DRAFT
DEPARTMENT OF ENERGY
1998 DRILL SITE
CHARACTERIZATION REPORT
AMCHITKA ISLAND, ALASKA

DRAFT
DEPARTMENT OF ENERGY
1998 DRILL SITE CHARACTERIZATION REPORT
AMCHITKA ISLAND, ALASKA

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Note: Volume II has not been distributed to all recipients of the Site Characterization Report; two copies of Volume II appendices have been provided to the Department of Energy.

ACRONYMS AND ABBREVIATIONS

ACGY	Aircraft Graveyard
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
AEC	United States Atomic Energy Commission
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
ATV	all terrain vehicle
AVS	acid volatile sulfides
AWQC	Ambient Water Quality Criteria
AWQS	Alaska Water Quality Standards
BTEX	benzene, toluene, ethylbenzene, and xylenes
BSF&W	U.S. Bureau of Sport Fisheries and Wildlife
°C	degrees Centigrade
CANN	Cannikin
Corps	United States Army Corps of Engineers
COPCs	contaminants of potential concern
CP	Control Point
cy	cubic yards
DO	dissolved oxygen
DOD	United States Department of Defense
DOE	United States Department of Energy
DOE-NV	DOE Nevada Operations Office
DOT	United States Department of Transportation
DQO	Data Quality Objective
DRO	diesel range organics
DRSD	Drill Site D
DRSE	Drill Site E
DRSF	Drill Site F
EML	Environmental Measurements Laboratory
EPA	United States Environmental Protection Agency
EPA-R&IE	EPA's Radiation and Indoor Environments National Laboratory
EPI	Environmental Physics, Inc.
ERBSC	ecological risk-based screening concentration
ERDA	Energy Research and Development
°F	degrees Fahrenheit
FS	fish
g	gram
g/L	grams per liter
GEL	General Engineering Laboratories, Inc.
GPS	global positioning system
GRO	gasoline range organics

ACRONYMS AND ABBREVIATIONS (cont.)

GW	groundwater
HRBSC	health risk-based screening concentration
ICP/MS	inductively coupled plasma/mass spectroscopy
I.D.	inside diameter
LOEL	lowest observed effect level
LOAEL	lowest observed adverse effect level
m	meter
MCL	maximum contaminant level
MDA	minimum detectable activity
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MILR	Milrow
ml	milliliter
mm	millimeters
MOA	Memorandum of Agreement
MS/MSD	matrix spike/matrix spike duplicate
NAD83	North American Datum of 1983
NCA	North Creek Analytical
ND	non-detect
NOEL	no observed effect level
NOAEL	no observed adverse effect level
O.D.	outside diameter
OEW	ordnance and explosive waste
OSWER	EPA Office of Solid Waste and Emergency Response
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCi/g	picoCuries per gram
PID	photoionization detector
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
Rad	radionuclide
RI	Remedial Investigation
ROTHR	Relocatable Over the Horizon Radar
RPD	relative percent difference
RS01	Reference Stream 1
RS02	Reference Stream 2
RS03	Reference Stream 3
RS04	Reference Stream 4
SD	sediment
SEM	simultaneously extracted metals

ACRONYMS AND ABBREVIATIONS (cont.)

SGZ	Surface Ground Zero
SIM	selective ion method
SL	soil
SOP	Standard Operating Procedure
sp.	species
SVOC	semivolatile organic compound
SW	surface water
TAL	Target Analyte List (i.e. metals)
TB	trip blank
TBC	to-be-considered criteria
TOC	total organic carbon
ug/L	micrograms per liter
USEPA	see EPA
USFWS	United States Fish and Wildlife Service
UTL	upper tolerance limit
UXO	unexploded ordnance
VOC	volatile organic compound
WACS	White Alice Communications System
WQS	water quality standard
WWII	World War II

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), through the Alaska District, U.S. Army Corps of Engineers (Corps), contracted an investigation of possible chemical impacts at drill sites on Amchitka Island that were used during underground nuclear testing in the late 1960s and early 1970s. Field work in support of this investigation was conducted during the summer of 1998. This Site Characterization Report presents the results of that investigation. This work was performed for the Corps under Contract No. DACA85-94-D-0009, Delivery Order No. 0021, under funding provided by the DOE.

The field sampling program was directed at evaluating present impacts, if any, from emplacement and exploratory hole drilling activities related to underground nuclear testing. Of particular concern was the potential for residual effects in freshwater drainages as a result of drilling mud releases and spills that occurred during the drilling operations and nuclear blasts. Another primary objective of the investigation was to characterize the contents and integrity of the remaining mud pits, to provide information for determining whether the mud pits pose a significant future risk to site drainages. The field program also included an investigation of potential polychlorinated biphenyl (PCB) contamination at the World War II era "Aircraft Graveyard" debris dump site near Kirilof Wharf, and sampling of freshwater fish for radionuclide analysis in support of DOE's overall program to evaluate the environmental effects of underground testing.

Chemical sampling to evaluate the effects of past emplacement and exploratory drilling activities included sediment and water sampling from the thirteen open mud pits at the drill and test sites, several potentially impacted lakes, and eight streams that drain the sites. Sediment and water samples were also collected from four reference streams to provide representative background conditions against which potential adverse effects could be assessed. Benthic sampling was also conducted in each of the streams to perform macroinvertebrate community assessments and bioassays to evaluate sediment toxicity. This information, combined with the chemical results, was used in a Triad Analysis to provide a more sensitive assessment of whether historic drilling mud releases are continuing to affect stream sediment quality and habitat. Resident fish were also collected from each of the drainages and analyzed for constituents of concern to evaluate whether bioaccumulation of drilling mud contaminants is occurring in the food web.

The drilling mud remaining in the open mud pits was typically found to contain elevated levels of diesel, chromium, and copper. Elevated concentrations refer to values exceeding the project comparison criteria of both background and Ecological Risk-Based Screening Concentrations (ERBSCs). A few of the pits also contain elevated levels of nickel, cadmium, and zinc in some of the drilling mud-samples. Relatively low concentrations of diesel-related polycyclic aromatic hydrocarbons and volatile organic compounds were found in some pits, and low levels of PCBs (in excess of human risk-based concentrations) were detected in some of the mud samples from the Cannikin Test Site and Drill Site D mud pits. Water contained within the mud pits is considerably less contaminated than the underlying drilling mud. Only in a relatively small mud pit at Drill Site F were any constituents of concern (aluminum and copper) consistently detected

in water at concentrations above ERBSCs. Elsewhere, the mean concentrations in water samples from each pit were well below ERBSCs, although isolated samples contained aluminum or manganese at concentrations that exceeded these levels.

In spite of historical reports of voluminous releases or spills of drilling mud to several site streams and lakes, virtually no visible evidence of drilling mud remains in the site drainages. It appears that erosion and flushing has removed most of the mud over the intervening three decades. Chemical sampling of the sediment and water in the streams generally supports the visual evidence. Taken as a whole, none of the streams show pervasive chemical contamination in either the sediment or the water. Only a few of the stations had any chemical concentrations that exceeded those detected in the reference streams. The uppermost stations (closest to the mud pit sources) in a few of the streams tend to have the most evidence of sediment contamination. Notably, the sediments from some of these locations have elevated levels of chromium and/or copper, and DRO concentrations well below ADEC action levels but exceeding biogenic levels found in the reference streams. The greatest identified sediment impacts, based on chemical sampling, were in upper Rainbow Creek (Station 3), along the southwest shoreline of Cannikin Lake where drilling mud was found, and in White Alice Creek at the station just downstream of Cannikin Lake. In each instance this contamination was not reflected in the corresponding water samples, nor were the stream sediment and water samples affected farther downstream.

Toxicity testing on stream sediment samples also identified very few locations where drill site streams showed greater toxicity than the reference streams. The one notable exception was from Rainbow Creek Station 3, where the sediment was found to be toxic in the laboratory tests. The benthic macroinvertebrate communities at site stream stations were also generally comparable to those in reference streams. The benthic sampling did not indicate major impacts at any site stream or station location, including Station 3 of Rainbow Creek.

Combining the results of the chemical sediment sampling, toxicity testing, and benthic community assessments, the Triad Analysis identified no clear indication of degraded conditions at any of the streams that drain Drill Sites D, E, and F. Similarly, most of the streams that drain the Milrow, Long Shot, and Cannikin Test Sites ranked comparably with the corresponding reference streams. The only exceptions were the middle stations on Rainbow Creek and the White Alice Creek station immediately below Cannikin Lake. These stations are considered to be potentially impacted from historic drilling-mud releases, because the Triad results show a strong concordance between chemical contamination, toxicity, and macroinvertebrate degradation.

Chemical analyses of resident fish show very little evidence of residual contamination from the historic drilling-mud releases. Possible exceptions are inorganic arsenic and Aroclor 1260. Inorganic arsenic was detected at slightly elevated levels in some of the samples from White Alice, Bridge, Rainbow, and Clevenger Creeks. Aroclor 1260 was detected at low concentrations in several fish samples from Cannikin Lake and White Alice Creek, in one sample from Rainbow Creek, and in two samples each from Clevenger Creek and the streams that drain Drill Sites D and F.

Groundwater, surface water, and sediment were sampled downstream and downgradient of the Aircraft Graveyard to evaluate whether PCBs are migrating from the site. No PCBs were detected, even though relatively high concentrations were previously detected in groundwater. The 1998 results indicate the site does not appear to pose a risk to the adjoining wetlands and Kirilof Bay, and suggest that previous results may not reflect true site conditions.

Fish were sampled from Cannikin Lake, White Alice Creek, Cloudberry Creek, and a background lake near Base Camp for the radioisotopes americium-140, plutonium-238, plutonium 239/240, and cesium-137. Only cesium-137 was detected; it was measured at low levels in all six of the samples tested, both in gut samples and in the gutted fish. The highest concentration measured (0.739 pCi/gm), from Cloudberry Creek, was somewhat higher than the background sample. Cesium-137 levels measured in fish from Cannikin Lake and White Alice Creek were comparable to the background sample.

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DEPARTMENT OF ENERGY
1998 DRILL SITE CHARACTERIZATION REPORT
AMCHITKA ISLAND, ALASKA

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

Through the Alaska District, U.S. Army Corps of Engineers (Corps), the U.S. Department of Energy (DOE) in early 1998 contracted the planning of an investigation of possible chemical impacts at drill sites used during underground nuclear testing by its predecessor agencies on Amchitka Island. Field work in support of this investigation was conducted during late summer 1998. This Site Characterization Report presents the results of that investigation.

Amchitka Island is located near the far western end of the Aleutian Islands, approximately 1,340 miles west-southwest of Anchorage, Alaska (Figure 1-1). It is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge, which is administered by the U.S. Fish and Wildlife Service (USFWS). Since World War II (WWII) Amchitka has been used by U.S. government agencies for a variety of military and research activities. From 1943 to 1950 it was used as a forward air base for the U.S. Armed Forces. During the late 1960s and early 1970s it was used by the U.S. Department of Defense (DOD) and the U.S. Atomic Energy Commission (AEC) as a site for three underground nuclear tests. Most recently, during the late 1980s and early 1990s, the U.S. Navy (Navy) constructed and operated a radar station on the island. Amchitka is currently uninhabited, and access is restricted to USFWS and other government personnel and contractors.

The nuclear testing activities on Amchitka necessitated the drilling of both exploratory and emplacement boreholes. Drilling mud used during this drilling may have contained diesel fuel and possibly metals-containing additives. Spills and releases of drilling mud into freshwater drainages at the drill sites have been documented by the AEC. During and after the nuclear testing period, the AEC, Environmental Protection Agency (EPA), and DOE performed ecological and environmental studies. However, no study prior to 1998 provided a comprehensive assessment of the levels of contaminants (if any) in drilling mud that may remain at the sites, contaminant levels in the impacted surface waters and sediments, or impact to the fish and invertebrates in the affected freshwater drainages. An additional issue addressed during the 1998 investigation was the potential for polychlorinated biphenyl (PCB) contamination to have resulted from releases at the "Aircraft Graveyard" site near Kirilof Wharf.

As outlined in the August 14, 1998, *Management Plan* the scope of the 1998 field work included:

- Sampling and analysis of surface water and sediment in drilling mud pits associated with the underground nuclear testing program, and lakes either used for drilling mud storage or possibly impacted by releases of drilling mud.
- Sampling and analysis of surface water and sediment in streams potentially impacted by releases of drilling mud, and in unimpacted reference streams for comparison.
- Determination of the abundance and diversity of benthic invertebrates in streams potentially impacted by releases of drilling mud, and in unimpacted reference streams for comparison.
- Performance of bioassays using sediment from streams potentially impacted by releases of drilling mud, and in unimpacted reference streams for comparison.
- Measurement of chemical concentrations in fish tissue samples from streams potentially impacted by releases of drilling mud, and in unimpacted reference streams for comparison.
- Measurement of radionuclide concentrations in fish tissue samples from Cannikin Lake, White Alice Creek at the Cannikin site, Cloudberry Creek at the Long Shot site, and one reference lake.
- Sampling and analysis for PCBs in surface water, sediment, and groundwater samples from the "Aircraft Graveyard."

This Site Characterization Report documents the findings of the 1998 field work conducted between August 26 and September 17. This work was performed for the Corps under Contract No. DACA85-94-D-0009, Delivery Order No. 0021, under funding provided by the DOE. The scope of work executed under this Delivery Order is described in the August 14, 1998, *Management Plan, Department of Energy 1998 Drill Site Investigation, Amchitka Island, Alaska.* This document was prepared as an addendum to the *Final Report, Amchitka Army Air Base, Phase I Remedial Investigation, Amchitka Island, Alaska, Management Plan*, issued on December 16, 1996. The August 1998 DOE *Management Plan* referred to the December 1996 *Management Plan* for detailed information regarding specific sampling and sample handling procedures. Appendix A to this current report summarizes the field modifications to the activities and procedures described in the August 1998 DOE *Management Plan.*

1.2 SITE DESCRIPTION

This section presents a history of the drilling and nuclear testing activities on Amchitka as well as a description of previous environmental studies. The primary source of the information contained in this section is the document titled *The Environment of Amchitka Island, Alaska* (Merritt and Fuller, 1977). This document, which was published by the Energy Research and Development Administration (ERDA), describes the bioenvironmental studies carried out by the AEC on Amchitka during the nuclear test period. The studies were conducted between 1967 and

1973, a period that began just prior to the Milrow test of 1969 and continued for a short time after the Cannikin event of 1971. Only limited bioenvironmental studies were conducted for the Long Shot event (the earliest of the three tests). Information on environmental sampling events conducted in 1993 and 1997 was provided by the DOE, of which the ERDA became a part in 1979. Other historic information summarized in this section was obtained from construction design and as-built drawings of some of the nuclear test and drill sites, AEC documents regarding demobilization and cleanup activities on Amchitka following the tests, and air photos of some or all of the sites from the years 1968, 1969, and 1986.

1.2.1 Location and Site Description

A total of three nuclear tests were conducted on Amchitka Island. The Department of Defense (DOD) in conjunction with the AEC conducted the first nuclear test (Project Long Shot) in order to provide data that would improve the United States capability of detecting underground nuclear explosions. The 80-kiloton Long Shot device was detonated on October 29, 1965. The second nuclear test (Project Milrow) was conducted by the AEC as a means to study the feasibility of detonating a much larger device in the future. The 1-megaton Milrow device was detonated on October 2, 1969. The third nuclear test (Project Cannikin), in which a 5-megaton device was detonated, was conducted by the AEC on November 6, 1971. Project Cannikin was a test of the Spartan antiballistic missile warhead. The locations of the nuclear test sites and drill sites discussed in this section are shown in Figure 1-2.

In addition to the three sites that were used for nuclear tests, six other sites were considered for possible nuclear testing. The other potential sites were designated A, D, E, F, G, and H; Sites B and C were Milrow and Cannikin. Large-diameter emplacement holes were drilled at Sites D and F but were not used. An exploratory hole was drilled at Site E. Site H was graded in preparation for drilling activities which did not occur. Sites A and G were located and staked, but no further preparation was made. It was estimated that, at Sites B, C, D, E, F, and H combined, about 195 acres were disturbed by drilling or preparation for drilling. This figure includes access roads and spoil-disposal areas (Fuller and Kirkwood, 1977).

Amchitka Island can be divided into three distinctive physiographic regions: the southeastern, central, and northwestern regions, which have corresponding variations in ecological habitat. As shown in Figure 1-2, the Long Shot, Milrow, and Cannikin test sites are located in the southeastern portion of the island, at elevations ranging from 125 to 205 feet above mean sea level. Drill Sites D, E, and F are located in the central region of the island, at elevations ranging from 300 to 500 feet. No sites investigated as part of this study are in the northwestern region.

The southeastern region of Amchitka is a lowland that has low relief. Many small shallow ponds are interconnected by streams and narrow channels with low volume, gradient, and velocity. The land cover consists of tundra, which forms overhanging banks on streams that provide cover for fish. The stream substrate is predominantly soft organic muck, which supports an abundance of

vegetation. Few gravel or rocky areas are present except near the stream outlets. Streamflow varies seasonally, with the lowest flows in the months of March to September. Once the water-holding capacity of the tundra mats is re-saturated after the dry season, direct stream flow effects from precipitation can be seen. The anadromous salmonid migration coincides with periods of higher stream flow. Although the vegetation and overhanging banks provide good habitat, the fish populations are limited by the lack of gravel for spawning habitat.

The central region of the island is higher in elevation. Ponds in this area are similar to the southeastern region but confined to a large plateau along the center of the island. Streams draining the ponds are typically better developed and have steeper gradients. Some of these streams are graded to the present sea level, whereas others drop to the sea over sea cliffs. Many of the streams in this area have a bedrock substrate along much of their length. Gravel deposits are typical near the stream outlets, and accumulations of silt and clay occur in the quieter reaches of the streams. Anadromous salmonids are restricted to spawning in gravel near the outlets of these streams. Landlocked forms spawn in isolated gravel deposits much farther upstream. Most ponds in this area are phytogenic and lack an inlet, outlet, or both.

Three other sites related to the nuclear testing activities were investigated during 1998. These include the Milepost 13 and 14 lakes and the Rifle Range mud sumps that reportedly were used to store drilling mud. The lake known as "Milepost 13 Lake," located about midway between Cannikin and Drill Site D, was reportedly used for drilling-mud storage. Similarly, "Milepost 14 Lake," located immediately northeast of Drill Site D, was also reportedly used for drilling-mud storage. About one mile east of Milrow a series of drilling mud pits known as the Rifle Range Road Mud Sumps were also investigated during 1998.

In addition to the investigation of the drill sites, test sites, and mud storage areas, the 1998 field work included sampling at the "Aircraft Graveyard." This is a WWII-era scrap metal and debris dump located about 1,000 feet north of Kirilof Wharf, as shown in Figure 2-1. The site is one of eleven shared or uncertain liability sites under a Memorandum of Agreement (MOA) between the USFWS, Navy, DOE, and DOD. A site thought to be the Aircraft Graveyard is mentioned in the AEC document *Planning Directive: Mobilization, Restoration, and Monitoring, Amchitka Island, Alaska*, dated June 1972. The document refers to the site as:

> "A WWII Dump on a side road near the Kirilof Dock. Most of the residue originated during WWII."

The Aircraft Graveyard has been the subject of several investigations that included the collection of samples for chemical analysis. The results of these studies, which are summarized in Section 4.10.1, suggested that the Aircraft Graveyard site had been impacted by PCBs. Although not related to the DOE drill and test sites, the Aircraft Graveyard was included in the 1998 investigation at the request of the USFWS to further evaluate the potential for PCB contamination.

1.2.2 History of Site Use

Amchitka Island was occupied by the U. S. Army during WWII, beginning in 1943. The island served as a forward air base between Adak Island to the east and the Japanese-held Kiska Island 69 miles to the west. During the occupation, facilities were constructed for house and support nearly 15,000 men. The Army abandoned the island in August 1950. The U. S. Air Force operated a weather station on Amchitka in the early 1950s, a White Alice Communications System (WACS) site from 1959 to 1961, and a temporary radio relay site in the 1960s and 1970s.

The AEC occupancy of Amchitka, between 1967 and 1973, included use of the Base Camp area, especially around Baker Runway, and development of the Milrow and Cannikin test sites, and Drill Sites D, E, and F. A small construction camp also was installed at the northwest end of the island; it was also used as the Control Point (CP) for the Milrow and Cannikin tests. With the exception of the test sites and drill sites, facilities constructed by the AEC were located in areas disturbed by previous occupants of the island, primarily areas disturbed during WWII and areas occupied by DOD during the Long Shot project. In addition, the AEC rehabilitated and used structures built during WWII and used for the Long Shot project.

Available DOE records regarding AEC activities on the island focus primarily on the three test areas and three drill sites. Little information has been found on day-to-day operations in the Base Camp area or at the CP. Specific records on the use or storage of potentially hazardous or toxic materials other than drilling-mud additives have not been found. However, personnel from the U.S. Bureau of Sport Fisheries and Wildlife (BSF&W), the predecessor to the USFWS, were present on the island continuously during the AEC's occupancy, and intensive studies of the island's ecological systems were conducted throughout the AEC's stay on the island. No records from these agencies have been found regarding the release of any toxic materials into the island environment other than drilling-mud spills into various streams and lakes.

The AEC conducted an extensive restoration program prior to demobilizing from the island. The primary goals of that program were to restore areas disturbed by AEC operations to the condition they were in before AEC use, and prevent future environmental damage from areas and facilities used by the AEC (AEC/NV, 1972). The AEC identified 120 sites that required restoration based on discussions with the BSF&W (AEC/NV, 1972). Following completion of the restoration activities, BSF&W signed off on all 120 sites.

The primary focus of the 1998 investigation was to investigate the current status of impacts from the use of drilling mud in the emplacement and/or exploratory holes at the three test sites and three drill sites. The boreholes were drilled using methods that employed drilling mud, some of which may have contained additives such as diesel fuel, ferrochrome lignosulfonate, and chrome lignite to control viscosity and mitigate loss of drilling mud in the borehole. The composition of the mud used for the drilling on Amchitka is described by Valdez, et al, 1977 as:

"... 91 to 93% water and 6 to 8% oil with such additives as bentonite, lignite, cement, sodium bicarbonate, paper, and Q-BROXIN ([a registered trademark of Georgia Pacific Corp.] ferrochrome lignosulfonate) to maintain the desired viscosity and consistency. A pH range of 10 to 12 was attained with this mixture."

In general, the AEC tried not to use drilling mud for the exploratory holes, because these holes were intended in part for hydrologic and chemical testing, and the presence of drilling mud in a hole would affect the results of the testing. Drilling mud that contained diesel was used for all of the emplacement holes (emplacement holes were drilled, or at least started, at all sites).

The three test sites each contain at least one exploratory hole, an emplacement hole, and various monitoring holes. Cannikin was the only test site where a post-shot re-entry hole was drilled. The mud used in drilling the post-shot hole was reportedly left in the hole when it was sealed. The drilling history at the three drill sites where no test was performed is summarized below:

- Drill Site D was developed by the AEC as an underground test site but was never used. The AEC drilled a 4,550-foot-deep, 10-foot-diameter emplacement hole and two 7,000-foot-deep exploratory holes at the site.

- At Drill Site E the emplacement hole was abandoned after drilling 10 feet. There was one 7,495-foot-deep exploratory hole drilled at the site.

- The Drill Site F emplacement hole was abandoned after drilling a 7.5-foot-diameter hole to a depth of 531 feet. A 7,012-foot-deep exploratory hole was drilled at the site

The drilling mud was commonly stored near the drill sites in bermed pits, the walls of which were prone to leakage or outright failure. Many of the mud pits used during drilling were backfilled following use. The status of pits at the sites is summarized below:

- The Milrow test site does not contain any open mud pits; four drilling mud pits identified in AEC drawings have been backfilled. The historical information states that a nearby lake (Heart Lake) was also used for drilling mud storage. A former mud pit located approximately one mile east of Milrow was investigated in 1998. The Rifle Range Road mud pit, as it was designated, contained an estimated 1,890 cy of drilling mud.

- Based on 1986 air photos, the Long Shot test site contained three or possibly four side-by-side mud pits. These mud pits were not backfilled so that they could be sampled as part of the site's long-term monitoring program. They were excavated in a low lying area that is drained by a shallow trench. Based on the 1998 investigation, approximately 5,480 cy of drilling mud remains in the mud pits.

- The Cannikin test site originally contained 4 or 5 drilling mud pits. When the DOE visited the site in 1997, only one open mud pit was observed. The remaining mud pits were thought to have been backfilled. However, during the 1998 investigation two additional open mud pits near an exploratory boring were discovered. The mud pit closest to the SGZ contains an estimated 3,000 cy of mud. The two mud pits near the exploratory holes contain approximately 355 cy and 133 cy, based on field measurements.

- Drill Site D contains three large drilling mud pits that were not backfilled. DOE records indicate that drilling mud was mixed at Drill Site D and piped to other drill sites for use. Weekly reports of AEC activities on the island during site restoration and demobilization indicate that the drilling mud was removed from the mud pits before the AEC left the island; however, the mud pits were left open with the concurrence of the BSF&W. Based on the 1998 investigation, the following estimated quantities of drilling mud remain in the three mud pits: south pit, 2,350 cubic yards(cy); northwest pit, 7,820 cy; and northeast pit 4,870 cy.

- Drill Site E was thought to have originally contained a single mud pit. The historical information states that the mud pit slid into the nearby stream and is no longer present at the site. When the DOE visited the site in 1997, neither the drilling pad nor a mud pit was observed. However, during the 1998 investigation the drill pad and two small mud pits were located (north and south). An estimated 415 cy of drilling mud remains in the northern mud pit. The south mud pit contains approximately 4 cy of mud.

- Drill Site F originally contained four drilling mud pits. These features were visible in the available air photos (taken in 1968). When the DOE visited the site in 1997, only one partially-backfilled mud pit was observed in the vicinity of the drilling pad, south of the emplacement hole. The remainder of the mud pits have apparently been backfilled. Based on the 1998 investigation, the remaining, partially-backfilled mud pit contains an estimated 310 cy of drilling mud.

Historical data indicates that freshwater drainages at all six drill sites (Milrow, Long Shot, Cannikin, and Drill Sites D, E, and F) were impacted by drilling mud spills or releases. Information about spills at the individual sites is summarized below. Most of this information was excerpted from the document *The Environment of Amchitka Island, Alaska* (Valdez et. al. 1977; and Fuller and Kirkwood, 1977).

- At Drill Site D some drilling mud may have splashed out of holding ponds at the time of the Milrow test. The pond walls cracked and failed during the Cannikin test. Drilling mud residue and silt from pond walls covered the bed and banks of Falls Creek. A subsequent intentional release in 1972 of 20,000 to 25,000 barrels caused

further damage to this stream. At that time, the upper portion of Falls Creek contained heavy deposits of silt and was "devoid of fish and macroinvertebrates."

- The mud pits at Drill Site E were constructed on what proved to be unstable soil, and a failure in 1968 caused "a massive slide of semiliquid soil down the stream bed." This slide reportedly "grossly altered" the morphology of the upper two-thirds of the stream channel.

- The AEC document titled *Planning Directive, Demobilization, Restoration and Monitoring, Amchitka Island, Alaska*, (AEC/NV, 1972) indicated that the Limpet Creek drainage, as well as an additional potentially-impacted stream drainage due west of the drill site, "suffered pollution from mud escaping from the sumps" at Drill Site F.

- The AEC *Planning Directive* identifies three streams as impacted by drilling mud from Long Shot. Fuller and Kirkwood (1977) attribute "oil contamination ... in a stream draining the site" to "ruptured banks of settling basins." At least in the case of Bridge Creek, this explanation is contradicted by the fact that the mud pits are excavated into the native soils and do not have banks that could rupture overlying bedrock. Nevertheless, drainage of surface water from the mud pits may have caused some of the stream impacts.

- Small losses occurred from the Milrow mud pits into Clevenger Creek in January 1968, and large spills occurred between mid-May to mid-June 1969. Reportedly, ground motion from the Milrow detonation liberated much of the oily residue of the drilling mud that had been taken up by organic matter and vegetation in and along Clevenger Creek.

- Contamination of White Alice Creek, near the Cannikin site, occurred from summer 1968 until just before the Cannikin test of November 1971. An inspection in June 1970 revealed that the bottom of White Alice Creek was covered with caked and peeling mud and silt, and the odor of oil was very apparent. In mid-July 1970 there was evidence of spills of supernatant liquid from five locations. At least four were intentional releases, since two originated from drain pipes installed in sump walls and two others from trenches cut through these walls.

Releases of drilling mud affected all forms of stream life, because of the toxicity of the mud and because the stream beds were temporarily clogged with fine sediment. In the case of White Alice Creek and Falls Creek, the drilling mud releases had long-lasting impacts due to the high concentrations of drilling mud and extensive siltation of the stream bottom. The recovery of the macroinvertebrate populations was delayed because of the siltation of the stream bottoms. This in turn delayed the recovery of the fish population, because it restricted the source of food

available to the fish. According to Valdez et. al. (1977), it appears that fish and macroinvertebrate populations recovered once the stream was flushed of the residual drilling mud.

In spite of the apparent frequency and volume of releases of drilling mud, it was recognized in the 1970s that in most cases the stream environment would rehabilitate. According to the document *The Environment of Amchitka Island, Alaska* (Fuller and Kirkwood, 1977):

> "In those instances where contamination was limited to sporadic releases of drilling wastes or supernatant from drilling sumps, stream morphology was not altered; effects were primarily on populations of fish and invertebrates and changes in habitat, such as siltation of spawning gravels. The effects were largely transient in nature; toxic contaminants and silt were flushed from the streams during heavy flows, and fish and invertebrate populations have an opportunity to recover. Valdez et al. (Chap. 14, this volume) describes the results of a series of drilling-waste spills into Clevenger Creek from Site B (Milrow). In 1968 and 1969 toxic releases into the stream almost eliminated fish (juvenile Dolly Varden) and macroinvertebrates from the affected section of the Clevenger Creek drainage. Recovery of fish and invertebrates was nearly complete by 1974.
>
> Studies of mud-spill effects and subsequent recovery of freshwater biota in other drainages contaminated by drilling operations were not as detailed as those in Clevenger Creek. There is good reason; however, to believe that restoration of normal habitat and biotic populations will ultimately take place in all drainages except that below Site E, where irreversible morphological changes in the stream occurred. In all instances where stream biota were adversely affected, parts of the drainages escaped contamination, stocks of fish and invertebrates remained available for recruitment to the affected portion once stream flushing had made the habitat suitable for recolonization."

In addition to the drilling mud pits at each of the drill sites discussed above, freshwater lakes referred to as the Milepost 13 and Milepost 14 Lakes were reported to have been used for drilling mud storage. Drilling mud is known to have been transferred from one site to another via pipelines. In addition to these two lakes, the Rifle Range Road Mud Sumps, located southeast of the Milrow test site, were used to store drilling mud.

1.2.3 Previous Environmental Investigations

An extensive scientific investigation of Amchitka was conducted during the 1960s and 1970s to characterize the environment of the island before and after the AEC conducted underground nuclear testing. Much of the scientific information collected during that investigation is included in *The Environment of Amchitka Island, Alaska* (Merritt and Fuller, 1977). This publication compiled research on the geology, hydrology, climate, geomorphology, and land and marine

biota of the island, as well as information on environmental contaminants and the nuclear test effects.

While the information contained in this volume is valuable, it generally does not include site-specific chemical analyses. Site-specific environmental investigations that were available as background information before the 1998 investigation are discussed in the following subsections.

1.2.3.1 1993 DOE Chemical Sampling

In 1993, the DOE performed investigations at the three nuclear test sites that included the collection of soil, surface water, and groundwater samples. The investigations were part of initial efforts to characterize possible chemical impacts at the sites. The sampling program included analysis for Target Analyte List (TAL) metals (includes 23 metals), volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). The soil samples were collected from the surface of the emplacement hole pads near ground zero at each site. Surface water samples were collected from lakes, mud pits, and streams near the test sites. The groundwater samples were collected from monitoring wells installed near the test sites as part of a long-term monitoring program. A summary of the 1993 analytical results is provided in Appendix B.

The only 1993 DOE sampling results that are directly applicable to the 1998 Drill Site Investigation are surface water samples from some streams, lakes, and mud pits. No sediment or drilling mud samples were collected by DOE during 1993. The 1993 surface water sample locations that were resampled during 1998 and the number of samples collected in 1993 are listed by site below.

Cannikin	Ice Box Lake (in White Alice Creek drainage, one sample) and White Alice Creek (one sample)
Milrow	Heart Lake (one sample) and Clevenger Creek (one sample)
Long Shot	Three mud pits (one sample each) and Reed Pond (nearest pond southeast of mud pits, one sample)

Metals, VOC, and SVOCs were detected in the 1993 surface water analyses. The metals' results are included in the discussion of the 1998 results in the appropriate subsections of Section 4.0 of this report.

VOCs were detected in only two surface water samples: 2 ug/L toluene in a sample from White Alice Creek, and 2 to 4 ug/L of benzene, toluene, chlorobenzene, and trichloroethene in a sample from Heart Lake at Milrow. One SVOC (diethylphthalate) was detected in the surface water sample from Heart Lake, at 23 ug/L.

1.2.3.2 1997 DOE Chemical Sampling

The DOE visited Amchitka again in 1997 to conduct an investigation for radionuclides in plants and sediments collected from streams draining the three nuclear test sites, as well as from one reference stream. In addition to radionuclides, approximately half of the stream sediment samples were analyzed for a list of 32 metals and total organic carbon (TOC). Three samples of drilling mud were also collected from the Long Shot mud pits and analyzed for 32 metals and diesel range organics (DRO). A summary of the 1997 chemical results is provided in Appendix B. The 1997 sample locations also sampled during 1998 and the number of samples collected in 1997 are listed by site below.

Cannikin White Alice Creek (three samples)

Long Shot Southern drainage stream (Cloudberry Creek; one sample) and four mud pits (two composite samples and one duplicate sample)

The results for these 1997 sediment analyses are included in the discussion of the 1998 results in the appropriate subsections of Section 4.0 of this report.

1.2.3.3 1997 DOE Radionuclide Sampling

In 1997, the EPA's Radiation and Indoor Environments National Laboratory (EPA-R&IE), by interagency agreement with the DOE Nevada Operations Office (DOE-NV), conducted radiological sampling of aquatic plants and sediment on Amchitka. This work was designed to identify the presence or absence of manmade radionuclides in aquatic plants and stream sediments near the three underground nuclear test sites, and determine whether they could be attributed to cavity leakage or worldwide fallout. Samples of aquatic vegetation and sediment were collected primarily from streams within the drainage basins associated with the Cannikin, Milrow, and Long Shot test sites. Reference samples were collected from a stream located southwest of Drill Site D. Samples were also collected from ponded water in the three mud pits associated with the drilling of the Long Shot test hole. Results from these analyses are not yet validated and therefore not presented in this report.

1.2.3.4 Aircraft Graveyard

There have been several previous sampling events at the Aircraft Graveyard. These have included the analysis of samples for both organic and inorganic compounds. In requesting that the DOE perform the 1998 sampling, the only contaminants of concern identified by the USFWS for this study at the Aircraft Graveyard are PCBs. For this reason, the following discussions of past sampling events present the results of PCB sampling only.

The USFWS collected a single composite soil sample at the Aircraft Graveyard in 1985. No PCBs were found above the method detection limits. In 1993, the USFWS collected two surface soil and two sediment samples from the Aircraft Graveyard. Low levels (from 0.001 to 0.08 mg/kg) of individual PCBs were found in each of the four samples.

In 1995, Foster Wheeler Environmental Corporation performed a Site Inspection on Amchitka that targeted the eleven MOA sites in the USFWS Database. A comprehensive sampling program was conducted at the Aircraft Graveyard including a geophysical survey and the collection of surface soil, surface water, sediment, subsurface soil, and groundwater samples. Screening samples were collected first and analyzed in an on-island laboratory (using immunoassay test kits) to target potentially-contaminated areas. These potentially-contaminated areas were then resampled for analysis by an off-site laboratory. Off-site analyses reported just less than 0.5 mg/kg PCBs in one soil and one sediment sample, and 3.7 and 19 ug/L PCBs in two water samples. The results of these investigations are included in Section 4.10.1 of this report.

1.2.4 Current Site Status

Since 1980 Amchitka Island has been part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge. Protected status for the island was originally established by Executive Order 1733 in 1913, which created the Aleutian Islands Reservation, a "preserve and breeding ground for native birds, for the propagation of reindeer and fur bearing animals, and for the encouragement and development of the fisheries." The Alaska Maritime National Wildlife Refuge is managed by the USFWS of the Department of the Interior. Although Amchitka Island is part of the wildlife refuge, Executive Order 1733 also stated, "The establishment of this reservation shall not interfere with the use of the islands for lighthouse, military, or naval purposes, or with the extension of the work of the Bureau of Education on Unalaska and Atka Islands." This provision ensures that future human occupancy will be limited to defense-related needs.

Under the Alaska National Interest Lands Conservation Act, about 22,000 acres on Amchitka were designated as National Wildlife Refuge Wilderness Area. The USFWS continues to focus on non-intensive use and protective management of the island, focusing special concern on the plight of the Aleutian Canada goose. It is anticipated that the island will continue to be used for biological research.

During WWII there were reportedly about 2,000 structures on Amchitka. About 400 of these were demolished at the end of AEC operations on the island in 1973. In 1986, the Corps completed a cleanup project that resulted in the demolition of most of the remaining WWII buildings and debris in the Base Camp area. A few structures were saved for historical purposes.

When the Navy left Amchitka in 1993, portions of the retractable over-the-horizon radar (ROTHR) equipment were removed from the island. Although the radar was designed to be relocatable, the substantial effort expended to remove the system indicated that the Navy did not

intend to reoccupy the island in the near future. At the current time the Navy is considering the demolition of some or all of the structures they constructed on the island in the late 1980s. Therefore, they apparently have no intention of reoccupation.

Based on foreseeable human use of Amchitka, the only current users are trespassers from passing fishing vessels that visit the island on occasion and USFWS researchers who spend very limited periods on the island. Near-term occupants of Amchitka will primarily be personnel conducting wildlife research, environmental investigations, remediation, or demolition work. This occupation of the island would consist of a limited number of personnel working for tours of duty that are far shorter than the exposure duration involved in a typical residential or industrial use scenario. The scenario of occasional visitors should be protective of transient future use. The primary concern is ecological exposure, rather than human health issues.

1.3 OVERALL PROJECT OBJECTIVES

The primary objective of this 1998 Drill Site Investigation is to provide an assessment of the current and potential impacts to the freshwater environment on Amchitka caused by DOD and AEC drilling activities. A secondary objective is to assess whether the Aircraft Graveyard is a source area for PCBs that may be migrating from the site. Specific objectives include:

- Provide chemical data on the levels of contaminants in the surface water and sediments from streams potentially impacted by drilling mud. These data will be used by IT Corporation to assess the potential risk to ecological receptors in the streams.

- Use data developed from taxonomic identification studies, bioassays, and a triad analysis of stream sediments to: (1) provide an assessment of the current population and diversity of invertebrates in the potentially impacted streams; (2) compare these populations to populations that exist in unimpacted reference streams; (3) determine whether COPCs are present in the sediment at levels that cause a measurable impact to invertebrates in bioassay tests; and (4) determine whether there is a statistically significant correlation between COPC concentrations and impacts on invertebrate abundance or diversity.

- Provide chemical data on the concentrations of contaminants in drilling mud, sediments, and surface water in remaining mud pits and lakes used for mud storage. Also provide estimates of the volume of mud remaining in the pits and the condition of the pit walls. The data will be used to evaluate whether any future remedial actions may be warranted.

- Provide data on the concentrations of chemical COPCs in the tissue of fish collected from four reference streams that drain the three drill sites, and three test sites.

Compare the results of the analyses to assess the possibility of current impacts to fish by COPCs from historic drilling mud releases.

- As a secondary objective, provide data on the levels of radionuclides in the tissue of fish collected from streams that drain the three test sites. The results of the analyses were to be compare to the results of fish collected from two reference streams, assess whether radionuclides are present at levels exceeding those that would be expected from worldwide fallout from atmospheric testing. Fish were also collected from Cannikin Lake for analysis of radionuclides. A scarcity of fish in most streams required modification of this objective.

- Provide an assessment of whether PCBs are migrating at levels of concern from the Aircraft Graveyard in sediment, surface water, and/or groundwater. Previous investigations have suggested the presence of PCBs at the site. PCBs have been identified by the USFWS as a concern due to studies of birds, mammals, and fish on Amchitka with identified levels of PCBs that are higher than in ecological equivalents elsewhere (Merritt and Fuller, 1977).

The specific data quality objectives (DQOs) of the 1998 Drill Site Investigation, and the types and quality of data needed to meet these objectives and fill the data gaps, are described in detail in Table 1-1.

1.4 REPORT ORGANIZATION

This Drill Site Characterization Report is presented in six sections, including this introduction. Section 2.0 summarizes the scope of the field investigation and the field and analytical procedures used during the investigation. Section 3.0 presents a synopsis of the environmental setting of the island, based on observations during this investigation and the results of the AEC bioenvironmental studies during the late 1960s and early 1970s. Section 4.0 is divided into subsections that describe the results (both field observations and laboratory analyses) at each of the sites investigated during the 1998 field season. Section 5.0 summarizes the conclusions of the 1998 Drill Site Investigation. Section 6.0 is a list of the references used in this report.

In Sections 1.0 and 2.0 of this report, tables and figures are presented at the end of each section. Section 4.0 is divided into subsections (4.1, 4.2, etc.) for each of site. Tables, figures, and photos pertaining to a given site appear at the end of each respective subsection.

Appendices to this report present data and documentation supporting the discussions in the text. Appendix A is a summary of the field modifications to the activities and procedures described in the *Final Management Plan*. Appendix B contains figures and tables summarizing the results of applicable previous sampling of surface water and sediment by DOE. Appendix C consists of an assessment of the laboratory data quality. Appendix D presents the calculation of naturally occurring background concentrations of metals. Appendix E (included only in selected copies of

this draft report) is an electronic "disk" file, in Microsoft Excel 6.0 format, of the laboratory results for the investigation. Appendix F contains the Triad Assessment Report prepared by IT Corporation based on an evaluation of the results of the invertebrate taxonomy, bioassays, and sediment chemistry results. These appendices are contained in Volume I of this Site Characterization Report.

Two copies of Volumes II of this report, which have been provided to the DOE, contain additional supporting documentation from the 1998 investigation. Appendix G presents tabulated results of all laboratory data printed from the Excel file in Appendix E. A single hard copy and electronic copy of the laboratory report have also been transmitted separately to the DOE. Appendix H includes copies of all Chain of Custody forms. Appendix I consists of copies of the field notes. Appendix J includes copies of the ecological reconnaissance forms completed as part of the investigation of site-related and reference streams.

TABLE 1-1
DATA QUALITY OBJECTIVES FOR THE 1998 DOE DRILL SITE INVESTIGATION

DATA QUALITY OBJECTIVES	WORK ELEMENT	DATA TYPE AND QUALITY	DATA USE
Determine surface water and sediment quality in drilling mud pits and lakes used for drilling mud storage	•Visual assessment •Sediment and surface water sampling	•Qualitative documentation, mapping, and photographs •Level I field screening data for VOCs •Level II measurement of water quality parameters •Level III analyses for appropriate COPCs	•Determine the presence or absence of drilling mud in mud pit and lake sediment •Determine the presence or absence of drilling-mud additives in mud pit or lake surface water and sediment •Determine whether ecological risks potentially exist by comparing to available screening levels •Support development of remedial alternatives, if required
Determine surface water and sediment quality in streams and lakes potentially impacted by releases of drilling mud and background surface water and sediment quality in comparable reference streams	•Visual assessment •Sediment and surface water sampling	•Qualitative documentation, mapping, and photographs •Level I field screening data for VOCs •Level II measurement of water quality parameters •Level III analyses for appropriate COPCs	•Determine the presence or absence of drilling mud in stream and lake sediment •Determine whether COPC concentrations in site-related streams exceed those in comparable reference streams •Determine whether ecological risks potentially exist by comparing to available screening levels •Support a triad approach to determine the potential effects of drilling mud on impacted streams •Support development of remedial alternatives, if required
Determine bioavailability of COPCs in sediment in streams potentially impacted by releases of drilling mud	•Sediment sampling	•Level III analyses for Acid Volatile Sulfides and Simultaneously Extracted Metals, and total organic carbon	•Support the ecological risk assessment
Determine benthic invertebrate abundance and diversity in streams potentially impacted by releases of drilling mud, and in comparable reference streams	•Reconnaissance by biologist/ecologist •Collection of benthic invertebrate samples	•Qualitative documentation, mapping, and photographs, including completion of Rapid Bioassessment field forms •Taxonomic identification and tallying of invertebrates	•Determine whether invertebrate abundance and diversity in site-related streams is significantly different than in comparable reference streams •Support a triad approach to determine the potential effects of drilling mud on impacted streams
Determine toxicity of sediment in streams potentially impacted by releases of drilling mud, and in comparable reference streams	•Collection of sediment samples for bioassay tests	•Level II bioassay tests	•Determine whether possible COPC-related toxicity of sediment in site-related streams exceeds that in comparable reference streams •Support a triad approach to determine the potential effects of drilling mud on impacted streams

TABLE 1-1 (cont.)
DATA QUALITY OBJECTIVES FOR THE 1998 DOE DRILL SITE INVESTIGATION

DATA QUALITY OBJECTIVES	WORK ELEMENT	DATA TYPE AND QUALITY	DATA USE
Determine concentrations of chemical COPCs in fish tissue from streams potentially impacted by releases of drilling mud, and from comparable reference streams	•Collection of fish samples	•Level III analyses for appropriate COPCs, but only if COPC concentrations in surface water or sediment in the site-related stream exceed background concentrations in the associated reference streams	•Support the ecological risk assessment
Determine concentrations of radionuclides in fish tissue from test site streams, and from comparable reference streams	•Collection of fish samples	•Level III analyses for appropriate radionuclides	•Determine whether radionuclide concentrations in fish tissue from test site streams exceed those expected from worldwide fallout from atmospheric testing (based on comparison to fish from reference streams)
Determine concentrations of radionuclides in fish tissue from Cannikin Lake	•Collection of fish samples	•Level III analyses for appropriate radionuclides	•Determine whether radionuclide concentrations in fish tissue from Cannikin Lake exceed human health ingestion benchmarks
Determine stability of remaining mud pits	•Visual assessment	•Qualitative documentation, mapping, and photographs	•Determine potential for catastrophic releases of water or drilling mud from remaining mud pits •Support development of remedial alternatives, if required
Determine whether Rifle Range Road Sumps have been backfilled	•Visual assessment •Discretionary sediment and surface water sampling, if warranted	•Qualitative documentation, mapping, and photographs •Level III analyses for appropriate COPCs if discretionary sampling is authorized	•Determine the presence or absence of drilling mud in mud pit sediment •Determine the presence or absence of drilling mud additives in mud pit surface water and sediment •Determine whether ecological risks potentially exist by comparing to available screening levels •Support development of remedial alternatives, if required
Characterize potential off-site migration of PCBs from the Aircraft Graveyard	•Visual assessment •Groundwater, sediment, and surface water sampling	•Qualitative documentation, mapping, and photographs •Level II measurement of water quality parameters •Level III analyses for PCBs	•Determine whether ecological risks potentially exist by comparing to available screening levels •Support development of remedial alternatives, if required
Identify the presence of OEW/UXO	•Visual assessment •Magnetometer survey	•Qualitative documentation based on visual assessment and magnetometer surveys	•Safety of field crews

NOTE: Quality assurance objectives and sample quantitation limits for individual analytes are presented in Tables 6-2 through 6-5 of the August 1998 *DOE 1998 Drill Site Investigation Management Plan*, and in the Shannon & Wilson's December 1996 final *Quality Assurance Project Plan* for the Corps Phase I Remedial Investigation.

