 =>	95%	98%	95%	58%
#200 =>	77.1%	97.2%	92.2%	44.6%
Wt Rcvd	40.4801	27.064	28.9111	35.541
Wt Oven Dried	29.1052	18.593	21.5388	25.5895
Moisture Content =>	39.1%	45.6%	34.2%	38.9%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>				0.086 mm
D60 size =>				0.112 mm
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.2%	0.0%	0.0%	0.7%
Sand percentage =	22.9%	2.8%	7.8%	55.4%
Fines percentage =	77.1%	97.2%	92.2%	44.6%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**SM**

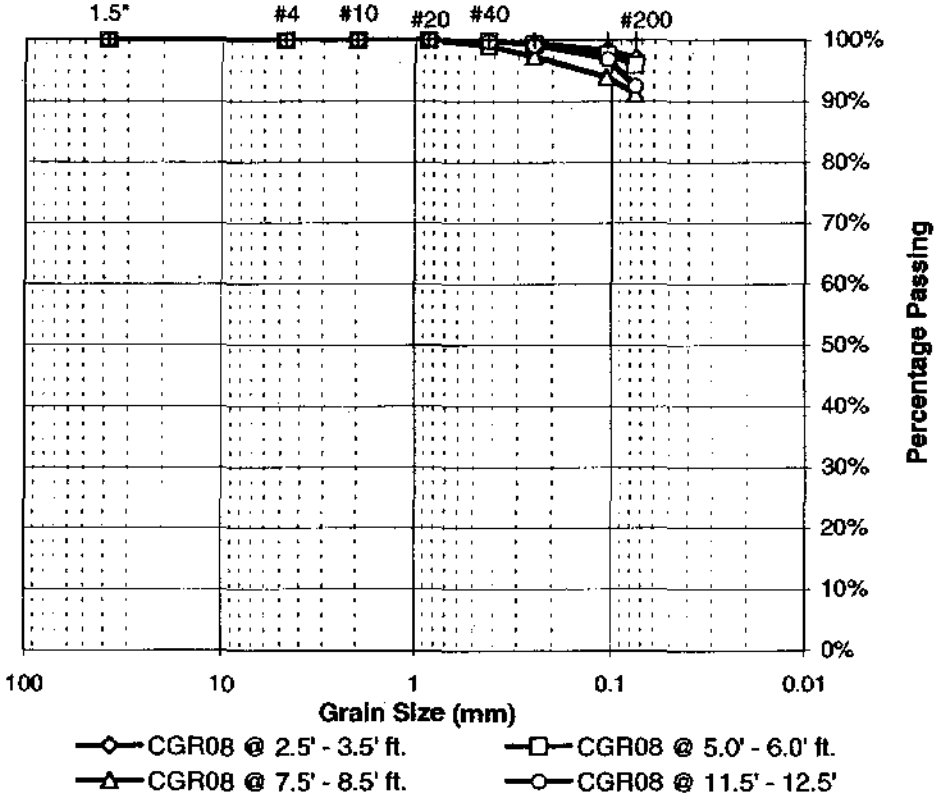


Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
33

Boring =>	CGR08	CGR08	CGR08	CGR08
Sample Number =>	CGR08A	CGR08B	CGR08C	CGR08D
Depth =>	2.5' - 3.5'	5.0' - 6.0'	7.5' - 8.5'	11.5' - 12.5'
1 1/2" =>	100%	100%	100%	100%
#4 =>	100%	100%	100%	100%
#10 =>	100%	100%	100%	100%
#20 =>	100%	100%	100%	100%
#40 =>	100%	100%	99%	100%
#60 =>	100%	99%	97%	99%
#140 =>	98%	97%	94%	97%
#200 =>	97.0%	95.9%	91.2%	92.5%
Wt Rcvd	29.4231	25.9443	29.2121	31.0347
Wt Oven Dried	20.7727	16.2411	19.5429	22.345
Moisture Content =>	41.6%	59.7%	49.5%	38.9%
Analysis of Data				
D10 size =>				
D30 size =>				
D50 size =>				
D60 size =>				
Coeff. of Uniformity, Cu =				
Coeff. of Curvature, Cc =				
Gravel (+#4) percentage =	0%	0%	0%	0%
AASHTO Gravel (+#10) =	0.0%	0.0%	0.0%	0.0%
Sand percentage =	3.0%	4.1%	8.8%	7.5%
Fines percentage =	97.0%	95.9%	91.2%	92.5%
Unified Soil MLass Symbol =	**ML**	**ML**	**ML**	**ML**



Duane Miller & Associates
Job No. 4119.30
June 2001

PARTICLE SIZE DATA
Liberty Development
Foggy Island Bay, Alaska

Plate
34