2.0 SITE INVESTIGATIONS

This section summarizes the scope and procedures used during the 1998 Drill Site Investigation on Amchitka. The work was performed in general accordance with the August 1998 *Final Management Plan, Department of Energy 1998 Drill Site Investigation, Amchitka Island, Alaska.* Where activities or procedures described in either that plan or the Corps December 1996 *Phase I RI Management Plan* were modified, the modification is described in attached Appendix A.

2.1 SCOPE OF FIELD INVESTIGATIONS

The 1998 Drill Site Investigation included:

- Sampling for chemical analysis of surface water and sediment (drilling mud) in former mud pits at each of the drill sites and test sites where they are still present, and in lakes that reportedly were used for mud storage.
- Sampling for chemical analysis of stream water and sediment in streams draining each of the drill sites and test sites, and in four reference streams.
- Sampling these same streams to determine the abundance and diversity of benthic invertebrates and to collect sediment samples for bioassays.
- Collection of fish for chemical analysis from these same streams.
- Collection of fish for radionuclide analysis from as many of the planned streams as contained a sufficient number of fish (this was limited to White Alice Creek, Cannikin Lake, and Cloudberry Creek at Long Shot, plus a background sample from Pumphouse Lake).
- Sampling surface water, sediment, and groundwater from the Aircraft Graveyard for PCB analysis.

Table 2-1 lists the number of features (mud pits, lakes, and streams) that were sampled at each of the drill sites. Conditions encountered in the field differed somewhat from those anticipated when the *Management Plan* was written, resulting in a greater or lesser number of mud pits, streams, or lakes being sampled than had been planned. Modifications to the scope of work are described in Appendix A.

The samples of sediment, water, and fish from each of these features were analyzed for different suites of parameters, as specified in the *Management Plan* and listed in Table 2-2. Table 2-3 summarizes the number of samples analyzed for each parameter, for each type of feature, at each site.

Sample locations are described in each subsection of Section 4.0 and illustrated in figures accompanying each subsection. Where applicable, such as for samples collected at various stations along the length of a stream, tables in those subsections list the latitude and longitude of each sample location (determined with hand-held Global Positioning System [GPS] receivers).

Those tables also include the elevation of each stream sample location, interpolated for the topographic maps of the streams.

The field investigation was conducted between August 26 and September 17, 1998, by a crew consisting of the following:

Shannon & Wilson, Inc.	Management and field work (11 persons)
EcoMunition, Inc.	UXO avoidance (4 persons)
Fairweather, Inc.	Emergency medic
Security Aviation	Aircraft support
Clearwater Environmental, Inc.	Camp services

Also present in the field during this investigation were Mr. Frank Maxwell of the DOE and Mr. Mike Murray of IT Corporation, under their support contract to the DOE. Both of these individuals assisted substantially in the field effort in addition to their role as oversight personnel. Mr. Doug Dasher of ADEC was also present during most of the investigation, during which time he participated in research for ADEC and provided a limited oversight for the field investigation.

During the course of the field work, Shannon & Wilson also collected samples for the U.S. Army Corps of Engineers in support of the Phase II Remedial Investigation of the former Amchitka Army Air Base (under Delivery Order 0020). The results of that work have been reported separately and are not included in this report. In addition, camp and logistics support was also provided for a field team from the ADEC, who performed sampling for radionuclides as part of a separate investigation.

2.2 ANALYTICAL PROCEDURES

2.2.1 Types of Analytical Procedures

Analytical procedures used in the field in support of the 1998 Drill Site Investigation included:

- headspace gas screening with photoionization detectors (PIDs) for field screening of volatile organic compounds (VOCs) in soils, and
- measurements of water quality parameters (temperature, pH, conductivity, dissolved oxygen [DO], and turbidity) at the time of collection of groundwater and surface water samples.

All other analyses were conducted in an off-site analytical laboratory and consisted of Level III analyses. The suites of laboratory analyses performed on samples from a given category of site were agreed upon during project scoping and described in the final *Management Plan*. There were no substantive deviations from that plan. Table 2-3 summarizes the numbers of analyses performed on samples from each medium at each site.

2.2.2 Analytical Laboratories

The project chemistry laboratory was the Bothell, Washington, facility of North Creek Analytical (NCA). All soil and water samples were analyzed in Bothell, with the exception of the 5035/8260 field-extracted volatiles analyses on sediment samples, since only the Portland facility of NCA was set up to perform these analyses. All chemical analyses of fish tissue were performed in the Portland facility, except as noted below.

Analysis of inorganic arsenic in fish tissue was performed at the Battelle Marine Sciences Laboratory in Sequim, Washington.

The radionuclide analyses on fish tissue were performed at the Charleston, South Carolina, facility of General Engineering Laboratories (formerly known as Environmental Physics, Inc.).

Identification of invertebrates in the stream sediment samples was performed in the Somerset, New Jersey, office of IT Corporation, under subcontract to DOE.

American Aquatics Testing, Inc., in Allentown, Pennsylvania, under subcontract to IT Corporation, performed bioassay tests using the stream sediment samples.

Organic content and grain-size analyses on stream sediment samples were performed in Shannon & Wilson's Fairbanks, Alaska, soil laboratory.

2.2.3 Analytical Methods

The following sections discuss the laboratory procedures used for the chemical analysis of sediment and water samples, chemical and radionuclide analysis of fish tissue samples, and invertebrate taxonomy and bioassay tests.

2.2.3.1 Chemical and Physical Analyses of Sediment and Water

Chemical and physical analyses of sediment and water samples were performed using the following methods:

Gasoline Range Organics (GRO)	AK 101
Diesel Range Organics (DRO)	AK 102
Volatile Organic Compounds (VOC)	EPA 5035/8260B
Polycyclic Aromatic Hydrocarbons (PAHs)	EPA 8270C SIM
PCBs only	EPA 8082
Modified TAL Metals	EPA 6020/6010B
Total Organic Carbon	E415.1
Acid Volatile Sulfides	EPA August 1991 draft
Simultaneously Extracted Metals	EPA 6020/August 1991 draft

Organic Content	ASTM D 2974
Grain Size	ASTM C 136-92

Tables within each subsection of Section 4.0 list field sample numbers and reported concentrations of all analytes detected in project samples. Detection limits for nondetected compounds are presented in the electronic file contained in Appendix E of some copies of this report. Two copies of Volume II, which in Appendix G contains tables of all laboratory results, have been provided to the DOE.

The following subsections discuss pertinent issues regarding the test methods performed for this project.

2.2.3.1.1 Gasoline Range Organics

Alaska Method AK 101 quantifies C_6 through the start of C_{10} as gasoline range organics (GRO). Gasoline was not a COPC for the Drill Site Investigation. The only samples that were analyzed for GRO were three sediment samples collected from Cannikin Lake downhill from the area previously referred to as a landfill. GRO was analyzed in those samples to test for a broader range of possible contaminants than the COPCs associated with the drilling mud.

2.2.3.1.2 Diesel Range Organics

Alaska Method AK 102 quantifies C_{10} through the start of C_{25} as diesel range organics (DRO). DRO was analyzed because the historical information and results of past sampling had documented the presence of DRO in the drilling mud used on Amchitka. Since ecological risk benchmarks are not available for whole diesel fuel, the risk associated with diesel fuel can only be assessed using a surrogate approach, unless constituent concentrations are known. For this reason, diesel constituents including VOCs and PAHs were also analyzed in all potentially diesel-impacted media. DRO was analyzed in both water and sediment, because low levels of DRO can often be detected in water or sediment when the diesel-associated VOCs and PAHs are not present above their detection limits (i.e., DRO is a more sensitive test). However, naturally occurring organic compounds can be quantified within the diesel range, which complicates the interpretation of instances where low levels of DRO are reported. As discussed further in Sections 2.3.1.5 and 2.3.2.5, DRO suspected to be of biogenic origin was reported in both water and sediment from reference streams.

2.2.3.1.3 VOCs

Analysis for VOCs by EPA Method 8260B was conducted to provide data for assessment of the possible risk posed by the potential presence of alkylated benzenes from diesel fuel. The results from the 1998 Drill Site Investigation were similar to those from obtained samples of diesel fuel believed to be of WWII age during the Corps 1997 Phase I RI. Benzene and toluene was

detected in only three mud pit samples. However, ethylbenzene, xylenes, and several of the other alkylated benzenes were detected in several samples (including trimethylbenzenes; butyl-, propyl-, and isopropylbenzenes; and isopropyltoluene). A list of the individual VOCs included in Method 8260B is provided in Table 2-4.

In accordance with current EPA and Corps guidance, EPA Method 5035 was used to preserve or extract sediment samples for analysis of VOCs in the field at the time of collection. Samples with "low" levels (0 to 200 ug/kg) of individual volatile constituents were preserved in the field using an aqueous acid solution. Samples with "high" levels (greater than 200 ug/kg) of individual constituents were extracted in the field using methanol. This preparation method, described in greater detail in the August 1998 *Management Plan*, involved collecting both a low level sample and a high level sample from each sampling location. The laboratory analyzed either one or both of these samples, depending on whether the results of the first analysis were within the applicable range for the method. The data tables in the various subsections of Section 4.0 present the highest valid result for each sample or the lowest valid reporting limit for nondetected compounds.

All water samples from the drill site mud pits, lakes, and streams were analyzed for VOCs. A minimum of one sediment sample per drill site was analyzed for VOCs. Reference stream water and sediment were not analyzed for VOCs. Other stream sediment samples were analyzed for VOCs only if the sample location exhibited evidence of possible hydrocarbon contamination.

2.2.3.1.4 PAHs

All drilling mud, sediment, and surface water samples collected during the 1998 Drill Site Investigation (except reference stream samples) were analyzed for PAHs by EPA Method 8270C SIM (selective ion method). Samples from reference streams were not analyzed for PAHs, since they are not commonly found as naturally occurring compounds. A list of individual PAHs included in Method 8270C SIM is provided in Table 2-5.

According to Kent Patton of North Creek Analytical, eight of the 16 PAHs fall within the range quantified as DRO by Method AK 102, and another two PAHs are probably quantified within this range. This group includes:

Acenaphthene	Chrysene	Phenanthrene
Acenaphthylene	Fluoranthene	Pyrene
Anthracene	Fluorene	
Benzo (a) anthracene	Naphthalene	

Naphthalene is on the analyte list both for PAHs and for VOCs. The data tables in the various subsections of Section 4.0 present the highest valid naphthalene result for a given sample, or the

lowest valid reporting limit for a nondetected compound, regardless of the test method. For consistency, naphthalene is listed in the "volatiles" section of those tables.

2.2.3.1.5 PCBs

PCBs were originally a COPC only at the Aircraft Graveyard (the MOA site at which a follow-up investigation was performed in conjunction with the 1998 Drill Site Investigation). A field modification to the sampling plan added analysis for PCBs for three surface water and sediment samples collected from Cannikin Lake downslope from the area that USFWS representatives thought might be a landfill. PCBs were analyzed in those samples because of the potential for PCBs to have been used and disposed at the test site. The reporting of low levels of PCBs in two of those sediment samples resulted in the additional analysis of sediment samples from the Cannikin site and White Alice Creek for PCBs, to evaluate the extent of PCBs at the site. The results of these additional analyses included two more detections of PCBs, and so an additional group of drilling mud samples from Drill Site D were analyzed for PCBs to assess whether the drilling mud was a potential source of the PCBs identified. Sediment samples from three reference streams were also tested for PCBs. Table 2-6 lists the individual PCB analytes in Method 8082.

2.2.3.1.6 Metals

The list of trace elements and heavy metals (which are collectively referred to in this report as metals) analyzed for the 1998 Drill Site Investigation, presented in Table 2-7, is a modification of the EPA target analyte list (TAL) metals list. This list of metals, which does not include the entire TAL but includes additional metals, was developed by IT Corporation based on a review of metals detected in sediment, surface water, and drilling mud in previous DOE sampling events. Metals were retained as COPCs (and included in the list to be analyzed during the 1998 investigation) if they either exceeded ecological benchmarks in previous sampling, or if no ecological benchmark is currently available.

2.2.3.1.7 Total Organic Carbon

Total organic carbon (TOC) was determined for all stream sediment samples. TOC is a measure of the amount of organic carbon (both naturally occurring and as a result of the presence of hydrocarbons such as diesel fuel) in sediment. TOC impacts the bioavailability of contaminants such as PAHs. Ecological risk-based screening levels are typically expressed as a contaminant concentration normalized to the organic carbon content of the sediment; thus the need to quantify the carbon content. TOC was not determined for drilling-mud samples from the mud pits, since the diesel fuel in the mud would have biased the results high. In addition, little organic carbon would be expected in bentonite-based drilling mud (if the diesel were not present).

EPA Method 415.1 reports the organic carbon present in the sample but not other elements that are present in peat or other organic matter. As a result, the TOC does not equal the organic content (determined by ASTM D2974; see Section 2.2.3.1.9).

2.2.3.1.8 Acid Volatile Sulfides/Simultaneously Extractable Metals

Acid Volatile Sulfides/Simultaneously Extractable Metals (AVS/SEM) is a method used to assess the bioavailability of metals. This is done by determining the acid volatile sulfides and metals that are solubilized during the acidification step. SEM are extracted with a weaker acid than is used during the analysis of total metals in a sediment sample; thus it can be expected that SEM concentrations will be lower than the corresponding total metals concentration for the same sample. This method measures the capacity of the sulfides in the sediment to bind metals and provides an indication of whether that binding capacity is completely utilized. If the SEM to AVS ratio is greater than 1, the available metals exceed the binding capacity of the sulfides and the metals are available for uptake by organisms. Conversely, if the SEM to AVS ratio is less than 1, the metals are completely bound by sulfides and not available for uptake by organisms. The metals are analyzed by EPA Method 6020 following the extraction step. All stream sediment samples, including reference streams, were analyzed by this methodology to support the ecological risk assessment being performed by IT Corporation. The only metal COPCs specific to the 1998 Drill Site Investigation for which the AVS/SEM procedure is applicable are cadmium, copper, nickel, and zinc. These were the only metals analyzed by the laboratory by the SEM methodology. Mercury and lead are also commonly included in AVS/SEM analyses but were not COPCs for this investigation.

2.2.3.1.9 Organic Content

Organic content determination by ASTM Method D 2974 is a method to determine the amount of plant organic matter in a sample that is lost by ignition at 750°C. In a few rare cases, some mineral soil is also subject to transformation at this temperature and would be included in the reported result. The weight loss after ignition is expressed as a percent of the dry weight of the mineral soil fraction of the sample. Since this method results in the ignition of the entire organic fraction of the sample and not just the carbon, the organic content measured by this method will be greater than the TOC value determined by Method E415.1 (described in Section 2.2.3.1.7). Also, since the amount of organic material is expressed as a percentage of the weight of the mineral soil, it is possible to have an organic content higher than 100 percent.

2.2.3.1.10 Grain Size

Grain size analyses were performed by ASTM Method C 136-92 on the sediment samples that had a substantial mineral soil fraction. The sample is first washed over a #200 sieve (about 0.07 millimeter openings). The fraction of soil lost through this sieve represents the silt- and clay-sized particles. The soil retained on the #200 sieve is dried and then sieved through a nest of

other sieve sizes. The soil retained on each sieve is weighed, and a grain size plot is drawn that graphically depicts the percentage of soil (on a dry weight basis) that is coarser or finer than each sieve size. Since organic material has a considerably lower specific gravity than soil grains, this test would be inaccurate for samples with a high organic content. Accordingly, grain size analyses were performed only on samples with an organic content less than about 16 percent.

2.2.3.2 Chemical Analysis of Fish

Fish samples were to be tested for selected COPCs found at elevated levels in stream sediment or water. Based on test results from stream water and sediments, the fish samples from drill/test site and reference streams were analyzed for metals, PAHs, PCBs, and inorganic arsenic. Selected fish samples were also analyzed for lipids. PCBs were added to the list of analyses after they were detected in Cannikin Lake sediments, to determine the presence or absence of PCBs in fish from Cannikin Lake and from project streams. Inorganic arsenic was added after initial metals results showed relatively high concentrations of total arsenic in fish.

Chemical analyses of fish samples were performed using the following methods:

Modified TAL Metals	SW6020
PAHs	SW8270C SIM
PCBs	SW8081
Inorganic Arsenic	EPA Draft Method 1632
Lipids	Percent Lipids

Tissue preparation and extraction methods varied for different test methods. Discussions of the analyses are presented below.

2.2.3.2.1 Metals

Fish samples were prepared using EPA Method SW 200.3. This method specifies sample preparation procedures for the determination of total recoverable elements in biological tissue. Up to 5 grams of frozen whole fish sample were transferred to a flask and digested with nitric acid, hydrogen peroxide, and heat. This digestion results in a clear solution that is then analyzed by EPA Method SW6010B/SW6020 series inductively coupled plasma/mass spectroscopy (ICP/MS), in accordance with the procedures described in the *1998 DOE Management Plan*. For comparison, the same metals were analyzed in fish, sediment, and water. The list of metals was developed by IT Corporation based on a review of metals detected during other DOE projects.

2.2.3.2.2 PAHs

Fish samples were prepared using a procedure developed in accordance with EPA Region 10, Puget Sound Water Quality Authority guidance document "*Recommended Guidelines for*

Measuring Organic Compounds in Puget Sound Water, Sediment, and Tissue Samples", February 1996. The method requires that approximately 60 grams of whole fish be placed in a blending device, ground, and homogenized until tissue becomes a paste. The paste is combined with sodium sulfate to prepare an extract that is then analyzed using EPA SW8270C SIM.

2.2.3.2.3 PCBs

During project planning PCBs were not considered as a COPC for fish on Amchitka. However, PCBs were tested for and detected in two sediment samples from Cannikin Lake as well as in drilling-mud pits. Consequently, it was decided that fish samples should be analyzed for PCBs to determine whether they were present and, if so, to what extent. The test method for PCBs is the same one used for sediment; however, the extraction procedure for fish tissue is performed differently.

2.2.3.2.4 Inorganic Arsenic

After initial metals results revealed relatively high total arsenic concentrations, it was decided to perform inorganic arsenic analyses to determine the concentration of the form(s) of arsenic believed to be potentially harmful to fish and mammals. The organic component of total arsenic, arsenobetaine, is not believed to be bioavailable to animals. Inorganic arsenic is typically on the order of 1 percent of total arsenic.

An aliquot of fish homogenate (blended whole fish) for each sample was sent to a Battelle Marine Science Laboratory for the analysis. The preparation of tissue sample involves taking 1 gram of wet tissue and digesting it in 10 ml of hydrochloric acid solution. The digestate is then heated in an oven for several hours. EPA Draft Method 1630 was then performed on the extract.

2.2.3.2.5 Lipids

The percent of lipids by weight was measured in six fish samples. Aliquots from the laboratory-prepared blended fish samples were used. The samples were selected to represent the different size ranges of fish collected during the project. The whole fish was homogenized, including guts, heads, fins, and tails, prior to testing.

Lipids were originally scheduled for testing from a variety of fish before it was evident that only one species of fish (resident Dolly Varden) would be collected for the project. The percent lipids would be expected to vary between species.

2.2.3.3 Radionuclide Analysis of Fish

Fish samples were to be collected from the streams draining the three test sites, two lowland reference streams, and Cannikin Lake for analysis of radionuclides. However, priority was given to collecting fish for chemical analyses, and there were insufficient fish to allow both chemical and radionuclide analyses except in White Alice Creek (downstream of Cannikin Lake), Cloudberry Creek (Station 1, near Long Shot), and Cannikin Lake. Sufficient fish were present in the other streams to allow fish to be collected for chemical analyses. A background fish sample for radionuclide analysis was collected from Pumphouse Lake (Lake Aldine), located about 0.8 miles south of the east end of Baker runway in the Base Camp area.

The detonation-related radionuclides of potential concern for fish tissue are cesium-137, plutonium-238, plutonium-239, plutonium-240, and americium-241. Alpha spectrometry was used to quantify the levels of americium and plutonium. Plutonium was quantified as plutonium-238 and plutonium-239 plus plutonium-240. The alpha spectrometry method used was developed in accordance with the Department of Energy's Environmental Measurements Laboratory (EML) Methods Manual HASL 300 E-U-04, and the EPA's Environmental Monitoring and Support Laboratory's Radiochemical Analytical Procedures for Analysis of Environmental Samples, 1979. This method was described in a standard operating procedure provided in Appendix E of the August 1998 *Management Plan*. Test results are reported on a dry weight basis.

Gamma spectroscopy was used to quantify cesium-137 isotope levels. The test method was developed from EPA 600-4-80-032 Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA Method 901.1). This method was also described in a standard operating procedure provided in Appendix E of the August 1998 *Management Plan*. Test results are reported on a dry weight basis.

With the exception of the Cloudberry Creek sample, the fish samples submitted for radionuclide analysis were gutted, either in the field or in the lab, and the guts and fish bodies analyzed separately. The separate analyses allowed for a distinction between measurement of the radionuclide burden in the fish gut and in the fish itself. If the fish had recently ingested an anomalous burden of radionuclides, it was desired to be able to distinguish this from the burden in the gutted fish. The gastrointestinal tract contents were not emptied prior to analysis of the guts. The samples consisted of composited multiple fish guts and bodies. Compositing was done not as an attempt to integrate the measurement over multiple fish, but rather because the individual fish were too small to achieve the desired reporting limits. The composite fish and gut samples were ground and homogenized before analysis.

2.2.3.4 Triad Assessment Approach

Sediment quality in site and reference streams was evaluated by IT Corporation using a weight-of-evidence approach known as a Sediment Quality Triad. A copy of the Triad analysis report is

included in Appendix F. It includes complete descriptions of the methods employed and results of that study.

In summary, the Triad approach incorporates three measures of sediment quality: sediment chemistry, sediment bioassay or toxicity, and benthic macroinvertebrate (BMI) community structure. These three components of the Triad approach integrate chemical and biological response information and can provide stronger evidence of degraded sediment quality than evaluation of any single component.

Sediment chemistry information was based on DRO, metals, and PAH analyses of sediment from each stream, as discussed in the appropriate subsections of Section 4.0. Sediment toxicity was determined by conducting bioassays on sediment samples collected from streams from the same locations where invertebrates were collected. These samples were submitted to American Aquatics Testing, Inc., of Allentown, Pennsylvania, under subcontract to IT Corporation. Bioassay testing included normalized measurements of survival, growth, and biomass of the midge *Chironomus tentans*, in accordance with ASTM Method E 1706-95b (1997). The BMI community component of the Triad approach included determining the Family Biotic Index (FBI), Ephemeroptera-Plecoptera-Trichoptera (EPT) relative abundance, and species diversity of BMI samples collected in project streams.

2.2.4 Sampling Handling and Transportation

Sample containers were supplied by the laboratory in a pre-cleaned and pre-preserved condition. Upon collection all samples were placed directly into the appropriate sample containers, which were then placed directly into coolers chilled with ice substitute. At the end of each day, the samples were transferred to temperature-controlled refrigerators at the camp for storage until they could be shipped to the laboratory. The samples were packaged for shipment to the analytical laboratory with sufficient coolant to maintain the sample temperature at or near 4°C until they reached the laboratory.

Samples were generally packed and shipped from Amchitka to Adak by charter aircraft the day before a scheduled twice-weekly Reeve Airlines flight was due in Adak. On Adak, an agent of Clearwater Environmental took custody of the coolers and stored them in a cool, secure location. The coolers were then shipped to Anchorage as priority freight on Reeve, arriving about 30 hours after they had been packed. In Anchorage the samples were retrieved by a representative of North Creek Analytical (NCA), who checked cooler temperatures, re-iced the coolers, and shipped them on a night flight to the Seattle-Tacoma Airport via Alaska Airlines Gold Streak service. There they were picked up by a NCA courier and transported to their Bothell laboratory, arriving about 48 hours after they originally left Amchitka. The exception to this procedure was on weekends, when there were no Reeve flights; in these instances, samples were flown directly from Amchitka to Anchorage on a charter aircraft.

All fish samples were stored and shipped in a frozen condition. Upon collection the fish were placed in resealable plastic storage bags, which were then placed into coolers chilled with ice

substitute. At the end of each day the fish samples were transferred to temperature-controlled freezers at the camp for storage until they were shipped to the laboratory. All samples were frozen as whole fish, with the exception of the samples for radionuclide analysis from White Alice Creek, Cannikin Lake, and Pumphouse Lake. These latter samples were gutted, and the gutted fish and the associated guts were frozen as separate samples. The samples were packaged for shipment with sufficient coolant to maintain the sample temperature well below 0°C until their arrival at their destination.

Fish samples were shipped from Amchitka only on charter flights directly to Anchorage, in order to reduce their length of time in transit. Fish samples for chemical analysis were retrieved by a representative of NCA, who re-iced the coolers, and shipped them on a night flight to the Portland Airport via Alaska Airlines Gold Streak service. There they were picked up by a NCA courier and transported to NCA's Portland laboratory, where they were stored in a secure freezer until analysis. The fish for radionuclide analysis were initially shipped via Alaska Airlines Gold Streak Service from Anchorage to Fairbanks, where they were stored in a secure freezer at Shannon & Wilson's Fairbanks office. After General Engineering Laboratories was under contract, the samples were shipped from Fairbanks to Charleston, South Carolina, via Federal Express.

Benthic invertebrate samples were preserved immediately after collection in 10 percent neutral-buffered formalin and shipped to IT Corporation at ambient temperature.

NCA analyzed samples from both the 1998 DOE Drill Site Investigation and the Corps Phase II RI. Therefore, samples from the two projects were often shipped in the same cooler, although separate chain-of-custody forms were completed for each project (see Appendix H). The laboratory also analyzed samples from both projects in the same sample delivery group and laboratory QC samples that were common to the two projects. Trip blanks common to the two projects were also analyzed.

2.2.5 Sample Numbering System

A modification of the Corps standard sample numbering system was used for sample number designation during the 1998 Drill Site Investigation. All samples were assigned a unique alphanumeric sample number using the following format:

98DOE - XXXX-YYYY-ZZ, where:

98DOE - 98 designates the last two digits of the sampling year; DOE denotes work on Amchitka Island for the Department of Energy (differentiated from work for the Corps of Engineers Phase II RI;

XXXX - is a four-character letter or letter and number combination, which differentiates the site at which the sample was collected, in accordance with the table presented below;

CANN:	Cannikin Site
LONG:	Long Shot Site
MILR:	Milrow Site
DRSD:	Drill Site D
DRSE:	Drill Site E
DRSF:	Drill Site F
ACGY:	Aircraft Graveyard
RS01:	Reference Stream 1
RS02:	Reference Stream 2
RS03:	Reference Stream 3
RS04:	Reference Stream 4

YYYY - is a four-digit consecutive sample number in order of collection; of the first digit identifies the number of the sampling team collecting the sample (1, 2, 3, or 4);

ZZ is a two-letter indication of the medium sampled (SL for soil, SD for sediment, SW for surface water, GW for groundwater, FS or FI for fish tissue, WR for equipment blank, TB for trip blank).

For example, sample number 98DOE-CANN-2012-SD represents: a sample obtained for DOE from Amchitka Island in 1998; collected at the Cannikin site; the twelfth consecutive sample collected by sampling team 2; and a sediment matrix.

Quality control (QC) duplicate samples were numbered with the consecutive number following the number of the sample they represent, so they could not be identified as QC samples by the laboratory personnel. For instance, if a field duplicate sample had been collected for the sample used in the above example, the duplicate sample number would be 98DOE-CANN-2013-SD. Rinsate blanks were labeled in a similar manner, but with the number prior to the next sample that was to be obtained with the cleaned equipment. In cases where additional sample volume was collected to allow matrix spike/matrix spike duplicate analyses by the laboratory, the same 4-digit "YYYY" number was used as for the project sample, except that the "ZZ" suffix was "MS."

2.3 REGULATORY AND RISK-BASED CRITERIA FOR CONTAMINANTS OF POTENTIAL CONCERN

The December 1996 *Management Plan* presents both regulatory cleanup levels and risk-based criteria for a number of contaminants of potential concern (COPCs) that might be encountered on Amchitka based on historical activities. These potential applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria (TBCs) were used in establishing appropriate project-specific detection limits for chemical analyses. In this report these comparison criteria are used to determine the significance of COPCs identified on the island.

Tables 2-8, 2-9, and 2-10 list all analytes that were detected in surface water, sediment, and fish collected during the 1998 Drill Site Investigation. These tables indicate the maximum concentration of each analyte reported by the laboratory as well as applicable regulatory and/or risk-based comparison benchmarks. Numbers of compounds detected in each medium are summarized below by analyte:

Compounds Detected During 1998 Drill Site Investigation

Analyte	Number of Compounds Detected in Surface Water	Number of Compounds Detected in Sediment	Number of Compounds Detected in Fish
VOCs	2	15	NA
PAHs	0	14	1
PCBs	0	2	1
Metals	22	27	25
Hydrocarbons	1	2	NA

NA – not analyzed

Regulatory and/or risk-based criteria were compared with surface water, sediment, and fish results as a basis for evaluating the significance of the compounds detected. Appendix D presents the calculated background concentrations for naturally occurring metals in surface water, sediment, and fish on Amchitka Island, based on concentrations in lowland and upland reference streams.

2.3.1 Comparison Criteria for Surface Water

Water cleanup levels have not been promulgated federally. The following subsections examine the available criteria against which the reported concentrations of organic and inorganic substances in the surface water samples from the 1998 Drill Site Investigation can be compared

2.3.1.1 18 AAC 75 Cleanup Standards

In Alaska the Oil and Other Hazardous Substances Pollution Control Regulations, 18 AAC 75, present groundwater cleanup standards for petroleum hydrocarbons, 92 organic compounds, and 14 metals. These numerical standards apply only to groundwater and not to surface water Surface water quality issues are addressed by the Alaska Water Quality Standards, 18 AAC 70 (discussed in Section 2.3.1.2).

Drinking water maximum contaminant levels (MCLs) serve as the basis for the Alaska groundwater cleanup standards (for the listed compounds for which MCLs exist), even though the MCLs were not originally promulgated as water cleanup levels. Therefore, the Alaska

groundwater cleanup levels are based on human health considerations. In cases where the groundwater is not currently being used as a drinking water source, and not reasonably expected to be used as a drinking water source, the Alaska regulations incorporate a provision whereby the cleanup standard may be increased by a factor of ten with appropriate approval. However, when the groundwater is closely hydrologically connected to surface water, the regulations require that the groundwater not cause an exceedance of the surface water quality standards listed in 18 AAC 70.

Where the regulations contain groundwater cleanup levels, they are included in Table 2-8 for reference as TBC criteria.

2.3.1.2 18 AAC 70 Water Quality Standards

The Alaska Water Quality Standards (AWQS) have also been applied as cleanup levels in some cases. Standards are established for protection of surface water for a particular use, such as drinking, growth, and propagation of shellfish, etc. There are several levels of regulation. First there is a general antidegradation policy. Petroleum hydrocarbons are not allowed to cause a film, sheen, or discoloration. Total aromatic hydrocarbons (defined as the sum of benzene, toluene, ethylbenzene, and xylenes [BTEX]) in the water column may not exceed 10 ug/L. Total aqueous hydrocarbons (defined as the sum of BTEX and 16 individual PAHs) in the water column may not exceed 15 ug/L. Concentrations of other toxic or deleterious organic and inorganic substances may not exceed the criteria in EPA *Ambient Water Quality Criteria* (AWQC; EPA, 1985), or if those criteria do not exist, the primary MCLs of the Alaska Drinking Water Standards, 18 AAC 80 (i.e., the MCLs upon which the groundwater cleanup standards in 18 AAC 75 are based).

Both AWQC and AWQS include separate criteria for freshwater and saltwater. The AWQC also include separate values for acute (maximum) and chronic (continuous) exposure for ecological receptors. The AWQS only have a single standard for each chemical, which is based on either acute or chronic exposures, or the level of detection where no "safe" level has been defined.

Where these provisions of 18 AAC 70 result in numerical standards, they have been included in Table 2-8.

2.3.1.3 Human Health Risk-Based Concentrations

The EPA Region III Risk-Based Concentration Table (EPA, 1999) presents concentrations of a variety of compounds that correspond to a target risk of 1×10^{-6} for carcinogenic effects, or a target hazard quotient of 1 for noncarcinogenic effects, for several exposure pathways, one of which is a standard drinking water scenario. Where available, and for chemicals for which no other comparison criterion exists, these RBCs are presented in Table 2-8 for use as a TBC.

2.3.1.4 Ecological Risk-Based Concentrations for Surface Water

Because Amchitka is currently uninhabited and future habitation is likely to occur under a controlled setting such as the recent use by the Navy for the ROTHR facility, ecological risk concerns are more likely to drive risk assessment issues on the island than are human health concerns.

Ecological risk-based screening concentrations (ERBSCs) for the compounds detected in both the mud pit water and stream water during the 1998 DOE Drill Site Investigation are presented in Table 2-8. These ERBSCs are based on: (1) National Recommended Water Quality Criteria, (2) EPA Tier II Secondary Chronic Values, and (3) EPA Region IV Chronic Screening Values. Where criteria were available from multiple sources, the lowest concentration has been listed in Table 2-8 and the source footnoted.

2.3.1.5 Surface Water Background Concentrations

The metals that were analyzed in most of the 1998 Drill Site Investigation samples also occur naturally in the soil and rock on Amchitka. Therefore, measurable concentrations of these metals may be naturally occurring in surface water on the island. To evaluate background concentration of naturally occurring metals, surface water samples were collected from four reference streams, each of which was selected because it appeared unlikely to have been impacted by DOE, WWII, or Navy activities on the island. Two of the reference streams (Streams 1 and 2) were located in lowland terrain in the vicinity of the three test sites, while the other two (Streams 3 and 4) were located in upland terrain in the vicinity of the three drill sites (Figure 1-2). Water samples from these streams were analyzed for the same list of metals as the samples from the site-related streams and mud pits. In addition, the reference stream water samples were analyzed for DRO to determine the possible presence of biogenic material that could be reported as part of hydrocarbon compounds. Field observations and laboratory results from the reference streams are presented in Section 4.9 of this report.

Metals concentrations in the reference stream water samples were examined statistically to evaluate whether upland and lowland reference streams were statistically similar. The methodology and results of this analysis are presented in Appendix D. The results indicate that the lowland and upland streams demonstrated a statistically significant difference. Therefore the lowland and upland results were pooled separately for the calculation background values. The 95 percent upper tolerance limit (95 UTL) background values are presented in Table 2-8 for comparison with the values from the site-related streams. For some metals the numbers of detections in the reference streams were so few that statistical analysis has no validity. For these metals Table 2-8 lists the highest value that was reported.

All of the lowland stream water samples were reported to contain DRO. Half of the upland stream water samples were reported to contain DRO. It is well known that biogenic material can be reported as part of hydrocarbon analyses such as DRO. However, laboratory method blanks associated with four of the ten lowland samples, and one of the five upland samples, were

reported to contain similar concentrations of DRO as reported in the samples. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. Thus some uncertainty exists whether the DRO reported in those samples is the result of biogenic compounds or of laboratory contamination. DRO results from the stream samples are summarized below.

DRO Concentrations in 1998 Reference Stream Water Samples

Location	DRO Concentration in ug/L			Number of Samples	
	Range		Mean (excluding contaminated blanks)	With DRO Detections	Associated with Contaminated Method Blank
	Minimum	Maximum			
Lowland Streams	51	146	92	10/10	5/10
Upland Streams	54	85	61	5/10	1/10

The DRO in reference streams is assumed to be biogenic. These biogenic concentrations of DRO have not been used to correct any reported DRO concentrations for project samples However, in some cases these background levels are referenced in the text for qualitative comparison to the concentration reported in a project sample that might reflect a biogenic concentration rather than site-related contamination.

2.3.1.6 1997 Phase I RI Background DRO Levels

During the 1997 Corps Phase I RI on Amchitka, samples of surface water, groundwater, sediment, and surface soil were obtained from undisturbed background locations and analyzed for the DRO, and other metals and compounds. In most cases, the 1997 surface water samples were obtained from lakes or ponds rather than streams. The sampling procedures and results are described in Appendix E of the *Phase I Report.*

It is well known that biogenic material can be reported as part of hydrocarbon analyses such as DRO. This was the case with the background samples collected during the Phase I RI. and is discussed in greater detail in Appendix E of the March 1998 *Phase I RI Site Characterization Report.* The following table summarizes the maximum concentration of DRO reported in 1997 background water samples.

DRO Concentrations in 1997 Corps Background Water Samples

Media	DRO Concentration in ug/L			Number of Samples with DRO Detections
	Range		Mean	
	Minimum	Maximum		
Surface Water	64	241	130	12/13
Groundwater	63	2,470J	825	7/7

A comparison of these results with the 1998 Drill Site Investigation background concentrations (presented in Section 2.3.1.5) shows that the 1998 mean surface water DRO concentration is slightly lower than the 1997 surface water concentration, and much lower than the 1997 groundwater concentration. The difference in the surface water results may reflect the difference between ponds and flowing streams. It is reasonable that the background groundwater values are much higher, since many of the groundwater samples were obtained from the perched aquifer in the peaty soil that overlies bedrock on Amchitka.

2.3.2 Comparison Criteria for Sediment

Sediment cleanup levels have not been promulgated federally. The following subsections describe the available criteria against which the reported concentrations of organic and inorganic substances in the sediment samples from the 1998 Drill Site Investigation can be compared.

2.3.2.1 18 AAC 75 Soil Cleanup Standards

In Alaska, the Oil and Other Hazardous Substances Pollution Control Regulations, 18 AAC 75, present cleanup levels for petroleum hydrocarbons, 92 organic compounds, and 14 metals in soil (not sediment). These soil cleanup standards are based on risk to human health. The regulations present risk-based cleanup standards for ingestion, inhalation, and migration to groundwater pathways. For the compounds detected during the 1998 Drill Site Investigation the most stringent standard (most conservative value) is generally the migration to groundwater pathway, except for a few PAHs, for which the ingestion pathway is more stringent (under-40-inch precipitation zone). Table 2-9 includes a list of compound concentrations using ADEC's soil cleanup standards under the most stringent pathway. Note that no soil samples were collected for the project; these values are included as TBC criteria.

2.3.2.2 Human Health Risk-Based Concentrations for Soil

The EPA Region III Risk-Based Concentration Table (EPA, 1999) presents concentrations for a variety of compounds that correspond to a target risk of 1×10^{-6} for carcinogenic effects, or a target hazard quotient of 1 for noncarcinogenic effects, for several exposure pathways. The values for soil include residential and industrial scenarios based on either ingestion or inhalation

pathways (whichever poses the higher risk). Where available, and for chemicals with no other comparison criterion, the more conservative residential scenario RBCs are presented in Table 2-9 for use as TBCs. These values are simply provided as a point of reference rather than to imply a residential use scenario is applicable to Amchitka.

2.3.2.3 Ecological Risk-Based Concentrations for Sediment

Ecological risk-based screening concentrations (ERBSCs) for the compounds detected in both the drilling mud and stream sediment during the 1998 DOE Drill Site Investigation are presented in Table 2-9. These ERBSCs are based on: (1) threshold effects concentrations from the EPA *Assessment and Remediation of Contaminated Sediments Project* (EPA, 1996), (2) the lowest effect level from the Ontario Ministry of the Environment (1993), (3) EPA Region IV Ecological Screening Values, (4) OSWER Ecotox Thresholds, and (5) sediment quality criteria derived by equilibrium partitioning. Where criteria are available from multiple sources, the lowest most conservative concentration has been listed in Table 2-9, and the source of the criterion has been footnoted.

2.3.2.4 Sediment Background Concentrations

Sediment samples were collected from each of the four reference streams described in Section 2.3.1.5. These samples were analyzed for the same list of metals as the samples from the site-related streams and mud pits. The reference stream sediment samples were also analyzed for DRO to determine the possible presence of biogenic material. Field observations and laboratory results from the reference streams are presented in Section 4.9 of this report.

Metals concentrations in the reference stream sediment samples were examined statistically. The methodology and results of this analysis are presented in Appendix D. It was concluded that results from the lowland streams and upland streams were significantly different. Therefore, the results from the lowland and upland stream sediment samples were pooled separately for the calculation background values. The 95 UTL background values are presented in Table 2-9 for comparison to the values from the site-related streams and mud pits. For some metals, the numbers of detections in the reference streams were so few that statistical analysis had no validity. For these metals the highest reported value is considered the background value.

About half of the reference stream sediment samples were reported to contain DRO. Results from these samples are summarized in the following table.

DRO Concentrations in 1998 Reference Stream Sediment Samples

Location	DRO Concentration in mg/kg			Number of Samples with DRO Detections
	Minimum	Maximum	Mean	
Lowland Streams	9.5	15.3	13.3	4 of 10
Upland Streams	6.6	206	48.7	5 of 10

The DRO reported in reference stream sediment samples is assumed to be biogenic. These DRO concentrations have not been used to correct any reported DRO concentrations for project samples. However, in some cases these background levels are referenced in the text for qualitative comparison to the concentration reported in a project sample that might reflect a biogenic concentration rather than site-related contamination.

2.3.2.5 1997 Corps of Engineers Phase I RI Background Levels

During the 1997 Corps Phase I RI on Amchitka, samples of surface water, groundwater, sediment, and surface soil were obtained from undisturbed background locations and analyzed for the DRO, and other metals and compounds. In most cases, the sediment samples were obtained in conjunction with surface water samples from lakes or ponds rather than streams, primarily because dry conditions during the 1997 field season resulted in few background streams that were available for sampling. The sampling procedures and results are described in Appendix E of the *Phase I Report*.

Biogenic material is often reported as part of hydrocarbon analyses, particularly for DRO. This was the case with the background samples collected during the Phase I RI, and is discussed in greater detail in Appendix E of the March 1998 *Phase I RI Site Characterization Report*. The following table summarizes the maximum concentration of DRO reported in 1997 background sediment and surface soil samples.

DRO Concentrations in 1997 Corps Background Sediment and Soil Samples

Media	DRO Concentration in mg/kg			Number of Samples with DRO Detections
	Minimum	Maximum	Mean	
Sediment	7.9J	184	54	13 of 14
Surface Soil	17.9	176	80	13 of 13

Comparing the 1997 results with the results from the 1998 Drill Site Investigation presented in Section 2.3.2.5 shows that the 1998 mean sediment DRO concentration for the lowland streams

is several times lower than the 1997 sediment samples, while the upland stream mean is comparable to the 1998 data.

2.3.3 Comparison Criteria for Fish

Table 2-10 lists the maximum concentrations of all chemical analytes detected in fish during the 1998 Drill Site Investigation. This table also provides EPA Region III Risk-Based Concentrations for Fish Ingestion (from the April 1999 RBC Table).

2.3.3.1 Background Chemical Concentration in Fish

Background concentrations were calculated for metals, including inorganic arsenic, in fish tissue based on reference stream fish results. Two sets of background values were determined, one for upland streams and one for lowland streams. These values were used as a basis of comparison for metals in fish from site-related streams. Methods for calculating UTLs from metals results are discussed in Appendix D.

Fish samples from the four reference streams were also tested for PAHs and PCBs. The presence of either compound in fish suggests an anthropogenic influence. Background concentrations were not established for these compounds since they were not detected in the samples, with the following exceptions. One sample contained the PAH naphthalene, and one sample contained the PCB Aroclor 1254. Note that in both cases the reported concentrations were estimated values below the detection limits of comparable test results (refer to Table 4.9-3).

2.3.3.2 Background Radionuclide Concentrations in Fish

The August 1998 *Management Plan* specified the analysis of fish samples from reference streams for radionuclides as background samples. However, these streams contained an insufficient number of fish to provide the sample size (about 2,000 grams) necessary to achieve reporting limits low enough to detect radionuclide concentrations resulting from world-wide fallout from atmospheric testing. Accordingly, a consensus was reached in the field to not collect stream reference samples, rather than deplete streams where there were few fish. Instead, a background fish sample for radionuclide analysis was collected from Pumphouse Lake (Lake Aldine), located about 0.8 mile south of the east end of Baker Runway in the Base Camp area. This sample (CANN-3077-FS) consisted of 11 individual Dolly Varden, ranging in size from 11 to 13.5 inches, with a total sample weight of 3,360 grams. These fish were submitted whole to the laboratory where they were gutted. The guts and the remainder of the sample were analyzed separately. Laboratory results for this sample are presented in the following table.

Background Radionuclide Concentrations in Fish, Pumphouse Lake

Isotope	Gutted Fish			Fish Guts		
	Flag	Result (pCi/g)	Detection Limit	Flag	Result (pCi/g)	Detection Limit
Americium-241	U	0.000379 ±0.00103	0.0214	U	0.00297 ±0.00423	0.0227
Plutonium-238	U	0.000425 ±0.00843	0.0261	U	-0.000609 ±0.00122	0.0134
Plutonium-239/240	U	0.00605 ±0.00951	0.0184	U	-0.000608 ±0.00122	0.0134
Cesium-137	J	0.0613 ±0.0575	0.0527	U	0.0600 ±0.0924	0.0640

U = analyte was not detected at a concentration greater than the detection limit.
J = analyte was present at a concentration greater than the detection limit but less than the reporting limit (0.100 pCi/g).

These results provide a basis for comparison for the radionuclide results from other stream and lake fish samples in this study.

2.4 FIELD PROCEDURES AND METHODS

2.4.1 Field Team Composition

The field crew for the 1998 Drill Site Investigation was divided into four, three-person teams, each comprised of two geologists, engineers, or environmental scientists (one serving as Field Team Leader and the other as a sampler) and one UXO Supervisor. The primary role of the UXO Supervisors was to screen the approach routes and sites for ordnance and explosive waste (OEW) avoidance. UXO personnel assisted in sampling activities on an as-needed basis. The fieldwork was directed by an on-site manager and supported by a full-time field chemist and camp personnel.

Also present in the field during this investigation were Mr. Frank Maxwell of the DOE and Mr. Mike Murray of IT Corporation as a support contractor to the DOE. Both of these individuals assisted substantially in the field effort in addition to their role as oversight personnel. Mr. Doug Dasher of ADEC was also present during the investigation, while working on a separate sampling project for the state. As time permitted he provided limited oversight for the drill site investigation.

2.4.2 Documentation

Each field team recorded the details of its reconnaissance and sampling activities in bound field books, as well as a variety of field forms. Forms were used to record information such as stream characteristics, water quality parameters, observations of benthic invertebrates, and details of fish sample collection. Pertinent data have been extracted from this field documentation and

presented in the various subsections of Section 4.0. Copies of the field notes are presented in Appendix I, and copies of field forms are presented in Appendix J.

Borings for monitoring wells were drilled at the Aircraft Graveyard. Soil and groundwater conditions encountered during the drilling of these borings are summarized in logs presented in Figure 4.10-2, along with the construction details of monitoring wells.

A photographic record was maintained of each site and significant sampling activities. Copies of photographs of selected sites accompany the discussions of sites in Section 4.0.

2.4.3 Sampling Methodology

The method of sample collection generally followed the procedures outlined in the 1996 *Final Sampling and Analysis Plan* and the 1998 *Management Plan* and are briefly described below.

2.4.3.1 Mud Pits and Lakes

Most water and sediment samples from the mud pits and lakes were collected from a flat-bottomed aluminum skiff, with the exception of the mud pits at Drill Sites E and F (which were not accessible to a skiff). At these drill sites, samples were collected from near shore. The skiff was decontaminated with a high-pressure, hot-water washer between lakes or mud pits, to reduce the potential for cross contamination between water bodies.

2.4.3.1.1 Surface Water

All surface water samples from mud pits and lakes were collected prior to collection of the first sediment sample from a given water body, to prevent the introduction of stirred-up sediment into the water samples. Samples were collected by using new, unpreserved, laboratory sample containers as disposable beakers to collect the water prior to pouring it into the appropriate sample containers for submittal to the laboratory. An exception is that surface water samples for metals analysis were collected using a peristaltic pump and field-filtered using an in-line 0.45 micron filter. A new section of peristaltic pump tubing was used for each sample. The samples were collected from approximately 6 inches below the surface of the water. Following the collection of each surface water sample, the water quality parameters of temperature, pH, conductivity, dissolved oxygen, and turbidity were measured using a multifunction field meter.

2.4.3.1.2 Sediment

The first activity at each mud pit or lake sediment sampling location (after all water samples were collected) was to measure the apparent thickness of the drilling mud with a decontaminated

probe (consisting of an ½-inch-diameter steel rod) and a steel tape measure. The depth of water at the sampling location was also measured using the probe and tape. In general, if the drilling mud was less than 1 foot thick, it was sampled using a decontaminated Eckman dredge sampler. Drilling mud that was greater than 1 foot thick was sampled with either a 2¾-inch or 4-inch outside diameter (O.D.) hand auger, or a 2-inch inside diameter (I.D.) split-spoon drive sampler equipped with a butterfly valve in its tip to retain the sample. The samples were collected from borings that were advanced using the hand auger. Prior to drilling, the borings were cased by pushing a decontaminated length of 4¼-inch O.D. polyvinyl chloride (PVC) pipe into the undisturbed drilling mud by hand. The borings were then advanced through the interior of the pipe using the auger. Due to the stiffness of the drilling mud, the casing usually could not be pushed all the way to the base of the drilling mud. However, the mud was generally stiff enough that the borings stayed open, allowing representative samples to be collected at depth. Prior to collecting the deeper samples, drilling mud that had sloughed into the hole was removed using the split-spoon drive sampler (equipped with a butterfly valve).

When two samples of drilling mud were collected at a sampling location, the first sample was collected from a 1-foot-thick zone at the top of the mud layer, and the second sample was collected from a 1-foot-thick zone at the bottom of the mud. Once retrieved, the samplers were placed on fresh plastic sheeting on the floor of the boat and opened. Prior to sample collection (except as noted below for VOCs), the sample was observed to describe the sampled sediments, and observations were recorded in the field logbook.

Samples for VOCs (both low- and high-level) were containerized immediately following retrieval of the sampler, using the procedures for field preservation and extraction described for EPA Method 5035 in the August 1998 *Management Plan*. An alternative sample collection method was used when the soil sample was too fibrous (such as in some of the peaty lake sediment samples) for collection using a syringe coring device. In these cases, the samples were collected using the handle of a single-use sampling spoon. VOC samples were not homogenized.

After the VOC samples were containerized, the remaining sediment was homogenized prior to placement in the appropriate sample containers. Samples were homogenized by the sampling crew in the boat using single-use stainless steel spoons and aluminum pans. The procedure for homogenization is described in Section 6.9 of the December 1996 *Sampling and Analysis Plan*.

2.4.3.1.3 Mud Pit Volume Estimates

The quantities of drilling mud and surface water in the mud pits were estimated based on field measurements. The lateral dimensions of the mud pits (essentially the length and width of the water surface in the mud pits) were measured using a hand-held cloth tape. The depth of surface water and the thickness of drilling mud were measured at the sampling locations in each mud pit. These measurements were also made at several additional locations in the relatively smaller and shallower mud pits where accurate measurements could be made from shore (Rifle Range Road,

Cannikin Exploratory Hole, Drill Site E, and Drill Site F mud pits). The depth measurements were made using a combination of steel probing rod, hand auger, and steel measuring tape. The volume of drilling mud and surface water in each mud pit was estimated by multiplying the calculated surface area of the mud pit by the average thickness of drilling mud and the average depth of surface water. The average drilling mud thickness and water depth in each pit was calculated by averaging all of the thickness and depth measurements made.

Since the mud pit berms were constructed of yielding soil that could not be distinguished from drilling mud by use of the probing rod, accurate drilling mud thickness measurements could not be obtained at the edges of the mud pits. Nearer the center of the mud pits, where the samples were collected, the thickness of the drilling mud was easier to determine using the probing rod, because bedrock was encountered below the drilling mud at these locations. Reliable thicknesses of drilling mud generally could not be obtained using the probe near the edges of the pits, because the mud could not always be distinguished from the earthen berms. Therefore, the volume calculation method used does not account for the sloping sides of the mud pits and should produce slight overestimates of mud volume. In the larger mud pits (Cannikin, Long Shot, and Drill Site D) an attempt was made to account for this overestimation effect by reducing the calculated volume of mud to account for an assumed berm slope of one vertical to one and one-half horizontal.

2.4.3.1.4 Fish from Cannikin Lake

The only fish samples collected from lakes were two samples for chemical analysis and three samples for radionuclide analysis from Cannikin Lake, and a single background sample for radionuclide analysis from Pumphouse Lake (Lake Aldine). In each case the samples were composed of multiple fish, and the fish were caught with hook and line.

2.4.3.2 Streams

Prior to the collection of any surface water or sediment samples from a stream, an initial ecological reconnaissance was performed of the entire length of the stream. The descriptive data collected during this reconnaissance were used to designate stream reaches (defined as portions of the stream with similar physical characteristics and habitat) and select sampling stations within those reaches. The first ecological stream reconnaissance was performed at Bridge Creek on August 28, 1998, by both stream sampling teams working together to promote consistency in reach identification. After that, the two teams separately conducted reconnaissance of streams assigned to their respective team. No samples were collected until the reconnaissance of a given stream was complete.

In-stream sampling activities began at the farthest downstream sampling station and proceeded upstream, to minimize disturbance of a sampling site by upstream activities.

2.4.3.2.1 Surface Water

Surface water samples were collected from streams prior to sediment sampling to prevent the introduction of stirred-up sediments into the samples. Samples generally were collected using a disposable beaker to collect the water prior to pouring it into the sample containers. In some instances water samples were collected directly into the sample container, taking care to not aerate the sample or lose or dilute the preservative. Surface water samples for metals analysis were field filtered using a hand-operated vacuum pump, single-use Erlenmeyer flask, and in-line 0.45 micron filter. A new filter, flask, and tubing were used at each sampling location.

Following the collection of each stream water sample, the temperature, pH, conductivity, dissolved oxygen, and turbidity were measured using a multifunction field meter.

2.4.3.2.2 Sediment

Sediment samples for chemical and bioassay analyses were collected by gloved hand; new gloves were worn at each sample location. Given the loose nature of the sediment, this method was more practical than the use of tools specified in the *Management Plan*. Where there was a sufficient amount of sediment the sample was collected from the top 2 to 4 inches. When the amount of sediment was limited the required sediment volume was collected from the stream bottom regardless of depth. The August 1998 *Management Plan* contained provisions to bias the selection of sampling locations to those places where drilling mud was observed. However, sediment resembling drilling mud was only observed at two locations (Falls Creek Station 1 and Limpet Creek Station 3). At these locations the drilling mud from the uppermost part of the sediment profile was homogenized with the underlying native sediment prior to placing the samples in their respective containers.

Stream sediment samples were to be analyzed for VOCs only if the sample exhibited elevated headspace gas concentrations based on field screening with a photoionization detector (PID). In practice, it was found that headspace screening was not reliable due to interference from the high levels of organic material and high moisture content of the sediment samples. Therefore, the screening of sediment was discontinued. In accordance with the default prescribed in the *Management Plan*, the fourth sediment sample up from the mouth (Station 2) was generally analyzed for VOCs in most streams.

Sediment samples were collected by scraping any loose vegetation away from the sample location and scooping the sediment into a clean, disposable foil pan. The sediment in the foil pan was mixed thoroughly with a stainless steel spoon. The appropriate containers were filled for chemical analyses, and then two liters of sample were containerized for the bioassay sample, as required. Since oxygenation of the sample would alter the SEM to AVS ratio, the AVS/SEM sediment sample was kept as intact as possible; this sample was not homogenized. Samples for this analysis were collected by pushing the sample container into the *in situ* sediment, taking care

to fill the sample container as completely as possible. Similarly, samples for VOC analysis were collected directly from the *in situ* sediment using a syringe with a plunger to place sediment directly into preservative and minimize exposure, in accordance with the procedure specified in EPA Method 5035.

2.4.3.2.3 Benthos

Benthic macroinvertebrate (BMI) sampling in a given stream was performed after the collection of water, sediment, and fish from that stream. Sampling was conducted in general accordance with the rapid bioassessment approach outlined by the USEPA (1998) for multiple habitat streams. Sampling began at the downstream end of the sampled section (approximately 300 feet long) and proceeded upstream. A total of 20 kicknet samples were taken over the length of the stream sampling section. For each sample the sediment immediately upstream of the open net was agitated by kicking to disturb and collect BMI samples. For less accessible habitat, some samples were collected by repeatedly jabbing the net against the sediment, for instance, of a vertical or undercut stream bank. The different types of habitat present within the sampling section were sampled in rough proportion to their representation of surface area of the total macroinvertebrate habitat. The netted material was rinsed with stream water to remove fine soil particles. Large debris that would not fit into a sample container, such as rocks or clumps of moss, were removed after rinsing and inspecting for organisms.

Rinsed samples were placed, without sorting individual organisms from detritus, into 2-liter plastic containers and preserved with a formalin solution. Sorting of these samples was conducted in the laboratory. However, at Clevenger Creek (the first stream to be sampled for benthics) and Reference Stream 1 individual organisms were hand-picked from nets in the field with forceps and placed in preserved containers. This procedure was abandoned as too time-consuming and inefficient.

2.4.3.2.4 Fish

Following reconnaissance of all of the drill sites and reference streams, it was concluded that fish sampling would be restricted to resident Dolly Varden. This approach was taken to minimize variables in fish population and focus on fish restricted to the island that could not have been exposed to contamination from elsewhere. In general, any fish over 8 inches was considered a potential sea-run fish. The resident Dolly Varden were identifiable by their darker coloration and smaller size compared to sea-run Dolly Varden. The sea-run fish were typically brighter in color.

Fish samples from the streams were collected at least 24 hours or more after water and sediment samples had been collected. Benthic samples were collected shortly after the fish. Samples were collected beginning downstream and working upstream, both in terms of stations and within each

station sampling area. Working downstream not only would have disturbed sediment significantly, but would have allowed fish to escape downstream ahead of the sampling team. Sampling areas for benthos and fish were separated such that undisturbed portions of the stream were available for collecting BMI after fishing was complete.

Fish samples were collected from most streams using a backpack-type electroshocking device and landing nets. Minnow traps were used in a few instances to avoid electroshocking where salmon were observed. Most of the electroshocking was conducted using a Coffelt generator-powered backpack electroshocker with CPS circuitry. This circuitry significantly reduces the mortality of shocked fish by decreasing the pulse frequency and providing the most effective electrical wave. This technology appeared to be effective in that nontarget fish such as sea-run (anadromous) Dolly Varden were released alive and were able to maintain equilibrium and swim. On the few occasions when two teams were required to be electroshocking at the same time a Smith-Root battery-powered electroshocker also was used. After collection, fish were killed and stored on ice in the field until they could be returned to the camp and frozen. Most fish for radionuclide analysis were gutted before freezing. Fish for chemical analysis were frozen whole.

Samples totaling 300 grams, minimum, were attempted in all cases (excluding radionuclide samples which were 900 grams). However, in several locations either no fish or few fish were available. Consequently, samples were either not obtained or were smaller than desirable. These locations are noted in Section 4.0 for each site.

All fish sampling was conducted in accordance with the scientific collection permit issued by the Alaska Department of Fish and Game to collect fish from Amchitka Island streams.

2.4.3.3 Aircraft Graveyard

Sampling for PCBs at the Aircraft Graveyard included groundwater sampling from two temporary monitoring wells and surface water and sediment sampling from a small stream that drains the site. The monitoring wells were installed in borings advanced with a 4-inch O.D hand auger and were constructed from 2-inch I.D. PVC pipe with machine-slotted well screens. When caving conditions in the hole did not prevent it, a filter pack consisting of 10- to 20-mesh sand was installed around the screen. The wells were left in place for possible future sampling. Well construction diagrams are presented in Figure 4.10-2.

The wells were developed to the extent possible prior to groundwater sample collection using a disposable bailer. The development was performed in order to collect water samples that were relatively free of sediment and would reflect only dissolved concentrations of COPCs, without requiring the sample to be filtered. Groundwater samples were collected using a disposable bailer.

Surface water samples at the Aircraft Graveyard were collected using a new, unpreserved laboratory sample container as a disposable beaker to collect the water, which was then

transferred to the sample containers for submittal to the laboratory. Care was taken to avoid disturbance of sediments at the sampling location. Surface water samples were collected prior to collecting the associated sediment sample at a given location for the same reason. Surface water samples were not filtered. Sediment samples were collected with a single-use stainless steel spoon and placed directly into the sample container.

2.4.4 Site Location Surveys

The locations of the stream stations from which samples were collected during the 1998 Drill Site Investigation were plotted on maps by the field crews as the samples were collected. In addition, station coordinates were determined during the field work using hand-held GPS receivers. These instruments typically have an accuracy of about ± 100 feet. Latitude and longitude for these sample locations are tabulated within the various subsections of Section 4.0 that describe the stream sampling. The basis for control of these coordinates is the North American Datum of 1983 (NAD83). Because of the lower reliability of elevation measurements made using hand-held GPS receivers, sampling station elevations were not based on GPS measurements. Instead, elevations were interpolated from contours on existing topographic maps.

At mud pits and lakes, sample locations were documented by measuring from adjacent shorelines at right angles. These measurements are the basis for the sample locations shown in the figures within the various subsections of Section 4.0 that describe mud pit sampling.

2.4.5 UXO/OEW Avoidance

A UXO Supervisor subcontracted from EcoMunition, Inc., accompanied each field team. The primary duty of the UXO Supervisor was to ensure the safety of the field team members from unexploded ordnance. They also assisted with reconnaissance and sampling activities. No UXO was discovered in the vicinity of any of the drill sites or streams that were investigated for DOE during 1998. Numerous antipersonnel spikes (Rommel stakes) were detected, located, and flagged to alert people to their presence.

2.4.6 Equipment Decontamination

All reusable sampling equipment was decontaminated prior to field activities and between use at sample locations. Equipment such as stainless steel sampling spoons, sample containers, disposable aluminum pans for sample homogenization, and disposable bailers were considered single-use items and did not receive additional decontamination.

Reusable sampling tools that came in contact with the samples, such as the split-spoon drive sampler, were decontaminated prior to each sampling attempt. Decontamination procedures for these items consisted of:

- Tap water rinse
- Wash and scrub in diluted laboratory-grade detergent, such as Liquinox®
- Tap water rinse
- Isopropanol rinse
- Hexane rinse
- Isopropanol rinse
- Air dry (disposable paper towel dry, if necessary)
- Distilled water rinse
- 10% Nitric acid rinse
- De-ionized water rinse

Decontamination wash and rinse water were discharged to the ground surface (with the exception of the water used following the nitric acid rinse). Used isopropanol, hexane, and nitric acid were collected in 5-gallon buckets. These used fluids were then allowed to evaporate. No disposal of decontamination fluids was required.

2.5 FIELD QUALITY CONTROL

Quality control was maintained during the field portion of this project by:

- the use of trained and experienced personnel,
- selection of representative sampling locations,
- adherence to standard sample collection and handling procedures described in the Corps 1996 *Final Management Plan* and the DOE August 1998 *Management Plan*,
- oversight of the field work by a senior RI Task Manager who was present in the field, and
- the collection and analysis of field QC samples.

A discussion of the field modifications to the activities and procedures described in the August 1998 *Management Plan* is presented in Appendix A.

Field QC samples are used to assess the influence of sampling procedures, equipment, and handling on the reported results. They are also used to characterize matrix heterogeneity. The goal was to collect field QC samples at a rate of at least 10 percent of the project samples submitted for analysis. They included:

- ***Duplicate samples:*** Field duplicates are samples collected from the same location as the original samples and submitted to the project laboratory as "blind" samples, to provide a check that the data generated by the laboratory is of suitable quality. Field duplicate samples were collected simultaneously or sequentially to the project samples, using identical sampling techniques, and treated identically during transportation and analysis. Duplicate samples were collected both from areas where visual evidence of contamination was present and where no contamination was

expected. Duplicate samples were generally analyzed for the same suite of analytes being tested in the associated project samples. Nine sediment, five surface water, and three fish tissue field duplicate samples were analyzed during the 1998 Drill Site Investigation.

- ***Equipment blanks:*** Equipment or rinsate blanks consisted of ASTM Type II water that was collected after it had been poured over or through decontaminated sampling equipment, as a check on decontamination procedures. Two equipment blanks were collected from the hand auger during its use to collect drilling mud samples from the mud pits. Equipment blank samples were analyzed for DRO, PAHs, and metals.

- ***Trip blanks:*** Trip blanks consisted of laboratory-prepared, organic-free water samples, which were stored and transported with water samples scheduled to be analyzed for volatiles, to test for possible cross-contamination by volatile compounds. Trip blanks were analyzed for VOCs. Eight aqueous trip blanks were analyzed during the 1998 Drill Site Investigation.

- ***Method 5035 Trip blanks:*** Soil samples for volatiles analysis that are field extracted by EPA Method 5035 are transported in vials filled with an aqueous sodium bisulfate solution (low level samples) and methanol (high level samples). Trip blanks for this method consisted of laboratory-prepared, aqueous sodium bisulfate samples, and laboratory-prepared methanol samples; both were stored and transported with soil samples scheduled to be analyzed for volatiles, to test for possible cross-contamination by volatile compounds. These trip blanks were analyzed for VOCs by the appropriate corresponding method (low level or high level), depending on which analyses were ultimately performed on the project samples. Three sodium bisulfate and three methanol trip blanks were analyzed during the 1998 Drill Site Investigation.

In accordance with the August 1998 *Management Plan*, triplicate samples were not analyzed as part of the 1998 Drill Site Investigation.

A discussion of field QC based on the analysis of the QC samples described above is presented in Appendix C of this report.

TABLE 2-1
SUMMARY OF FEATURES SAMPLED AT EACH SITE

Site	Number of Features Sampled		
	Mud Pits	Lakes	Streams
Drill Site E	2	0	1
Drill Site F	1	0	1
Drill Site D	3	1	1
MP 14 Lake	0	1 [a]	0
MP 13 Lake	0	1 [b]	0
Cannikin	3	1	1
Long Shot	2 [c]	0	3
Milrow	0	1	1
Rifle Range Road	1	0	0
Lowland Reference	0	0	2
Upland Reference	0	0	2
Totals	12	5	12

[a] Milepost 14 Lake was found to contain no drilling mud; no samples were analyzed
[b] Milepost 13 Lake was found to have been backfilled; no samples were collected
[c] Three or four original small mud pits at Long Shot currently appear as only two pits

TABLE 2-2
SUMMARY OF ANALYSES BY MEDIA

Analysis	Mud Pit/Lake Sediment	Mud Pit/Lake Water	Stream Sediment	Stream Water	Fish Tissue	Reference Stream Sediment	Reference Stream Water	Reference Stream Fish
DRO	X	X	X	X		X	X	
PAHs	X	X	X	X	X			X
VOCs	X	X	X	X				
Metals	X	X	X	X	X	X	X	X
PCBs	X[1]	X	X[1]		X	X[1]		X
TOC			X			X		
AVS/SEM			X			X		
Lipids					X[2]			
Invertebrates/ Bioassay			X			X		
Radionuclides					X[3]			

1 PCBs were analyzed in sediment only from Cannikin Lake, selected mud pits at Cannikin and Drill Site D, and selected streams.

2 Two fish tissue samples from Cannikin Lake and four other samples selected from streams (including one reference stream) were analyzed for lipids.

3 Fish from the three test site streams and two lowland reference streams were to be analyzed for radionuclides; however, sufficient fish were not available except in Cloudberry Creek at Long Shot and White Alice Creek at Cannikin. Fish from Cannikin Lake, and from Pumphouse Lake for background, also were analyzed for radionuclides.

TABLE 2-3
SUMMARY OF 1998 DRILL SITE SAMPLING

Site	Location	Media	Number of Analyses									
			GRO	DRO	VOCs	PAHs	PCBs	AVS/SEM	Metals	TOC	Rad	Lipids
Milrow	Heart Lake	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			
	Clevenger Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			1
Rifle Range Road	Mud Pit	Sediment		3	3	3			3			
Long Shot	Mud Pits	Surface Water		6	6	6			6			
		Sediment		12	12	12			12			
	Bridge Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				2	2		2			
	Rainbow Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				1	1		2			
	Cloudberry Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3		1	
	Reed Pond	Surface Water		2	2	2			2			
		Sediment		2	2	2			2			
Cannikin	Mud Pits	Surface Water		7	7	7			7			
		Sediment		10	10	10	10		10			
	Cannikin Lake	Surface Water		3	3	3	3		3			
		Sediment	3	3	3	3	3		3			
		Fish				2	2		2		6	2
	White Alice	Surface Water		5	5	5			5			
		Sediment		5	1	5	5	5	5	5		
		Fish				5	5		5		2	1
Drill Site D	Mud Pits	Surface Water		9	9	9			9			
		Sediment		24	24	24	15		24			
	Lake	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			

TABLE 2-3 (cont.)
SUMMARY OF 1998 DRILL SITE SAMPLING

Site	Location	Media	Number of Analyses[1]									
			GRO	DRO	VOCs	PAHs	PCBs	AVS/SEM	Metals	TOC	Rad	Lipids
Drill Site D (cont.)	Stream	Surface Water		5	5	5			5			
		Sediment		5	4	5		5	5	5		
		Fish				2	2		2			
Drill Site F	Mud Pits	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			
	Stream	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			1
Drill Site E	Mud Pits	Surface Water		2	2	2			2			
		Sediment		2	2	2			2			
	Stream	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			
Pumphouse Lake		Fish									2	
Reference Streams	Stream 1	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				4	4		4			
	Stream 2	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			
	Stream 3	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			
	Stream 4	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			1
Aircraft Graveyard		Surface Water					3					
		Sediment					3					
		Groundwater					2					

1 Numbers of analyses are project samples only, and do not include duplicates, trip blanks, or rinsates.

TABLE 2-4
VOLATILE ORGANIC COMPOUNDS, METHOD SW8260B

Analyte	
1,1,1,2-Tetrachloroethane	Bromoform
1,1,1-Trichloroethane	Bromomethane
1,1,2,2-Tetrachloroethane	Carbon disulfide
1,1,2-Trichloroethane	Carbon tetrachloride
1,1-Dichloroethane	Chlorobenzene
1,1-Dichloroethene	Chloroethane
1,1-Dichloropropene	Chloroform
1,2,3-Trichlorobenzene	Chloromethane
1,2,3-Trichloropropane	Cis-1,2-Dichloroethene
1,2,4-Trichlorobenzene	Cis-1,3-Dichloropropene
1,2,4-Trimethylbenzene	Dibromochloromethane
1,2-Dibromo-3-chloropropane	Dibromomethane
1,2-Dibromoethane	Dichlorodifluoromethane
1,2-Dichlorobenzene	Ethylbenzene
1,2-Dichloroethane	Hexachlorobutadiene
1,2-Dichloropropane	Isopropylbenzene
1,3,5-Trimethylbenzene	m,p-Xylene (Sum of Isomers)
1,3-Dichlorobenzene	Methylene chloride
1,3-Dichloropropane	n-Butylbenzene
1,4-Dichlorobenzene	n-Propylbenzene
2,2-Dichloropropane	Naphthalene
2-Butanone	o-Xylene
2-Chlorotoluene	Sec-Butylbenzene
2-Hexanone	Styrene
4-Chlorotoluene	Tert-Butylbenzene
4-Isopropyltoluene	Tetrachloroethene
4-Methyl-2-pentanone	Toluene
Acetone	Trans-1,2-Dichloroethene
Benzene	Trans-1,3-Dichloropropene
Bromobenzene	Trichloroethene
Bromochloromethane	Trichlorofluoromethane
Bromodichloromethane	Vinyl chloride

TABLE 2-5
POLYCYCLIC AROMATIC HYDROCARBONS, METHOD SW8270C SIM

Analyte
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

TABLE 2-6
POLYCHLORINATED BIPHENYLS AND PESTICIDES, METHOD SW8082

Analyte
PCB-1016 (Aroclor 1016)
PCB-1221 (Aroclor 1221)
PCB-1232 (Aroclor 1232)
PCB-1242 (Aroclor 1242)
PCB-1248 (Aroclor 1248)
PCB-1254 (Aroclor 1254)
PCB-1260 (Aroclor 1260)
PCB-1262 (Aroclor 1262)
PCB-1268 (Aroclor 1268)

TABLE 2-7
METAL COPCs ANALYZED DURING 1998 DOE DRILL SITE INVESTIGATION

Method	Analyte
SW6020	Aluminum
SW6020	Arsenic
SW6020	Barium
SW6020	Beryllium
SW6020	Boron
SW6020	Cadmium
SW6010B	Calcium
SW6020	Cerium
SW6020	Cesium
SW6020	Chromium
SW6020	Cobalt
SW6020	Copper
SW6010B	Iron
SW6020	Lithium
SW6010B	Magnesium
SW6020	Manganese
SW6020	Molybdenum
SW6020	Nickel
SW6010B	Potassium
SW6020	Selenium
SW6020	Strontium
SW6020	Thallium
SW6020	Thorium
SW6020	Titanium
SW6020	Uranium
SW6020	Vanadium
SW6020	Zinc

TABLE 2-8
COMPARISON CRITERIA FOR CHEMICALS IN SURFACE WATER

Analyte		Maximum Concentration in Project Samples (ug/L)	ADEC Groundwater Cleanup Standards [A] (ug/L)	Human Health Risk-Based Concentration [B] (ug/L)	EPA [C] AWQC Freshwater Acute/ Chronic (ug/L)	EPA [C] AWQC Marine Acute/ Chronic (ug/L)	ADEC [D] WQS Freshwater Acute/ Chronic (ug/L)	ADEC [D] WQS Saltwater Acute/ Chronic (ug/L)	Lowland Stream Background Concentration [E] (ug/L)	Upland Stream Background Concentration [E] (ug/L)	Ecological Risk-Based Screening Concentration (ug/L)
Volatiles											
Methylene Chloride		25.6	5	4.1	-	-	11,000 [F,G]/ -	12,000 [F,G]/ 6,400 [F,G]	-	-	1,930 [P]
Toluene		1.06	1,000	750	-	-	17,500 [F]/-	6,300 [F]/ 5,000 [F]	-	-	9.8 [O]
Inorganics											
Aluminum		625	-	37,000	750/87	-	-	-	269	87.1 [H]	87 [N,P]
Arsenic	III	7.53	50	0.045	340 [K]/150 [K]	69 [K]/36 [K]	360/190	69 /36	ND	ND	190 [P]
	V				-/-	-/-	850 [F]/48 [F]	2,319 [F]/13 [F]			150 total [N,Q,R,S] 3.1 [O]
Barium		53	2,000	2,600	-	-	-	-	ND	ND	4 [O]
Boron		468	-	3,300	-	-	-	-	ND	ND	1.6 [O]
Calcium		11,600	-	-	-	-	-	-	4,320 [I]	8,810 [H]	-
hromium	III	12	36,500	55,000	570 [J,K]/74 [J,K]	-/-	1,700 [J]/210 [J]	10,300 [F] /-	2.25 [I]	3.49 [H]	74 [N,R,S,T]
	VI		100	110	16 [K]/11 [K]	1,100 [K]/50 [K]	16/11	1,100/50			11 [N,R,S]
Cobalt		7.67	-	2,200	-	-	-	-	3.35	9.52	23 [O]
Copper		22.9	1,300	1,500	13 [J,K]/9 [J,K]	4.8 [K]/3.1 [K]	18 [J]/12 [J]	2.9 /-	10.83	13.4 [H]	9 [N,R,S,T,U]
Iron		2,830	-	11,000	-/1,000	-	-	-	993	2,830 [H]	1,000 [N,P]
Lithium		1.21	-	730	-	-	-	-	1.17 [I]	ND	14 [O]
Magnesium		6,700	-	-	-	-	-	-	4,690 [I]	5,250	-
Manganese		353	-	730	-	-	-	-	267	748	120 [O]
Molybdenum		1.31	-	180	-	-	-	-	ND	ND	370 [O]

TABLE 2-8 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN SURFACE WATER

Analyte	Maximum Concentration in Project Samples (ug/L)	ADEC Groundwater Cleanup Standards [A] (ug/L)	Human Health Risk-Based Concentration [B] (ug/L)	EPA [C] AWQC Freshwater Acute/ Chronic (ug/L)	EPA [C] AWQC Marine Acute/ Chronic (ug/L)	ADEC [D] WQS Freshwater Acute/ Chronic (ug/L)	ADEC [D] WQS Saltwater Acute/ Chronic (ug/L)	Lowland Stream Background Concentration [E] (ug/L)	Upland Stream Background Concentration [E] (ug/L)	Ecological Risk-Based Screening Concentration (ug/L)
Nickel	7.49	100	730	470 [J,K]/52 [J,K]	74 [K]/8.2 [K]	1800 [J] /96 [J]	140/7.1	ND	1.69 [H]	52 [N,R,S,T]
Potassium	2,860	-	-	-	-	-	-	2,623	1,190 [H]	-
Selenium	1.53	50	180	-/5	290 [K]/71 [K]	-	-	ND	ND	5 [N,V]
Strontium	58.7	-	22,000	-	-	-	-	36.07	44.1 [H]	1,500 [O]
Thallium	7.07	2	2.6	-	-	1,400 [F]/40 [F]	2,130 [F]/-	7.07 [I]	2.13 [H]	4 [P,X]
Thorium	1.55	-	-	-	-	-	-	ND	1.14 [H]	-
Titanium	123	-	150,000	-	-	-	-	6.13	2.37 [H]	-
Vanadium	5.31	260	260	-	-	-	-	4.43 [I]	1.44 [H]	20 [O]
Zinc	77.8	11,000	11,000	120 [J,K]/120 [J,K]	90 [K]/81 [K]	320 [J]/47 [J]	170/58	50.3 [I]	12.8 [H]	106 [P,W]
Petroleum Hydrocarbons										
Diesel Range Organics	286	1,500	-	-	-	15 [L] ;10 [M]	15 [L] ;10 [M]	-	-	-

Notes:

A ADEC Groundwater Cleanup Standards, 18 AAC 75, as amended through January 22, 1999. Note that in accordance with 18 AAC 75.325(g), cumulative risk ceiling provisions may result in more stringent cleanup levels in the event of multiple contaminants that impact the same pathway.
B Drinking water scenario health risk-based screening concentrations (HRBSCs) from EPA Region III Risk-Based Concentration table, April 1999.
C USEPA National recommended Water Quality Criteria, Federal Register, December 10, 1998 (63 FR 68354-68364).
D ADEC, Water Quality Standards, 18 AAC 70. March 1, 1998; All values presented are based on no observed effect levels (NOELs) unless otherwise noted.
E The concentration shown is an upper tolerance limit (UTL) unless otherwise noted. See Appendix D of this report for a description of the calculation of background concentrations.
F Denotes a toxicity test based on a lowest observed effects level (LOEL), which is not applied by ADEC but is provided as a reference value to be considered.
G This value was based on a LOEL for halomethanes as a group.
H The concentration shown is the maximum detected concentration in upland stream background samples.
I The concentration shown is the maximum detected concentration in lowland stream background samples.
J Hardness-dependent value.
K The dissolved metals criterion is shown.
L Total aqueous hydrocarbons, defined (ADEC, 1998) as the sum of the BTEX constituents and 16 individual PAH compounds, is not to exceed 15 ug/L.
M Total aromatic hydrocarbons, defined (ADEC, 1998) as the sum of the concentrations of the various BTEX constituents, is not to exceed 10 ug/L.
N Ecological risk-based screening concentration selected by IT Corp. for this project; national recommended water quality criteria.
O Ecological risk-based screening concentration selected by IT Corp. for this project; USEPA Tier II secondary chronic values.
P Ecological risk-based screening concentration selected by IT Corp. for this project; ESEPA Region IV chronic screening values, based on Region IV Water Management Division, Water Quality Standards Unit, Screening List.
Q Derived from data for arsenic III, but applied here to total arsenic, which might imply that arsenic III and arsenic V are equally toxic to aquatic life and that their toxicity's are additive.

TABLE 2-8 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN SURFACE WATER

R	The value was calculated by converting the previous 304(a) aquatic life criteria for total recoverable metal to dissolved metal; see *Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria*, 40 CFR 131.36(b)(1), Oct. 1, 1993.
S	*Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*, EPA-820-B-96-011, September 1996.
T	Hardness dependent; presented value based on hardness of 100 mg/L
U	When dissolved organic carbon concentration is elevated, copper is substantially less toxic; use of Water-Effect Ratios might be appropriate.
V	Presented criterion is based on total recoverable metal; conversion factor of 0.922 used in the GLI could be used to convert this to dissolved metal.
W	Hardness dependent; Region IV values are based on 100 mg/L hardness
X	Calculated using the Great Lakes Water Quality Initiative Tier II methodology (USEPA, 1995).
	ADEC Alaska Department of Environmental Conservation
AWQC	Ambient Water Quality Criteria
EPA	Environmental Protection Agency
ND	Non-detect
ug/L	Micrograms per liter
WQS	Water quality standard
-	Indicates that a value is not available

Shaded cells indicate exceedance of comparison criteria. For inorganics, cells are shaded only if maximum concentration also exceeds 1998 background concentrations.

TABLE 2-9
COMPARISON CRITERIA FOR CHEMICALS IN SEDIMENT

Analyte	Maximum Concentration in Sediment Samples (mg/kg)	Soil Cleanup Levels [A] (mg/kg)	Human Health Risk-Based Concentration [B] (mg/kg)	Lowland Stream Background Concentration [D] (mg/kg)	Upland Stream Background Concentration [D] (mg/kg)	Ecological Risk-Based Screening Concentration (mg/kg)
Volatiles						
1,2,4-Trimethylbenzene	198	-	3,900	-	-	-
1,3,5-Trimethylbenzene	39.1	-	3,900	-	-	-
2-Butanone (MEK)	0.136	-	47,000	-	-	0.27 [J]
Acetone	1.02	10	7,800	-	-	0.0087 [J]
Benzene	0.0058	0.02	22	-	-	0.057 [I]
Carbon disulfide	0.318	17	7,800	-	-	0.00085 [J]
Ethylbenzene	3.19	5.5	7,800	-	-	0.089 [J]
Isopropylbenzene (cumene)	2.83	-	7,800	-	-	-
n-Butylbenzene	20.6	-	780	-	-	-
n-Propylbenzene	8.02	-	780	-	-	-
Naphthalene	137	43	1,600	-	-	0.033 [F]
p-Isopropyltoluene	14.6	-	-	-	-	-
sec-Butylbenzene	6.74	-	780	-	-	-
Toluene	0.0434	5.4	16,000	-	-	0.05 [J]
Xylenes (Total)	3.04	78	160,000	-	-	0.025 [I]
Semivolatiles						
Acenaphthene	3.34	210	4,700	-	-	0.33 [H]
Acenaphthylene	0.802	-	-	-	-	0.33 [H]
Anthracene	0.823	4,300	23,000	-	-	0.032 [F]
Benzo(a)anthracene	0.034	6	0.87	-	-	0.11 [J]
Benzo(a)pyrene	0.05	1	0.087	-	-	0.14 [J]
Benzo(b)fluoranthene	0.088	11	0.87	-	-	0.027 [F]
Benzo(g,h,i)perylene	0.014	-	-	-	-	0.17 [G]

TABLE 2-9 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN SEDIMENT

Analyte	Maximum Concentration in Sediment Samples (mg/kg)	Soil Cleanup Levels [A] (mg/kg)	Human Health Risk-Based Concentration [B] (mg/kg)	Lowland Stream Background Concentration [D] (mg/kg)	Upland Stream Background Concentration [D] (mg/kg)	Ecological Risk-Based Screening Concentration (mg/kg)
Benzo(k)fluoranthene	0.032	110	8.7	-	-	-
Chrysene	0.027	620	87	-	-	0.33 [H]
Fluoranthene	0.311	2,100	3,100	-	-	0.064 [F]
Fluorene	13	270	3,100	-	-	0.035 [F]
Indeno(1,2,3-cd)pyrene	0.022	11	0.87	-	-	0.078 [F]
Phenanthrene	19.7	-	-	-	-	0.33 [H]
Pyrene	0.802	1,500	2,300	-	-	0.33 [H]
PCBs						
Aroclor 1248	0.215	10 [C]	0.32	-	-	0.023 [I,K]
Aroclor 1260	0.308	10 [C]	0.32	-	-	0.005 [G,K]
Inorganics						
Aluminum	90,600	-	78,000	45,400	47,500	-
Arsenic	109	2	0.43	100	30.5	6 [G]
Barium	690	1,100	5,500	469	468	-
Beryllium	2.9	42	160	ND	ND	-
Boron	198	-	7,000	7.18 [E]	6.42 [E]	-
Cadmium	3.17	5	39	0.608 [E]	ND	0.59 [F]
Calcium	133,000	-	-	7,300	7,720	-
Cerium	61.4	-	-	14.2	13.0	-
Cesium	5.72	-	-	ND	ND	-
Chromium	1,090	(III) > 1,000,000 (VI) 26	(III) 120,000 (VI) 230	11.8	18.9	26 [G]
Cobalt	100	-	4,700	43.7	37.3	-
Copper	474	-	3,100	71.1	82.4	16 [G]
Iron	192,000	-	23,000	155,000	123,000	20,000 [G]
Lithium	41.7	-	1,600	48.8	21.7	-

TABLE 2-9 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN SEDIMENT

Analyte	Maximum Concentration in Sediment Samples (mg/kg)	Soil Cleanup Levels [A] (mg/kg)	Human Health Risk-Based Concentration [B] (mg/kg)	Lowland Stream Background Concentration [D] (mg/kg)	Upland Stream Background Concentration [D] (mg/kg)	Ecological Risk-Based Screening Concentration (mg/kg)
Magnesium	37,500	-	-	9,320	17,000	-
Manganese	46,300	-	1,600	20,700	26,500	460 [G]
Molybdenum	8.47	-	390	5.5 [E]	ND	-
Nickel	125	87	1,600	13.6	23.8	15.9 [H]
Potassium	4,340	-	-	1,390	1,290	-
Selenium	8.86	3.5	390	5.44 [E]	3.15 [E]	-
Strontium	1,120	-	47,000	164	207	-
Thallium	4.08	-	5.5	1 [E]	ND	-
Thorium	21.3	-	-	0.5 [E]	ND	-
Titanium	15,400	-	310,000	3,010	1,480	-
Uranium	6.72	-	230	4.13 [E]	ND	-
Vanadium	645	3,400	550	734	336	-
Zinc	292	9,100	23,000	434	185	120 [G]
Petroleum Hydrocarbons						
Gasoline Range Organics	25.9	300	-	-	-	-
Diesel Range Organics	58,800	250	-	-	-	-

Notes:

A ADEC soil cleanup standards, most stringent (generally migration to groundwater) pathway, under 40 inch precipitation zone, 18 AAC 75 as amended through January 22, 1999. Note that in accordance with 18 AAC 75.325(g), cumulative risk ceiling provisions may result in more stringent cleanup levels in the event of multiple contaminants that impact the same pathway.

B Residential soil scenario health risk-based screening concentrations (HRBSCs) from U.S. Environmental Protection Agency (EPA) Region III Risk-Based Concentration table, April 1999.

C Sum of individual PCB compounds

D The concentration shown is an upper tolerance limit (UTL) unless otherwise noted. See Appendix D of this report for a description of the calculation of background concentrations.

E This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL, or the distribution of results was not appropriate for the calculation of a meaningful UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

F Ecological risk-based screening concentration selected by IT Corp. for this project; threshold effects concentration from EPA 1996 Assessment and Remediation of Contaminated Sediments Project. *Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomous riparius*. EPA 905-R96-008, Great Lakes National Program Office, 1996.

TABLE 2-9 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN SEDIMENT

G	Ecological risk-based screening concentration selected by IT Corp. for this project; lowest effect level from Ontario Ministry of Environment and Energy, Persaud, et. al., *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*, 1993.
H	Ecological risk-based screening concentration selected by IT Corp. for this project; EPA Region IV, *Ecological Screening Values for Sediments*, 1995.
I	Ecological risk-based screening concentration selected by IT Corp. for this project; OSWER *Ecotox Thresholds*, ECO Update 3(2): 1-12, 1996.
J	Ecological risk-based screening concentration selected by IT Corp. for this project; sediment quality criteria derived by equilibrium partitioning. From Jones, et. al., *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment Associated Biota*, assuming 1% total organic carbon. Site-specific TOC values for samples where organic compounds were detected are 1.2% and greater.
K	Total PCBs

mg/kg	milligrams per kilogram
ND	non-detect
-	Indicates that a value is not available

Shaded cells indicate exceedance of comparison criteria. For inorganics, cells are shaded only if maximum concentration also exceeds 1998 background concentrations.

TABLE 2-10
COMPARISON CRITERIA FOR CHEMICALS IN FISH
(concentrations in mg/kg, wet weight basis)

Analyte	EPA Region III Fish Consumption RBC (a) (mg/kg)	EPA Fish Tissue Screening Values (b) (mg/kg)	FDA Action Levels	Lowest Avian LOAEL Benchmark (c) (mg/kg)
Polycyclic Aromatic Hydrocarbons				
Total PAHs	-	0.01	-	-
Naphthalene	27.0	-	-	-
Polychlorinated Biphenyls				
Total PCBs	0.0016	0.01	-	-
Aroclor 1254	0.0016	-	-	9.0
Aroclor 1260	0.0016	-	-	-
Metals				
Aluminum	1,400	-	-	88
Arsenic (inorganic)	0.0021	3.00	-	15
Barium	95	-	-	82
Boron	120	-	-	197
Cadmium - food	1.4	10.0	3.0	39
Calcium	-	-	-	-
Cerium	-	-	-	-
Cesium	-	-	-	-
Chromium	-	-	12.0	-
Chromium III	2,000	-	-	10
Chromium VI	4.1	-	-	NDA
Cobalt	81	-	-	-
Copper	54	-	-	120
Iron	410	-	-	-
Lithium	27.0	-	-	-
Magnesium	-	-	-	-
Manganese - food	190	-	-	1,967[d]
Molybdenum	6.8	-	-	70
Nickel	27.0	-	70.0	211
Potassium	-	-	-	-
Selenium	6.8	50.0	-	2.0
Strontium, stable	810	-	-	-
Thallium	0.095	-	-	-
Thorium		-	-	-
Titanium	5,400	-	-	-
Vanadium	9.5	-	-	22[d]
Zinc	410	-	-	260

TABLE 2-10 (Cont.)
COMPARISON CRITERIA FOR CHEMICALS IN FISH
(concentrations in mg/kg, wet weight basis)

a Based on target risk level of $1x10^{-6}$ for carcinogens and an HQ of 1.0 of noncarcinogens; assumes a fish ingestion rate of 54 grams/day (EPA, 1999)

b EPA fish tissue screening values are concentrations of target analytes in fish or shellfish tissue that are of potential public health concern and that are used as standards against which levels of contamination in similar tissue collected from the ambient environment can be compared. (EPA, 1995) assumes a fish consumption rate of 6.5 grams/day and a target risk level of $1x10^{-5}$ for carcinogens and an HQ of 1.0 of noncarcinogens.

c Based on fish ingestion by piscivorous birds (Sample et al., 1996)

d NOAEL value

HQ -

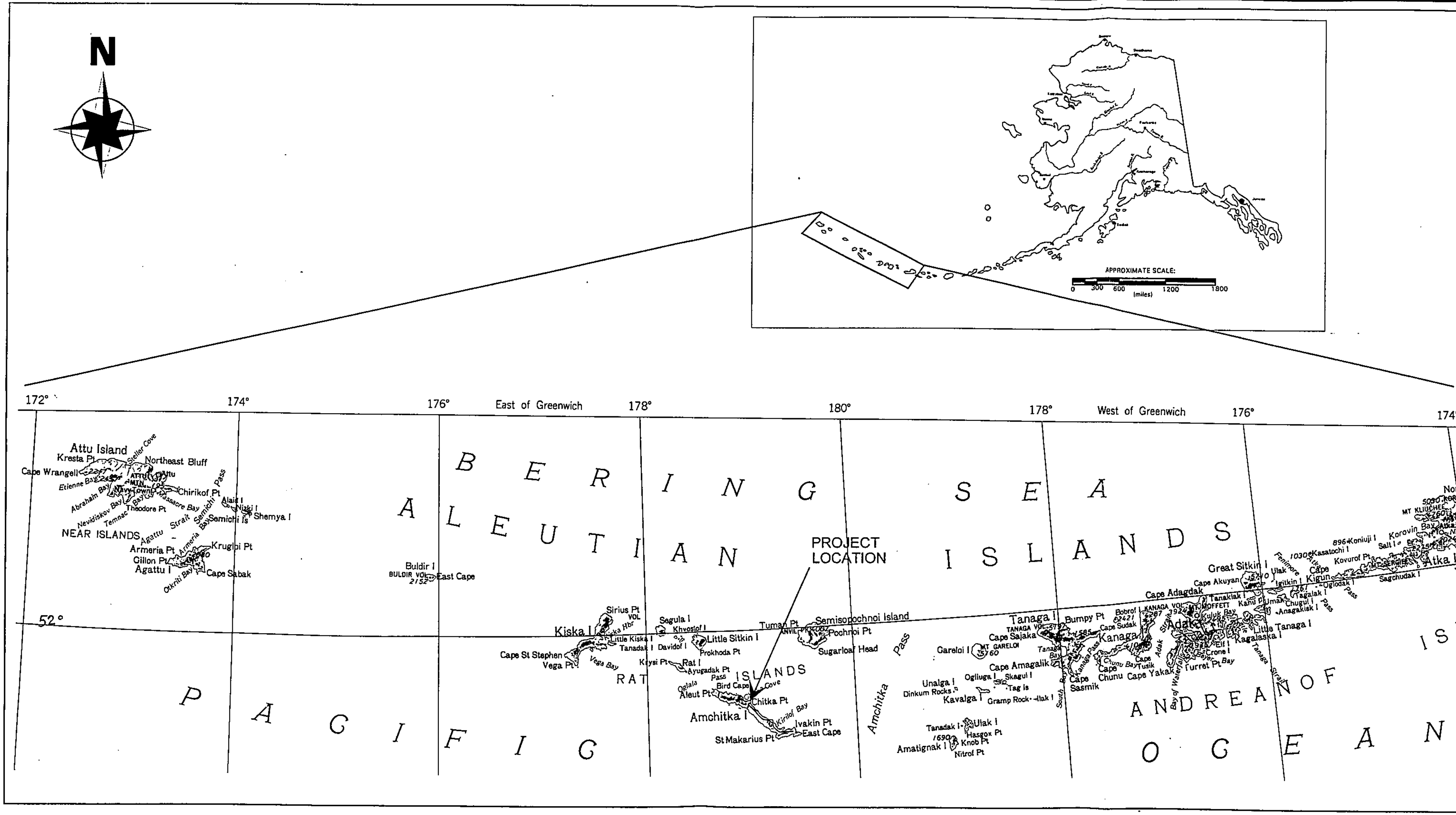
LOAEL - lowest observed adverse effect level

NOAEL - No observed adverse effect level

mg/kg – milligram per kilogram

EPA, 1999 – Region IIII. Risk Based Concentrations Table, April

EPA, 1995 – Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories. Volume 1. Fish Sampling and Analysis, Second Edition



Base map from USGS State of Alaska Map E, scale 1:2,500,000. The contour interval is 1,000 feet. Revised in 1987.

APPROXIMATE SCALE: 1 inch = 40 miles

0 20 40 80 120

(miles)

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

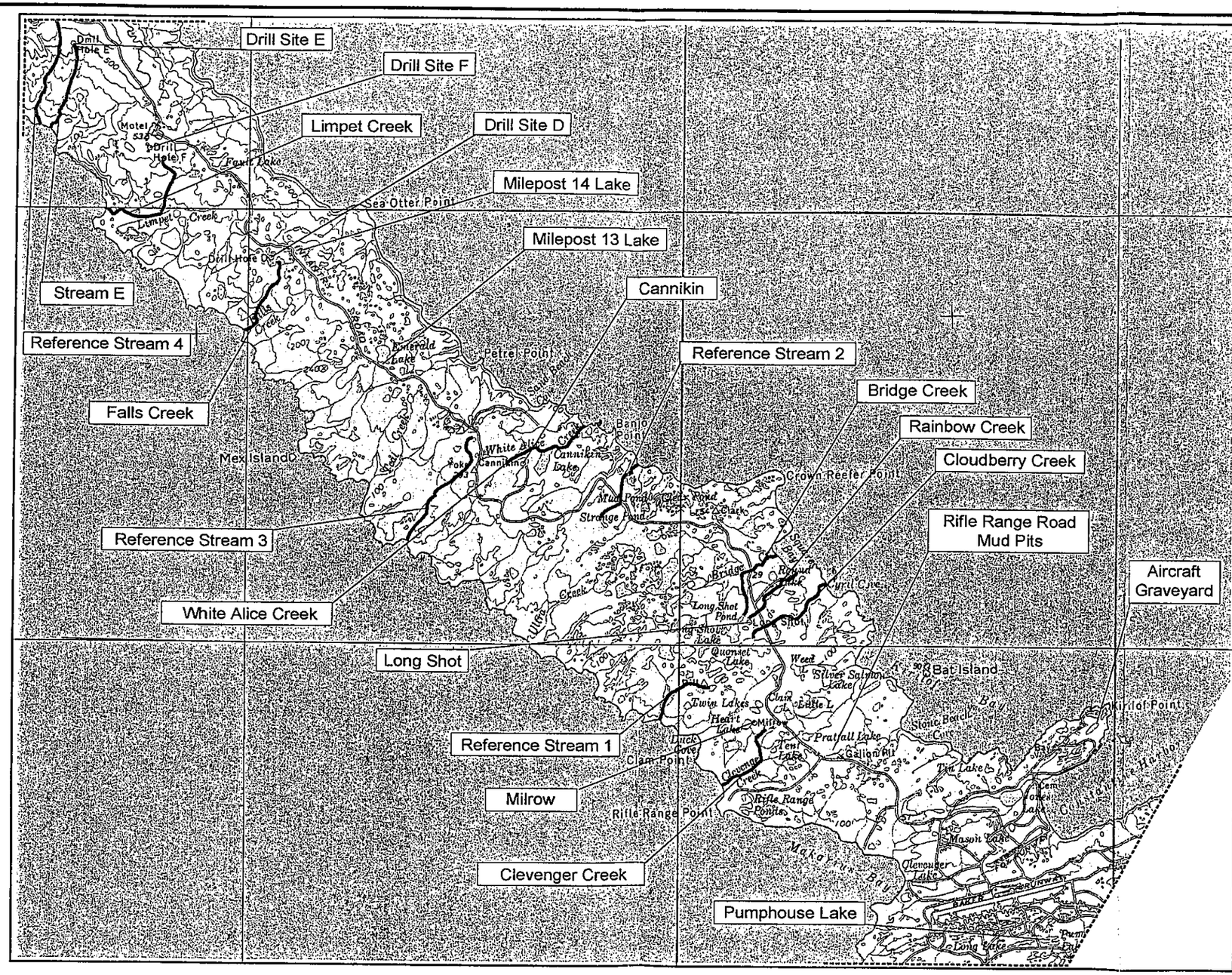
LOCATION MAP

September 1999
Revision Number: 0

X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1-1



SCALE 1:100,000

0 ½ 1 2 3

(miles)

Reference: Map titled *Amchitka Island, Alaska*, prepared in 1975 by the Geological Survey for the Energy Research and Development Administration

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE AND STREAM LOCATIONS

Sept. 1999
Revision Number: 0

X-0926

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Figure 1-2

3.0 ENVIRONMENTAL SETTING

3.1 PHYSIOGRAPHY

Amchitka is approximately 42 miles long and generally 3 to 4 miles wide, with elevations ranging from sea level to about 1,200 feet. The sites investigated during the 1998 Drill Site Investigation are located in the central third of the island, at elevations ranging from about 125 to 500 feet (Figure 2-1). The Bering Sea lies to the north of island and the Pacific Ocean to the south. Deep ocean passes, Amchitka Pass and Oglala Pass, lie off the eastern and western shores.

The island's coastline consists predominantly of sea cliffs and steep bluffs capped by grassy slopes. Beaches are present along the coast in some areas and usually consist of narrow, discontinuous belts of sand, gravel, and cobble deposits that extend along the shore up to several hundred feet. Constantine Harbor, on the northern side of the east end of the island, is the only natural harbor. Most of the island is fringed by a narrow (up to 100 feet wide) wave-cut, bedrock bench. This bench lies within the intertidal zone and experiences the erosive action of waves during stormy periods.

The eastern end of the island, from East Cape to Kirilof Point, has inland elevations of up to 230 feet. This area is characterized by gently rolling topography, many shallow ponds with few drainage connections, and narrow streams that are partially concealed by the abundant surface vegetation.

The central portion of the island, from Kirilof Peninsula to Chitka Point (where DOE/AEC drill sites are located), has inland elevations up to 650 feet near Chitka Point. The average elevation rises towards the northwest.. The three test sites are about 100 to 200 feet above sea level, while the drill sites are at 300 to 500 feet above sea level. A better developed surface water drainage system, fewer ponds, and patches of bare bedrock forming relatively high ridges characterize this portion of the island. The broad upland region between Banjo Point and Kirilof Peninsula is thought to be a wave-cut terrace from a time when ocean levels were higher.

The west-central portion of the island, from Chitka Point to Midden Cove, is mountainous, with elevations to 1,200 feet. Steep sea cliffs form most of the coastline. This region is highly dissected by stream valleys and postglacial features including U-shaped valleys, cirque basins, and bare bedrock ridges resembling arêtes.

The westernmost 3 miles of the island is a barren, windswept rocky plateau with elevations to 800 feet. At Bird Cape, the western tip of the island, the surface elevation averages about 100 feet, and the bedrock is mantled by a veneer of sand dunes partially stabilized by a lush cover of grass.

3.2 METEOROLOGY

Amchitka is characterized by a pronounced maritime climate. In general, weather in the outer Aleutian Islands is the result of migratory, large-scale pressure systems and their associated fronts that pass along the North Pacific storm track (Armstrong, 1977).

Daily and annual fluctuations in temperature are minimal on Amchitka due to the moderating affect of the surrounding seas. Between March and December the mean daily high and low are 36 degrees Fahrenheit (°F) and 23°F, respectively. From April to November the mean daily high and low are 45°F and 39°F, respectively. August is the warmest month, with a mean temperature of 48°F. January is the coldest month, with a mean temperature of 31°F. The mean daily temperature range is 7°F, and the annual range of the mean daily temperature is 17°F.

The mean annual precipitation on Amchitka is 33 inches, which includes approximately 71 inches of snow. Some form of precipitation is experienced 20 percent or more of the time in all months. Rain and snow are common between December and April; whereas rain and fog are most common between May and November. Low clouds cover the skies between 50 percent and 90 percent of the time. Low ceilings and fog occur with the greatest frequency in the summer months and often persist for days at a time. Advection fog is common during this period, resulting from relatively warm, moist air flowing over the cooler ocean surface.

According to Armstrong (1977), there is no prevailing wind direction on Amchitka, although during the summer months the winds are generally out of the southwest. The mean wind speed between December and February is 30 miles per hour; from March to May, 26 miles per hour; from June to August, 22 miles per hour; and between September and November, 27 miles per hour. The wind is calm less than 1 percent of the time. The maximum recorded wind velocity on Amchitka is 115 miles per hour.

The meteorological statistics described above were collected by the Army and the AEC on the low, eastern end of the island, and according to Armstrong (1977), are not directly applicable to the higher western end of the island. In general, at the higher elevations in the western third of the island, weather conditions can be expected to be more extreme than the eastern end, with elevated precipitation levels, greater temperature variations, and more severe storms (Armstrong, 1977). Also, when the eastern end of the island is experiencing low cloud cover, the higher western third of the island is often experiencing heavy fog.

3.3 GEOLOGY

The Aleutian Islands are an arcuate chain of volcanoes that extends from the Gulf of Alaska to the Kamchatka Peninsula of Russia. The Aleutians are the exposed part of a large, undersea mountain system that has developed on the leading edge of the North American plate from volcanic eruptions over the last 20 to 30 million years. Many volcanoes in this system are active, and the island arc is subjected to relatively intense seismic activity. Amchitka Island has no

active volcanoes. The geology of Amchitka as it pertains to this investigation is briefly summarized below. More detailed accounts are presented in Powers and others (1960) and Gard (1977 and 1980).

Amchitka apparently formed in early Tertiary time (roughly 50 million years ago) as a result of tectonic uplift and deposition of volcanic flows and marine sediments collectively known as the Amchitka Formation. These strata underlie the easternmost part of the island, east of St. Makarius Bay.

A major period of marine sedimentation followed deposition of the Amchitka Formation in Late Eocene to Early Oligocene time (30 to 40 million years ago), resulting in deposition of the Banjo Point Formation. This formation is exposed between Petrel Point and the zero-mile marker on Infantry Road (thus encompassing the Milrow, Long Shot, and Cannikin sites), with the best exposures along the coast. The Banjo Point Formation is of at least 3,100 feet thick. It consisted primarily of turbidites derived from the weathering and erosion of nearby basaltic lavas along the flanks of subaerial volcanoes. These turbidites include breccias, conglomerates, sandstones, and mudstones. Submarine lavas are a minor component of the Banjo Point Formation near its base.

During Middle and Late Miocene (5 to 15 million years ago) the central and western Aleutians experienced widespread uplift, erosion, and shallow intrusive igneous activity. This period of tectonism is recorded in the White House Cove and East Cape plutons and a series of northeast-trending normal faults that cut across the island. Extensional faulting resulted in two northeast-trending cross-island grabens. One, referred to as Constantine graben, extends from Constantine Harbor southwestward to St. Makarius Bay. The other, referred to as South Bight graben, extends across the island from North Bight to South Bight. The initiation of the faulting that formed these grabens is inferred to have occurred in Middle to Late Miocene based on the age of the other extensional faults on the island. These graben-bounding faults remained active at least until the last glaciation of the island, which is believed to have been about 10,000 years ago.

Andesitic lavas, laharic breccias, bedded tuffs, and minor volcaniclastic sedimentary rocks of the Chitka Point Formation record the second major episode of volcanism in Middle to Late Miocene time. These strata were interpreted by Gard (1977) to represent the eroded remnants of a subaerial stratovolcano.

Most of the island has a thin, discontinuous veneer of unconsolidated sediments overlying the volcanic and volcaniclastic bedrock. These sediments consist largely of Pleistocene glacial till and outwash sands and gravels. Within the grabens, however, relatively thick sequences of unconsolidated sediments are preserved. More than 320 feet of Pleistocene lacustrine and marine sediments have been preserved in South Bight graben. The character of the sedimentary fill within Constantine graben is not as well known as that in South Bight graben, but probably consists of at least "several tens of meters" of Pleistocene sediments (Merritt, 1977). Coats (1947) estimated that the bedrock surface has dropped approximately 130 feet along the north side of the graben.

Minor accumulations of Holocene eolian sand deposits are present at scattered locations along the coast. Small, semiactive sand dunes are present at South Bight, and more extensive dune deposits are located at the northwestern end of the island at Bird Cape (Merritt, 1977).

3.4 SOILS

Amchitka's maritime climate, with cool temperatures, abundant precipitation, and low evapotranspiration rate, produces a luxuriant blanket of mosses, sedges, lichens, and grasses that covers much of the island, including all but the steepest slopes. This organic carpet and associated underlying peat layer typically have high water-holding capacities, and the resulting soils are at or very near saturation year-round. In addition, the volcanic bedrock is highly susceptible to physical and chemical weathering due to the moist climate and mafic (iron and magnesium rich) composition of the rocks. These factors, along with variations in topography, combine to produce both organic and mineral soils.

As part of AEC environmental studies on Amchitka, Everett (1977) recognized seven different soil types on Amchitka. Three of these consist largely of organic material (peat) in various stages of decomposition. Organic soils are present throughout the island, but are most common in the low-lying eastern part of the island. The remaining four soil types consist largely of mineral soils with subordinate amounts of decomposed plant material. These mineral soils are most common in the higher western half of the island.

3.5 HYDROGEOLOGY

Amchitka is characterized by a pronounced maritime climate with cool temperatures and approximately 33 inches of precipitation annually. The climate and the island's volcanic bedrock combine to support lush tundra vegetation and an underlying highly organic soil. Throughout most of the island the surficial soils are at or near saturation year-round, which strongly influences the island's hydrogeology.

Amchitka is covered with hundreds of small shallow ponds up to 330 feet wide and 10 feet deep. The smaller ponds are considerably shallower, typically ranging from 12 to 20 inches deep. Ponds are most numerous on the eastern two-thirds of the island, where they have developed above marine terraces and are confined by thick vegetation and peat (Dudley and others, 1977). Fewer ponds are present on the western third of the island, where they typically occupy bedrock depressions. Relatively little is known about the characteristics of the ponds on the western third of the island.

Many of the ponds at lower elevations on the eastern half of the island are closely spaced, and drained through networks of poorly defined streams. The bottoms of the larger ponds are variable in sediment characteristics and usually include one of the following: up to 12 inches of floc (suspension of low-density detrital organic material) over gravel, organic silts over gravel,

or clean gravel. The bottoms of most smaller ponds are usually composed of peat or fine sediment covered with floc (Everett, 1977). Many closely-spaced ponds have water levels that differ by 1.5 feet or more, indicating the presence of low-permeability sediments at the bottom of the ponds and reduced hydraulic communication with the shallow water-bearing zone.

During the 1998 Drill Site Investigation, reconnaissance and sampling were performed along the lengths of twelve streams. These streams typically averaged 1 to 3 feet in width. Water depth averaged 4 to 12 inches, although pools up to 5 feet deep were observed. Gradients ranged from about 1 to 5 percent. The highest gradients were generally in the middle reaches of the streams in the western part of the study area. Most of the streams on the island reportedly flow year-round. During relatively dry periods stream flows are sustained by baseflow from soils and the underlying weathered bedrock; both surface runoff and baseflow contribute to stream flows during wet periods.

The groundwater system on Amchitka consists of a shallow water-bearing zone developed entirely within the organic soils and peat, and a deeper bedrock aquifer. The shallow water-bearing zone occurs largely in the tundra vegetation, peat, and underlying organic soils and accumulates due to the high porosity and low vertical permeability characteristics of these materials.

Observations during the Corps 1997 Phase I Remedial Investigation suggest that in many areas groundwater in this shallow zone is likely perched above deeper groundwater zones by the bedrock surface or a layer of low permeability organic or mineral soil. Where groundwater is perched above bedrock, flow is likely concentrated along the base of the higher permeability soil from which it discharges to ponds, streams, and springs. Perched groundwater is likely widespread in the eastern half of the island as indicated by the large number of ponds in this region. Water level changes in shallow observation wells during rainstorms indicate that the shallow groundwater zone is characterized by relatively high infiltration rates. However, in many instances head differences were noted between shallow groundwater levels and nearby ponds, suggesting a lack of hydrologic connection between surface water bodies and the shallow groundwater.

Observations also indicate a lack of connection between shallow groundwater and the deeper bedrock aquifer. During an August 1995 site visit in support of the Corps RI, a WWII well east of Base Camp was sounded to determine the depth to water. The water table was not present within the 100-foot depth capability of the sounding instrument, even though the well was surrounded by standing water at the ground surface.

Groundwater in the bedrock occurs predominantly in fractures. Hydraulic conductivity may be greater in the shallower bedrock, where more open fractures and weathering processes have resulted in increased effective porosity. Greater lithostatic pressure, and probably less weathering, should result in reduced hydraulic conductivity values for the deeper bedrock. Also, due to greater lithostatic pressures, fractures are likely not as open compared to fractures at shallower depths. The observation that hydraulic heads decreased with depth in test holes near

Project Long Shot (Dudley and others, 1977) suggests that downward flow probably characterizes the upper part of the bedrock aquifer.

Groundwater-discharging springs are known to be present on Amchitka. The best example is Constantine Spring, located along the south boundary fault of Constantine graben. This spring served as a water supply during Army, AEC, and Navy occupation of the island. The literature (Dudley and others, 1977) also indicates that some of the deeper lakes on the island (Pumphouse Lake, Long Lake, and Jones Lake) are fed by bedrock springs. Insufficient detail is presented regarding the setting of these lakes to establish whether the springs reflect an artesian discharge or because the lake is deep enough to intersect the bedrock aquifer water table. Springs in the vicinity of Pumphouse Lake are described as probably "rising along [a]...fault line" (Burkett, 1977).

3.6 NATURAL RESOURCES

Amchitka Island is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge. The refuge's original purpose, when it was established in 1913 as the Aleutian Islands Reservation, was to "establish a preserve and breeding ground for native and migrant birds, encourage and develop fisheries, and allow for propagation of reindeer and fur bearing animals." Current refuge management objectives include biodiversity and protection of: commercial and subsistence fisheries, birds and nesting habitat, sea otters, and sea lions. Both the bald eagle and cormorant have been identified as species of concern.

Terrestrial (disturbed and undisturbed), freshwater, and marine habitats are briefly described below.

3.6.1 Terrestrial Ecology

The terrestrial habitat of eastern Amchitka consists of gently rolling, meadow-like maritime tundra characterized by sedges, grasses, and lichens. There are many shallow ponds and small streams half-hidden by the vegetation. In the higher central portion of the island there are fewer lakes, patches of bare bedrock, and an increased presence of grasses and crowberry. The western portion of the island is mountainous with sparse vegetation. The far western portion of the island consists mainly of windswept rocky and barren plateaus, as well as coastal dunes and sandy beaches.

The terrestrial flora is typical of maritime tundra, a uniform meadow-like vegetation composed of relatively few types of plants. The three main groups of plants include: (1) grasses, sedges, herbs, and ferns; (2) subshrubs; and (3) mosses, lichens, and liverworts. From lowland to upland there is a shift from sedge to grass dominance and an increased presence of crowberry. Turf mounds within the lowlands support more upland-type plants. The beach and dune communities above tide and storm flooding levels are dominated by beach and dune grass with scattered

succulent herbs. Based on 1998 field observations, stream bank vegetation consisted predominantly of grasses and sedges with other plants less common, such as ferns, cow parsnip and wild celery.

Terrestrial invertebrates include springtails and other insects, mites, nematodes, and spiders. The only terrestrial mammals on Amchitka are rats, with the Norway Rat being the predominant, if not the only, species.

3.6.2 Freshwater Ecology

Freshwater habitats on Amchitka include numerous streams, seasonal rivulets, and hundreds of lakes and ponds.

The dominant stream macrophyte, based on field observations for this study, was moss (*Fontinalus* sp.). Other rooted aquatic vegetation observed include mare's tails, marsh marigolds, sedges, and water milfoil. Filamentous algae was also commonly observed.

Freshwater ponds and streams support few species of vertebrates and invertebrates. The most common benthic macroinvertebrates found in study streams were Chironomid larvae, tubifex worms, and caddis fly larvae. Less common were amphipods, mayfly nymphs, fingernail clams, flat worms, snails, springtails, isopods, and blackfly larvae. Tables in Section 4.0 and Appendix F provide data about benthic macroinvertebrate communities.

Vertebrates consist of threespine stickleback, Dolly Varden, coast-range sculpin, and Pacific salmon (pink, silver, and occasionally sockeye). Based on field observations during the 1998 Drill Site Investigation, Dolly Varden were the dominant fish species in streams, while stickleback and sculpin were rare. Both resident and anadromous Dolly Varden were present in some streams. The anadromous variety was commonly present in streams without waterfalls or other barriers and with favorable spawning habitat. Landlocked Dolly Varden were present in all of the study streams. Salmon were observed near the mouths of a few streams including Bridge Creek and Clevenger Creek. Salmon typically spawn in gravelly habitat close to the ocean and do not migrate inland more than a few hundred feet.

3.6.3 Coastal/Marine Ecology

The rugged coastline of Amchitka consists predominantly of sea cliffs covered by grassy slopes; sand beaches are few. Much of the island is fringed by a wave-cut rock bench that extends seaward from the cliffs. The rocky shores are densely carpeted with marine algal communities. A mat of algae covers most intertidal benches, channels, and tide pools. Beyond the area exposed by tides the marine algal community extends into the subtidal zones, where floating kelp beds are the dominant flora. Marine flora provide food sources, habitat, and protection from wave action.

Drift kelp and rotting algae onshore provide habitat for amphipods, kelp/coelopid flies, nematodes, and marine arthropods. Mussels, barnacles, sea urchins, and limpets are generally found in low densities due to heavy predation by sea otters, competition by algae, and reduced wave shock as a result of kelp beds. The most abundant invertebrates are polychaetes, amphipods and isopods, sea anemones, sea cucumbers, and mollusks. Sea urchins are more abundant at depths of 50 to 65 feet.

Over 90 fish species are found in the waters near Amchitka, including lamprey, shark, skates, trout, salmon, smelts, lightfish, viperfish, lancetfish, lanternfishes, cod fishes, grenadiers, stickleback, sandfish, ronquils, pricklebacks, gunnels, prowfish, sand lance, scorpionfishes, sablefish, greenling, sculpins, poachers, snailfishes, lumpfishes, flounders. The rock greenling is the most abundant and widely distributed fish in the inshore rock-algae community.

A variety of marine mammals inhabit the waters adjacent to Amchitka Island. Of particular importance is the sea otter, which is a top carnivore in the nearshore ecosystem. Sea otter predation may be responsible for the sparse populations of benthic invertebrates; black Oystercatchers may exert a similar effect. In addition, harbor seals, Steller sea lions, northern fur seals, whales, porpoises, and the Pacific whitesided dolphin dwell in the surrounding seas.

3.6.4 Birds

Over 130 species of birds have been identified on Amchitka, of which approximately 30 species breed on the island. The terrestrial avian community is dominated by relatively few species. Lapland longspurs make up over half of all breeding birds. The other abundant birds on Amchitka are the Cormorant, Green-winged Teal, Common Goldeneye, Bufflehead, Harlequin Duck, Common Eider, Rock Ptarmigan, Rock Sandpiper, Glaucous-winged Gull, Tufted Puffin, Winter Wren, Grey-crowned Rosy Finch, and Snow Bunting. Bald Eagles and Peregrine Falcons uniformly use the perimeter of the island. Cormorant colonies are less uniformly distributed. Marine and freshwater bird communities vary seasonally and are much more diverse than the terrestrial bird community.

During the 1998 investigation, a Steller Sea Eagle was sighted by several people on at least two occasions. These sightings were considered extremely rare since the sea eagle's range is typically farther east towards Russia.

3.6.5 Rare, Threatened, Endangered, and Commercially-Important Species

The Aleutian Canada Goose population on Amchitka was eradicated shortly after the introduction of blue fox in 1921. Attempts to recolonize the island with this threatened species have failed; however, reproductive success on other Aleutian Islands may result in a future delisting of this species. Marine mammals, including the Steller sea lion (threatened) and eight

endangered species of whale, use the shore and/or marine waters surrounding Amchitka. There are no reported sightings of listed plant species occurring on Amchitka Island.

Species of potential commercial importance are found in marine waters surrounding Amchitka but not on Amchitka itself. Salmon spawn in the streams and lakes of Amchitka but not in commercially viable numbers. Dolly Varden were of recreational importance during periods when the island was occupied.

4.0 SITE CHARACTERIZATION

The 1998 drill site characterization program was directed at evaluating past and potential environmental impacts from releases of drilling mud at AEC and DOE sites on Amchitka Island. Historic releases of drilling mud have been documented to adjoining streams at the Long Shot, Milrow, and Cannikin test sites and at drill sites D, E, and F. These releases, which occurred in the late 1960s and early 1970s, significantly impacted the stream environments at that time. Though environmental recovery from the releases is believed to have been substantial if not complete, open mud pits remaining at each of these locations potentially pose a future hazard to the stream environments. Historical records also indicate that drilling mud was stored at three other locations apart from the drill sites: Milepost 13 Lake, Milepost 14 Lake, and the Rifle Road Mud Sumps. Whereas there is no record of releases from these areas, the potential for such a release warranted evaluation.

Primary objectives of the 1998 Drill Site Characterization program were to assess the residual effects of past drilling mud releases, and develop site-specific information for use in evaluating the environmental hazard posed by drilling mud that remains in the old mud pits or nearby streams and lakes. A secondary objective of the characterization program was to evaluate whether resident fish contain radionuclides at concentrations in excess of what would be expected from world-wide fallout. Although sampling for radionuclides was conducted concurrently with the drilling mud investigation, it was accomplished in support of DOE's overall program to evaluate the impacts of the underground testing rather than the environmental effects from drilling mud.

At each of the three test sites and three drill sites, characterization activities included sediment and surface water sampling in: (1) the remaining open drilling-mud pits or lakes used for drilling-mud storage, (2) lakes potentially impacted by drilling mud, and (3) the stream or streams draining the site. This approach was designed to evaluate the possibility that concentrations of COPCs in stream water and sediment are related to COPC concentrations in the mud pits. Similarly, site reconnaissance and mud pit sampling was planned for the Milepost 13 and 14 Lakes and the Rifle Range Road Mud Sumps.

In order to establish baseline conditions for the test site and drill site streams, a series of four reference streams were also investigated, two similar in setting to the three test sites, and two similar in setting to the three drill sites. For background radionuclide sampling, a fish sample was collected for analysis from Powerhouse Lake in the Base Camp area, far from the test sites

Each of the following subsections presents the results of investigation of both mud pits and drainage streams for a given site. The sites are discussed in a sequence of east to west: Milrow, Long Shot, Cannikin, and Drill Sites D, F, and E. Milepost 13 and 14 Lakes are discussed in their appropriate location between Cannikin and Drill Site D. The Rifle Range Road Mud Sumps are discussed as part of the Milrow site. The four reference streams are discussed following the test sites and drill sites, and the Aircraft Graveyard results are presented in the last section (Section 4.10).

4.1 MILROW

4.1.1 Site Description

The Milrow site is located just south of Infantry Road near Mile 3.4 (Figure 1-2). A plan showing site features in detail is presented in Figure 4.1-1. The AEC developed the Milrow site for the second underground nuclear test performed on Amchitka (the first was conducted at the Long Shot site). The test, conducted on October 2, 1969, involved the underground detonation of an approximately one-megaton nuclear device. The device was detonated at the bottom of a 3,866-foot-deep emplacement hole that was drilled at the site. The diameter of the emplacement hole varied between 3.0 and 5.5 feet. Two smaller-diameter instrument holes were also drilled at the site. Drilling took place between October 1967 and August 1968.

The site formerly contained four drilling mud pits, which were backfilled during the AEC's demobilization. During the 1998 Drill Site Investigation, the area of the former mud pits was observed to be graded and sparsely vegetated. The location of Surface Ground Zero (SGZ) at the site is marked by a concrete and brass monument. The drill site borders a large lake (Heart Lake) that was partially drained by the Milrow event (the lake was approximately two-thirds dry during the 1998 field work). Based on the 1986 air photos, Heart Lake was originally about 500 feet by 800 feet in size.

The site and its vicinity are located in a relatively flat area drained by nearby Clevenger Creek (Figure 4.1-2). Clevenger Creek flows into the Pacific Ocean approximately 6,500 feet downstream from the site.

In addition to the mud pits at the Milrow site, the AEC reportedly constructed two mud pits near the intersection of Infantry Road and Rifle Range Road. The purpose of these latter mud pits was to provide temporary storage of drilling mud following the completion of the Milrow emplacement hole. Two former mud pits were observed just south of the intersection of Infantry Road and Rifle Range Road (Figure 4.1-3). In addition to these two mud pits, a third mud pit was reportedly built on the north side of the road intersection to contain drilling mud that leaked from the other two pits (AEC/NV, 1972). A mud pit that may correspond to this third mud pit was found approximately 2,000 feet northwest of the road intersection. Historical information indicates that all three pits were emptied and the mud transported to Drill Site E for disposal before the Milrow test was conducted. Detailed information regarding the Rifle Range Road mud pits is presented in Section 4.1.4.3.

4.1.2 Site History

The historical information obtained for this study states that Clevenger Creek was significantly impacted by drilling mud from the Milrow site, and Heart Lake was used for drilling mud storage. According to the AEC planning document (AEC/NV, 1972):

> "The sumps at this site were formed by constructing the surrounding embankments on top of the tundra. They were unable to hold liquids and mud materials without prepared bottoms, thus there was considerable mud leakage ... the stream bed of Rifle Range Creek [Clevenger Creek] suffered extensive damage from mud escaping from the Site B sumps, the mud was then diverted into Heart Lake as an alternate to further damage of the creek."

The following excerpts regarding spills and releases at the Milrow site were taken from Chapter 14 of *The Environment of Amchitka Island, Alaska* (Valdez et. al., 1977):

> "The 1968 spills into Clevenger Creek resulted in modest reductions of Dolly Varden and macroinvertebrates, but the larger spills in 1969 eliminated virtually all life in the portion of stream receiving the toxic liquid.
>
> At the time of the Milrow detonation, ground motion liberated much of the oily residue of the drilling mud that had been taken up by organic matter and vegetation in and along Clevenger Creek. With no new additions of this material, the stream populations gradually recovered. Although the odor of oil was still apparent in late July 1970, pink salmon apparently spawned successfully near the mouth of this stream in August. Since these spawners could have strayed from some other stream, their presence was not absolute proof of successful spawning in 1970.
>
> It appears that the spills of drilling mud into Clevenger Creek resulted in mortalities of aquatic organisms without any long-term effects on the habitat. Particulate material from the mud was gradually eliminated, and no additional mud escaped into the stream."

The AEC planning document (AEC/NV, 1972) indicates that the Silver Salmon Lake drainage system was "adversely affected" by "pollution and siltation from ... [gravel pits] ... and from the Rifle Range Sumps." However, reports on the studies of the fresh water ecosystems on the island indicate that the primary impacts to the Silver Salmon Lake drainage system from AEC operations were caused by siltation from the roads and gravel pits (Koob, 1968; Neuhold and Helm, 1968). Significant drilling-mud spills into watersheds generally were reported by the scientists studying the freshwater ecosystems of the island (Burkett, 1977; Valdez et. al., 1977; Fuller and Kirkwood, 1977), because of the dramatic effects of such spills on stream biota. No reports have been found in DOE records concerning drilling-mud spills into the Silver Salmon

Lake watershed. Therefore, it is likely that leaks from the sumps into the watershed, if they did occur, did not result in significant damage to the watershed.

4.1.3 Characterization Activities

Investigation activities at the Milrow site consisted of a brief reconnaissance of the drill site to verify site features, and a reconnaissance and sampling effort at Heart Lake and Clevenger Creek. Five locations were selected in Heart Lake for the collection of sediment samples. The sampling locations were selected in representative areas of both the dry and submerged portions of the lakebed. Surface water samples were collected at the three sediment sample locations within the current confines of the lake. Heart Lake sampling locations are shown in Figure 4.1-1.

A detailed reconnaissance of Clevenger Creek was performed to observe the stream's ecology as a basis for selecting sediment, surface water, invertebrate, and fish sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along the stream. Invertebrate, bioassay, and fish samples were also collected from three of these stations. Stream sampling locations are shown in Figure 4.1-2.

Reconnaissance was also performed to locate the three mud pits reported to have been present near the intersection of Infantry Road and Rifle Range Road, about one mile southeast of the test site. Two former mud pits were observed just south of the road intersection. The third mud pit, reportedly located just north of the intersection, could not be found. However, a third mud pit was found in a gravel pit about 2,000 feet northeast of the road intersection. Two soil samples were collected from this mud pit, referred to here as the "Rifle Range Road Additional Mud Pit." The samples collected from the Milrow site, Clevenger Creek, and the Rifle Range Road Additional Mud Pit were shipped to off-site laboratories for testing. The types of tests performed and their results are discussed in the following sections.

4.1.4 Observations and Analytical Results

4.1.4.1 Heart Lake

Heart Lake is a shallow heart-shaped lake located approximately 300 feet from the Milrow emplacement hole. A southwest-flowing ephemeral stream connects Heart Lake with Clevenger Creek. Photo 4.1-1 shows Heart Lake. The lake is at elevation 121 feet and located in the lowlands in the eastern part of the island. At the time of the 1998 field work, Heart Lake occupied approximately one-third of its lakebed, covering an area of about two acres, with a maximum observed water depth of 4.5 feet. The remaining two-thirds of the lakebed was dry and had a thick to sparse grass cover. The surface soils in the dry lakebed varied from brown,

gravelly, sandy silt to brown peat. The surficial sediment in the submerged portion of the lake consisted of brown peat.

No drilling mud or evidence of diesel contamination (odor, sheen. distressed vegetation, etc.) was observed during the reconnaissance and sampling activities. Three surface water and sediment samples were collected at evenly spaced intervals from the lake. The remaining two sediment samples were collected from the dry portion of the lakebed. Sample descriptions and field screening results are provided in the following table.

Heart Lake Sample Descriptions, Milrow Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Screening Results (ppm)
Heart Lake	4.1	NA	1001-SW		Surface Water	
			1004-SD	0 to 0.3	Brown Peat	ND
	4.5	NA	1002-SW		Surface Water	
			1005-SD	0 to 0.3	Brown Peat	PID=12
	2.1	NA	1003-SW		Surface Water	
			1006-SD	5 to 6	Brown Peat	PID=5
	Dry	NA	1007-SD	0 to 0.3	Brown, gravelly, sandy Silt	PID=1
	Dry	NA	1008-SD	0 to 0.3	Brown Peat	PID=1

* Sample depth measured from the ground or sediment surface
ND Not determined
** Sample not field screened

4.1.4.1.1 Surface Water

The three lake surface water samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.1-1. DRO was reported in all of the surface water samples, at concentrations ranging from 56.8 to 236 ug/L. However, the laboratory method blank associated with two of the DRO analyses contained 82.7 ug/L of DRO. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991) these samples have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. The reported concentrations of DRO are also generally comparable to the 92 ug/L average concentration of DRO reported in water from half of the lowland reference stream samples, as explained in Section 2.3.1.5. Therefore, it is possible that the reported values of DRO could be due either to laboratory contamination or biogenic hydrocarbons within the carbon range of DRO.

The only VOC detected in Heart Lake water samples was methylene chloride, which was detected in two samples at concentrations of 3.55 and 5.48 ug/L. This substance is a common

laboratory contaminant, and based on the low concentrations and lack of likely sources, these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

The Heart Lake water samples contained a total of 11 metals, most at levels well below those established during this study as background for surface water in lowland streams. Only nickel and titanium occurred at concentrations that exceeded background levels. Nickel was not detected in the lowland reference stream samples (at a detection limit of 1 ug/L), but was present in Heart Lake at estimated concentrations of 1.41 to 1.81 ug/L. These concentrations are well below the ecological risk-based screening concentration (ERBSC) for nickel in surface water of 52 ug/L (see Table 2-8). Titanium was present in the three Heart Lake samples at about 130 percent of the background value. However, there is no ERBSC for titanium in surface water.

DOE analyzed a single surface water sample collected from Heart Lake in 1993 for metals (see Appendix B, Sample SW-HL, and Figure 4.1-2). In general, the concentrations of metals detected in 1998 were lower than those reported in 1993. For example, four metals (calcium, iron, magnesium, and manganese) were reported at two to five times lower concentrations in 1998; aluminum was reported at a ten times lower concentration in 1998. Both the 1993 and 1998 water samples were filtered, to measure dissolved metals only. Thus, incorporation of sediment in the 1993 samples, which would have resulted in elevated concentrations for some metals, does not explain this discrepancy. Sample SW-HL also detected low concentrations of one semivolatile compound and four volatile compounds that were not detected in 1998 (Appendix B).

Surface water quality parameters measured in Heart Lake during the 1998 Drill Site Investigation are presented below.

Surface Water Parameters for Heart Lake, Milrow Site

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1001-SW	7.1	11.0	10.9	110	30
1002-SW	7.5	10.9	10.9	90	10
1003-SW	7.7	11.0	11.7	90	10

4.1.4.1.2 Sediment

The Heart Lake sediment samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.1-2. DRO was not detected in the five sediment samples. No PAHs were detected in the sediment samples, nor were VOCs with the exception of 2-butanone (at 0.092 to 0.127 mg/kg), which is a common laboratory contaminant.

The sediment samples contained 19 of the 22 metals analyzed. The concentrations of these metals were compared to the background concentrations for sediment from lowland reference streams. Concentrations of the following metals exceeded their background values in one or more samples (the asterisk indicates the metal also exceeds its ERBSC value).

Aluminum	Calcium	Cerium	Chromium
Copper*	Magnesium	Potassium	Strontium
Thorium			

Most of these exceedances were no more than 20 percent higher than the background values. However, copper and magnesium concentrations were two to three times higher than their respective background values in at least one sample. All of the metals listed above, with the exception of aluminum and potassium, were found in the drilling mud on the island at an average concentration higher than the background concentration in stream sediment. Thus, it is possible that the elevated metals concentrations found in the Heart Lake sediment are residual from the lake's previous use for drilling-mud storage, even though no visibly obvious drilling mud was observed during sampling.

Those metals found in Heart Lake sediment samples that exceeded background concentrations were then compared to the ERBSCs. Chromium, although exceeding background, did not exceed its ERBSC. Copper concentrations in all five samples exceeded its ERBSC, which is about one-quarter of the background concentration of copper found in the lowland reference streams. No ERBSCs are available for aluminum, cerium strontium, or thorium. Nor are ERBSCs available for calcium, potassium, and magnesium, which are considered essential nutrients in most organisms and not likely to result in significant ecological effects.

4.1.4.2 Clevenger Creek

Clevenger Creek is the primary drainage stream of the Milrow Site watershed. It is connected to Heart Lake by a small tributary that drains the lake. It is located south of the site and flows southwest to the Pacific Ocean (Figure 4.1-2). The studied portion of Clevenger Creek is approximately 6,500 feet long. As noted in Section 4.1.2, portions of Clevenger Creek were inundated with drilling mud in 1969, presumably through the tributary stream from Heart Lake. Fish and benthos were reportedly eliminated in portions of the stream following this inundation. However, field observations indicate that significant recovery has taken place since then.

Field activities at Clevenger Creek included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). One surface water and sediment sample was collected at each of five sampling stations positioned along the length of the creek. At Stations 1, 2, and 5, benthic macroinvertebrates, sediment samples for bioassays, and fish samples were also collected. No fish samples were collected for radionuclide testing due to the low numbers of observed fish.

The following table lists the sample numbers of each medium collected at each station, as well as station coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver, and are accurate to about ±100 feet. Station elevations were interpolated from topographic contours on Figure 4.1-2.

Sample Numbers and Station Coordinates for Clevenger Creek, Milrow Site

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 24' 51.1"	179° 10' 57.8"	78	4018-SW 4019-SD 4029-FS 4033-IN
2	51° 24' 37.2"	179° 10' 47.7"	60	4015-SW 4016-SD/4017-SD 4028-FS 4032-IN
3	51° 24' 26.6"	179° 10' 50.3"	51	4013-SW 4014-SD
4	51° 24' 18.6"	179° 10' 36.4"	30	4011-SW 4012-SD
5	51° 24' 9.9"	179° 10' 10.5"	15	4007-SW 4008-SD/4009-SD 4095-FS 4026-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities, and discuss laboratory results for surface water, sediment, benthos, and fish samples.

4.1.4.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, Clevenger Creek was divided into three stream reaches (Figure 4.1-2). The stream reach numbering system for all the streams discussed in this report follows the convention of beginning with the reach farthest upstream. Reach 1 of Clevenger Creek begins at a small source pond about 600 feet southwest of Infantry Road and ends at the confluence with the Heart Lake drainage tributary. This tributary was flowing slightly at the time of reconnaissance, contributing less than five percent to the overall stream discharge. Reach 2 extends from the Heart Lake drainage stream confluence downstream to about 100 feet below the confluence with an eastern tributary of Clevenger Creek. This eastern tributary contributes slightly less discharge than the subject stream channel. Reach 3 extends from this tributary confluence downstream through a culvert under Rifle Range Road, and ends at a cobble beach on the Pacific Ocean. Two notable tributaries enter Reach 3: one from the south and one from the north; each increases the overall stream discharge by about 15 to 20

percent. In general, the upper and lower reaches have flatter gradients than the middle reach, which is more incised and has a higher stream velocity. No significant fish barriers such as waterfalls were observed along the stream. The following table summarizes reach characteristics for Clevenger Creek.

Reach Characteristics for Clevenger Creek, Milrow Site

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,400	1.8	Straight	Silty peat
2	1,600	2.0	Straight	Sand and gravel over peat
3	3,500	0.75	Straight, few meanders	Silty peat

Reach 1

Reach 1 is roughly 1,400 feet long. The upper portion of Reach 1 lies within a broad, gently-sloping, sedge-covered meadow. The lower portion of this reach becomes more incised with a slightly steeper gradient. The overall gradient averages from 1 to 2 percent. The stream typically ranges from 2 to 3 feet wide, and 6 inches to 3 feet deep, with few bends. The dominant streambed substrate is soft silty peat. Little sand or gravel was observed. The dominant aquatic vegetation was marsh marigold (*Caltha palustris*).

Station 1 was located in Reach 1, about 600 feet upstream of the confluence with the Heart Lake tributary.

Reach 2

Reach 2 is roughly 1,600 feet long. It has a gradient of 2 to 4 percent, slightly steeper than other reaches. The channel along this reach is also more incised within a relatively straight and narrow valley. Several small tributaries enter along the length of the reach. The stream bottom consists of well-graded sand and gravel superimposed on peat and silt. The stream channel is typically 2 to 3 feet wide, and 6 to 8 inches deep, with pools up to 4 feet deep. Numerous pools are present, often undercutting the banks and providing favorable fish habitat. Aquatic vegetation consisted primarily of moss (*Fontinalus* sp.).

Station 2 was located in the upper part of Reach 2, and Station 3 was located in the middle of Reach 2. A sheet metal weir and gauging station were observed just downstream of Station 3. These were most likely installed in the late 1960s for hydrologic studies.

Reach 3

Reach 3 is roughly 3,500 feet long, with an overall gradient of about 0.75 percent, making it the flattest reach on Clevenger Creek. The channel has more bends and curves than the upper two reaches. The stream valley along this lower part of the stream becomes broad, widening towards the ocean. A grass and sedge meadow covers the valley floor. The dominant stream channel

substrate consists of silty peat. The average stream depth ranges from 3 to 5 feet and the width from 8 inches to 4 feet. A few tributaries enter Clevenger Creek within Reach 3, each adding approximately 15 to 20 percent to the flow of Clevenger Creek. The stream passes under Rifle Range Road through a 36-inch culvert; much of the road embankment overlying the culvert has washed away. About 300 feet downstream of the road crossing, the channel meets the tidal zone at a boulder/cobble beach. The stream contains large detritus such as driftwood at its mouth.

Station 4 was located in the upper end of Reach 3, approximately 250 feet below the confluence that marks the upstream extent of the reach. Station 5 was located just upstream of the culvert at Rifle Range Road. *Fontinalus* was the dominant aquatic vegetation type, with about 30 percent coverage.

4.1.4.2.2 Surface Water

Five surface water samples were collected from Clevenger Creek, one per sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.1-3.

DRO was reported in each of the surface water samples, at concentrations ranging from 98.9 to 225 ug/L. However, 82.7 ug/L of DRO was present in the laboratory method blank associated with this batch of samples. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. The reported concentrations of DRO are also comparable (1½ to 3 times) to the DRO concentrations reported in water from lowland reference streams, as explained in Section 2.3.1.5.

The only VOC detected was methylene chloride in four samples at concentrations of 2.63 to 4.51 ug/L. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

Seventeen metals were detected in the surface water samples from Clevenger Creek. About half of these were present in samples from each of the five stations, while the other metals were detected at only some of the stations. The concentrations of the following ten metals exceeded their respective background values lowland reference streams at one or more stations.

Aluminum*	Arsenic	Boron*	Calcium
Cobalt	Copper*	Iron*	Nickel
Potassium	Titanium		

The metals with an asterisk exceeded their respective ERBSC values as well as background concentrations for at least one station sample.

Three of the metals detected in Clevenger Creek water (arsenic, boron, and nickel) were not detected in the lowland reference streams. In most cases, the metals concentrations in stream water samples exceeded background values by less than 30 percent. The aluminum concentrations were two to three times background for samples from Stations 3 and 4.

Seven of the ten metals that exceeded background values in Clevenger Creek water also exceeded background in sediment (see Section 4.1.4.2.3). Specifically, aluminum, boron, calcium, copper, nickel, potassium, and titanium also exceeded background values in sediment samples

Metals found in Clevenger Creek water samples that exceeded background concentrations were then compared to the project ERBSCs. Aluminum concentrations at Stations 1, 3, and 4 exceeded the aluminum ERBSC. However, this ERBSC is about one-third the background concentration of aluminum found in the lowland reference streams. The ERBSC for boron is 1.6 ug/L, which was exceeded where detected at Stations 2 and 3. Copper concentrations exceeded the ERBSC at Stations 1 and 4; however, only the concentration at Station 1 exceeded background. Iron exceeded its ERBSC by 7 percent at Station 3, which is also the only station where it exceeded the background concentration.

Arsenic, cobalt, and nickel exceeded background concentrations, but did not exceed their respective ERBSCs. No ERBSC is available for titanium. No ERBSCs are available for calcium or potassium, but these metals are considered essential nutrients and are unlikely to result in toxic effects.

DOE analyzed a single surface water sample (SW-RRC) collected from Clevenger Creek in 1993 for metals (see Appendix B). The sample location was just upstream of 1998 Station 5 (Figure 4.1-2). A comparison between SW-RCC and the 1998 Station 5 sample results indicates generally similar concentrations of metals with the following exceptions. Aluminum, chromium, copper, and zinc concentrations dropped significantly from the 1993 results to the 1998 results. Both the 1993 and 1998 water samples were filtered to measure dissolved metals only, so the possible incorporation of sediment in the 1993 samples does not explain this discrepancy.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Clevenger Creek, Milrow Site

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	8.2	9.5	8.2	235	0
2	8.6	8.2	12.0	340	1
3	8.3	7.7	11.3	335	0
4	7.6	7.8	12.0	241	1
5	7.4	7.3	12.4	240	1

4.1.4.2.3 Sediment

One sediment sample was collected at each of the five Clevenger Creek stations. Field duplicates were also collected at Stations 2 and 5. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. Only one sediment sample (Station 2) and its duplicate were analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.1-4.

DRO was detected in four of the five sediment samples, at concentrations of 29.6 to 542 mg/kg. The highest value for DRO in Clevenger Creek sediment was found in the sample from Station 1, upstream of the confluence with the Heart Lake tributary (Figure 4.1-2). DRO concentrations downstream of the site were comparable with background levels.

No VOCs were detected in the sediment sample or duplicate from Station 2, except for carbon disulfide, which was detected at 0.318 and 0.0901 mg/kg. According to the laboratory, this is suspected to be cross-contamination from the sample containers (see Section 2.3). PAHs were not detected in the sediment samples.

A total of 20 metals were reported in the Clevenger Creek sediment samples. The concentrations of these metals were compared to background concentrations for lowland reference streams. In the farthest downstream sample (the duplicate pair from Station 5), twelve metals exceeded their respective background concentrations. At the other four stations only boron and chromium exceeded background concentrations. Boron was present in two of ten lowland reference stream sediment samples; the concentrations in four Clevenger Creek samples (from Stations 2, 4, and 5) exceeded the highest reference stream concentration by 10 to 28 times. Chromium concentrations in five of the Clevenger Creek samples (from all five stations) exceeded the lowland background concentration; the mean Clevenger Creek concentration was 19.3 mg/kg, compared to a background value of 11.8 mg/kg.

Metals that exceeded background values at Station 5 included:

Aluminum	Boron	Calcium	Cerium
Cesium	Chromium	Copper*	Magnesium
Nickel*	Potassium	Strontium	Titanium

The asterisk indicates metal concentrations that also exceeded the ERBSC values.

Cesium was not detected in reference stream sediment (either lowland or upland), but two of the three site-related stream samples where it was detected were from Clevenger Creek (the sample and duplicate from Station 5). However, these cesium concentrations were comparable to the detection limits in samples in which it was not detected. On average, the highest concentration of the other metals in the duplicate pair of samples from Station 5 were 2.6 times the background values. However, there is poor agreement between the concentrations reported for the original sample and its duplicate. The original sample on average contained 2.5 times the concentration

of the duplicate sample (a relative percent difference of 86 percent, which exceeds the project quality assurance goal for precision of 20 percent for most metals). The laboratory reported a solids content of 18.5 percent for the original sample (corresponding to a sample with considerable organic material) and 49 percent for the duplicate sample. This suggests considerable variability in the matrix, which may have affected the accuracy of the reported concentrations in the original sample.

Selenium and thorium were not detected in the sediment samples from Clevenger Creek, even though they were each detected in sediment samples from Heart Lake.

Those metals found in Clevenger Creek sediment samples that exceeded background concentrations were then compared to project ERBSCs. Chromium, although above background, did not exceed its ERBSC. Copper concentrations at all stations exceeded its ERBSC, but only at Station 5 did it exceed the background concentration for lowland reference streams. Nickel exceeded its ERBSC only in the original sample from Station 5, but not the duplicate. No ERBSCs are available for aluminum, boron, calcium, cerium, cesium, magnesium, potassium, strontium, or titanium. Calcium, potassium, and magnesium are considered essential nutrients in most organisms and not likely to result in significant ecological effects.

In addition to the total metals results discussed above, AVS and SEM were analyzed to provide information on the bioavailability of metals. AVS and SEM concentrations in the sediment samples from Clevenger Creek are presented in the following table. The ratio of SEM to AVS ranged from 0.002 to 0.49, suggesting that there are sufficient acid volatile sulfides present to limit the bioavailability of the SEM metals. However, in the duplicate sample from Station 5 no AVS was detected (compared to 112 micromoles per gram in the original sample). This absence of AVS could indicate the bioavailability of the SEM metals; thus, no conclusive statement can be made regarding metals bioavailability at Station 5.

AVS and SEM Concentrations for Clevenger Creek, Milrow Site

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4019-SD	776	4.05	0.01
2	4016-SD	1,110	2.56	0.002
3	4014-SD	24.4	12	0.49
4	4012-SD	659	2.24	0.003
5	4008-SD/4009-SD	112/ND	1.67/0.823	0.01/NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon and comparison of the substrate at the various stations. Also, organic content determinations were performed on all samples, and the grain size gradation was measured on those samples with a sufficient mineral soil content (rather than peat and other organics, whose lighter specific gravity render a grain size analysis invalid). These analyses

were also performed to allow comparison of sediment between stations. The results are presented in the following table, and the grain size gradations are plotted in Figure 4.1-5.

Sediment Characteristics for Clevenger Creek, Milrow Site

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4019-SD	178,000	-	Brown PEAT with silt
2	4016-SD	120,000	35.1	Brown, slightly fine sandy SILT with organics
3	4014-SD	111,000	44.8	Brown, fine sandy SILT with abundant organics and peat
4	4012-SD	116,000	-	Dark brown, fine sandy SILT, with abundant organics
5	4008-SD	92,000	14.0	Organics, roots, peat, some silt

DOE also collected a number of sediment samples in 1997 from Clevenger Creek; these locations are shown in Appendix B. However, the only 1997 samples from this area that were analyzed for metals were from the Pacific Ocean beach near the mouth of Clevenger Creek. Since the marine environment would not be expected to be comparable to the freshwater stream environment, the 1997 results have not been compared to the 1998 results.

4.1.4.2.4 Benthos

Benthic samples were collected on Clevenger Creek at Stations 1, 2, and 5. The sampling technique used at this stream involved hand picking (with forceps) individual invertebrates from kick nets and placing them into sample jars preserved with 10-percent formalin solution. This procedure differed from benthic samples from other streams, except for Reference Stream 1. Elsewhere, benthic samples were collected by placing sediment and detritus from the kick net into preserved sample jars without sorting. Sorting of these samples was conducted in the laboratory.

These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table.

Benthic Invertebrates in Clevenger Creek, Milrow Site

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	5
Turbellaria	Tricladida	Planariidae	flatworm	adult		2	
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult		6	7
Gastropoda	Mesogastropoda	Lymnaidae	snail	juvenile			1
Insecta	Ephemeroptera	Baetidae (Pseudocloeon sp.)	mayfly	nymph		13	
Insecta	Hemiptera	Veliidae	ripple bug	nymph	2	1	
	Trichoptera	Limniphilidae	caddisfly	larva	2		2
	Diptera	Chironomidae	midge	larva	53	8	
		Chironominae	midge	larva		1	3
		Tanypodinae	midge	larva			1
		Rhagionidae	snipefly	pupa	1		
		Simulidae	blackfly	larva	1	3	
Crustacea	Isopoda	Asellidae	isopod	adult	24		
				Total	**83**	**34**	**14**
				Family Biotic Index	6.55	5.45	6.83
				EPT Relative Abundance	2.4%	38.0%	14.3%
				Species Diversity	0.93	1.6	1.33

The variations in benthic community structure between the three stream stations cannot be directly attributed to site-related effects. A variety of natural causes (such as the type of substrate and presence or absence of predators) can affect the benthic community, in addition to site-related chemical impacts. For this reason, the benthic data were evaluated along with the results of sediment bioassays and sediment chemical analyses using a weight-of-evidence approach known as the Sediment Quality Triad. The Triad Analysis of Drill Site and Test Stream Sediments, prepared by IT Corporation under subcontract to DOE, is presented in Appendix F. This report evaluates the benthic abundance and diversity data for this stream in comparison to the other site-related and reference streams, as one component of the Sediment Quality Triad.

4.1.4.2.5 Sediment Toxicity Tests

Sediment samples collected from the same three stations as the benthic invertebrate samples were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed under subcontract to IT Corporation by American Aquatic Testing in Allentown, Pennsylvania.

Measurements of toxicity include survival (percentage of initial seed organisms surviving to the end of the test), growth (average dry weight of surviving organisms), and biomass (total dry weight of surviving organisms). Since the toxicity tests were conducted in three batches, the data were control normalized in order to make appropriate comparisons. Normalization consisted of expressing the results as a percentage of the average laboratory control response for the laboratory control sample tested concurrently with the particular sample. Results are presented in the following table.

Sediment Toxicity, Clevenger Creek, Milrow Site

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	45.00%	48.00%	0.945	127.90%	4.17	60.30%
2	51.25%	54.67%	0.741	100.30%	3.74	54.10%
5	45.00%	48.00%	0.680	92.00%	2.93	42.40%

As is the case with benthic community structure, the variations in the bioassay results between the three stations in the stream cannot be directly attributed to site-related effects. Laboratory bioassays measure sediment toxicity but do not indicate the specific cause of toxicity, nor do they indicate actual field effects. A variety of natural causes (such as the type of substrate and presence or absence of predators) can affect the benthic community, as can site-related chemical impacts. For this reason, the bioassay data were evaluated along with the benthic data and results of sediment chemical analyses as part of the Sediment Quality Triad. The *Triad Analysis of Drill Site and Test Site Stream Sediments* prepared by IT Corporation under subcontract to DOE is presented in Appendix F. This report evaluates the bioassay results for this stream in comparison to the other site-related and reference streams, as one component of the Sediment Quality Triad.

4.1.4.2.6 Fish

Fish samples were collected from Clevenger Creek at Stations 1, 2, and 5. Specific data on fish sampling, such as the size and weight of individual fish, are presented in the field fish collection forms provided in Appendix J.

The fish collected and included in the samples consisted of resident Dolly Varden. One 1.5-inch stickleback and one 14-inch sea-run Dolly Varden at Station 1 and six sea-run Dolly Varden at Station 2 were also caught during sampling and released.

Fish Sample Descriptions for Clevenger Creek, Milrow Site

Station	Sample Number	Length (inches)	Number of fish	Total Sample Weight (grams)	Average Weight per Fish (grams)	Electroshock Time (seconds)
1	4029	1 - 9	14	330	23.6	465
2	4028	1 – 8	14	340	24.3	787
5	4095	1 - 8.3	29	650	22.4	1.590

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, PCBs, and percent lipids. Analytical results are presented in Table 4.1-5 and summarized below.

Twenty-two metals were detected in the fish tissue samples. Concentrations were compared to background concentrations determined for fish from lowland reference streams, and to EPA Region III RBCs for fish consumption. With the exception of inorganic arsenic, no metals in fish from Clevenger Creek exceeded their respective RBCs. Total arsenic in the sample from Station 5 had a slightly higher concentration than the RBC (0.225 versus 0.21 mg/kg). Total arsenic in the sample from Station 5 was about twice the background concentration from reference streams. The inorganic arsenic concentration in fish samples from Clevenger Creek ranged from 6 times the RBC at Station 1 to 26 times the RBC at Station 5. In relation to the background concentration of inorganic arsenic, the Station 1 sample was below background, Station 2 exceeded the background by 29 percent, and Station 5 was close to three times background. Cesium in the samples from Stations 2 and 5 exceeded the background concentration of cesium in fish from the reference streams by about 10 percent. Copper exceeded the reference stream background concentration by 6 percent in the sample from Station 5. Nickel was reported in the sample from Station 5 at 0.127 mg/kg (wet weight basis); nickel was not reported (at a reporting limit of 0.125 mg/kg in any of the reference stream fish samples or in samples from the other stations on Clevenger Creek).

Naphthalene was the only PAH detected in fish tissue, at a concentration of 0.0155 mg/kg in the sample from Station 5. This concentration is well below the EPA Region III RBC. The PCB Aroclor 1260 was detected in samples from Stations 1 and 2 at estimated concentrations of 0.0094 and 0.00649 mg/kg, respectively. Both occurrences exceed the 0.0016 mg/kg RBC for fish consumption by humans. The percent lipids measured for fish tissue from Station 1 was 2.21 percent.

4.1.4.3 Rifle Range Road Mud Pits

Two disturbed areas that resembled backfilled mud pits were observed near the south side of the intersection of Rifle Range Road and Infantry Road (Figure 4.1-3). Construction drawings were provided by DOE for two mud pits formerly located in this area. The disturbed areas observed during the reconnaissance have the same approximate dimensions as the pits shown in the

construction drawings, and are thought to be the backfilled remains of those mud pits. The pits have been backfilled with sandy gravel and are partially overgrown with grasses.

A reconnaissance was performed of the suspected former mud pits and their vicinity (including a nearby lake) to search for evidence of impact by drilling mud. During this work, it was observed that several low-lying areas at the surface of the former mud pits were full of water, creating small ponds. In two of these ponds, located in the southwestern-most of the two former mud pits, a sheen formed when the bottoms of the ponds were probed with a steel rod. However, the pond bottoms were hard, gravelly materials, and no drilling mud was observed in or around the ponds. Neither pond had an outlet stream or obvious drainage channel. Aside from these impacted ponds, no other evidence of drilling mud was apparent during the reconnaissance.

An area just north of the intersection of Infantry Road and Rifle Range Road was investigated for the presence of the third reported mud pit. The search area included the vicinity of 1986 Disposal Area DA02. No evidence of the third mud pit was found near Infantry Road.

An alternate location about 2,000 feet northeast of the road intersection was also searched for the third mud pit. This location was suspected based on air photo review during planning for the 1998 Drill Site Investigation. Air photos taken in 1969 show a pond and a gravel pit located north of the intersection of Infantry Road and Rifle Range Road that contained light-colored fluid. The light color of the fluid contrasted with the apparent dark color of the water in nearby ponds, suggesting that these water bodies contained some sort of sediment, possibly the result of siltation from gravel pit operations. It was also speculated that the light color might indicate the presence of drilling mud. The locations of this pond and gravel pit are shown in Figure 4.1-3. During the 1998 investigation, neither the pond nor the gravel pit identified in the 1969 air photo appeared to be impacted by drilling mud. However, a broad, low-lying area located adjacent to the gravel pit did contain drilling mud. This suspected mud pit was characterized by the collection and analysis of discretionary soil samples (samples that were not planned in the August 1998 *Management Plan*).

The former mud pit measured approximately 200 feet by 150 feet, and was located in a depressed area about 1 to 2 feet lower in elevation that the surrounding ground surface (see Photo 4.1-2). The surface of the pit was dry and covered with what appeared to be gray, sandy bentonite with a diesel odor. The drilling mud in portions of the mud pit contained fibrous particles that had the effect of reducing the density of the material. This fibrous material may have been a mud additive used to control circulation loss. Several hand-augered borings were drilled in the mud pit to determine the drilling mud thickness. Based on the test borings, the soils in the pit area are approximately 2 feet thick and consist of approximately 1 foot of diesel-impacted drilling mud overlying 1 foot of gray sand. The sand layer below the drilling mud was also observed to be diesel-impacted. Groundwater with a heavy sheen was encountered at a depth of about 6 inches in each boring. Two soil samples were collected from one of the

borings, and a surface soil sample was collected from a second location. Test boring and sampling locations are shown in Figure 4.1-4. Based on the field measurements, the mud pit contains an estimated volume of 1,880 cubic yards of drilling mud and contaminated sand (see Section 2.4.3.1.3 for a description of the assumptions and method used in making this estimate). Soil sample descriptions and field screening results are provided in the following table.

Rifle Range Road Additional Mud Pit Sample Descriptions, Milrow Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Rifle Range Road Additional Mud Pit	Dry	1.0	1076-SL	0 to 0.3	Gray Bentonite	Strong diesel odor	PID=4
			1078-SL	1.5 to 2	Gray Sand	Strong diesel odor, groundwater with a heavy sheen at 6-inch depth	PID=3
	Dry	unknown	1077-SL	0 to 0.2	Gray, fibrous Bentonite	Moderate diesel odor	PID=1

* Sample depth measured from ground surface

The three drilling-mud and soil samples were analyzed for DRO, VOC, PAHs, and metals. The results of these analyses are presented in Table 4.1-6. DRO was detected in each of the samples. The two bentonite samples contained 981 and 2,620 mg/kg DRO. The sample of sand underlying the bentonite contained 60.9 mg/kg DRO. Five to seven PAHs were detected in each sample, at total PAH concentrations of 0.48 to 9.11 mg/kg (about 0.1 to 0.8 percent of the DRO concentration).

Concentrations of acenaphthene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene exceeded the sediment ERBSCs. The results for naphthalene were "R"-flagged (rejected) due to low LCS recovery. No VOCs were detected in the samples.

All 24 metals analyzed were detected in samples from this former mud pit. The following ten metals exceeded background concentrations, for lowland reference stream sediment, in at least one of the three samples collected in the Rifle Range Road Mud Pit (an asterisk indicates that the ERBSC was also exceeded.)

Calcium	Cerium	Cesium	Chromium*	Copper*
Magnesium	Nickel	Potassium	Strontium	Thorium

The metals concentrations which exceeded background were then compared to the project ERBSCs. Only chromium and copper also exceeded the ERBSCs. In the case of chromium, the ERBSC of 26 mg/kg was exceeded in two sample by up to 25 times. For copper, all three

samples exceeded the ERBSC while only two exceeded background. The background copper value is 71.1 mg/kg while the ERBSC is 16 mg/kg.

4.1.5 Summary

The features observed at the Milrow test site were similar to those identified during the planning phase. Therefore, the original scope of work planned for the drill site (not including the Rifle Range Road Mud Pits) was considered adequate to meet the project objectives. The former mud pits at the site are filled in and covered, and no deposits of drilling mud or areas that were contaminated with diesel were observed at the site.

The reconnaissance and sampling of Heart Lake indicate that drilling mud does not presently impact the lake. DRO was reported in one sample of the lake's surface water, but based on its relatively low estimated concentration (56.8 mg/kg), this detection likely represents biogenic hydrocarbons rather than diesel. Although both arsenic and copper were detected in Heart Lake sediment at concentrations above ERBSCs, only one of the five sediment samples had a copper concentration that was also significantly above the background concentration. None of the arsenic concentrations detected approached the background level. Considering the lack of any apparent residual drilling mud in the lake, and the general lack of contaminants that are commonly associated with it, it is likely that the lake was never contained significant amounts of drilling mud.

Five stations were sampled along Clevenger Creek for sediment and surface water chemistry. DRO was detected at an elevated concentration in sediment at the station farthest upstream (Station 1 at 542 mg/kg). This result suggests that drilling mud entered Clevenger Creek upstream from the Heart Lake outlet stream, which is consistent with the likely pathway for mud that would have spilled from the mud pits. A number of metals were detected at concentrations above background in one or more stream surface water samples. Seven of the ten metals that exceeded background in Clevenger Creek water also exceeded background in the stream sediment. Specifically, aluminum, boron, calcium, copper, nickel, potassium, and titanium also exceeded background values in sediment samples. A few of these metals were elevated above ERBSCs in some surface water and sediment samples, but none were consistently high in stream samples. For example, aluminum, boron, copper, and iron exceeded both their background concentrations and ERBSCs in one or two surface water samples (most often at Station 3). Titanium, which has no ERBSC in surface water, also significantly exceeded its background concentration at Stations 1, 3, and 4. In sediment, Station 5 had copper at a concentration above both background and the ERBSC, while boron was significantly higher than background at Stations 2, 4, and 5 (there is no ERBSC for boron).

Fish samples were collected from three of the stream stations along Clevenger Creek. Two of these fish samples contained the PCB Aroclor 1260 at estimated concentrations of 0.0094 and 0.00649 mg/kgw (below the detection limit of 0.01 mg/kg). These concentrations are slightly above the EPA Region III fish consumption RBC for PCBs of 0.0016 mg/kg. Inorganic arsenic

concentrations in all three samples exceeded the RBC for this metal, while two of the samples also slightly exceeded the background concentration for inorganic arsenic in fish.

A Triad Analysis approach (see Appendix F) was used to develop an overall ranking of the sediment quality at three stations along Clevenger Creek relative to a total of 22 lowland stream stations. This overall ranking combines benthic, sediment chemistry, and sediment toxicity rankings; a lower ranking (higher number) is indicative of relatively greater degradation of sediment quality in a stream location. The overall sediment quality ranking for these stations was as follows:

Clevenger Creek

Station 1	16th
Station 2	5th
Station 5	15th

The sediment quality of Clevenger Creek as a whole is within the range of the lowland reference streams. The upstream Station 1 is within the range of comparable locations on the reference streams, whereas the downstream Station 5 was shown to have sediment quality lower than the comparable reference stream stations.

Based on their reported association with drilling operations at the Milrow site, three mud pits near Rifle Range Road were also investigated. Reconnaissance of the area determined that two former mud pits located south of the intersection of Rifle Range Road and Infantry Road had been backfilled and no drilling mud could be found. The third pit, which was previously unidentified, is located in the former borrow area north of the intersection of Rifle Range Road and Infantry Road, and contains an estimated 1,880 cubic yards of diesel-contaminated drilling mud and soil. DRO was detected at concentrations of 60.9 to 2,620 mg/kg, and metals concentrations were also significantly elevated, particularly chromium. This mud pit is located in a flat, low-lying area on the floor of the borrow area. As a result, the drilling mud is not likely to be transported significantly either by gravity (e.g. during an earthquake) or erosion. At the time of the field work, the mud pit contained only a small quantity of standing water, which was not sampled. Groundwater, observed in borings at a depth of 6 inches, appeared to be impacted by diesel, based on a hydrocarbon sheen and strong odor.

TABLE 4.1-1
SURFACE WATER ANALYTICAL RESULTS FOR HEART LAKE, MILROW SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-MILR-1001-SW	98DOE-MILR-1002-SW	98DOE-MILR-1003-SW
Diesel Range Hydrocarbons	AK 102	-	236 U	220 U	56.8 J
Volatile Organic Compounds					
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	3.55 U	5.48 U	ND(2)
Polycyclic Aromatic Hydrocarbons	EPA 8270C	-	ND	ND	ND
Metals					
Aluminum	EPA 6020	269	244	231	261
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)
Calcium	EPA 6010B	4,320 [b]	1,390	1,490	1,410
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	3.35	1.06 J	1.82 J	ND(1) UJ
Copper	EPA 6020	10.8	4.47	3.75	3.23
Iron	EPA 6010B	993	243	232	234
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	1,480 J	1,480 J	1,460 J
Manganese	EPA 6020	267	6.98	6.86	6.54
Nickel	EPA 6020	ND(1)	**1.49 J**	**1.81 J**	**1.41 J**
Potassium	EPA 6010B	2,620	1,110	1,160	1,210
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	12	12.4	11.6
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	**7.94 J**	**8.21 J**	**7.95 J**
Vanadium	EPA 6020	4.43 [b]	ND(1)	ND(1)	ND(1)
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)	ND(10)

TABLE 4.1-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR HEART LAKE, MILROW SITE
(concentrations in micrograms per liter)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.1-2
SEDIMENT ANALYTICAL RESULTS FOR HEART LAKE, MILROW SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-MILR-1004-SD	98DOE-MILR-1005-SD	98DOE-MILR-1006-SD	98DOE-MILR-1007-SD	98DOE-MILR-1008-SD
		Depth (feet)	0-0.25	0-0.25	0-0.25	0-0.25	0-0.25
Diesel Range Hydrocarbons	AK 102	-	ND(29.9)	ND(31.6)	ND(24.4)	ND(4)	ND(32.7)
Volatile Organic Compounds							
2-Butanone	EPA 8260B	-	0.0922 J	0.0964 J	0.127 J	ND(0.01) UJ	ND(0.0817) UJ
Carbon disulfide	EPA 8260B	-	ND(0.0374) UJ	ND(0.0383) UJ	ND(0.0336) UJ	ND(0.005) UJ	ND(0.0409) UJ
Methylene chloride	EPA 8260B	-	ND(0.0374) UJ	ND(0.0383) UJ	ND(0.0336) UJ	ND(0.005) UJ	ND(0.0409) UJ
Polycyclic Aromatic Hydrocarbons	EPA 8270C	-	ND	ND	ND	ND	ND
Metals							
Aluminum	EPA 6010B	45,400	**48,000**	44,700	35,400	**77,500**	29,500
Arsenic	EPA 6020	100	ND(3.74)	ND(3.95)	ND(3.06)	ND(0.5)	ND(4.09)
Barium	EPA 6020	469	**141**	188	101	93.5	60.3
Boron	EPA 6010B	7.18 [b]	ND(18.7)	ND(19.7)	ND(15.3)	ND(2.5)	ND(20.4)
Calcium	EPA 6010B	7,300	**8,130**	**7,640**	3,920	5,500	1,390
Cerium	EPA 6020	14.2	9.85	9.63	8.29	**16.3**	11.4
Cesium	EPA 6020	ND	ND(3.74)	ND(3.95)	ND(3.06)	ND(0.5)	ND(4.09)
Chromium	EPA 6020	11.8	**20.6 J**	**21.7 J**	7.76 J	9.99 J	9.95 J
Cobalt	EPA 6020	43.7	10.1	11.1	7.52	27	5.74

TABLE 4.1-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR HEART LAKE, MILROW SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-MILR-1004-SD	98DOE-MILR-1005-SD	98DOE-MILR-1006-SD	98DOE-MILR-1007-SD	98DOE-MILR-1008-SD
		Depth (feet)	0-0.25	0-0.25	0-0.25	0-0.25	0-0.25
Copper	EPA 6020	71.1	74.3	73.4	66.7	**192**	75.2
Iron	EPA 6010B	155,000	26,100	26,400	16,400	66,400	7,660
Lithium	EPA 6020	48.8	14.9	16.3	14.7	19.1	10.9
Magnesium	EPA 6010B	9,320	7,570	7,370	**9,520**	**29,400**	2,510
Manganese	EPA 6020	20,700	173	170	86.8	309	28.4
Nickel	EPA 6020	13.6	6.72	6.51	6.54	13.6	6.61
Potassium	EPA 6010B	1,390	925	1,000	847	**1,580**	258
Selenium	EPA 6020	5.44 [b]	ND(3.74) UJ	ND(3.95) UJ	ND(3.06) UJ	ND(0.5) UJ	4.67 J
Strontium	EPA 6020	164	99.9	117	62	**196**	30.7
Thorium	EPA 6020	0.5 [b]	ND(3.74)	ND(3.95)	ND(3.06)	**0.855**	ND(4.09)
Titanium	EPA 6020	3,010	1,770	1,830	1,670	1,520	1,460
Vanadium	EPA 6020	734	125	126	118	212	125
Zinc	EPA 6020	434	51.9	53.8	33.6	71	ND(40.9)

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

TABLE 4.1-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR HEART LAKE, MILROW SITE
(concentrations in milligrams per kilogram)

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.1-3
SURFACE WATER ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-MILR-4018-SW	98DOE-MILR-4015-SW	98DOE-MILR-4013-SW	98DOE-MILR-4011-SW	98DOE-MILR-4007-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	142 U	201 U	98.9 U	225 U	126 U
Volatile Organic Compounds							
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	2.95 U	2.92 U	4.51 U	ND(2)	2.63 U
Polycyclic Aromatic Hydrocarbons	EPA 8270C	-	ND	ND	ND	ND	ND
Metals							
Aluminum	EPA 6020	**269**	**137**	75.8	**625**	**557**	83.5
Arsenic [c]	EPA 6020	ND(1)	ND(1)	**1.68**	**1.85**	ND(1)	**1.25**
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	**88.7**	**59.7**	ND(50)	ND(50)
Calcium	EPA 6010B	4,320 [b]	3,720	3,340	**4,470**	4,130	**4,330**
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)	1.25	ND(1)
Cobalt	EPA 6020	3.35	ND(1)	ND(1)	1.47	**4.32**	3.24
Copper	EPA 6020	**10.8**	**11.8 J**	4.11 J	4.09 J	**9.43 J**	3.7 J
Iron	EPA 6010B	993	802	336	**1,070**	932	515
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)	1.14	ND(1)
Magnesium	EPA 6010B	4,690 [b]	2,520	2,110	2,780	3,100	3,250
Manganese	EPA 6020	**267**	26.1	13.1	12.6	27.2	18.4
Nickel	EPA 6020	ND(1)	ND(1)	ND(1)	**1.97**	**1.65**	ND(1)
Potassium	EPA 6010B	2,620	1,570 J	2,510 J	**2,730 J**	2,560 J	2,240 J
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	14.4	10.5	13.2	17.9	18.9
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	**30.6 J**	3.17 J	**123 J**	**87.4 J**	2.79 J
Vanadium	EPA 6020	4.43 [b]	1.44 J	**4.44 J**	4.33 J	4.12 J	ND(1) UJ

TABLE 4.1-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-MILR-4018-SW	98DOE-MILR-4015-SW	98DOE-MILR-4013-SW	98DOE-MILR-4011-SW	98DOE-MILR-4007-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Zinc	EPA 6020	50.3 [b]	36 J	ND(10) UJ	15.7 J	25.1 J	44.9 J

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples. see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination. result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8

TABLE 4.1-4
SEDIMENT ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-MILR-019-SD Station 1	98DOE-MILR-016-SD Station 2	98DOE-MILR-017-SD (Duplicate) Station 2	98DOE-MILR-014-SD Station 3	98DOE-MILR-012-SD Station 4	98DOE-MILR-008-SD Station 5	98DOE-MILR-009-SD (Duplicate) Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	542	90.3	-	ND(28.2)	99.1	29.6	ND(8.5)
Volatile Organic Compounds										
2-Butanone	EPA 8260B	mg/kg	-	-	ND(0.09)	ND(0.017) UJ	-	-	-	-
Carbon disulfide	EPA 8260B	mg/kg	-	-	0.318 U	0.0901 U	-	-	-	-
Methylene chloride	EPA 8260B	mg/kg	-	-	ND(0.045)	ND(0.0085) UJ	-	-	-	-
Polycyclic Aromatic Hydrocarbons	EPA 8270C	mg/kg	-	ND	ND	-	ND	ND	ND	ND
Metals										
Aluminum	EPA 6010B	mg/kg	45,400	16,000	20,100	-	22,700	17,200	**90,600**	34,900
Arsenic	EPA 6020	mg/kg	100	13.9 J	11.1 J	-	48.9 J	18 J	14.6 J	6.05 J
Barium	EPA 6020	mg/kg	469	104	146	-	253	173	355	121
Boron	EPA 6010B	mg/kg	7.18 [b]	ND(20.1) R	**101 J**	-	ND(17.6) R	**198 J**	**193 J**	**76.8 J**
Calcium	EPA 6010B	mg/kg	7,300	2,880	3,730	-	5,510	2,450	**20,200**	**8,180**
Cerium	EPA 6020	mg/kg	14.2	9.97	7.58	-	10.2	8.19	**30.9**	13.5
Cesium	EPA 6020	mg/kg	ND	ND(4.02)	ND(2.04)	-	ND(3.52)	ND(3.43)	**4.26**	**1.8**
Chromium	EPA 6020	mg/kg	11.8	**22.2**	**20.6**	-	**14.3**	**24.3**	**24.7**	9.8
Cobalt	EPA 6020	mg/kg	43.7	15.9	14.5	-	22.3	13.5	38.3	14.5
Copper	EPA 6020	mg/kg	71.1	63.2	43.9	-	47.8	40.6	**247**	**94.2**

TABLE 4.1-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-MILR-4015-SD Station 1	98DOE-MILR-4016-SD Station 2	98DOE-MILR-4017-SD (Duplicate) Station 2	98DOE-MILR-4014-SD Station 3	98DOE-MILR-4012-SD Station 4	98DOE-MILR-4008-SD Station 5	98DOE-MILR-4009-SD (Duplicate) Station 5
Iron	EPA 6010B	mg/kg	155,000	50,500	47,700	-	91,300	108,000	93,100	36,000
Lithium	EPA 6020	mg/kg	48.8	5.84 J	10.6 J	-	9.38 J	7.15 J	41.7 J	16.9 J
Magnesium	EPA 6010B	mg/kg	9,320	6,290	6,320	-	8,210	5,280	**37,500**	**15,500**
Manganese	EPA 6020	mg/kg	20,700	1,130	1,450	-	9,020	2,650	793	297
Nickel	EPA 6020	mg/kg	13.6	6.66	5.47	-	6.09	7.51	**18.9**	7.35
Potassium	EPA 6010B	mg/kg	1,390	462	925	-	1,160	359	**3,560**	**1,480**
Selenium	EPA 6020	mg/kg	5.44 [b]	ND(4.02)	ND(2.04)	-	ND(3.52)	ND(3.43)	ND(2.7)	ND(1.06)
Strontium	EPA 6020	mg/kg	164	44.4	82.4	-	119	78.4	**609**	**262**
Thorium	EPA 6020	mg/kg	0.5 [b]	ND(4.02)	ND(2.04)	-	ND(3.52)	ND(3.43)	ND(2.7)	ND(1.06)
Titanium	EPA 6020	mg/kg	3,010	857 J	865 J	-	552 J	704 J	**5,760 J**	2,410 J
Vanadium	EPA 6020	mg/kg	734	151	186	-	242	193	420	154
Zinc	EPA 6020	mg/kg	434	129 J	92.2 J	-	133 J	105 J	208 J	90.5 J
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	178,000	120,000	-	111,000	116,000	92,000	44,900
Acid Volatile Sulfide	Titration	umol/g	-	776	1,110	-	24.4	659	112	ND(0.0106)
Simultaneously Extracted Metals	Summation	umol/g	-	4.05	2.56	-	12	2.24	1.67	0.823

- Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

TABLE 4.1-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

b	This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
ND(1)	Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
-	sample not analyzed for this parameter
mg/kg	milligrams per kilogram
umol/g	micromoles per gram
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U	analyte concentration attributed to blank contamination; result considered nondetect
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations
R	result rejected due to quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.1-5
FISH ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration[a]	98DOE-MILR-4029-FS Station 1	98DOE-MILR-4028-FS Station 2	98DOE-MILR-4095-FS Station 5
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	SW8270 SIM	mg/kg	81.1	-	ND(0.067)	ND(0.0067)	ND(0.0067)
Acenaphthylene	SW8270 SIM	mg/kg	NA	-	ND(0.067)	ND(0.0067)	ND(0.0067)
Anthracene	SW8270 SIM	mg/kg	405.6	-	ND(0.067)	ND(0.067)	ND(0.168)
Benzo(a)anthracene	SW8270 SIM	mg/kg	0.0043	-	ND(0.067)	ND(0.067)	ND(0.168)
Benzo(a)pyrene	SW8270 SIM	mg/kg	0.00043	-	ND(0.067)	ND(0.067)	ND(0.168)
Benzo(b)fluoranthene	SW8270 SIM	mg/kg	0.0043	-	ND(0.067)	ND(0.067)	ND(0.168)
Benzo(ghi)perylene	SW8270 SIM	mg/kg	NA	-	ND(0.067)	ND(0.067)	ND(0.168)
Benzo(k)fluoranthene	SW8270 SIM	mg/kg	0.043	-	ND(0.067)	ND(0.067)	ND(0.168)
Chrysene	SW8270 SIM	mg/kg	0.43	-	ND(0.067)	ND(0.067)	ND(0.168)
Dibenzo(a,h)anthracene	SW8270 SIM	mg/kg	0.00043	-	ND(0.067)	ND(0.067)	ND(0.168)
Fluoranthene	SW8270 SIM	mg/kg	54.1	-	ND(0.067)	ND(0.067)	ND(0.168)
Fluorene	SW8270 SIM	mg/kg	54.1	-	ND(0.067)	ND(0.0067)	ND(0.0067)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	mg/kg	0.0043	-	ND(0.067)	ND(0.067)	ND(0.168)
Naphthalene	SW8270 SIM	mg/kg	27.0	-	ND(0.067)	ND(0.0067)	0.0155
Phenanthrene	SW8270 SIM	mg/kg	NA	-	ND(0.067)	ND(0.067)	ND(0.168)
Pyrene	SW8270 SIM	mg/kg	40.6	-	ND(0.067)	ND(0.067)	ND(0.168)
Polychlorinated Biphenyls							
Aroclor 1016	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	mg/kg	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1242	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1248	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1260	SW8081	mg/kg	0.0016	-	0.00941	0.00649 J	ND(0.01) UJ
Metals							
Aluminum	SW6020	mg/kg	1351.9	475	16.1	44	61
Arsenic	SW6020	mg/kg	0.21	0.127	0.0533	0.112	0.225
Inorganic Arsenic	EPA Draft 1632	mg/kg	0.0021	0.0208	0.0138	0.0268	0.0551
Barium	SW6020	mg/kg	94.6	1.03	0.209	0.318	0.46
Beryllium	SW6020	mg/kg	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)

TABLE 4.1-5 (cont.)
FISH ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration[a]	98DOE-MILR-029-FS Station 1	98DOE-MILR-028-FS Station 2	98DOE-MILR-095-FS Station 5
Boron	SW6020	mg/kg	121.7	28.6	6.92 UJ	6.83 UJ	8.74 UJ
Cadmium	SW6020	mg/kg	1.4	0.0373[b]	ND(0.0250)	ND(0.0250)	ND(0.0250)
Calcium	SW6020	mg/kg	NA	19,200	8,600	8,800	7,500
Cerium	SW6020	mg/kg	NA	0.0280[b]	ND(0.0250)	ND(0.0250)	0.0278
Cesium	SW6020	mg/kg	NA	0.0258[b]	ND(0.0250)	**0.0285**	**0.0263**
Chromium	SW6020	mg/kg	4.1	1.03	0.359	0.326	0.509
Cobalt	SW6020	mg/kg	81.1	0.0780[b]	ND(0.0500)	0.0523	0.053
Copper	SW6020	mg/kg	54.1	1.20[b]	0.994 U	0.95 U	**1.27 U**
Iron	SW6020	mg/kg	405.6	310	50	136	206
Lithium	SW6020	mg/kg	27.0	0.0993[b]	ND(0.0250)	ND(0.0250)	0.028
Magnesium	SW6020	mg/kg	NA	408	323	310	330
Manganese	SW6020	mg/kg	189.3	160	10.5	17.9	25
Molybdenum	SW6020	mg/kg	6.8	0.173[b]	0.16 UJ	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	mg/kg	27.0	ND	ND(0.125)	ND(0.125)	**0.127**
Potassium	SW6020	mg/kg	NA	4,780[b]	4,580	4,500	4,150
Selenium	SW6020	mg/kg	6.8	0.936	0.359	0.337	0.348
Strontium	SW6020	mg/kg	811.1	22.1	8.79	5.89	12.6
Thallium	SW6020	mg/kg	0.09	0.0283[b]	ND(0.0250)	ND(0.0250)	ND(0.0250)
Thorium	SW6020	mg/kg	NA	3.43[b]	ND(2.50) UJ, B	ND(2.50) UJ, B	ND(2.50) UJ, B
Titanium	SW6020	mg/kg	5407.4	32.1	0.498	1.49	3.76
Uranium	SW6020	mg/kg	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	mg/kg	9.5	1.05	0.279	0.435	0.597
Zinc	SW6020	mg/kg	405.6	48.8	35.3	38.7	32.7
% Lipids	Lipids	% by Weight	-	-	2.21	-	-

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

TABLE 4.1-5 (cont.)
FISH ANALYTICAL RESULTS FOR CLEVENGER CREEK, MILROW SITE

- sample not analyzed for this parameter
mg/kg milligrams per kilogram
B analyte detected in method blank
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U analyte concentration attributed to blank or laboratory contamination; result considered nondetect
UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.

TABLE 4.1-6
SEDIMENT ANALYTICAL RESULTS FOR RIFLE RANGE ROAD MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-RRMP-1076-SL	98DOE-RRMP-1077-SL	98DOE-RRMP-1078-SL
		Depth (feet)	0-0.3	0-0.2	1.5-2
Diesel Range Hydrocarbons	AK 102	-	2,620	981	60.9
Volatile Organic Compounds					
Naphthalene	EPA 8260B	-	ND(0.25)	ND(0.1)	ND(0.5)
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	EPA 8270C	-	0.989	ND(0.02)	0.0365
Anthracene	EPA 8270C	-	0.823	0.169	0.0127
Benzo(a)anthracene	EPA 8270C	-	ND(0.0165)	0.0084	ND(0.0033)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.0165)	0.00525	ND(0.0033)
Chrysene	EPA 8270C	-	ND(0.0165)	0.0105	ND(0.0033)
Fluoranthene	EPA 8270C	-	0.177	ND(0.1)	ND(0.0033)
Fluorene	EPA 8270C	-	2.095	ND(0.02)	0.0992
Naphthalene	EPA 8270C	-	0.0939 R	ND(0.0033) R	0.0526 R
Phenanthrene	EPA 8270C	-	4.41	ND(0.5)	0.269
Pyrene	EPA 8270C	-	0.525	0.426	0.00763
Metals					
Aluminum	EPA 6010B	45,400	21,700	20,900	14,400
Arsenic	EPA 6020	100	119	9.58	1.75
Barium	EPA 6020	469	201	226	23.4
Calcium	EPA 6010B	7,300	**34,200**	**20,500**	3,240
Cerium	EPA 6020	14.2	**22**	**23.5**	8.78
Cesium	EPA 6020	ND	**0.748 J**	**0.781 J**	**0.937 J**
Chromium	EPA 6020	11.8	633	664	**18.6**
Cobalt	EPA 6020	43.7	9.3	9.45	7.72
Copper	EPA 6020	71.1	86	84.6	34.8
Iron	EPA 6010B	155,000	37,300	29,500	14,600
Lithium	EPA 6020	48.8	12.3	11.1	7.21
Magnesium	EPA 6010B	9,320	**10,600**	**9,800**	5,680
Manganese	EPA 6020	20,700	792	783	240
Molybdenum	EPA 6020	5.5 [b]	0.695	0.754	0.522

TABLE 4.1-6 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR RIFLE RANGE ROAD MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-RRMP-1076-SL	98DOE-RRMP-1077-SL	98DOE-RRMP-1078-SL
		Depth (feet)	0-0.3	0-0.25	1.5-2
Nickel	EPA 6020	13.6	5.67	7.54	**14.4**
Potassium	EPA 6010B	1,390	**1,770**	**1,640**	600
Selenium	EPA 6020	5.44 [b]	0.604	0.663	0.513
Strontium	EPA 6020	164	**363**	**262**	58.9
Thallium	EPA 6020	1 [b]	ND(0.5) UJ	ND(0.5) UJ	**0.522 J**
Thorium	EPA 6020	0.5 [b]	**4.43 J**	**4.45 J**	**1.2 J**
Titanium	EPA 6020	3,010	2,450 J	2,070 J	696 J
Uranium	EPA 6020	4.13 [b]	1.67 J	1.6 J	0.598 J
Vanadium	EPA 6020	734	95.1	95.8	44.9
Zinc	EPA 6020	434	89.3	93.8	32.9

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

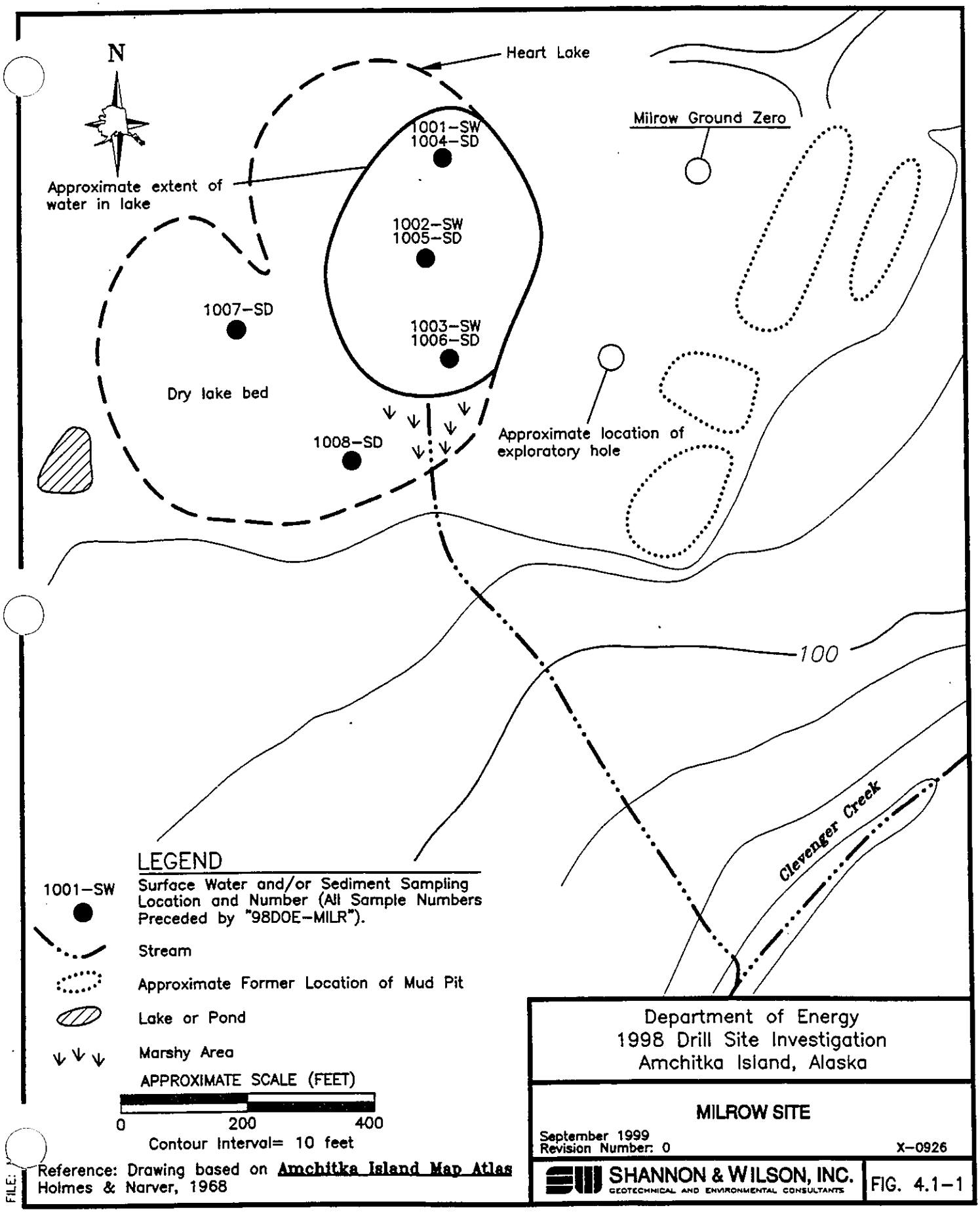
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

R result rejected due to quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.


N
Heart Lake
Milrow Ground Zero
1001-SW
1004-SD
Approximate extent of water in lake
1002-SW
1005-SD
1007-SD
1003-SW
1006-SD
Dry lake bed
1008-SD
Approximate location of exploratory hole
100
Clevenger Creek
LEGEND
1001-SW
Surface Water and/or Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE-MILR").
Stream
Approximate Former Location of Mud Pit
Lake or Pond
Marshy Area
APPROXIMATE SCALE (FEET)
0
200
400
Contour Interval= 10 feet
Reference: Drawing based on Amchitka Island Map Atlas Holmes & Narver, 1968
Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska
MILROW SITE
September 1999
Revision Number: 0
X-0926
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4.1-1

boggy area with no main channel. Subterranean flow is common, as are small ponds with no perceptible flow. The gradient is less than 1 percent across this area. Coverage of in-stream vegetation is nearly continuous; stream banks are vertical to undercut through peat.

In the lower portion of Reach 2, one main channel with surface flow emerges. The channel increases to 1 to 4 feet wide and 1 to 3 feet deep. The stream enters a narrow valley and becomes more incised at the end of the reach.

Station 3 was located in the upper part of Reach 2. A few pockets of grayish sediment were observed in the stream banks below the water level, which may indicate drilling-mud constituents; however, no odor or sheen was detected. Sediment consisted primarily of slightly silty peat. Benthic macroinvertebrates were rare to absent, and Dolly Varden were also limited. In both pools and stream channels visibility was extremely limited by abundant submergent macrophytes. Detailed sketches of the stream are presented in field notes, Appendix I.

Station 4 was located in the lower portion of Reach 2 in a pool. Sediment consisted of moss roots and peat, with a little silt. The channel continued to be extensively covered by aquatic vegetation. Photo 4.2-4 shows the view upstream from Station 4 as the stream becomes more incised.

Reach 3

In Reach 3 the stream gradient increases seaward with a steep drop-off just above the beach. A waterfall located about 100 feet upstream of the beach is about 4 feet high with a 50-degree slope. It is unlikely that any local fish would be able to overcome this barrier. In the steep lower portion of Reach 3 the substrate is primarily gravel, cobbles, and boulders. In general, there are fewer areas of deposition and more erosion on the lower portion of Reach 3 compared with the other reaches. Station 5 was located in the upper half of Reach 3. The sediment there was silty, fine to coarse sand with numerous organics. Approximately 75 percent of the stream bottom was covered with moss.

4.2.4.2.2.2 Surface Water

Five surface water samples were collected from Rainbow Creek, one per sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.2-3.

DRO was reported in four of the five surface water samples, at concentrations of 51.7 to 121 ug/L. The highest value was found at Station 1, where a sheen was observed upon disturbing sediments. The detection limit for DRO in water was 50 ug/L; the concentrations at Stations 2 and 5 were just over that amount (54.4 and 51.7 ug/L, respectively). All of the reported concentrations are comparable to the 92 ug/L average DRO detected in half the samples from lowland reference streams.

The only VOC detected in the surface water samples was methylene chloride. It was detected in all five samples at concentrations ranging from 4.64 to 10.3 ug/L. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (Section 2.3). No PAH compounds were detected in the water samples.

Eleven metals were detected in the surface water samples from Rainbow Creek. All but four of these metals (calcium, copper, magnesium, and strontium) had concentrations below the background concentrations from lowland reference streams. The copper concentration from Station 2 was 17.7 ug/L compared with the 10.8 ug/L background copper concentration. However, Station 2 was located in a tributary of Rainbow Creek, and not in the flow path from the Long Shot mud pits. Copper was not detected at the other four sampling stations on Rainbow Creek. Strontium concentrations exceeded background at four stations by as much as 1.6 times. Calcium was reported at above background concentrations at all five stations, and magnesium at two stations. Samples from Rainbow Creek contained the maximum detected concentrations of calcium, copper, and strontium in water from any site-related stream.

A comparison of the metals that exceeded background values in Rainbow Creek surface water to the list of metals that exceeded background values in sediment indicates that only calcium exceeded both sediment and water background values. Copper, magnesium, and strontium were present in both water and stream sediment, but did not exceed sediment background concentrations.

Those metals found in Rainbow Creek water samples that exceeded background concentrations were compared to Project ERBSCs (Table 2-10). The copper concentration at Station 2 was almost twice its ERBSC. Strontium concentrations found in Rainbow Creek were well below the ERBSC. No ERBSCs are available for calcium or magnesium; these are considered essential nutrients and unlikely to result in any toxic effects.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are as follows.

Surface Water Parameters for Rainbow Creek, Long Shot Site

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	7.3	11.5	9.9	197	Clear
2	6.9	6.8	11.4	223	Clear
3	6.8	8.4	11.0	205	Clear
4	7.0	9.5	11.5	195	Clear
5	6.7	8.5	11.5	192	Clear

4.2.4.2.2.3 Sediment

One sediment sample was collected at each of five stations on Rainbow Creek. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. Only the sediment sample from Station 3 was analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.2-4.

DRO was detected in four out of five sampling stations, at concentrations ranging from 84.4 to 2,110 mg/kg. The two highest reported concentrations for DRO in project stream sediment samples were found at Stations 3 and 4 (2,110 and 1,100 mg/kg, respectively). These values are significantly higher than other stream sediment concentrations, which are typically below 120 mg/kg. These values are more comparable to concentrations found in mud pit sediment samples. In contrast, the concentration in the sample from Station 1, where the sheen was observed, was only 110 mg/kg.

No PAHs were detected in any of the Rainbow Creek sediment samples. No VOCs were detected in the one sediment sample tested (from Station 3), although detection limits were elevated due to the high DRO concentration.

A total of 19 metals were detected in the Rainbow Creek sediment samples. The concentrations of these metals were compared to the background concentrations for lowland reference streams. Boron, chromium, and iron are the only metals that exceeded background concentrations. Boron was detected only at Station 5, at about twice the background concentration for lowland reference streams. Chromium exceeded background at Stations 3, 4, and 5, with a maximum concentration of 38.8 mg/kg, which is over three times the background concentration of 11.8 mg/kg. The 192,000 mg/kg of iron reported at Station 5 was the highest concentration of iron in sediment from the project.

These three metals that exceeded background concentrations were then compared to project ERBSCs. Chromium concentrations detected in Station 3 and 4 sediments are as much as 1.5 times the chromium ERBSC. The iron concentration at Station 5 was almost ten times greater than its ERBSC; however, the background concentration for iron in sediment is also almost eight times the ERBSC. No ERBSC is available for boron.

AVS and SEM concentrations in the sediment samples from Rainbow Creek are presented in the following table. No acid volatile sulfides were detected, so they do not limit the availability of the SEM metals to organisms.

AVS and SEM Concentrations for Rainbow Creek, Long Shot Site

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4124-SD	0	1.7	NA
2	4122-SD	0	0.962	NA
3	4120-SD	0	3.08	NA
4	4118-SD	0	4.47	NA
5	4116-SD	0	2.88	NA

TOC was determined for each of the sediment samples, to allow normalization of organic chemical concentrations to carbon and comparison between the substrate at the various stations. Organic content was also determined for all samples. Due to insufficient mineral soil content, no grain-size gradation analyses were performed. The sediment characteristics are summarized as follows..

Sediment Characteristics for Rainbow Creek, Long Shot Site

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4124-SD	171,000	-	Brown PEAT
2	4122-SD	248,000	366.0	Brown PEAT
3	4120-SD	192,000	181.0	Brown, slightly silty PEAT
4	4118-SD	235,000	-	Brown, slightly silty PEAT
5	4116-SD	63,300	29.1	Brown, slightly gravelly, silty SAND with organics

No prior DOE sampling appears to have been conducted along Rainbow Creek. One surface water sample, "SW-SELS," was collected in 1993 on a nearby creek or ditch (*Long Shot Surface and Groundwater Sampling Locations*, in Appendix B). Based on the available information, this sample does not appear to have been collected on the drainage ditch that flows into Rainbow Creek.

4.2.4.2.2.4 Benthos

Benthic samples were collected on Rainbow Creek at Stations 2, 3, and 5. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Results are evaluated in The *Triad Analysis of Drill Site and Test Site Stream Sediments* prepared by IT Corporation, presented in Appendix F.

Benthic Invertebrates in Rainbow Creek, Long Shot Site

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					2	3	5
Turbellaria	Tricladida	Planariidae	flatworm	adult			4
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult	8		15
Gastropoda	Mesogastropoda	Lymnaidae	snail	juvenile	9	12	
Insecta	Trichoptera	Limniphilidae	caddisfly	larva	8	24	6
	Diptera	Muscidae	fly	larva	16		
		Chironomidae	midge	larva		396	42
		Diamesinae	midge	larva	200		
		Rhagionidae	snipefly	pupa	16		
Arachnoidea	Arachnida		spider	adult	8		
				Total	**265**	**432**	**67**
				Family Biotic Index	6.00	5.89	6.15
				EPT Relative Abundance	3.1%	5.6%	8.9%
				Species Diversity	0.87	0.34	1.01

4.2.4.2.2.5 Sediment Toxicity Tests

Sediment samples collected from Stations 2, 3, and 5 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are evaluated in The *Triad Analysis of Drill Site and Test Site Stream Sediments* prepared by IT Corporation (Appendix F).

Sediment Toxicity Results, Rainbow Creek, Long Shot Site

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
2	67.50%	71.05%	0.459	87.90%	3.09	62.70%
3	0.00%	0.00%	0.000	0.00%	0.00	0.00%
5	83.75%	88.16%	0.262	50.20%	2.16	43.80%

4.2.4.2.2.6 Fish

Fish samples were collected at Stations 3 and 5 on Rainbow Creek. A third fish sample was attempted at Station 2; however, no fish were observed during electrofishing.

The sample weight from Station 3 was considerably less than the target sample weight of 300 grams. The visibility was poor due to overabundance of bank and in-stream vegetation. The fish

habitat also appeared to be poor. The visibility for shocking and netting fish at Station 5 was also poor due to aquatic vegetation and thick, overhanging vegetation along banks. All fish that were collected were resident Dolly Varden. Specific data on fish sampling, such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish.

Fish Sample Descriptions for Rainbow Creek, Long Shot Site

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
3	4157-FS	4	2	30	15	756
5	4155-FS	2 - 6	23	250	10.9	1376

Both fish tissue samples were analyzed for total metals and inorganic arsenic. The fish sample from Station 5 was also tested for PAHs and PCBs. Due to small sample size, the sample from Station 3 was not tested for PAHs or PCBs. Analytical results are presented in Table 4.2-5 and summarized below.

The PCB Aroclor 1260 was detected in the Station 5 fish sample at a concentration of 0.0161 mg/kg. This concentration is about 10 times the EPA Region III RBC of 0.0016 mg/kg.

Eighteen metals were detected in the two fish tissue samples. Concentrations were compared to background concentrations determined for fish from lowland reference streams, and EPA Region III RBCs for fish consumption. Only thorium exceeded background levels (at Station 3). There is no ERBSC for thorium.

Inorganic arsenic was detected in both samples at concentrations exceeding the fish consumption RBC. One of these samples from Station 5 also slightly exceeded the background concentration (0.0236 vs. 0.0208 mg/kg). Note that the background level of inorganic arsenic in lowland stream fish is almost ten times higher than the corresponding RBC.

PAHs were not detected in the fish sample from Station 5, Rainbow Creek.

4.2.4.2.3 Cloudberry Creek

During the 1998 field effort the name Cloudberry Creek was given to the stream previously referred to as the "unnamed southern drainage" of Long Shot. Cloudberry Creek begins upstream of Infantry Road (Mile 4.7), flows northeast beneath the road through a culvert, and eventually empties into Cyril Cove on the Bering Sea (Figure 4.2-2). Cloudberry Creek is approximately 7,200 feet long with an overall gradient of 1.6 percent.

Field activities at Cloudberry Creek included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). One surface water and sediment sample were collected at each of five sampling stations along the length of the creek. At three of the sampling stations (Stations 1, 2, and 5) benthic macroinvertebrates, sediment samples for bioassays, and fish samples were also collected. One fish sample was collected for radionuclide testing at Station 1; this was the only location where sufficient numbers of resident Dolly Varden were present for collection for radionuclide analysis.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ± 100 feet. Station elevations were interpolated from contours in Figure 4.2-2.

Sample Numbers and Station Coordinates for Cloudberry Creek, Long Shot Site

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 26' 06.7"	179° 10' 55.0"	130	4052-SW 4053-SD/4054-SD 4073-FS 4077-FS (Rad) 4078-IN
2	51° 26' 06.9"	179° 11' 05.3"	110	4050-SW 4051-SD 4074-FS 4076-IN
3	51° 26' 11.2"	179° 11' 36.2"	70	4048-SW 4049-SD
4	51° 26' 28.0"	179° 11' 57.4"	50	4046-SW 4047-SD
5	51° 26' 33.8"	179° 12' 06.3"	25	4044-SW 4045-SD 4111-FS 4075-IN

The following subsections present observations made during the reconnaissance and sampling activities, and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.2.4.2.3.1 Stream Characteristics

Based on observations during the initial reconnaissance, Cloudberry Creek was divided into three stream reaches (Figure 4.2-2). Reach 1 begins about 1,000 feet upstream of Infantry Road and ends at the road. The gradient of Reach 1 averages 0.9 percent. Midway downstream on

Reach 1 is the confluence with the ephemeral tributary from Reed Pond: no surface flow was observed in this small channel during the 1998 investigation. Reach 2 begins at the culvert beneath Infantry Road and flows for over a mile (5,500 feet). The overall gradient is 1.7 percent, with the upper portion of the reach being steeper than the lower portion. Reach 3 is about 700 feet long with a gradient of 2.1 percent. The stream channel is incised through a 200- to 300-foot-wide valley that broadens towards the beach. No significant fish barriers such as waterfalls were observed along the stream. The following table summarizes reach characteristics for Cloudberry Creek.

Reach Characteristics for Cloudberry Creek, Long Shot Site

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,000	0.9	Few bends	Silt with organics
2	5,500	1.7	Numerous bends	Sandy silt with organics
3	700	2.1	Few bends	Sand, gravel, and cobbles

Reach 1

Reach 1 begins downstream of the confluence of two tributaries (Figure 4.2-2). One tributary flows from Quonset Lake, south of Cloudberry Creek, and the other from an unnamed lake south of Long Shot Pond. Reach 1 is a depositional area, consisting of a series of slow-moving pools 3 to 5 feet wide and 3 to 5 feet deep. It appeared that the culvert draining Reach 1 was placed higher than the optimum position, causing water to pool upstream of the road. Aquatic vegetation covers about 90 percent of the stream bottom and consists predominantly of filamentous algae and moss (submergent) and mare's tails (emergent). The stream banks are vertical to undercut and overhung by grass and sedge. The dominant substrate is mud and silt with organics.

At the time of the 1998 investigation there was no direct surface channel from Reed Pond to Cloudberry Creek. The upper portion where a channel would have been was a gently-sloping boggy area. Any flow was apparently subsurface through the tundra mat. Closer to the creek, a small (4 inches wide), straight channel formed and entered Cloudberry Creek with trace flow

Station 1 within Reach 1 was located about 250 feet upstream of Infantry Road. Macrophytes were abundant. A biogenic sheen was observed on the water near Station 1. Resident Dolly Varden (sized 3 to 7 inches) were numerous; a radionuclide fish sample was obtained at this station. Photo 4.2-5 shows Station 1 during fish sampling.

Reach 2

Reach 2 of Cloudberry Creek begins at the culvert beneath Infantry Road (Photo 4.2-6). Downstream of the culvert the stream shows evidence of scouring, the channel is straight, and the gradient is 3 to 4 percent. In the middle and lower portions of Reach 2 the gradient becomes

flatter, and the channel has more bends. Three tributaries enter the lower half of Reach 2; they were estimated to contribute about 15 to 20 percent to the overall stream discharge. The channel typically ranges from 1 to 3 feet wide. The depth in the upper reach typically ranges from 4 to 12 inches; depth increases somewhat downstream to 2 to 3 feet. Banks are vertical to undercut and covered with grass and other vegetation. Aquatic vegetation consisted primarily of moss, which covered about 50 percent of the stream bottom. Stream sediment generally consisted of fine sandy silt with numerous organics.

Station 2 was located in the upper part of Reach 2. Station 3 was located in the middle of Reach 3, near a large bend in the stream channel. A tributary enters just downstream of Station 3, contributing about 20 percent of the total discharge. The number, size, and depth of pools increases through this portion of Cloudberry Creek.

Station 4 was located about two-thirds of the way down Reach 2. The substrate is primarily peat with areas of sandy gravel superimposed. There is a greater abundance of aquatic moss (*Fontinalus*, sp.) present. Channel width ranges from 1 to 3 feet and depth from 1 to 2 feet, typically.

Reach 3

Reach 3 is roughly 700 feet long, with an overall gradient of about 2.1 percent. The substrate consists of sand, gravel, and cobbles, with pockets of silty organic sediment. The stream channel is relatively straight and flows through a steep-sided valley to the sea. The stream valley and banks are covered primarily by grass that overhangs the channel. Station 5 was located halfway down Reach 3. The stream channel was about 3 feet wide and the average depth was 1 foot.

4.2.4.2.3.2 Surface Water

Five surface water samples were collected from Cloudberry Creek, one per sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.2-3.

DRO was reported in two of five surface water samples at concentrations of 54 and 54.6 ug/L. These levels were slightly above the detection limit of 50 ug/L and are comparable to the 92 ug/L average DRO detected in about half the samples from lowland reference streams.

The only VOC detected in the surface water samples was methylene chloride. It was detected in four samples at concentrations of 3.17 to 5.14 ug/L. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (see Section 2.3). No PAH compounds were detected in the water samples.

Fourteen metals were detected in the surface water samples from Cloudberry Creek. All but two of the detected metals (lithium and nickel) had concentrations below the background concentrations from lowland reference streams. The lithium concentration at Station 1 was 1.21

ug/L, just slightly higher than the background concentration and detection limit. This was the maximum detection of lithium in a water sample among relatively few occurrences in site-related streams. Lithium was not detected at the other four sampling stations on Cloudberry Creek. Likewise, the detected concentrations of nickel (1.27 ug/L maximum) were only slightly above the detection limits; nickel was not detected in the lowland reference streams, while the upland reference stream nickel concentration was 1.69 ug/L. Both the lithium and nickel concentrations in Cloudberry Creek water were well below the ERBSCs for these metals selected by IT Corporation for this project.

Neither of these metals that exceeded background values in Cloudberry Creek surface water exceeded background values in Cloudberry Creek sediment (see Section 4.2.4.2.3.3).

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented below.

Surface Water Parameters for Cloudberry Creek, Long Shot Site

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	7.2	11.6	10.2	175	Clear
2	6.9	11.3	10.6	173	Clear
3	7.1	10.4	10.3	185	Clear
4	7.0	9.6	10.7	204	Clear
5	7.0	9.7	11.1	210	Clear

4.2.4.2.3.3 Sediment

One sediment sample was collected at each of five stations on Cloudberry Creek. A field duplicate was also collected at Station 1. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. Only the Station 2 sediment sample was analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.2-4.

Neither DRO nor PAHs were detected in any of the Cloudberry Creek sediment samples. Carbon disulfide, at 0.0494 mg/kg, was the only VOC detected in the one sediment sample tested. According to the laboratory, this is suspected to be cross-contamination from the sample containers (see Section 2.3.1.5).

A total of 24 metals were detected in the Cloudberry Creek sediment samples. The following nine metals were reported at concentrations greater than the background concentrations for lowland reference streams (the asterisk indicates exceedance of the ERBSC as well).

Beryllium	Boron	Cadmium*	Calcium
Cesium	Magnesium	Potassium	Strontium
Thallium			

Of these metals, calcium and magnesium concentrations were greater than background for several stations, while the other six metals exceeded background at just one station each.

The 159 mg/kg of boron found at Station 3 was 22 times higher than background. Boron was not detected at the other sampling stations, although the detection limits ranged from 10 to 31 mg/kg. The strontium concentration found at Station 2 was about 35 percent higher than the background concentration (221 vs. 164 mg/kg).

No sediment ERBSCs are available for the metals that exceeded lowland reference stream background concentrations, with the exception of cadmium. The single cadmium occurrence at Station 5 reported a concentration five times greater than the ERBSC. Calcium, potassium, and magnesium are considered essential nutrients in most organisms and not likely to result in significant ecological effects.

AVS and SEM concentrations in the sediment samples from Cloudberry Creek are presented in the following table. The ratios of SEM to AVS ranged from 0.01 to 0.002, except at two stations where no AVS was detected. This suggests that there are sufficient acid volatile sulfides present to limit the availability of the SEM metals to organisms, except at Stations 2 and 5.

AVS and SEM Concentrations for Cloudberry Creek, Long Shot Site

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4053-SD/4054-SD	1550/1200	1.63/1.96	0.001/0.002
2	4051-SD	0	2.0	NA
3	4049-SD	166	1.43	0.01
4	4047-SD	288	2.39	0.01
5	4045-SD	0	1.77	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations. Organic content was also determined for all samples. No grain-size gradation analyses were performed due to insufficient mineral soil content. The results are presented in the following table.

Sediment Characteristics for Cloudberry Creek, Long Shot Site

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4053-SD/ 4054-SD	157,000/ 220,000	59.2	Dark brown, SILT with organics
2	4051-SD	91,900	35.4	Brown, slightly fine sandy SILT with organics
3	4049-SD	29,900	_	Brown, fine sandy SILT with organics
4	4047-SD	73,000	_	Brown SILT with organics
5	4045-SD	81,300	34.8	Brown SILT with organics

DOE collected several sediment samples from Cloudberry Creek in 1997; one was tested for metals. This sample, designated LS-2C, is shown near Station 3 in Figure 4.2-2. The DOE laboratory results are presented in Appendix B. The metals concentrations for Sample LS-2C fell were uniformly similar to the results obtained for the 1998 Station 3 Cloudberry Creek sediments. One exception was boron with a concentration at Station 3 (1998) of 159 ug/L, while the 1993 sample showed no detectable boron. 1998 samples from the other four stations on Cloudberry Creek also showed no detectable boron.

4.2.4.2.3.4 Benthos

Benthic samples were collected on Cloudberry Creek at Stations 1, 2, and 5. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. An evaluation of the results is presented in *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F).

Benthic Invertebrates for Cloudberry Creek, Long Shot Site

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	5
Turbellaria	Tricladida	Planariidae	flatworm	Adult		4	
Oligochaeta	Tubificida	Tubificidae	tubifex worm	Adult			9
Gastropoda	Mesogastropoda	Lymnaidae	snail	Juvenile		4	
Peleycopoda	Spaeracea	Sphaeriidae	clam	Juvenile	8	72	3
Collembola	Collembola	Hypogasturidae	springtail	Adult			
		Isotomidae	springtail	Adult	2	4	
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	Nymph			4
	Hemiptera	Veliidae	ripple bug	Nymph		20	
	Trichoptera	Limniphilidae	caddisfly	Larva		4	7
	Diptera	Chironomidae	midge	Larva	136	152	49

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	5
Insecta		Chironominae	midge	Larva	10		
		Tanypodinae	midge	Larva	8		
		Rhagionidae	snipefly	Pupa		4	
Hydracarina			watermite	Adult			1
Crustacea	Isopoda	Asellidae	isopod	Adult		84	6
				Total	**164**	**348**	**79**
				Family Biotic Index	6.10	6.94	6.18
				EPT Relative Abundance	0.0%	1.1%	13.9%
				Species Diversity	0.67	1.45	1.28

4.2.4.2.3.5 Sediment Toxicity Tests

Sediment samples collected from Stations 1, 2, and 5 of Cloudberry Creek were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are listed in the following table. An evaluation of the data is presented in *Triad Analysis of Drill Site and Test Site Stream Sediments* (see Appendix F).

Sediment Toxicity Results, Cloudberry Creek, Long Shot Site

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	51.25%	54.67%	1.315	177.90%	6.77	98.00%
2	62.50%	66.67%	0.700	94.70%	4.29	62.10%
5	73.75%	83.10%	0.203	40.30%	1.56	34.80%

4.2.4.2.3.6 Fish

Three resident Dolly Varden fish samples for chemical analysis and one for radionuclide analysis were collected from Cloudberry Creek. The following table summarizes the size and weight of the fish. Specific data on fish sampling are presented in the field fish collection forms in Appendix J.

Fish Sample Descriptions for Cloudberry Creek, Long Shot Site

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	4073-FS	4 – 6	9	300	33.3	331
1 (rad.)	4077-FS	3 – 7	27	825	30.5	1800
2	4074-FS	2 – 8	9	325	36.1	966
5	4111-FS	4.5 - 15	2	450	225	18

The results of chemical analyses are discussed separately from the results of radionuclide analysis.

4.2.4.2.3.6.1 Results of Chemical Analyses

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.2-5 and summarized below.

Twenty-one metals were detected in the three fish tissue samples. Concentrations were compared to background concentrations determined for fish from lowland reference streams. and to EPA Region III RBCs for fish consumption. Five metals were found to exceed background values: cerium, cobalt, copper, nickel, and thorium. Four of the five background-exceeding occurrences were from Station 2; the other was from Station 1. The concentrations of cobalt. copper, and nickel fall below their respective ERBSCs. There is no available RBC for cerium or thorium.

Inorganic arsenic was detected in one sample (from Station 2) at a concentration exceeding the fish consumption RBC but below the background level. Note that the background level of inorganic arsenic in lowland stream fish is almost ten times higher than the corresponding RBC

Neither PAHs nor PCBs were detected in the fish samples from Cloudberry Creek.

4.2.4.2.3.6.2 Radionuclides

Because numerous fish were present at Station 1, a sample was collected for radionuclide testing The results are shown in the following table. The fish sample collected at Cloudberry Creek differed from other fish samples tested for radionuclides in several ways. The fish sample consisted of smaller fish, sized 3 to 7 inches as opposed to 11 to 16 inches in other samples. Due to the smaller size the fish were analyzed whole (i.e. not gutted), and more fish were required to provide the minimum sample weight. Unlike the other fish samples, the fish from Cloudberry were not associated with a lake. This may indirectly account for their smaller size distribution.

Radionuclide Concentrations in Fish for Station 1 of Cloudberry Creek, Long Shot Site

Isotope	Whole Fish		
	Flag	Result (pCi/g)	Detection Limit
Americium-241	U	0.00449 ±0.0106	0.0348
Plutonium-238	U	0.00344 ±0.0188	0.0526
Plutonium-239/240	U	0.00465 ±0.0126	0.0323
Cesium-137		0.739 ±0.104	0.0447

U = analyte was not detected at a concentration greater than the detection limit.

The first three isotopes listed above were not detected in this or any other fish samples tested for this project. The cesium-137 concentration in this sample was significantly higher than in background or Cannikin fish samples.

4.2.4.3 Reed Pond and Long Shot Lake

The 1998 Drill Site Investigation included a reconnaissance of Long Shot Pond, Reed Pond, and the trenches that lead to each pond from the exploratory hole locations. The reconnaissance of Long Shot Pond included the collection of lake sediment samples for visual observation. The sediment samples were collected both near shore and from the middle of the pond. The samples from the middle of the pond were collected using a skiff. The near-surface lake sediments (within the top 1 foot of the sediments) consisted uniformly of brown peat. No drilling mud, diesel odors, or sheens were observed during the reconnaissance. The trench leading to Long Shot Pond from the exploratory hole was mostly dry and overgrown; no drilling mud was observed in the trench.

The trench leading to Reed Pond contained shallow standing water for much of its length. The trench averaged about 1.5 feet wide and 2.5 feet deep. The bottom of the trench was probed at random locations along its length with a hand auger. A sheen was generated in several places when the bottom sediments were probed. Most of the sediments retrieved with the hand auger were brown peat. However, in one location, gray bentonite with a diesel odor was encountered.

The near-shore sediments of Reed Pond were also probed with a hand auger. Particular attention was paid to the shoreline near the outlet of the impacted trench. No obvious drilling mud, diesel odor, or sheen was observed in Reed Pond. However, to better determine the potential impacts to Reed Pond, discretionary surface water and sediment samples (not in the originally planned scope of work) were collected near the outlet of the impacted trench and the outlet of an additional drainage trench leading to Reed Pond from the northeast. The sediments in this additional trench were also probed and did not appear to be impacted. Descriptions and field screening results for the samples collected in Reed Pond are provided in the following table.

Reed Pond Sample Descriptions, Long Shot Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Reed Pond	0.8	NA	1137-SW		Surface Water		
			1139-SD	0-0.3	Brown Peat		PID=1.5
	1.5	NA	1138-SW		Surface Water		
			1140-SD	0-1.0	Brown Peat	Trace gray sand	PID=0

* Sample depth measured from pond bottom
NA: No drilling mud observed

4.2.4.3.1 Surface Water

The two surface water samples from Reed Pond were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are presented in Table 4.2-6. Both of the surface water samples contained DRO, which was detected at concentrations of 113 and 137 ug/L. The reported concentrations of DRO are comparable to the 92 ug/L average concentration of DRO reported in water from half of the lowland reference stream samples, as explained in Section 2.3.1.5. Thus it is possible that the reported values of DRO could be due to biogenics.

The only VOC detected in Reed Pond water samples was methylene chloride. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

The Reed Pond water samples contained 11 metals, most at levels well below background concentrations established based on surface water from lowland streams. Exceptions were barium and calcium. Barium was not detected in the lowland reference stream water samples but was detected in the Reed Pond samples at 49.4 and 53 ug/L. The 7,330 ug/L calcium in one sample exceeded the background value by 70 percent. The barium concentrations in Reed Pond are an order of magnitude higher than the applicable ERBSC (see Table 2-10). No ERBSC is available for calcium, which is considered an essential nutrient in most organisms and not likely to result in significant ecological effects.

Surface water quality parameters measured in Reed Pond during the 1998 Drill Site Investigation are presented below.

Surface Water Parameters for Reed Pond, Long Shot Site

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1137-SW	5.6	9.0	8.16	160	0
1138-SW	5.7	8.8	9.0	125	0

DOE collected a water sample from Reed Pond in 1993 and analyzed it for metals. The sample location is shown in Figure 4.2.2. The test results are listed in Appendix B under "SW-REED." Concentrations were similar to those in the 1998 samples with the exception of barium, vanadium, and zinc, which decreased with time. Barium was present at about a 50 percent greater concentration in the 1993 sample. Vanadium and zinc were detected at 8 and 29 ug/L, respectively, in 1993 but not detected in 1998.

4.2.4.3.2 Sediment

The two sediment samples from Reed Pond were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are reported in Table 4.2-7. DRO was detected in one of the two sediment samples at a concentration of 42.6 mg/kg. An average of 13.3 mg/kg DRO was reported in sediment samples from lowland reference streams (Section 2.3.2.5). Concentrations of DRO as high as 184 mg/kg were found in Corps background sediment samples during the Phase I RI (Section 2.3.2.6). Thus, it is possible that the DRO reported in the Reed Pond sample is from a biogenic source.

Apart from two suspected laboratory contaminants (acetone at a maximum of 1.02 mg/kg, and 2-butanone at a maximum of 0.14 mg/kg), the only VOC detected was toluene in one sample at an estimated concentration of 0.0434 mg/kg. This concentration is slightly below the ERBSC of 0.05 mg/kg for sediment. No PAHs were detected in the samples.

The Reed Pond sediment samples contained 18 metals. Concentrations of these metals were below background concentrations from lowland reference streams, with the exception of calcium and cesium. Cesium was not detected in the lowland reference stream sediment samples but was detected in one Reed Pond sample at 5.72 mg/kg. The 9,230 mg/kg calcium in one sample exceeded the background value by 26 percent. No ERBSCs are available for either metal. However, calcium is considered an essential nutrient in most organisms and not likely to result in significant ecological effects.

4.2.5 Summary

The configuration of the mud pits, trenches and exploratory drill hole features at the Long Shot test site were consistent with information obtained from documentation during the planning phase. Therefore, the original scope of work planned for the site was considered generally adequate to meet the project objectives. However, an additional potentially impacted stream that drains the site (Rainbow Creek) was identified and investigated during the 1998 field work.

The mud pits at the site contain an estimated 5,480 cubic yards of diesel-contaminated drilling mud. The DRO levels in the drilling mud (296 to 58,000 mg/kg) are the highest concentrations detected at the drill sites investigated. Several VOCs and PAHs were also detected in the drilling mud at elevated concentrations relative to their respective ERSBCs. Although several metals

were detected, only chromium and copper exceeded both their background concentrations and ERBSCs. The surface water in the mud pits contains only low concentrations of DRO, at levels below the ADEC drinking water standard. Other constituents were generally either not detected or were well below ERBSCs or background concentrations.

The Long Shot mud pits were constructed below grade in a level area, so the drilling mud is relatively well contained in the pits. Therefore, the potential for the drilling mud to be rapidly released to a stream (such as during a catastrophic event like an earthquake) is low. The water currently flowing from the mud pits drains to Rainbow Creek along a shallow excavated trench, but does not appear to be eroding the drilling mud and carrying it downstream.

The two lakes in the immediate vicinity of the Long Shot Test Site, Long Shot Pond and Reed Pond were also investigated for evidence of drilling mud. No evidence of drilling mud or impacts from mud was found in Long Shot Pond, whereas Reed Pond appears to be slightly impacted by past drilling activities. A trench from an exploratory drill hole site to Reed Pond contained drill mud at the time of the field work, and may once have been used to transport drilling fluids to the lake. Although no drilling mud was observed in the lake, one sediment sample (collected near the outlet of the trench where drilling mud was observed) contained a low DRO concentration, as did the surface water in the lake. The DRO levels detected in Reed Pond are similar to the levels of biogenic DRO detected in the reference streams. However, since it is likely that drilling mud was once released into Reed Pond along the trench leading from the exploratory hole, the DRO found in the pond may reflect either the residual effects of the drilling mud or biogenic DRO.

The three streams that drain the Long Shot site were sampled to evaluate the residual impacts from previous releases of drilling mud. Surface water and sediment sampling was conducted in Cloudberry Creek, which drains Reed Pond and the southern part of the site; Rainbow Creek, which drains the mud pits and eastern part of the site; and Bridge Creek, which drains Long Shot Pond and the northern part of the site. Based on the analytical results from these streams, the residual effects of past drilling mud releases on current stream water and sediment chemistry appear to be minor. DRO concentrations in all the stream water samples were comparable to background levels, no PAHs or VOCs were detected, and none of the water samples contained metals at concentrations that exceeded both background and ERBSCs. Similarly, no PAHS or VOCs were detected in the sediment samples, and DRO was detected above reference stream levels in sediment only at Stations 3 and 4 of Rainbow Creek, where 2,110 and 1,100 mg/kg, respectively were found. Metals concentrations in sediment were also generally comparable to background levels. The main exceptions were chromium concentrations in sediment from Stations 3 and 4 of Rainbow Creek, which exceeded both the ERBSC and background concentrations. Also, in Cloudberry Creek, the boron level in sediment was relatively high at Station 3, and cadmium was elevated above the ERBSC at Station 5.

Aroclor 1260 was detected in the fish sample from Station 5 of Rainbow Creek at about 10 times the Region III RBC for human consumption. PCBs were not tested in drilling mud or stream sediment. No PAHs were detected in fish samples from any of the Long Shot streams. The fish

sample from Station 5 of Bridge Creek contained several metals. of which inorganic arsenic and iron exceeded the RBCs. The only other fish sample from the three creeks that had a metal concentrations in exceedance of both background and RBC values was the sample from Station 5 of Rainbow Creek, which also had an elevated concentration of inorganic arsenic, at about 10 times the RBC.

The Triad Analysis (see Appendix F) evaluated the relative sediment quality with respect to habitat for 22 locations on the lowland streams investigated. Using a system that combines benthic, sediment chemistry, and sediment toxicity rankings, the overall rankings obtained for the streams that drain the Long Shot site are as follows:

Bridge Creek		Rainbow Creek		Cloudberry Creek	
Station 2	2nd	Station 1	5th	Station 1	3rd
Station 3	14th	Station 3	20th	Station 2	10th
Station 5	1st	Station 5	17th	Station 5	8th

The lower the overall ranking (higher number) obtained using this approach, the greater the indication of low sediment quality. The low ranking at Rainbow Creek Station 3 was based in part on sediment toxicity test results that showed no survival. Sediment chemistry and benthic community rankings at this location were below average, but were within the range of the lowland reference stream stations.

The stream sediment quality in Rainbow Creek (Station 3, in particular) shows evidence of elevated diesel (no PAHs or VOCs) and chromium, which might have impacted benthic macroinvertebrates and fish. It may be that drilling mud that was released historically was deposited in the low gradient area between Station 1 and 3, and continues to leach with time. The sediment quality may be a factor in the poor habitat identified in this part of Rainbow Creek. However, the physical characteristics of this stream, such as low gradient, low discharge, poorly defined drainage, and excessive aquatic and bank vegetation, also contribute to poor habitat for benthic macroinvertebrates and fish throughout much of the stream.

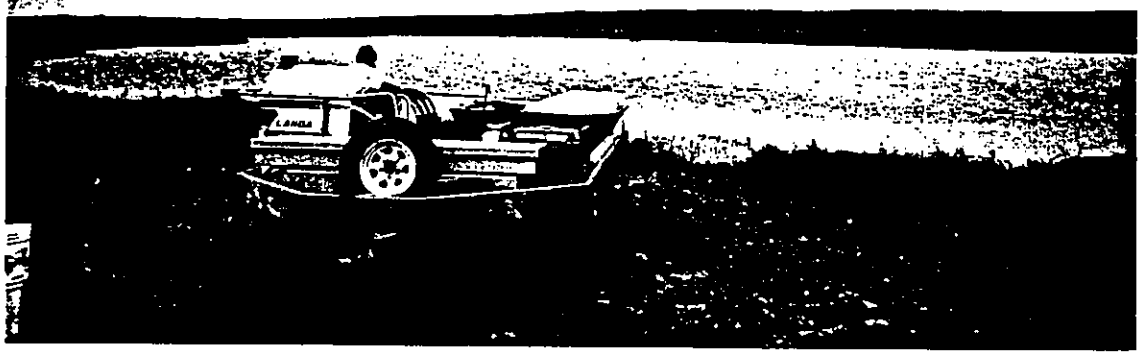
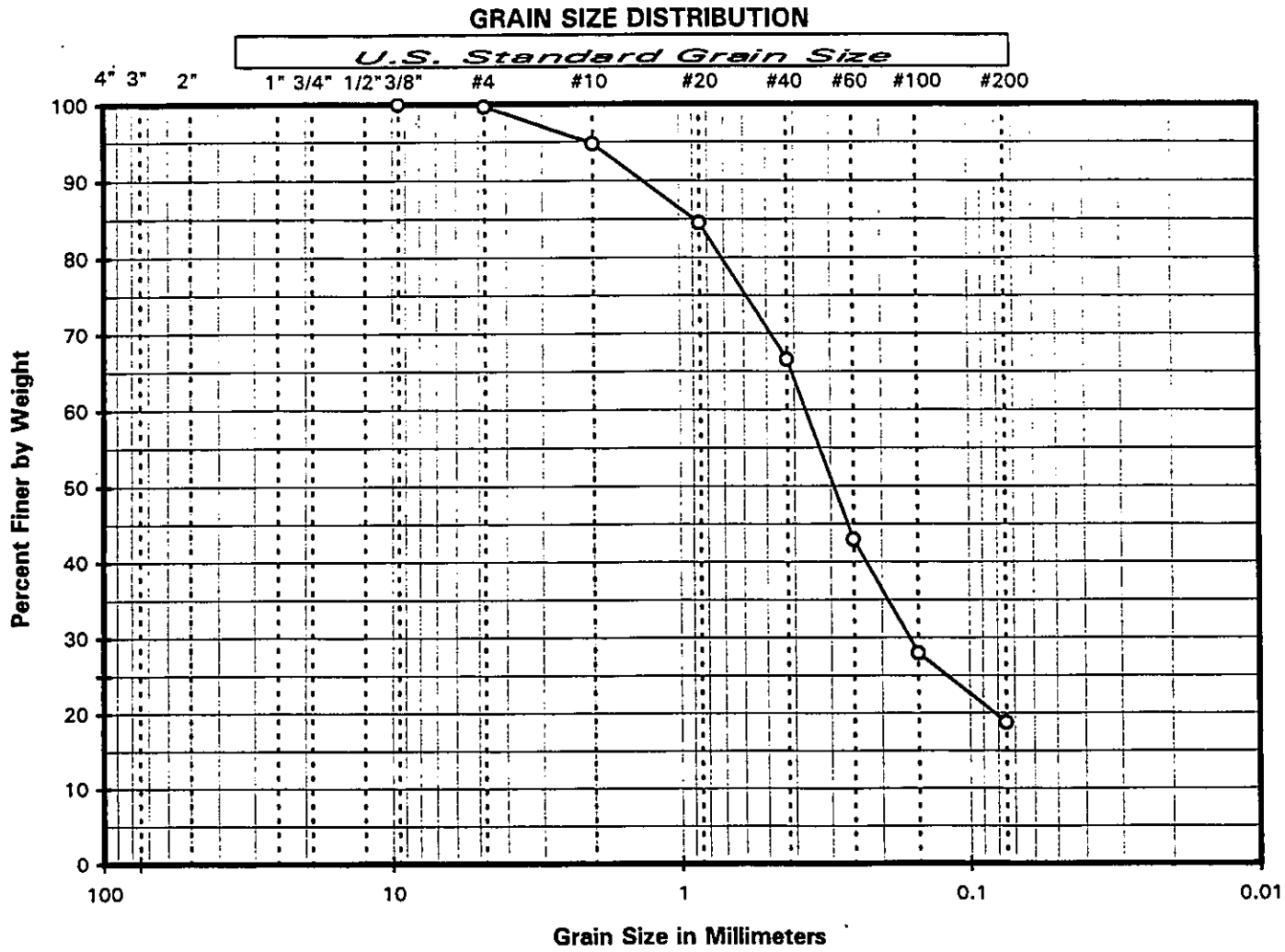


Photo 4.1-1: Heart Lake, facing west.

Photo 4.1-2: Rifle Range Road Additional Mud Pit, facing north. The location of this sampled mud pit is shown in Figure 4.1-3.



Marker	Sample ID	Percent Passing by Dry Weight — U.S. Standard Sieve Size															USC Soil Class
		4"	3"	2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.02m	
o	98DOE-MILR-4008-SD							100	100	95	85	67	43	28	19		SM
x																	
+																	
-																	

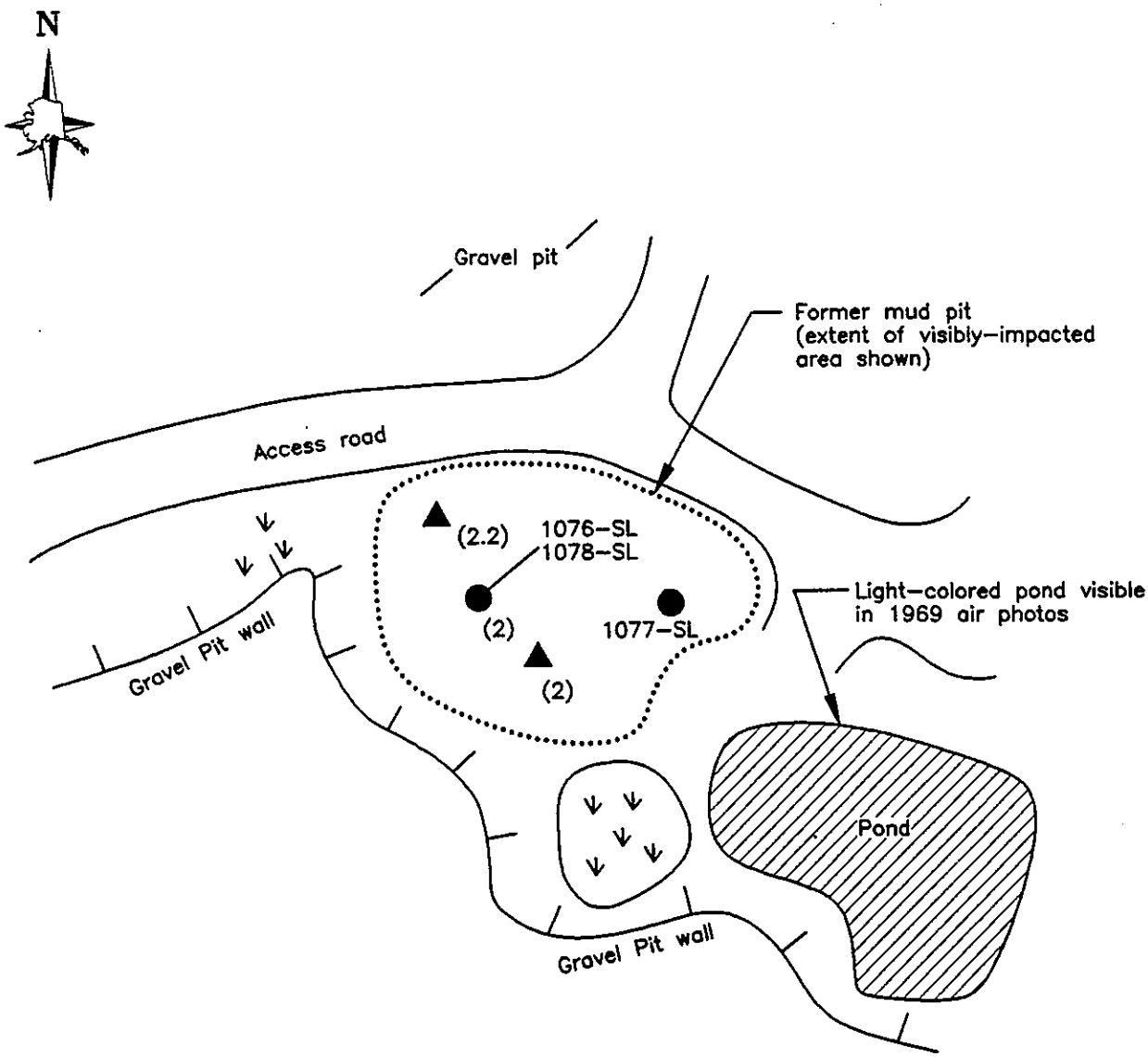
1998 Drill Site Investigation
Amchitka Island

GRAIN SIZE DISTRIBUTION CURVES
Station 5, Clevenger Creek, Milrow Site

September 1999 X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Figure 4.1-5



LEGEND

1076-SL ● (2) Soil Sample Location, Number and Depth to Bedrock in Feet (if Known) (All Sample Numbers Preceded by "98DOE-RRMP").

▲ (2) Test Boring Location and Depth to Bedrock in Feet

Lake or Pond

Marshy Area

APPROXIMATE SCALE (FEET)

0 100 200

Reference: Drawing based on 1969 air photos

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

RIFLE RANGE ROAD ADDITIONAL MUD PIT

September 1999
Revision Number: 0

X-0926

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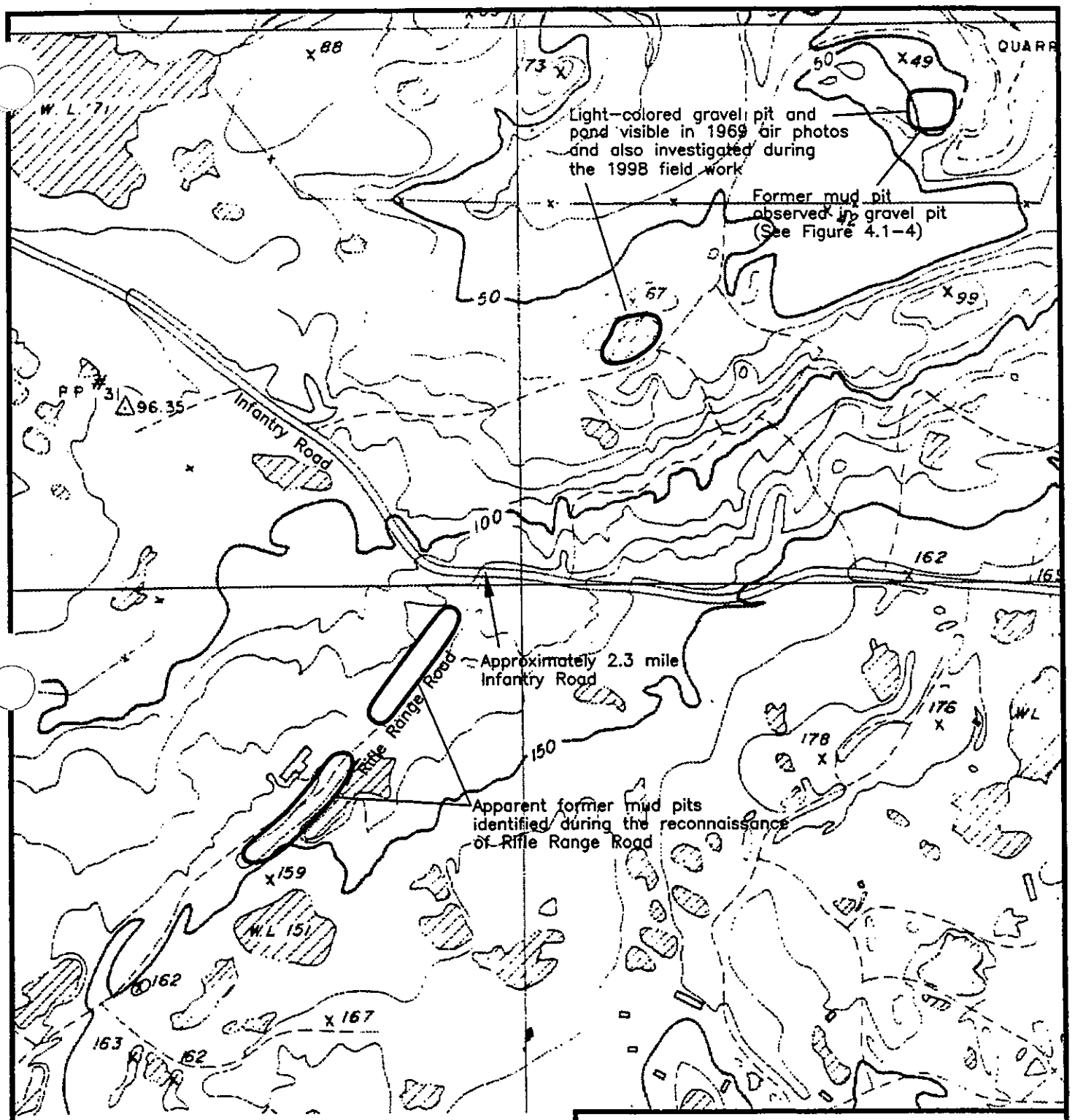
FIG. 4.1-4

FILE: R



APPROXIMATE SCALE (FEET)

0 500 1000

Contour Interval= 10 feet

N

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

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RIFLE RANGE ROAD MUD PITS

September 1999
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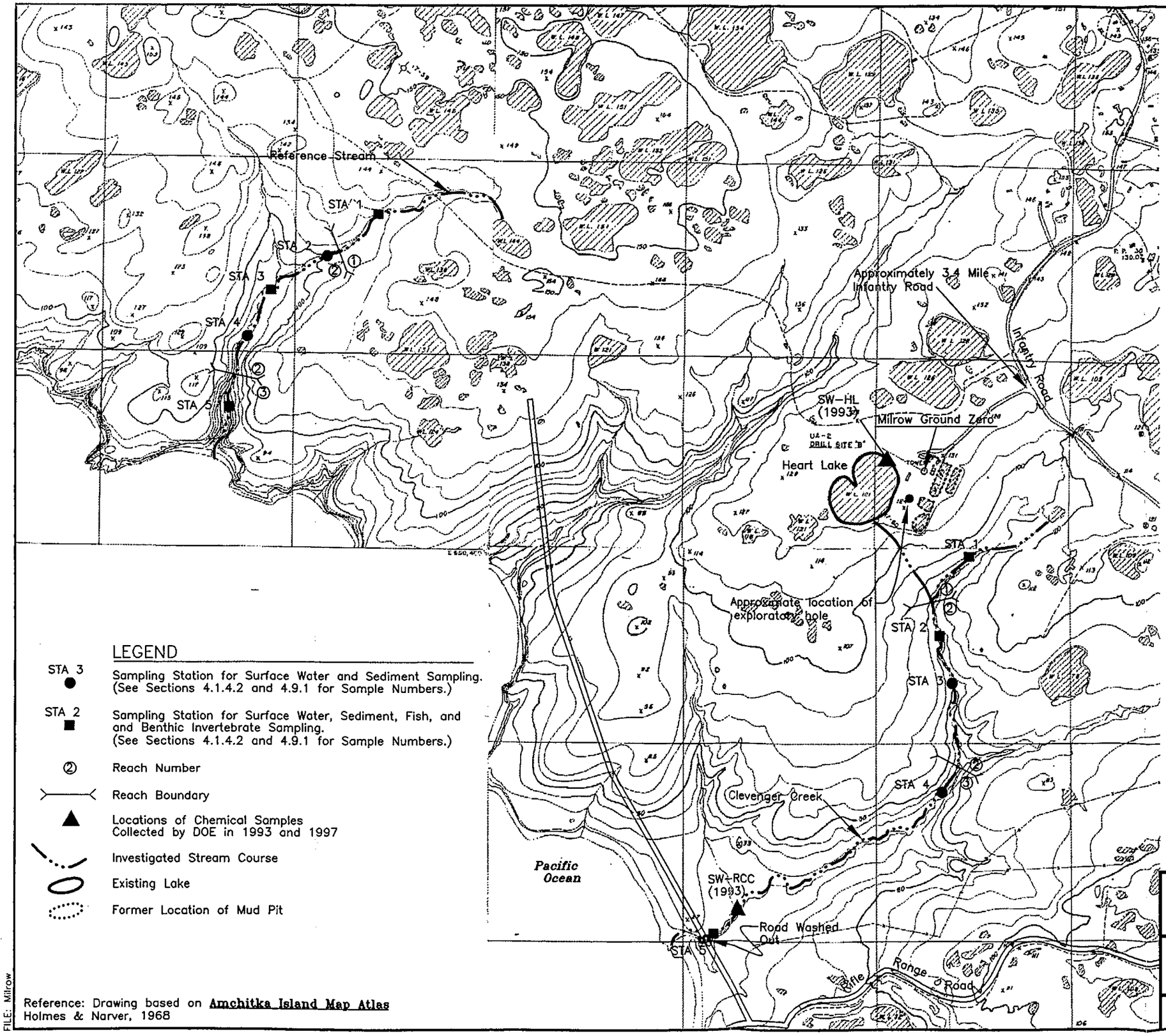
FIG. 4.1-3

FILE:



N

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Sections 4.1.4.2 and 4.9.1 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and and Benthic Invertebrate Sampling. (See Sections 4.1.4.2 and 4.9.1 for Sample Numbers.)

② Reach Number

Reach Boundary

▲ Locations of Chemical Samples Collected by DOE in 1993 and 1997

Investigated Stream Course

Existing Lake

Former Location of Mud Pit

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

FILE: Milrow

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

MILROW SITE STREAM AND REFERENCE STREAM 1

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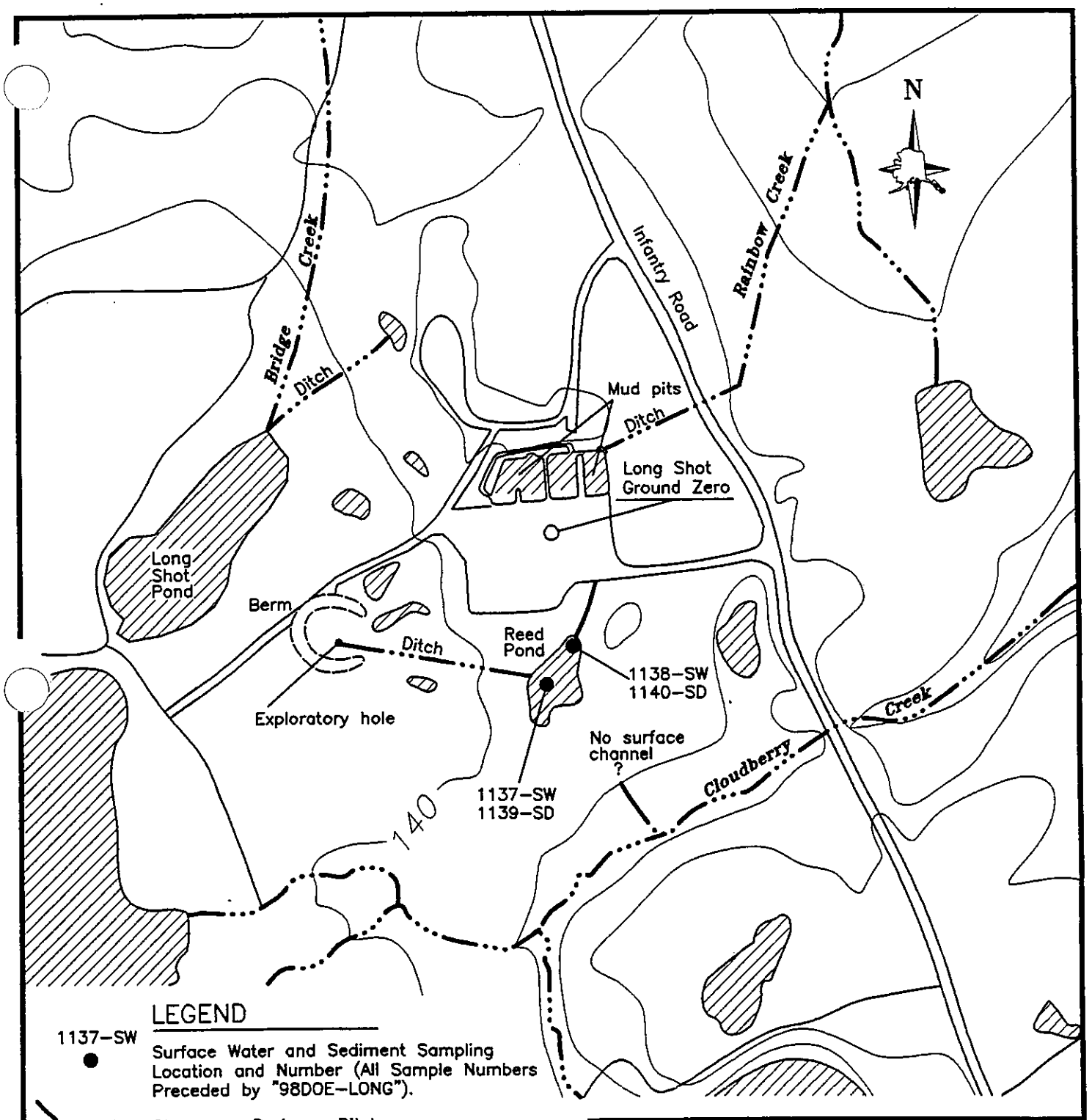
FIG. 4.1-2



LEGEND

1137-SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE-LONG").

Stream or Drainage Ditch

Pond or Mud Pit

APPROXIMATE SCALE (FEET)

0 400 800

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

LONG SHOT SITE

September 1999
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X-0926

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FIG. 4.2-1

FILE: B

TABLE 4.2-1
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-LONG-1009-SW	98DOE-LONG-1010-SW	98DOE-LONG-1011-SW	98DOE-LONG-1012-SW (Duplicate)	98DOE-LONG-1120-SW	98DOE-LONG-1121-SW	98DOE-LONG-1122-SW
			E mud pit				W mud pit		
Diesel Range Hydrocarbons	AK 102	-	198 B	223 B	284 B	278 B	125	114	120
Volatile Organic Compounds									
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Acetone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	2.14 U	2.05 U	7.67 U	3.59 U	24 U	16.1 UJ	25.6 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)

TABLE 4.2-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Eowland Stream Background Concentration	98DOE-LONG-1009-SW	98DOE-LONG-1010-SW	98DOE-LONG-1011-SW	98DOE-LONG-1012-SW (Duplicate)	98DOE-LONG-1120-SW	98DOE-LONG-1121-SW	98DOE-LONG-1122-SW
			E mud pit				W mud pit		
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals									
Aluminum	EPA 6020	269	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	**9,200**	**9,380**	**9,300**	**9,440**	**11,500**	**11,400**	**11,600**
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.03
Cobalt	EPA 6020	3.35	1.22 J	2.06 J	1.35 J	**5.56 J**	ND(1)	ND(1)	ND(1)

TABLE 4.2-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Low Land Stream Background Concentration	98DOE-LONG-109-SW	98DOE-LONG-110-SW	98DOE-LONG-111-SW	98DOE-LONG-112-SW (Duplicate)	98DOE-LONG-120-SW	98DOE-LONG-121-SW	98DOE-LONG-122-SW
			E mud pit				W mud pit		
Copper	EPA 6020	10.8	1.01	ND(1)	ND(1)	ND(1)	1.18 J	1.32 J	1.24 J
Iron	EPA 6010B	993	413	592	540	597	161	321	178
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	**5,480 J**	**5,320 J**	**5,280 J**	**5,420 J**	**6,600**	**6,620**	**6,700**
Manganese	EPA 6020	267	68.7	122	112	125	82.7	78.7	100
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	ND(1)	**1.37 J**	**2.44 J**	**1.61 J**	**5.91 J**	ND(1)	ND(1)	ND(1)
Potassium	EPA 6010B	2,620	1,240	1,300	958	1,430	1,640	1,570	1,760
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	**45.9**	**52.3**	**50.5**	**51.8**	**58.2**	**57.8**	**58.7**
Thallium	EPA 6020	1.07	ND(1)	ND(1)	ND(1)	1.09	ND(1)	ND(1)	ND(1)
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	1.3 J	1.37 J	1.65 J	1.6 J	ND(1) UJ	ND(1) UJ	ND(1) UJ
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	ND(1)	ND(1)	ND(1)	1.82	ND(1)	ND(1)	ND(1)
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)

TABLE 4.2-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in micrograms per liter)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

B analyte detected in method blank

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.2-5
FISH ANALYTICAL RESULTS FOR LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-LONG-072-FL	98DOE-LONG-071-FL	98DOE-LONG-073-FL	98DOE-LONG-074-FL	98DOE-LONG-111-FL	98DOE-LONG-157-FS	98DOE-LONG-155-FS
				Bridge Creek		Cloudberry Creek			Rainbow Creek	
				Station 3	Station 5	Station 1	Station 2	Station 5	Station 3	Station 5
Polycyclic Aromatic Hydrocarbons										
Acenaphthene	SW8270 SIM	81.1	-	ND(0.067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	-	ND(0.0335)
Acenaphthylene	SW8270 SIM	NA	-	ND(0.067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	-	ND(0.0335)
Anthracene	SW8270 SIM	405.6	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Benzo(a)anthracene	SW8270 SIM	0.0043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Benzo(a)pyrene	SW8270 SIM	0.00043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Benzo(b)fluoranthene	SW8270 SIM	0.0043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Benzo(ghi)perylene	SW8270 SIM	NA	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Benzo(k)fluoranthene	SW8270 SIM	0.043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Chrysene	SW8270 SIM	0.43	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Dibenzo(a,h)anthracene	SW8270 SIM	0.00043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Fluoranthene	SW8270 SIM	54.1	-	ND(0.168)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Fluorene	SW8270 SIM	54.1	-	ND(0.067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	-	ND(0.0335)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	0.0043	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Naphthalene	SW8270 SIM	27.0	-	ND(0.067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	ND(0.0067)	-	ND(0.0335)
Phenanthrene	SW8270 SIM	NA	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)
Pyrene	SW8270 SIM	40.6	-	ND(0.067)	ND(0.067)	ND(0.0335)	ND(0.067)	ND(0.0335)	-	ND(0.0335)

TABLE 4.2-5 (cont.)
FISH ANALYTICAL RESULTS FOR LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region IIIFat Consumption RBC	Lowland Stream Background Concentration	98DOE-LONG-4075-FI	98DOE-LONG-4071-FI	98DOE-LONG-4073-FI	98DOE-LONG-4074-FI	98DOE-LONG-4111-FI	98DOE-LONG-4157-FS	98DOE-LONG-4155-FS
				Bridge Creek		Cloudberry Creek			Rainbow Creek	
				Station 3	Station 5	Station 1	Station 2	Station 5	Station 3	Station 5
Polychlorinated Biphenyls										
Aroclor 1016	SW8081	-	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	ND(0.01) UJ
Aroclor 1221	SW8081	-	-	ND(0.054) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	-	ND(0.02) UJ
Aroclor 1232	SW8081	-	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	ND(0.01) UJ
Aroclor 1242	SW8081	-	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	ND(0.01) UJ
Aroclor 1248	SW8081	-	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	ND(0.01) UJ
Aroclor 1254	SW8081	-	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	ND(0.01) UJ
Aroclor 1260	SW8081	0.0016	-	ND(0.027) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	-	0.0161 J
Metals										
Aluminum	SW6020	1351.9	475	57	425	10.2	166	10.6	13.5 J	32.3 J
Arsenic	SW6020	0.21	0.127	0.0508	0.257	ND(0.0250)	0.0365	0.0413	0.049 J	ND(0.0250) UJ
Inorganic Arsenic	EPA Draft 1632	0.0021	0.0208	0.0109	0.154	0.00206	0.0152	0.000521	0.00521	0.0236
Barium	SW6020	94.6	1.03	0.261	1.62	0.0513	0.224	0.0448	0.158	0.233
Beryllium	SW6020	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Boron	SW6020	121.7	28.6	8.65 UJ	6.23 UJ	6.48 UJ	6.75 UJ	6.45 UJ	10.3 UJ	21.5 UJ
Cadmium	SW6020	1.4	0.0373 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)

TABLE 4.2-5 (cont.)
FISH ANALYTICAL RESULTS FOR LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-LONG-072-FI	98DOE-LONG-071-FI	98DOE-LONG-073-FI	98DOE-LONG-074-FI	98DOE-LONG-111-FI	98DOE-LONG-157-FS	98DOE-LONG-155-FS
				Bridge Creek		Cloudberry Creek			Rainbow Creek	
				Station 3	Station 5	Station 1	Station 2	Station 5	Station 3	Station 5
Calcium	SW6020	NA	19,200	7,280	8,080	6,680	5,430	9,800	6,950	4,130
Cerium	SW6020	NA	0.0280 [b]	ND(0.0250)	**0.088**	ND(0.0250)	**0.031**	ND(0.0250)	ND(0.0250)	ND(0.0250)
Cesium	SW6020	NA	0.0258 [b]	ND(0.0250)	**0.0305**	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Chromium	SW6020	4.1	1.03	0.395	0.39	0.3	0.337	0.303	ND(0.0500) UJ	0.353 J
Cobalt	SW6020	81.1	0.0780 [b]	ND(0.0500)	**0.257**	ND(0.0500)	**0.111**	ND(0.0500)	ND(0.0500) UJ	0.053 J
Copper	SW6020	54.1	1.20 [b]	0.864 U	**1.57 U**	0.783 U	**1.52 U**	0.678 U	1.08	0.979
Iron	SW6020	405.6	310	57	**10,900**	22.7	260	19.8	73 J	81.5 J
Lithium	SW6020	27.0	0.0993 [b]	0.0255	**0.17**	ND(0.0250)	0.0575	ND(0.0250)	ND(0.0250)	ND(0.0250)
Magnesium	SW6020	NA	408	273	**473**	315	373	350	298	244
Manganese	SW6020	189.3	160	10.2	93.6	3.88	20.3	1.83	22.3	23.9
Molybdenum	SW6020	6.8	0.173 [b]	0.163 UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	27.0	ND	ND(0.125)	**0.217**	ND(0.125)	**0.135**	ND(0.125)	ND(0.125)	ND(0.125)
Potassium	SW6020	NA	4,780 [b]	4,330	4,730	4,600	3,050	4,300	3,450	3,030
Selenium	SW6020	6.8	0.936	0.397	0.473	0.322	0.452	0.637	0.401	0.372
Strontium	SW6020	811.1	22.1	5.91	9.93	7.47	8.21	14.3	8.47 J	5.29 J
Thallium	SW6020	0.09	0.0283 [b]	**0.0503**	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250) UJ	ND(0.0250) UJ
Thorium	SW6020	NA	3.43 [b]	**4.06 J, B**	ND(2.50) UJ, B	**4.17 J, B**	ND(2.50) UJ, B	ND(2.50) UJ, B	**5.4 J, B**	ND(2.50) UJ, B

TABLE 4.2-5 (cont.)
FISH ANALYTICAL RESULTS FOR LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration[a]	98DOE-LONG-072-FI	98DOE-LONG-071-FI	98DOE-LONG-073-FI	98DOE-LONG-074-FI	98DOE-LONG-111-FI	98DOE-LONG-157-FS	98DOE-LONG-155-FS
				Bridge Creek		Cloudberry Creek			Rainbow Creek	
				Station 3	Station 5	Station 1	Station 2	Station 5	Station 3	Station 5
Titanium	SW6020	5407.4	32.1	2.03	12.1	0.244	4.64	0.227	0.358 J	0.763 J
Uranium	SW6020	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	9.5	1.05	0.389	**2.6**	0.166	0.853	0.303	0.314	0.359
Zinc	SW6020	405.6	48.8	28.6	33	33.9	34.1	37.3	41.9	38.2

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

mg/kg milligrams per kilogram

B analyte detected in method blank

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank or laboratory contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.

TABLE 4.2-6
SURFACE WATER ANALYTICAL RESULTS FOR REED POND, LONG SHOT SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-LONG-1137-SW	98DOE-LONG-1138-SW
Diesel Range Hydrocarbons	AK 102	-	113	137
Volatile Organic Compounds				
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)
Acetone	EPA 8260B	-	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	3.04 U	2.47 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)
Metals				
Aluminum	EPA 6020	269	ND(50)	82.2
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	53	49.4
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	7,330	3,420
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	1.15	1.4

TABLE 4.2-6 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR REED POND, LONG SHOT SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-LONG-1137-SW	98DOE-LONG-1138-SW
Cobalt	EPA 6020	3.35	ND(1)	ND(1)
Copper	EPA 6020	10.8	ND(1) UJ	1.04 J
Iron	EPA 6010B	993	370	571
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	3,870	2,310
Manganese	EPA 6020	267	42.4	6.85
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	ND(1)	ND(1)	ND(1)
Potassium	EPA 6010B	2,620	1,360	1,300
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	25.9	19.5
Thallium	EPA 6020	7.07 [b]	ND(1)	ND(1)
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	1.47 J	2.1 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	ND(1)	ND(1)
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.2-7
SEDIMENT ANALYTICAL RESULTS FOR REED POND, LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-LONG-1139-SD	98DOE-LONG-1140-SD
		Depth (feet)	0-1	0-1
Diesel Range Hydrocarbons	AK 102	-	42.6	ND(27.4)
Volatile Organic Compounds				
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
2-Butanone	EPA 8260B	-	0.136 J	0.0575 J
Acetone	EPA 8260B	-	1.02 J	0.38 J
Carbon disulfide	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
Ethylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
Isopropylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
m,p-Xylene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
Methylene chloride	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
n-Butylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
n-Propylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
Naphthalene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
o-Xylene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
p-Isopropyltoluene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
sec-Butylbenzene	EPA 8260B	-	ND(0.0533) UJ	ND(0.0188) UJ
Toluene	EPA 8260B	-	ND(0.0533) UJ	0.0434 J
Xylenes (total)	EPA 8260B	-	-	-
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	EPA 8270C	-	ND(0.0333)	ND(0.0226)
Acenaphthylene	EPA 8270C	-	ND(0.0333)	ND(0.0226)
Fluorene	EPA 8270C	-	ND(0.0333)	ND(0.0226)
Naphthalene	EPA 8270C	-	ND(0.0333)	ND(0.0226)
Phenanthrene	EPA 8270C	-	ND(0.0333)	ND(0.0226)
Metals				
Aluminum	EPA 6010B	45,400	13,100	10,000
Arsenic	EPA 6020	100	7.92	ND(3.42)
Barium	EPA 6020	469	ND(50.5)	43.6
Beryllium	EPA 6020	ND	ND(5.05) UJ	ND(3.42) UJ
Boron	EPA 6010B	7.18 [b]	ND(25.3) UJ	ND(17.1) UJ
Cadmium	EPA 6020	0.608	ND(5.05)	ND(3.42)
Calcium	EPA 6010B	7,300	**9,230**	3,570
Cerium	EPA 6020	14.2	5.72 J	3.87 J
Cesium	EPA 6020	ND	**5.72**	ND(3.42)

TABLE 4.2-7 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR REED POND, LONG SHOT SITE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-LONG-1139-SD	98DOE-LONG-1140-SD
		Depth (feet)	0-1	0-1
Chromium	EPA 6020	11.8	9.71	ND(3.42)
Cobalt	EPA 6020	43.7	7.57 J	3.99 J
Copper	EPA 6020	71.13	47.5	27.4
Iron	EPA 6010B	155,000	5,890	4,910
Lithium	EPA 6020	48.8	ND(5.05)	3.53
Magnesium	EPA 6010B	9,320	1,790	1,480
Manganese	EPA 6020	20,700	97.7	221
Molybdenum	EPA 6020	5.5 [b]	ND(5.05) UJ	ND(3.42) UJ
Nickel	EPA 6020	13.6	8.04 J	ND(3.42) UJ
Potassium	EPA 6010B	1,390	108	145
Selenium	EPA 6020	5.44 [b]	ND(5.05) UJ	ND(3.42) UJ
Strontium	EPA 6020	164	46.9	41
Thallium	EPA 6020	1 [b]	ND(5.05)	ND(3.42)
Thorium	EPA 6020	0.5 [b]	ND(5.05)	ND(3.42)
Titanium	EPA 6020	3,010	1,280	752
Uranium	EPA 6020	4.13 [b]	ND(5.05)	ND(3.42)
Vanadium	EPA 6020	734	340	46.6
Zinc	EPA 6020	434	ND(50.5)	ND(34.2)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

4.2 LONG SHOT

4.2.1 Site Description

The Long Shot site is located approximately 600 feet southwest of Infantry Road in the vicinity of Mile 4.8 (Figure 1-2). The site is situated at an approximate elevation of 135 feet in the eastern lowland. Site features are shown in Figures 4.2-1, 4.2-2, and 4.2-3. The DOD (in conjunction with the AEC) conducted the first underground nuclear test on Amchitka at the Long Shot site. The test involved the underground detonation of an approximately eighty kiloton nuclear device on October 29, 1965. A 2,300-foot-deep emplacement hole was drilled at the site for the test. The diameter of the emplacement hole varied between 32 and 74 inches. Eighteen smaller-diameter exploratory and observation holes were also drilled at the site (AEC/LV, 1974). Following the detonation, the emplacement hole was covered with a concrete and brass monument, which marks SGZ.

The site originally contained four side-by-side mud pits near SGZ. Collapse of one of the berms now gives the appearance of three pits. These mud pits were left open to permit sampling as part of the site's long-term monitoring program. Because of their relatively small size, the mud pits were considered to be two separate mud pits for the purposes of this investigation. No other open mud pits were observed at the site.

The Long Shot site is located in a relatively flat area, and drainage patterns from the immediate vicinity of the site are not readily apparent. However, based on historical information and site observations, impacted areas at Long Shot are drained by as many as three separate streams. As shown in Figures 4.2-1 and 4.2-2, these streams are Rainbow Creek, Cloudberry Creek, and a tributary of Bridge Creek. Rainbow Creek and Cloudberry Creek were previously unnamed; these names were designated for the purpose of this investigation. Two large ponds, Reed Pond and Long Shot Pond, are located near the site.

4.2.2 Site History

Bridge Creek, Cloudberry Creek, and Rainbow Creek are identified by the AEC planning document (AEC/NV, 1972) as having been impacted by drilling mud from the Long Shot site:

> "These streams were polluted by drilling mud from Long Shot. Effects on the ecology of the first two streams [Cloudberry and Rainbow] are still visible [in 1972]. No action required. The flow of fresh water in the drainage areas is gradually purging the systems so that the damage is believed to be self-restoring."

Further information is provided by Fuller and Kirkwood (1977), who attribute "oil contamination ... in a stream draining the site" to "ruptured banks of settling basins." During planning for the 1998 investigation, this quotation was considered contradicted by the fact that the Long Shot mud pits are located in a depressed area resulting from the excavation of the native soils overlying bedrock. Therefore, it was postulated that drilling-mud releases during drilling of the site's numerous exploratory boreholes may have caused some of the stream impacts, rather than mud from the open mud pits near SGZ.

For this reason, no investigation of the Rainbow Creek drainage was included in the initial scope of work for the site. Sampling was planned only in Bridge Creek and Cloudberry Creek. However, initial site reconnaissance revealed water flowing from the Long Shot mud pits into Rainbow Creek via a shallow interconnecting drainage trench. Therefore, sampling of Rainbow Creek was added to the scope of work.

Drilling-mud impacts were also suspected at Reed Pond and Long Shot Pond. A figure on page 1-98 of the AEC planning document (showing drill hole locations at the site) shows an apparent drainage trench extending between an observation hole and Long Shot Pond. Long Shot Pond is located at the headwaters of the tributary to Bridge Creek that was sampled during the 1998 investigation. Another apparent drainage ditch is shown extending between an exploratory hole and Reed Pond, which drains into Cloudberry Creek. Based on this map, it was suspected that drilling mud released into the drainage ditch from the exploratory hole sites might have impacted Long Shot Pond and Reed Pond. The locations of these ditches are shown in Figure 4.2-1.

4.2.3 Characterization Activities

Based on the historical information and site observations, investigations at the Long Shot site targeted the Bridge Creek tributary stream from Long Shot Pond to Infantry Road, Cloudberry Creek, Rainbow Creek, the open mud pits, Reed Pond, and Long Shot Pond. The section of Bridge Creek downstream of the Infantry Road Bridge was not included in this investigation, because it is known that diesel fuel spilled into Bridge Creek from a bulldozer that was wrecked in the creek near the Infantry Road Bridge. The 1998 investigation included a reconnaissance at all of the targeted features and sampling from the majority of the features, based on the results of the reconnaissance.

Three locations were selected in each mud pit for the collection of surface water and sediment samples. Two locations in Reed Pond were also selected for surface water and sediment sampling. The sampling locations were distributed evenly throughout the pond or mud pit. Mud pit sampling locations are shown in Figure 4.2-3. Reed Pond sampling locations are shown in Figure 4.2-1.

A detailed reconnaissance of each of the three streams was performed to observe the stream regimen and ecology and select sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along each stream at locations that were selected based on the reconnaissance. Invertebrate, bioassay, and fish samples were collected from three of these stations at each stream. Stream sampling locations are shown in Figure 4.2-2. The samples that were collected from the Long Shot mud pits, Reed Pond, and the three streams were shipped to off-site laboratories for testing. The types of tests performed and their results are discussed in the following sections.

4.2.4 Observations and Analytical Results

4.2.4.1 Mud Pits

A panoramic view of the mud pits is shown in Photo 4.2-1. They are located in a low-lying area and appear to have been constructed by scraping the surficial peat from the bedrock surface and forming low berms with the resulting soil. The berms appeared to be stable, and no areas of significant erosion or collapse were observed. The construction of the mud pits is such that the water surface in the pits is at a lower elevation than most of the surrounding ground surface. An exception is the northeast corner of the east mud pit, where the pit drains into two small trenches. The two trenches join a short distance from the pit and form a single drainage trench that crosses under Infantry Road in a culvert. The drainage trench intersects the headwaters of Rainbow Creek a short distance east of Infantry Road.

Together, the mud pits form two approximately square-shaped areas with dimensions of 150 feet by 150 feet each. The area within the berms was mostly submerged, although some dry areas were observed near the southern edge of the pits. The sediment at the bottom of the mud pits was observed to be a cohesive, gray clay, which appeared to be the settled-out remains of the bentonite used in the drilling mud. The bentonite contained some sand- and gravel-sized particles that are assumed to be drill cuttings. These cuttings were more prevalent in the deeper of the two samples collected at each sampling location. The bentonite had a slight to moderate diesel odor, and a sheen appeared on the surface of the water when some of the drilling-mud samples were collected.

Water depth and the thickness of the drilling mud were measured at each sampling location. The depth of water in the pits ranged from 1.0 to 2.1 feet. The thickness of drilling mud in the borings drilled in the pits varied from 2.0 to 7.7 feet. Based on these measurements, the estimated total volume of drilling mud remaining in both mud pits is 5,480 cubic yards. The estimated total volume of water in both mud pits (based on the water surface elevation at the time of the field work) is 338,500 gallons. The assumptions and methods used to make these estimates are explained in Section 2.4.3.1.3.

Descriptions and field screening results for the samples collected at the Long Shot site are provided in the following table:

Mud Pit Sample Descriptions, Long Shot Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
West Mud Pit	2	2.0	1120-SW		Surface Water		
			1126-SD	0-1.0	Gray Bentonite	Slight diesel odor and sheen	PID=40
			1127-SD	1.0-2.0	Gray, sandy Bentonite	Slight diesel odor and sheen	PID=43
	2.1	4.8	1121-SW		Surface Water		
			1128-SD	0-1.0	Gray Bentonite		PID=44
			1129-SD	3.1-4.1	Gray, sandy, gravelly Bentonite	Slight diesel odor	PID=32
	1.5	6.2	1122-SW		Surface Water		
			1123-SD 1124-SD (dup)	0-1.0	Gray Bentonite	Moderate diesel odor and sheen	PID=0
			1125-SD	4.0-6.0	Gray, sandy Bentonite	Slight diesel odor and sheen	PID=1
East Mud Pit	2.0	3.0	1009-SW		Surface Water		
			1134-SD	0-1.0	Gray Bentonite	Slight diesel odor and sheen	PID=13
			1135-SD	2.0-3.0	Gray, sandy Bentonite	Slight diesel odor and sheen	PID=25
	1.6	5.2	1010-SW		Surface Water		
			1132-SD	0-1.0	Gray Bentonite	Slight diesel odor	PID=26
			1133-SD	4.2-5.2	Gray, sandy, gravelly Bentonite	Slight diesel odor	PID=16
	1.0	7.7	1011-SW 1012-SW (dup)		Surface Water		
			1130-SD	0-1.0	Gray, sandy Bentonite		PID=25
			1131-SD	5.0-6.0	Gray, sandy, gravelly Bentonite	Slight diesel odor	PID=25

* Sample depth measured from mud surface

4.2.4.1.1 Surface Water

The mud pit surface water samples were analyzed for VOCs, DRO, PAHs, and metals. The results of these analyses are summarized in Table 4.2-1. All six samples and a duplicate contained DRO. Concentrations in the east mud pit ranged from 198 to 284 ug/L, while

concentrations in the west mud pit ranged from 114 to 125 ug/L. The laboratory method blank associated with the east mud pit samples contained 82.7 ug/L of DRO. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples could have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. However, this approach might be viewed as questionable when used on samples from a mud pit known to contain diesel. Accordingly, these four DRO results have been "B"-flagged. The laboratory contamination present in the method blank might explain why the average DRO concentration in the east mud pit (246 ug/L) is greater than the average concentration in the west pit (120 ug/L). The reported concentrations of DRO are also comparable to the 92 ug/L average concentration of DRO reported in water from half of the lowland reference stream samples, as explained in Section 2.3.1.5. In summary, DRO found in the samples could be due to diesel fuel from the drilling mud, from laboratory contamination, or from biogenic hydrocarbons.

The only VOC detected in Long Shot mud pit water samples was methylene chloride. It was detected in all seven samples at concentrations ranging from 2.05 to 25.6 ug/L. However, these results were attributed to blank contamination by the lab and should be considered as nondetects (Table 4.2-1). No PAH compounds were detected in the water samples.

The Long Shot mud pit water samples contained 12 metals, most at levels well below the background concentrations for surface water established from lowland reference streams. Notable exceptions were calcium, magnesium, and strontium, which exceeded background concentrations in all the mud pit samples. Nickel was not detected in the lowland reference stream samples (at a detection limit of 1 ug/L), but was present in the east mud pit at 1.37 to 5.91 ug/L. Cobalt exceeded background in one sample from the east mud pit, though the measured concentration of 5.56 ug/L was estimated and less than two times the background concentration.

A comparison of those metals that exceeded background in the Long Shot mud pit water samples with project ERBSCs (Table 2-10) shows that no ERBSCs were exceeded.

DOE collected three water samples from the Long Shot mud pits in 1993 for metals analysis. Concentrations were similar to those reported for the 1998 samples, except that the calcium and magnesium concentrations in the 1993 samples were about 40 percent higher than 1998 concentrations, and the single 8.7 ug/L occurrence of copper in 1993 was several times higher than the 1998 concentrations.

Surface water quality parameters measured in the Long Shot mud pits during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Long Shot Mud Pits

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1009-SW (east pit)	8.6	10.0	11.8	200	0
1010-SW (east pit)	8.6	10.0	11.4	190	0
1011-SW (east pit)	8.5	10.0	11.8	190	0
1120-SW (west pit)	6.7	9.6	8.45	216	1
1121-SW (west pit)	7.2	9.8	8.65	200	1
1122-SW (west pit)	7.2	9.8	8.8	210	2

4.2.4.1.2 Sediment

The mud pit sediment samples were analyzed for VOCs, DRO, PAHs, and metals. The results of these analyses are summarized in Table 4.2-2.

The Long Shot mud pit, sediment samples contained the highest DRO concentration of all drill sites. All of the sediment samples at Long Shot mud pits contained DRO. Concentrations in the west mud pit ranged from 296 to 15,200 mg/kg; whereas concentrations in the east mud pit ranged from 1,130 to 58,800 mg/kg. The average DRO concentration in the east mud pit (about 21,000 mg/kg) is about twice that in the west mud pit (about 10,000 mg/kg). This trend is consistent with the trend exhibited by DRO concentrations in water samples (the east pit also had higher DRO concentrations in water).

Since the sediment thickness was as much as 7.7 feet, two mud samples were analyzed at each sample location: one from the mud surface, and one from the bottom of the mud layer. In the west mud pit, DRO concentrations were comparable in the shallow and deeper samples, except at sample 1125-SD, where the concentration at depth was only 296 mg/kg. In the east pit, DRO concentrations in the deeper samples were an order of magnitude lower than the shallow samples (but still ranged from 1,130 to 9,540 mg/kg). All of the sediment samples were predominantly bentonite drilling mud, but the deeper samples contained higher proportions of sand and gravel drill cuttings. In general, these deeper samples also had a higher percent solids determined by the chemical laboratory, which reflects the presence of the drill cuttings. This partially explains the lower DRO concentration in the deeper samples, but there still appears to be a lower diesel content per unit volume of the deeper mud than there is in the shallow mud samples.

Each of the drilling-mud samples contained between three and nine alkylated benzenes, at a total concentration ranging from about 7 to 272 mg/kg. This represents an average of 1.8 percent of the DRO concentration. Naphthalene was also detected in all the samples at 16.3 to 137 mg/kg.

Four or five PAHs were present in each of the drilling-mud samples. at total concentrations ranging from about 1.4 to 78 mg/kg. This represents an average of 0.24 percent of the DRO concentration. The shallow mud samples contained only about half the total alkylated benzene concentration of the deeper samples, as a percentage of DRO (1.2 percent of the DRO versus 2.6 percent). The deeper samples contained about a 50 percent higher total PAH concentration than the shallow samples (0.27 percent of DRO versus 0.19 percent).

Twenty-four metals were detected in the samples from the Long Shot mud pits. Twelve of these exceeded background concentrations based on lowland reference stream sediment samples. The following metals were in exceedance in at least one of the 12 mud samples (an asterisk indicates that sample concentrations also exceeded the ERBSCs).

Calcium	Cerium	Cesium	Chromium*	Cobalt	Copper*
Magnesium	Nickel	Potassium	Strontium	Thorium	Titanium

Chromium exceeded both background and ERBS concentrations in half of the samples. All twelve samples exceeded both background and the ERBSC for copper. As noted previously, the copper ERBSC is lower than the background value.

DOE collected three sediment samples from the Long Shot mud pits in 1993. The samples were designated LSMP-1, LSMP-2, and LSMP-3, and are shown in Figure 4.2-3 and Appendix B. These samples were analyzed for metals. In most cases, the metals results from 1993 were significantly lower than the 1998 results. In a few cases the difference is an order of magnitude or more. The only comparable results were cases where metals were not detected in either set of samples.

Two additional sediment samples and a duplicate were collected from the mud pits by DOE in 1997. The results for the 1997 metals and TPH analyses are listed in Appendix B under the sample labels of "Mud Pits A and B" and "Mud Pits C and D." In most cases, the 1997 metals concentrations are intermediate values between the 1993 and 1998 results. Generally, the values are closer to the 1998 results than the 1993 results. The explanation of data differences is unknown. Perhaps the concentrations are increasing due to the consolidation of sediments over time. Some of the differences may be attributed to different analytical laboratories or methods.

4.2.4.2 Streams

Three streams drain the Long Shot site. As shown in Figure 4.2-2, these streams are Rainbow Creek, Cloudberry Creek, and a tributary to Bridge Creek. Rainbow Creek and Cloudberry Creek were previously unnamed and were named during this investigation for ease of reference.

4.2.4.2.1 Bridge Creek

For this study, the name Bridge Creek refers to the tributary that exits Long Shot Pond and flows north into a larger channel about 800 feet upstream of Infantry Road, as shown in Figure 4.2-2. Bridge Creek then passes under a small bridge at the road and flows into Square Bay on the Bering Sea. The portion of Bridge Creek downstream of the road was not investigated because of a documented diesel spill into the creek off the road embankment. The studied portion of Bridge Creek is approximately 3,900 feet long, with an overall gradient of 3.0 percent.

Field activities at Bridge Creek included a reconnaissance to document stream characteristics and select sample station locations (as shown in Figure 4.2-2), followed by sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). One surface water and sediment sample was collected at each of five sampling stations along the length of the creek. Benthic macroinvertebrates samples were collected at Stations 1, 2, and 5. Sediment samples for bioassays were collected at Stations 2, 3, and 5. Fish samples were collected at Stations 3 and 5. Fish were not observed during shocking at Stations 1 and 2; therefore a third fish sample was not collected. Similarly, no fish samples were collected for radionuclide testing due to the scarcity of fish.

The following table lists the sample numbers for each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver, and are accurate to ± 100 feet. Station elevations were interpolated from topographic contours on the Figure 4.2-2.

Sample Numbers and Station Coordinates for Bridge Creek, Long Shot Site

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 26' 23.1"	179° 10' 38.0"	120	4042-SW 4043-SD
2	51° 26' 30.0"	179° 10' 36.4"	100	4040-SW 4041-SD 4082-IN
3	51° 26' 37.4"	179° 10' 37.4"	70	4038-SW 4039-SD 4072-FS 4081-IN
4	51° 26' 47.4"	179° 10' 35.8"	35	4036-SW 4037-SD
5	51° 26' 47.4"	179° 10' 40.9"	32	4034-SW 4035-SD 4071-FS 4080-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities, and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.2.4.2.1.1 Stream Characteristics

Bridge Creek roughly parallels Infantry Road, about 350 to 800 feet to the west of the road. Based on the initial reconnaissance, Bridge Creek was divided into three stream reaches (Figure 4.2-2). The uppermost reach, Reach 1, begins at the outlet of Long Shot Pond, flows through a broad, gently-sloping, tundra-sedge meadow, and ends at a slope break below which the gradient sharply increases. Reach 2 flows down through a narrow, steeply-incised channel with several- to 3-foot falls, and ends about 300 feet upstream of the confluence with the larger channel of Bridge Creek. The lowest reach, Reach 3, includes the confluence and the low gradient, wider channel of Bridge Creek and ends at the road. Bridge Creek contributes about 15 percent of the total combined flow as measured just below its confluence with the main channel. Another tributary enters Reach 3 about 400 feet upstream of the road; it contributes about twice the discharge as the subject stream. The following table summarizes the reach characteristics.

Reach Characteristics for Bridge Creek, Long Shot Site

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	2,000	2.3	Many small bends	Peat
2	1,000	6.5	Straight	Peat
3	900	0.75	Straight with 90° bend at confluence	Sandy gravel over peat

Reach 1

Reach 1 is roughly 2,000 feet long. It begins at the outlet of Long Shot Pond. A relatively straight channel drains north from the pond across a gently-sloping, boggy, tundra area. The stream channel typically ranges from 4 to 12 inches wide and 2 to 8 inches deep, with many small bends. The gradient in the upper portion of the reach is about 1 percent. The dominant substrate is peat. The stream banks are typically low and vertical to undercut. In several places, the turf banks close together over the stream, such that the channel is underground. There are numerous deep pools both connected and adjacent to the stream throughout this reach. At least one appears to be manmade, with an angular "L" shape. The pools are often greater than 5 feet deep. No fish were observed in any of these pools, even after electroshocking. In the lower portion of Reach 1, several similar channels converge. The gradient of the stream increases downstream of this convergence.

Station 1 was located halfway down Reach 1. Through this portion of the stream, rooted plants typically cover about 50 percent of the stream bottom (Photo 4.2-2). Emergent and submergent vegetation mainly consists of grass, sedge, and mare's tail. A sheet metal weir is located about

100 feet downstream of Station 1, and a staff gage was observed in Reach 2. These were most likely installed in the late 1960s for hydrologic studies.

Station 2 was located at the lower end of Reach 1, below the point where the multiple channels converge. The channel width increases in this area to 1 to 3 feet, and the depth increases to 6 to 12 inches.

Reach 2

Reach 2 is roughly 1,000 feet long. It is characterized by a steep gradient (6.5 percent overall) and numerous 1- to 3-foot waterfalls. The stream flows through a steep-sided, narrow valley estimated at 50 to 70 feet wide and 15 feet deep (Photo 4.2-3). The stream channel is incised with vertical to undercut banks, often as high as 5 feet. During the 1998 field work the water level of Bridge Creek was relatively low, and the average stream depth within Reach 2 was 1 to 3 inches except in pools that were 1 to 3 feet deep. The dominant substrate is peat. The stream banks show exposed peat up to 6 feet thick. Sandy gravel is superimposed over peat in many places. Grass, cow parsnip, and wild celery are present along the banks, often overhanging and shading the channel. Submerged vegetation, mainly moss (*Fontinalus* sp.), covers approximately 25 percent of the stream bottom.

Station 3 was located in the middle of Reach 2.

Reach 3

Reach 3 is approximately 900 feet long, with an overall gradient of about 0.75 percent, making it the flattest reach on Bridge Creek. The stream channel is relatively straight except for a right angle turn at the confluence with the larger channel that enters from the west. The valley floor widens to 200 to 300 feet toward Infantry Road. The stream channel also widens to 2 to 5 feet, with depths varying from 6 inches to 4 feet. The dominant substrate consists of silty peat overlain by sandy gravel. About 20 percent of the stream bottom is covered with rooted vegetation (mainly *Fontinalus*), and the banks are overhung with grass and sedge.

Station 4 was located in the upper end of Reach 3, approximately 250 feet upstream of the Bridge Creek confluence, on the smaller channel. Station 5 was located about 30 feet downstream of the main confluence on Bridge Creek. Several sea-run Dolly Varden were observed in this area.

Downstream of Infantry Road, Bridge Creek continues for another 2,500 feet to the beach. The gradient is low, about 0.5 percent or less, and the channel meanders through a flat-bottomed valley. Silver salmon were observed in the creek below the road.

4.2.4.2.1.2 Surface Water

One surface water sample was collected at each of the five sampling stations. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.2-3.

DRO was detected in three of five surface water samples at concentrations ranging from 59.6 to 77.2 ug/L. These values are less than the DRO concentrations reported in surface water from lowland reference streams (Section 2.3.1.5) and thus may represent biogenic hydrocarbons.

The only VOC detected was methylene chloride in three samples at concentrations of 2.92 to 5.95 ug/L. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

Thirteen metals were detected in the surface water samples from Bridge Creek. All but three of the detected metals (calcium, magnesium, and nickel) had concentrations below the background concentrations from lowland reference streams. Of these three, calcium and magnesium were detected at concentrations above background levels in only at Station 3. Calcium was 50 percent greater in the Bridge Creek Station 3 sample than background; magnesium was only about 1 percent greater. Nickel was detected in four of the five surface water samples at concentrations of 1.02 to 1.32 ug/L; the reporting limit was 1 ug/L. Nickel was not detected in the lowland reference streams, while the upland reference stream nickel concentration was 1.69 ug/L.

The list of metals that exceeded background values in Bridge Creek surface water was compared with the list of metals that exceeded background values in sediment (see Section 4.2.4.2.1.3). Nickel concentrations in sediment did not exceed background values. Calcium and magnesium concentrations in Bridge Creek sediment and surface water both exceeded background concentrations.

None of the metals found in Bridge Creek water samples that exceeded background also exceeded project ERBSCs. The ERBSC for nickel in water is 52 ug/L, which is well above the concentrations detected in Bridge Creek. No ERBSCs are available for calcium or magnesium; both are considered essential nutrients and unlikely to produce toxic effects.

Surface water quality parameters measured at each Bridge Creek station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Bridge Creek, Long Shot Site

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	7.0	11	9.8	120	Clear
2	6.9	9.4	10.9	128	Clear
3	7.0	8.0	11.0	167	Clear
4	7.1	9.0	11.1	145	Clear
5	6.9	9.3	10.5	126	Clear

4.2.4.2.1.3 Sediment

One sediment sample was collected at each of the five Bridge Creek stations. Sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. Only the sediment sample from Station 5 was analyzed for VOCs. Analytical results are summarized in Table 4.2-4.

Neither DRO nor PAHs were detected in any of the Bridge Creek sediment samples. No VOCs were detected in the sample from Station 5.

Of 20 metals detected in the Bridge Creek sediment samples, the following seven were reported at levels greater than their respective background concentrations for lowland reference streams.

Aluminum	Calcium	Magnesium	Molybdenum
Potassium	Selenium	Strontium	

Each of these metals exceeded the background concentration for one sediment sample (i.e. one station), except for magnesium and potassium, which exceeded background at two stations. Exceedances ranged from 8 to 63 percent over the respective background concentrations, with the exception of one potassium sample that was 190 percent of the background value.

No ERBSCs are available for the seven metals that exceeded background concentrations (listed previously).

In addition to the total metals results discussed above, AVS and SEM were analyzed to provide information on the bioavailability of metals in the stream sediment. AVS and SEM concentrations in the sediment samples from Bridge Creek are presented in the following table. The ratio of SEM to AVS ranged from 0.002 to 3.45, suggesting that there are sufficient acid volatile sulfides present to limit the bioavailability of the SEM metals, except at Station 2.

AVS and SEM Concentrations for Bridge Creek, Long Shot Site

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4043-SD	830	1.86	0.002
2	4041-SD	0.747	2.58	3.45
3	4039-SD	255	2.22	0.01
4	4037-SD	3.27	2.57	0.79
5	4035-SD	7.8	1.52	0.19

TOC was determined for each of the sediment samples, to allow normalization of organic chemical concentrations to carbon and comparison between the substrate at the various stations. Organic content determinations were performed on all samples, and the grain-size gradation was measured on those with a sufficient mineral soil content (rather than peat and other organics. whose lighter specific gravity render a grain-size analysis invalid). These analyses were also performed to allow comparison between stations. The results are presented in the following table.

Sediment Characteristics for Bridge Creek, Long Shot Site

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4043-SD	194,000	65.3	Brown PEAT
2	4041-SD	169,000	37.9	Brown, slightly sandy, silty PEAT
3	4039-SD	50,200	30.1	Brown, fine sandy SILT with organics
4	4037-SD	43,300	33.3	Brown, slightly sandy, silty PEAT
5	4035-SD	95,300	39.3	Slightly silty sandy GRAVEL with organics

4.2.4.2.1.4 Benthos

Benthic samples were collected at Stations 2, 3, and 5 on Bridge Creek. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. The report *Triad Analysis of Drill Site and Test Site Stream Sediments,* prepared by IT Corporation under subcontract to DOE, is presented in Appendix F. This report evaluates the benthic abundance and diversity data for this stream in comparison to the other site-related and reference streams. and as one component of the Sediment Quality Triad.

Benthic Invertebrates in Bridge Creek, Long Shot Site

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					2	3	5
Turbellaria	Tricladida	Planariidae	flatworm	Adult		3	
Oligochaeta	Tubificida	Tubificidae	tubifex worm	Adult		60	8
Gastropoda	Mesogastropoda	Lymnaidae	snail	Juvenile	16		
Peleycopoda	Spaeracea	Sphaeriidae	clam	Juvenile	16		11
Insecta	Trichoptera	Limniphilidae	caddisfly	Larva	116	1	3
	Lepidoptera		moth	Larva	4		
	Diptera	Muscidae	fly	Larva	8		
		Chironomidae	midge	Larva	204	1	14
Crustacea	Amphipoda	Talitridae (genus Hyalella sp.)	scud	Adult	52		
				Total	**416**	**65**	**36**
				Family Biotic Index	5.76	7.72	6.89
				EPT Relative Abundance	28.2%	1.5%	8.3%
				Species Diversity	1.29	0.34	1.27

4.2.4.2.1.5 Sediment Toxicity Tests

Sediment samples collected from Stations 2 and 5 (which were also benthic invertebrate sample stations) and from Station 3 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. The *Triad Analysis of Drill Site and Test Site Stream Sediments* prepared by IT Corporation under subcontract to DOE is presented in Appendix F. This report evaluates the bioassay results for this stream in comparison to the other site-related and reference streams, and as one component of the Sediment Quality Triad.

Sediment Toxicity Results, Bridge Creek, Long Shot Site

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
2	52.50%	56.00%	0.718	97.20%	3.74	54.1%
3	62.50%	66.67%	0.731	98.90%	4.65	67.3%
5	87.50%	92.11%	0.397	76.10%	3.45	70.0%

4.2.4.2.1.6 Fish

Fish samples were collected at Stations 3 and 5 on Bridge Creek. No fish were observed at Stations 1 or 2 or in all of Reach 1 after 318 seconds of electroshock time.

For the fish sample at Station 3 the whole of Reach 2 was electroshocked. One sea-run Dolly Varden was observed in a small pool in the middle of Reach 2; it was captured and released alive. At Station 5, seven sea-run Dolly Varden were observed but not collected. No salmon were observed, except downstream of Infantry Road. All fish that were collected were resident Dolly Varden. Specific data on fish sampling, such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish.

Fish Sample Descriptions for Bridge Creek, Long Shot Site

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
3	4072-FS	1 – 5	23	150	6.5	721
5	4071-FS	1 – 5	25	200	8.0	1342

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.2-5 and summarized below.

Twenty-four metals were detected in the two fish tissue samples. Concentrations were compared to background concentrations determined for fish from lowland reference streams, and to EPA Region III RBCs for fish consumption. None of the metals exceeded background in both samples, but the following thirteen metals each exceeded background levels in one fish sample only (usually from Station 5).

Arsenic*	Barium	Cerium	Cesium
Cobalt	Copper	Iron*	Lithium
Magnesium	Nickel	Thallium	Thorium
Vanadium			

Of these thirteen metals, seven were below the corresponding RBCs, and five (arsenic, cerium, cesium, magnesium, and thorium) do not have established RBCs. Only arsenic and iron at Station 5 exceeded both its background concentration and fish consumption RBC (denoted above with an asterisk).

Inorganic arsenic was detected in both samples at concentrations exceeding the fish consumption RBC. One of these samples from Station 5 also exceeded the background level; the sample

concentration was over seven times the background (0.0208 vs. 0.154 mg/kg). A confirmation analysis was run on the fish sample from Station 5; this result was higher than the original at 0.219 mg/kg, which is over ten times background. However, the background level of inorganic arsenic in lowland stream fish also is almost ten times higher than the corresponding RBC.

Neither PAHs nor PCBs were detected in either fish sample from Bridge Creek.

4.2.4.2.2 Rainbow Creek

During the 1998 field season the name Rainbow Creek was given to the unnamed drainage channel and stream that begins at the Long Shot mud pits, flows east under Infantry Road, and then flows northeast to Square Bay on the Bering Sea (see Figure 4.2-4). The upper part of this stream system was referred to in the August 1998 *Management Plan* as "two apparent drainage trenches." Investigation of Rainbow Creek was added to the scope of work after investigators observed a hydrocarbon sheen and odor upon disturbing the sediment in the channel downstream of Infantry Road.

Rainbow Creek is approximately 4,500 feet long, with an overall gradient of 2.7 percent. The uppermost 1,000-foot (approximately) portion of Rainbow Creek consists of a straight, shallow, manmade drainage channel that ends in a boggy, gently-sloping area with poorly-defined drainage. In general, Rainbow Creek has extensive aquatic and overhanging terrestrial vegetation. A 4-foot-high waterfall is located just upstream from the beach at Square Bay.

Field activities at Rainbow Creek included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). Surface water and sediment samples were collected at each of five sampling stations along the length of the creek. At Stations 2, 3, and 5, benthic macroinvertebrates and sediment samples for bioassays were also collected. Fish samples were collected at Stations 3 and 5. At Station 2 no fish were observed during electrofishing, so a sample was not obtained.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ± 100 feet. Station elevations were interpolated from contours in Figure 4.2-2.

Sample Numbers and Station Coordinates for Rainbow Creek, Long Shot Site

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 26' 14.3"	179° 10' 55.8"	130	4123-SW 4124-SD
2	51° 26' 28.1"	179° 10' 59.7"	120	4121-SW 4122-SD 4159-IN
3	51° 26' 26.8"	179° 11' 03.7"	98	4119-SW 4120-SD 4157-FS 4158-IN
4	51° 26' 35.8"	179° 11' 18.5"	85	4117-SW 4118-SD
5	51° 26' 38.8"	179° 11' 25.9"	70	4115-SW 4116-SD 4155-FS 4156-IN

The following subsections present observations made during the reconnaissance and sampling activities, and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.2.4.2.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, Rainbow Creek was divided into three stream reaches (Figure 4.2-2). Reach 1 begins at the northeast corner of the Long Shot mud pits, where a manmade channel drains to the east-northeast to a culvert beneath Infantry Road (around 4.8 mile). The straight channel continues about 750 feet downstream of the road. The manmade channel then ends, and the water enters a boggy area where flow continues underground in places, and multiple small rivulets converge in a braided pattern. Reach 1 ends at the confluence of upper Rainbow Creek and a small western tributary that contributes about 30 percent to the overall discharge. Reach 2 begins at this confluence where the creek channel is better defined. The entire middle portion of Reach 2 is characterized by a low gradient and poor drainage. There are multiple small channels that spread out into a boggy wetland with a series of ponds. At the lower end of Reach 2, a single channel forms. Reach 3 begins as the gradient increases, and an incised valley (about 150 feet wide) forms. Reach 3 ends where the mouth of Rainbow Creek enters the southern corner of Square Bay. A 4-foot-high waterfall about 100 feet upstream of the cobble beach would prevent anadromous fish from moving up the channel. The following table summarizes reach characteristics for Rainbow Creek.

Reach Characteristics for Rainbow Creek, Long Shot Site

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,500	2.1	Straight	Peat with silt
2	1,600	1.2	Few bends	Peat with silt
3	1,400	5.0	Few bends	Gravel-cobble

Reach 1

As defined by the investigation, Reach 1 begins as a straight, 6-inch-wide ditch draining the Long Shot mud pits to the east under Infantry Road, continuing northeast in a straight, 6- to 8-inch-wide by 3- to 5-inch-deep ditch for another 750 feet. Water was flowing at the time of the investigation, and as noted previously, a hydrocarbon sheen was observed and an odor detected upon disturbing the sediments near Station 1. Two other small tributaries enter the main channel downstream of the straight portion; one contributed about 30 percent to the overall discharge, while the other was not flowing.

The ditch crosses a gently-sloping sedge-tundra meadow; once the manmade channel ends, drainage becomes poorly-defined. The channel enters a wide, wet area where multiple braided channels intersect and subterranean flow occurs. A single channel emerges after about 400 feet. The stream is heavily overgrown with bank and instream vegetation including mare's tail, marsh marigold, and sedges. The lower portion of Reach 1 is again a wide, wet area with braided channels and subterranean flow. The reach ends at the confluence of two main channels (Figure 4.2-2).

Station 1 within Reach 1 was located about 80 feet downstream of Infantry Road, in the manmade ditch. The substrate at Station 1 consists of 4 inches of gravel (presumably from the road embankment) over peat. Some of the sediment was grayish, possibly indicating the remnants of drilling-mud constituents.

Station 2 was located on a tributary of Rainbow Creek, about 50 feet upstream of the boundary between Reaches 1 and 2 (Figure 4.2-2). This station was chosen because it is upgradient of the confluence with the potentially-contaminated channel that leads from the mud pits, so water and sediment quality could be compared between this presumed undisturbed portion of Rainbow Creek and the remainder of the drainage system. At Station 2 the stream was 1 to 3 inches deep and about 6 inches wide, with a semisoft peat bottom and abundant aquatic vegetation; the discharge was low.

Reach 2

Reach 2 of Rainbow Creek begins at the confluence of the Station 2 tributary and the channel from the Long Shot site, though as noted previously, the drainage pattern was poorly-defined and numerous small channels converge. The middle 800 feet of Reach 2 consists of a 100-foot-wide

TABLE 4.2-2
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-LONG-1130-SD	98DOE-LONG-1131-SD	98DOE-LONG-1132-SD	98DOE-LONG-1133-SD	98DOE-LONG-1134-SD	98DOE-LONG-1135-SD	98DOE-LONG-1123-SD	98DOE-LONG-1124-SD (Duplicate)	98DOE-LONG-1125-SD	98DOE-LONG-1126-SD	98DOE-LONG-1127-SD	98DOE-LONG-1128-SD	98DOE-LONG-1129-SD
			E mud pit						W mud pit						
		Depth (feet)	0-1	4.3-5.3	0-1	4.2-5.2	0-1	2-3	0-1	0-1	1.3-2.1	0-1	1-2	0-1	3.1-4.1
Diesel Range Hydrocarbons	AK 102	-	37,000	1,780	17,000	1,130	58,800	9,540	11,600	15,200	296	10,100	13,700	8,760	6,780
Volatile Organic Compounds															
1,2,4-Trimethylbenzene	EPA 8260B	-	101	32.2	66.9	29.2	103	101	105	198	4.32	106	65.2	140	134
1,3,5-Trimethylbenzene	EPA 8260B	-	18.6	6.91	14	6.69	19.6	19.8	19.8	39.1	0.991	21.8	14.1	28	27.9
2-Butanone	EPA 8260B	-	ND(103)	ND(27.5)	ND(78.1)	ND(25)	ND(140)	ND(86)	ND(179)	ND(249)	ND(5)	ND(95.3)	ND(30)	ND(144)	ND(37.5)
Acetone	EPA 8260B	-	ND(103)	ND(27.5)	ND(78.1)	ND(25)	ND(140)	ND(86)	ND(179)	ND(249)	ND(5)	ND(95.3)	ND(30)	ND(144)	ND(37.5)
Carbon disulfide	EPA 8260B	-	ND(2.05)	ND(0.55)	ND(1.56)	ND(0.5)	ND(2.81)	ND(1.72)	ND(3.59)	ND(4.99)	ND(0.5)	ND(1.91)	ND(0.6)	ND(2.89)	ND(0.75)
Ethylbenzene	EPA 8260B	-	ND(4.1)	ND(1.1)	ND(3.12)	ND(1)	ND(5.62)	ND(3.44)	ND(7.17)	ND(9.98)	ND(0.2)	ND(3.81)	1.48	ND(5.78)	3.19
Isopropylbenzene	EPA 8260B	-	ND(4.1)	ND(1.1)	ND(3.12)	ND(1)	ND(5.62)	ND(3.44)	ND(7.17)	ND(9.98)	ND(0.2)	ND(3.81)	1.31	ND(5.78)	2.83
m,p-Xylene	EPA 8260B	-	111	21.3	77	ND(2)	ND(11.2)	12	ND(14.3)	ND(20)	ND(0.4)	11	9.37	15.5	19.2
Methylene chloride	EPA 8260B	-	ND(20.5)	ND(5.5)	ND(15.6)	ND(5)	ND(28.1)	ND(17.2)	ND(35.9)	ND(49.9)	ND(1)	ND(19.1)	ND(6)	ND(28.9)	ND(7.5)
n-Butylbenzene	EPA 8260B	-	8.85	4.08	6.95	4.32	11	9.82	9.23	20.6	0.636	10.6	6.28	13.7	11.5
n-Propylbenzene	EPA 8260B	-	4.98	1.64	3.72	1.52	ND(5.62)	4.98	ND(7.17)	ND(9.98)	0.251 J	5.68	3.73	7.45	8.02
Naphthalene	EPA 8260B	-	91	20.6	48.4	16.3	89.2	96.4	84.9	137	3.09	92.4	45.6	118	89.2
o-Xylene	EPA 8260B	-	65	15.9	39	12.7	ND(5.62)	7.4	ND(7.17)	ND(9.98)	0.231	6.29	5.12	9.26	11.2
p-Isopropyltoluene	EPA 8260B	-	ND(4.1)	2.7	4.78	2.69	7.54	6.57	ND(7.17)	14.6	0.396	7.06	4.54	9.59	8.13
sec-Butylbenzene	EPA 8260B	-	4.28	1.82	3.29	1.88	ND(5.62) UJ	4.53	ND(7.17)	ND(9.98)	0.281 J	4.83	3.19	6.74	6.16
Toluene	EPA 8260B	-	ND(4.1)	ND(1.1)	ND(3.12)	ND(1)	ND(5.62)	ND(3.44)	ND(7.17)	ND(9.98)	ND(0.2)	ND(3.81)	ND(1.2)	ND(5.78)	ND(1.5)
Xylenes (total)	EPA 8260B	-	176	0.432	122	ND(0.2)	145	195	167	2.79	0.802	1.73	1.45	2.46	0.04
Polycyclic Aromatic Hydrocarbons															
Acenaphthene	EPA 8270C	-	42	0.102	0.79	0.0676	2.05	0.579	1.65	0.802	0.0406	1.57	0.349	1.74	0.135
Acenaphthylene	EPA 8270C	-	0.587	ND(0.05)	ND(0.539)	0.029	0.802	ND(0.4)	0.509	ND(0.286)	0.0106	ND(0.748)	ND(0.2)	ND(0.729)	ND(0.033)
Fluorene	EPA 8270C	-	2.36	0.272	2.16	0.217	6.01	1.63	3.76	1.374	0.0821	7.03	1.07	3.35	0.315
Naphthalene	EPA 8270C	-	4.05	1.49	2.35	1.26	6.67	4.8	5.12	1.69	0.127	2.19	2.26	4.95	6.53
Phenanthrene	EPA 8270C	-	1.76	0.115	0.97	0.106	2.86	0.802	2.03	1.07	0.0357	3.29	0.454	2.29	0.158
Metals															
Aluminum	EPA 6010B	45,400	39,200	26,200	33,000	28,600	33,300	36,300	23,900	21,600	27,600	32,300	20,100	28,200	35,100
Arsenic	EPA 6020	1.00	8.03	1.79	5.31	3.66	5.76	4.33	5.82	5.25	2.56	5.22	4.33	3.4	2.25
Barium	EPA 6020	469	169	65.4	185	123	195	201	167	146	76.8	188	95.3	161	112

TABLE 4.2-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-LONG-1130-SD	98DOE-LONG-1131-SD	98DOE-LONG-1132-SD	98DOE-LONG-1133-SD	98DOE-LONG-1134-SD	98DOE-LONG-1135-SD	98DOE-LONG-1123-SD	98DOE-LONG-1124-SD (Duplicate)	98DOE-LONG-1125-SD	98DOE-LONG-1126-SD	98DOE-LONG-1127-SD	98DOE-LONG-1128-SD	98DOE-LONG-1129-SD
			L mud pit						W mud pit						
		Depth (feet)	0-1	4.3-5.3	0-1	4.2-5.2	0-1	2-3	0-1	0-1.85	3-4	0-1	1-2	0-1	3.1-4.1
Beryllium	EPA 6020	ND	ND(91.8) UJ	ND(10) UJ	ND(67.4) UJ	ND(25) UJ	ND(37.6) UJ	ND(25) UJ	ND(2.93)	ND(2.86)	ND(2.5)	ND(37.4) UJ	ND(0.5)	ND(36.4) UJ	ND(2.5)
Boron	EPA 6010B	7.18 [b]	ND(9.18) UJ	3.9 J	ND(6.74) UJ	3.34 J	ND(9.4) UJ	3.49 J	ND(14.7) UJ	ND(14.3) UJ	3.8 J	ND(9.35) UJ	2.98 J	ND(9.11) UJ	3.79 J
Cadmium	EPA 6020	0.608	ND(1.84)	ND(0.5)	ND(1.35)	ND(0.5)	ND(1.88)	ND(0.5)	ND(2.93) UJ	ND(2.86) UJ	ND(0.5) UJ	ND(1.87)	ND(0.5) UJ	ND(1.82)	ND(0.5) UJ
Calcium	EPA 6010B	7,300	39,800	24,700	27,600	10,500	19,500	20,000	46,200	40,400	8,260	27,600	13,000	24,500	9,060
Cerium	EPA 6020	14.2	31.9 J	11.4 J	22.4 J	13.9 J	26 J	16.8 J	31.3	28.2	11.3	26.2 J	11.5	29.6 J	13.4
Cesium	EPA 6020	ND	2.1	ND(0.5)	ND(1.35)	0.997	ND(1.88)	1.77	ND(2.93) UJ	ND(2.86) UJ	ND(0.5) UJ	ND(1.87)	ND(0.5) UJ	ND(1.82)	ND(0.5) UJ
Chromium	EPA 6020	11.8	ND(184)	ND(10)	ND(67.4)	ND(25)	117	14.2	98.6	89.4	6.9	65.4	42.4	57.5	8.61
Cobalt	EPA 6020	43.7	ND(91.8) UJ	20.1 J	100 J	ND(25) UJ	ND(37.6) UJ	44.4 J	13.2 J	11.7 J	16.6 J	ND(37.4) UJ	6.54 J	40.1 J	17.5 J
Copper	EPA 6020	71.1	410	89.6	171	165	166	176	123 J	108 J	163 J	152	160 J	161	175 J
Iron	EPA 6010B	55,000	64,600	42,900	47,200	39,700	56,200	42,200	52,200	48,000	49,600	53,200	36,400	44,600	44,900
Lithium	EPA 6020	48.8	21.4	11.5	18.2	15.2	18.7	13	14.5	12.8	14.7	16	8.75	15.8	13.4
Magnesium	EPA 6010B	9,320	28,500	19,200	15,900	17,400	20,500	16,500	21,800	19,100	22,200	18,500	16,200	16,500	20,000
Manganese	EPA 6020	2070	4,040	804	3,180	650	1,220	2,110	1,130	1,030	376	1,330	343	1,110	535
Molybdenum	EPA 6020	5.5 [b]	ND(184) UJ	ND(10) UJ	ND(67.4) UJ	ND(25) UJ	ND(18.8) UJ	ND(10) UJ	ND(2.93)	ND(2.86)	ND(0.5)	ND(37.4) UJ	0.808	ND(36.4) UJ	ND(2.5)
Nickel	EPA 6020	13.6	ND(91.8) UJ	14.5 J	ND(67.4) UJ	ND(25) UJ	ND(18.8) UJ	ND(25) UJ	7.88 J	7.12 J	11.2 J	ND(37.4) UJ	8.4 J	ND(36.4) UJ	11.5 J
Potassium	EPA 6010B	1,390	1,890	1,070	1,670	1,220	2,010	1,740	1,660 J	1,470 J	966 J	1,660	682 J	1,460	1,170 J
Selenium	EPA 6020	5.44 [b]	ND(1.84) UJ	ND(0.5) UJ	ND(1.35) UJ	ND(0.5) UJ	ND(1.88) UJ	ND(0.5) UJ	ND(2.93) UJ	ND(2.86) UJ	ND(0.5) UJ	ND(1.87) UJ	0.637 J	ND(1.82) UJ	ND(0.5) UJ
Strontium	EPA 6020	164	1,120	131	521	343	582	615	431	404	61.8	515	71.5	367	121
Thallium	EPA 6020	1 [b]	ND(1.84)	ND(0.5)	ND(1.35)	ND(0.5)	ND(1.88)	ND(0.5)	ND(2.93)	ND(2.86)	ND(0.5)	ND(1.87)	ND(0.5)	ND(1.82)	ND(0.5)
Thorium	EPA 6020	0.5 [b]	4.28	0.863	3.44	1.19	5.12	1.52	6.51	6.04	0.9	4.56	2.03	7.83	1.37
Titanium	EPA 6020	3,010	5,370	829	2,410	1,670	2,160	5,140	1,220	1,120	673	2,380	519	1,620	622
Uranium	EPA 6020	4.13 [b]	ND(1.84)	ND(0.5)	ND(1.35)	0.536	ND(1.88)	0.55	ND(2.93)	ND(2.86)	ND(0.5)	ND(1.87)	0.846	2.27	0.594
Vanadium	EPA 6020	734	5.35	124	254	210	215	180	108	92.8	140	221	76.2	231	114
Zinc	EPA 6020	1484	87.9	51.2	74.7	49.3	94.1	58.4	79.4	72.9	53.9	84.3	47.7	78.9	49.2

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
\- sample not analyzed for this parameter
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

TABLE 4.2-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT MUD PITS
(concentrations in milligrams per kilogram)

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.2-3
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration[1]	98DOE-LONG-4042-SW	98DOE-LONG-4040-SW	98DOE-LONG-4038-SW	98DOE-LONG-4036-SW	98DOE-LONG-4034-SW	98DOE-LONG-4052-SW	98DOE-LONG-4050-SW	98DOE-LONG-4048-SW	98DOE-LONG-4046-SW	98DOE-LONG-4044-SW	98DOE-LONG-4123-SW	98DOE-LONG-4121-SW	98DOE-LONG-4119-SW	98DOE-LONG-4117-SW	98DOE-LONG-4115-SW
			Bridge Creek					Cloudberry Creek					Rainbow Creek				
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	ND(50)	59.6	ND(50)	74.4	77.2	ND(50)	54	ND(50)	54.6	ND(50)	121	54.4	ND(50)	80.6	51.7
Volatile Organic Compounds																	
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Acetone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	ND(2)	ND(2)	5.95 U	2.92 U	5.55 U	4.78 U	3.17 U	4.17 U	5.14 U	ND(2)	7.2 U	6.35 U	9.21 U	4.64 U	10.3 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons																	
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals																	
Aluminum	EPA 6020	269[1]	69.7	56.1	ND(50)	75.6	85.1	77.1	59.6	ND(50)	ND(50)	51.8	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)

TABLE 4.2-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-LONG-4042-SW	98DOE-LONG-4040-SW	98DOE-LONG-4038-SW	98DOE-LONG-4036-SW	98DOE-LONG-4034-SW	98DOE-LONG-4052-SW	98DOE-LONG-4050-SW	98DOE-LONG-4048-SW	98DOE-LONG-4046-SW	98DOE-LONG-4044-SW	98DOE-LONG-4123-SW	98DOE-LONG-4121-SW	98DOE-LONG-4119-SW	98DOE-LONG-4117-SW	98DOE-LONG-4115-SW
			Bridge Creek					Cloudberry Creek					Rainbow Creek				
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	3,960	**4,360**	**7,250**	4,040	3,700	3,490	3,610	3,780	4,130	4,300	**8,220**	**8,090**	**7,440**	**5,890**	**5,530**
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	3.35	1.02	1.28	ND(1)	ND(1)	1.25	2	1.21	ND(1)	ND(1)	1.17	ND(1)	2.48	ND(1)	1.41	ND(1)
Copper	EPA 6020	10.8	ND(1)	ND(1)	ND(1)	1.78	1.56	3.03 J	3.19 J	2.87	1.79	1.82 J	3.16	17.7	1.27	ND(1)	ND(1)
Iron	EPA 6010B	993	535	199	310	264	269	323	252	214	196	349	221	ND(150)	304	282	321
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	**1.21**	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	3,210	3,430	**4,750**	3,310	3,170	3,610	3,640	3,690	3,800	3,910	**5,350**	4,210	**4,870**	4,210	4,160
Manganese	EPA 6020	267	52.1	26	38.6	7.24	14	35.4	14.2	8.88	5.84	6.16	7.74	27.8	44.4	29.9	17.5
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	ND(1)	**1.02**	**1.08**	**1.32**	ND(1)	**1.18**	**1.27**	ND(1)	**1.03**	**1.02**	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Potassium	EPA 6010B	2,620	493	ND(200)	1,100	536	939	1,470	1,480	1,270	915	1,140	1,270	967	1,080	898	995
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	28.8	30.8	33.7	23.3	22.1	18.6	18.5	1.85	19.5	20.8	**45.4**	**58.3**	**46.5**	**37.9**	35
Thallium	EPA 6020	17.07 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	2.01	3.85	1.38	2.23	2.64	3.13 J	2.44 J	2.18	1.72	2.17 J	1.09	1.37	1.94	1.31	1.5
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	ND(1)	ND(1)	ND(1)	ND(1)	1.03	2.87	1.42	ND(1)	1.4	1.03	ND(1)	2.12	ND(1)	ND(1)	ND(1)
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)	ND(10)	12.2	ND(10)	17	ND(10)	ND(10)	ND(10)	ND(10)	23.3	ND(10)	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
\- sample not analyzed for this parameter
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U analyte concentration attributed to blank contamination; result considered nondetect

TABLE 4.2-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LONG SHOT STREAMS
(concentrations in micrograms per liter)

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.2-4
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT STREAMS

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-LONG-4043-SD	98DOE-LONG-4041-SD	98DOE-LONG-4039-SD	98DOE-LONG-4037-SD	98DOE-LONG-4035-SD	98DOE-LONG-4053-SD	98DOE-LONG-4054-SD (Duplicate)	98DOE-LONG-4051-SD	98DOE-LONG-4049-SD	98DOE-LONG-4047-SD	98DOE-LONG-4045-SD	98DOE-LONG-4124-SD	98DOE-LONG-4122-SD	98DOE-LONG-4120-SD	98DOE-LONG-4118-SD	98DOE-LONG-4116-SD
				Bridge Creek					Cloudberry Creek						Rainbow Creek				
				Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	ND(64.5)	ND(24.3)	ND(16.1)	ND(15.2)	ND(27)	ND(50.5)	ND(49.7)	ND(20.7)	ND(12.1)	ND(23.1)	ND(16.1)	110	84.4	2,110	1,100	ND(19.9)
Volatile Organic Compounds																			
1,2,4-Trimethylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
1,3,5-Trimethylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
2-Butanone	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.142) UJ	-	-	ND(0.0778) UJ	-	-	-	-	-	ND(146)	-	-
Acetone	EPA 8260B	mg/kg	-	-	-	-	-	ND(1.01) UJ	-	-	ND(0.907) UJ	-	-	-	-	-	ND(146)	-	-
Carbon disulfide	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	0.0494 UJ	-	-	-	-	-	ND(29.2)	-	-
Ethylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
Isopropylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
m,p-Xylene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(11.7)	-	-
Methylene chloride	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(29.2)	-	-
n-Butylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
n-Propylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
Naphthalene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
o-Xylene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
p-Isopropyltoluene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
sec-Butylbenzene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
Toluene	EPA 8260B	mg/kg	-	-	-	-	-	ND(0.071) UJ	-	-	ND(0.0389) UJ	-	-	-	-	-	ND(5.84)	-	-
Xylenes (total)	EPA 8260B	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons																			
Acenaphthene	EPA 8270C	mg/kg	-	ND(0.0532)	ND(0.0201)	ND(0.0133)	ND(0.0126)	ND(0.0223)	ND(0.0417)	ND(0.041)	ND(0.0171)	ND(0.00996)	ND(0.0191)	ND(0.0133)	ND(0.0242)	ND(0.045)	ND(0.0454)	ND(0.0339)	ND(0.0164)
Acenaphthylene	EPA 8270C	mg/kg	-	ND(0.0532)	ND(0.0201)	ND(0.0133)	ND(0.0126)	ND(0.0223)	ND(0.0417)	ND(0.041)	ND(0.0171)	ND(0.00996)	ND(0.0191)	ND(0.0133)	ND(0.0242)	ND(0.045)	ND(0.0454)	ND(0.0339)	ND(0.0164)
Fluorene	EPA 8270C	mg/kg	-	ND(0.0532)	ND(0.0201)	ND(0.0133)	ND(0.0126)	ND(0.0223)	ND(0.0417)	ND(0.041)	ND(0.0171)	ND(0.00996)	ND(0.0191)	ND(0.0133)	ND(0.0242)	ND(0.045)	ND(0.0454)	ND(0.0339)	ND(0.0164)
Naphthalene	EPA 8270C	mg/kg	-	ND(0.0532)	ND(0.0201)	ND(0.0133)	ND(0.0126)	ND(0.0223)	ND(0.0417)	ND(0.041)	ND(0.0171)	ND(0.00996)	ND(0.0191)	ND(0.0133)	ND(0.0242)	ND(0.045)	ND(0.0454)	ND(0.0339)	ND(0.0164)
Phenanthrene	EPA 8270C	mg/kg	-	ND(0.0532)	ND(0.0201)	ND(0.0133)	ND(0.0126)	ND(0.0223)	ND(0.0417)	ND(0.041)	ND(0.0171)	ND(0.00996)	ND(0.0191)	ND(0.0133)	ND(0.0242)	ND(0.045)	ND(0.0454)	ND(0.0339)	ND(0.0164)
Metals																			
Aluminum	EPA 6010B	mg/kg	45,400	11,200	63,900	22,500	33,600	34,200	17,100	18,000	41,800	27,900	25,400	29,500	35,400	3,990	9,900	12,700	28,600
Arsenic	EPA 6020	mg/kg	100	8.76	19	16.7	5.42	9.21	ND(6.31)	6.45	3.58	8.01 J	9.89 J	8.68 J	ND(3.67) UJ	ND(6.83) UJ	9.15 J	5.14 J	32 J

TABLE 4.2-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT STREAMS

Analyte	Analytical Method	Units	Lowland Stream Background Concentration[a]	98DOE-LONG-4043-SD	98DOE-LONG-4041-SD	98DOE-LONG-4039-SD	98DOE-LONG-4037-SD	98DOE-LONG-4035-SD	98DOE-LONG-4053-SD	98DOE-LONG-4054-SD (Duplicate)	98DOE-LONG-4051-SD	98DOE-LONG-4049-SD	98DOE-LONG-4047-SD	98DOE-LONG-4045-SD	98DOE-LONG-4124-SD	98DOE-LONG-4122-SD	98DOE-LONG-4120-SD	98DOE-LONG-4118-SD	98DOE-LONG-4116-SD
				Bridge Creek					Cloudberry Creek						Rainbow Creek				
				Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Barium	EPA 6020	mg/kg	469	ND(80.6)	144	271	185	206	79.5	68.5	131	94.6	107	151	70.6	ND(68.3)	84.7	143	266
Beryllium	EPA 6020	mg/kg	ND	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51) UJ	ND(2.89) UJ	**2.9 J**	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Boron	EPA 6010B	mg/kg	7.18 [b]	ND(40.3)	ND(15.2)	ND(10.1)	ND(9.51)	ND(16.9)	ND(31.6) UJ	ND(31) UJ	ND(13) UJ	**159**	ND(14.5)	ND(10)	ND(18.3) UJ	ND(34.1) UJ	ND(34.4) UJ	ND(25.7) UJ	**18.2 J**
Cadmium	EPA 6020	mg/kg	0.608 [b]	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51) UJ	ND(2.89) UJ	3.17 J	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Calcium	EPA 6010B	mg/kg	7,300	3,930	7,120	5,570	**8,770**	5,900	**8,010**	**7,840**	7,000	5,950	**7,450**	5,460	5,970	7,300	2,880	6,510	6,470
Cerium	EPA 6020	mg/kg	14.2	11.9	9.24	7.11	9.8	11.6	6.83	7.7	8.92	7.34	8.18	12	13.1	ND(6.83)	8.19	8.79	9.58
Cesium	EPA 6020	mg/kg	ND	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51) UJ	ND(2.89) UJ	**3.51 J**	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Chromium	EPA 6020	mg/kg	11.8	ND(8.06)	5.82	6.56	9.27	10	ND(6.31)	6.45	6.84	5.55	7.09	11.3	11.1 J	ND(6.83) UJ	133 J	38.8 J	**12.8 J**
Cobalt	EPA 6020	mg/kg	43.7	8.35	15.7	20.3	16.2	15.8	8.33	8.82	19.9	24.6	22.7	10	8.2 J	ND(6.83) UJ	ND(6.87) UJ	9.6 J	28 J
Copper	EPA 6020	mg/kg	71.1	32.2	41.5	39	68.4	62.6	59.3	52.6	71.7	54.4	57.8	59.6	61.4 J	13 J	46.1 J	47.4 J	41.8 J
Iron	EPA 6010B	mg/kg	55,000	39,400	47,400	98,600	47,700	56,500	49,600	48,200	51,700	79,900	47,300	18,700	30,400	8,070	12,400	38,500	192,000
Lithium	EPA 6020	mg/kg	48.8	ND(8.06)	14.5	10.3	18	17.5	10.2	12	17	17	14.4	14.1	7.41	ND(6.83)	ND(6.87)	ND(5.13)	9.52
Magnesium	EPA 6010B	mg/kg	9,320	1,930	7,200	9,070	**12,300**	**11,900**	7,490	7,620	**16,800**	**11,400**	**10,700**	**9,730**	6,480	1,890	3,770	6,250	7,650
Manganese	EPA 6020	mg/kg	20,700	599	373	6,320	1,270	605	718	566	1,750	1,760	5,160	140	196	1,320	588	1,690	14,700
Molybdenum	EPA 6020	mg/kg	5.5 [b]	**8.47**	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51)	ND(2.89)	3.79	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Nickel	EPA 6020	mg/kg	13.6	ND(8.06)	6.83	9.33	9.8	9.46	6.86 J	7.61 J	9.37 J	8.26 J	8.13 J	9.67 J	5.67	ND(6.83)	ND(6.87)	6.83	9.66
Potassium	EPA 6010B	mg/kg	1,390	432	**4,050**	**1,850**	1,000	688	1,080 J	1,220 J	**2,630 J**	1,280 J	1,150 J	537 J	561 J	370 J	324 J	567 J	748 J
Selenium	EPA 6020	mg/kg	5.44 [b]	**8.86**	ND(3.04)	ND(2.02)	ND(1.9)	3.88	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51) UJ	ND(2.89) UJ	4.55 J	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Strontium	EPA 6020	mg/kg	164	66.4	142	**178**	132	135	59.6	50.8	**221**	92.4	87.6	114	90.2 J	59.5 J	70.7 J	84.7 J	94.1 J
Thallium	EPA 6020	mg/kg	1 [b]	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31)	ND(6.21)	ND(2.59)	ND(1.51) UJ	ND(2.89) UJ	**4.08 J**	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Thorium	EPA 6020	mg/kg	0.5 [b]	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31) UJ	ND(6.21) UJ	ND(2.59) UJ	ND(1.51)	ND(2.89)	ND(2.01)	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Titanium	EPA 6020	mg/kg	3,010	440	1,260	954	1,350	1,460	702	639	925	1,150	1,100	1,640	1,550 J	285 J	640 J	637 J	1,250 J
Uranium	EPA 6020	mg/kg	4.13 [b]	ND(8.06)	ND(3.04)	ND(2.02)	ND(1.9)	ND(3.38)	ND(6.31) UJ	ND(6.21) UJ	ND(2.59) UJ	ND(1.51)	ND(2.89)	ND(2.01)	ND(3.67)	ND(6.83)	ND(6.87)	ND(5.13)	ND(2.48)
Vanadium	EPA 6020	mg/kg	734	109	230	294	200	217	135	121	197	225	215	230	112 J	54.7 J	141 J	182 J	296 J
Zinc	EPA 6020	mg/kg	434	98.6	109	188	119	231	70.2	71.5	86.8	106	93.8	57.8	ND(36.7) UJ	ND(68.3) UJ	ND(68.7) UJ	114 J	142 J
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	194,000	169,000	50,200	43,300	95,300	157,000	220,000	91,900	29,900	73,000	81,300	171,000	284,000	192,000	235,000	63,300
Acid Volatile Sulfide	Titration	umol/g	-	830	0.747	255	3.27	7.8	1550	1200	ND(0.0259)	166	288	ND(0.0201)	ND(0.0367)	ND(0.0683)	ND(0.0687)	ND(0.0513)	ND(0.0248)
Simultaneously Extracted Metals	Summation	umol/g	-	1.86	2.58	2.22	2.57	1.52	1.63	1.96	2	1.43	2.39	1.77	1.7	0.962	3.08	4.47	2.88

TABLE 4.2-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LONG SHOT STREAMS

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
- sample not analyzed for this parameter
mg/kg milligrams per kilogram
umol/g micromoles per gram
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations
Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

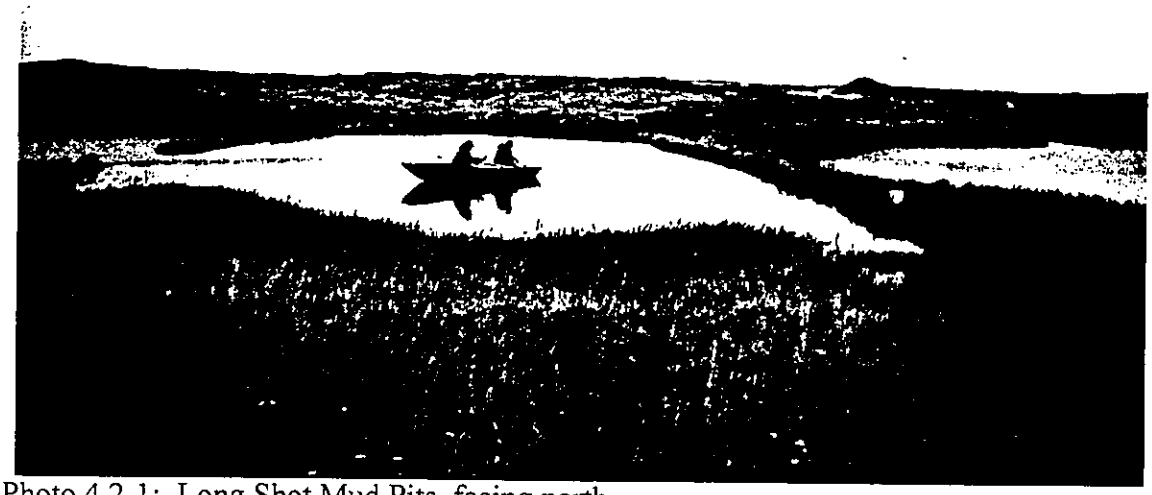


Photo 4.2-1: Long Shot Mud Pits, facing north.

Photo 4.2-2: Station 1 of Bridge Creek. The stream has a peat bottom and numerous rooted macrophytes including mare's tails and sedges.

Photo 4.2-3: Reach 2 of Bridge Creek, facing upstream and south. The stream channel is mostly hidden and can be identified at a distance by the change in vegetation type.

Photo 4.2-4: Rainbow Creek, facing upstream and southwest, towards Station 4. Downstream the channel becomes more incised.

Photo 4.2-5: Fish sampling at Station 1 of Cloudberry Creek. The pool shown is over 5 feet deep. The view is upstream, to the southwest.

Photo 4.2-6: The view from Station 2 of Cloudberry Creek, facing upstream towards Infantry Road.

4.3 CANNIKIN

4.3.1 Site Description

The Cannikin test site is located north of Infantry Road in the vicinity of Mile 10.5 (Figure 1-2). The AEC developed this site for the third and final underground nuclear test on Amchitka. During the test on November 6, 1971, a 5-megaton nuclear device was detonated in a 5,875-foot-deep emplacement hole. The diameter of the emplacement hole varied between 54 and 94 inches. Six smaller-diameter instrument and exploratory holes were also drilled at the site between May 1967 and July 1969. Following detonation, the location of SGZ was marked with a concrete and brass monument. Features of the Cannikin site are shown in Figure 4.3-1.

The site originally contained six drilling mud pits, which are shown in Figure 4.3-1. When the DOE visited the site in 1997, only one of the mud pits was observed, a short distance west of the SGZ monument. The remaining mud pits were thought to have been backfilled. The mud pit observed by the DOE was found and investigated during the 1998 Drill Site Investigation. In addition, two disturbed areas were observed near SGZ that appeared to be possible former mud pits that had not been backfilled. One of these areas corresponds to the location of a former mud pit as interpreted from Sheet 19 of the *Amchitka Island Map Atlas* (Holmes & Narver, 1968). The second disturbed area does not correspond to a known former mud pit location.

The Cannikin vicinity, including streams that drain the area, is shown in Figure 4.3-2. White Alice Creek drains the site to the north, and a small, ephemeral stream drains part of the site to the south. Both of these drainages feed into Cannikin Lake, which formed in the depression created by subsidence in the blast chimney following the Cannikin detonation. Cannikin Lake has submerged the former south fork of White Alice Creek.

The USFWS Database entry for the Cannikin site states that USFWS personnel observed an apparent landfill southwest of Cannikin Lake. No documentation has been found in available DOE records to indicate the AEC created a landfill in the Cannikin vicinity. To evaluate this potential landfill, reconnaissance was performed in 1998 in the immediate Cannikin vicinity, as well as to the southwest where the landfill had been reported. No landfills were apparent during the reconnaissance. Since the on-site USFWS representative, Ms. Sonce deVries, expressed concern that landfilling in the vicinity of the Cannikin mud pits could have impacted Cannikin Lake, an agreement was reached between Ms. deVries and the DOE project manager, Mr. Frank Maxwell, to add collection of surface water and sediment samples from Cannikin Lake to the scope of work in order to investigate possible impacts. The samples were collected in shallow water near the Cannikin Site (Figure 4.3-2).

During reconnaissance for the possible landfill, two additional mud pits were observed near an exploratory hole located southeast of the Cannikin Site (hole number UA-1-P-1). Sampling of these mud pits was added to the scope of work for the 1998 Drill Site Investigation. The locations of the exploratory hole and mud pits relative to the Cannikin site are shown in Figure 4.3-2. The mud pits are shown in detail in Figure 4.3-3.

Cannikin was the only test site where a post-shot reentry hole was drilled. The post-shot hole is located southeast of the Cannikin SGZ, on the east side of the south fork of White Alice Creek (Figure 4.3-2). The hole location is marked by a section of steel casing extending up from a large steel mud pan (Photo 4.3-1). DOE records indicate that drilling mud used for the post-shot drilling was mixed at Drill Site D and pumped through a pipeline from Site D to the post-shot location. The mud used in drilling the post-shot hole was reportedly left in the hole when it was sealed. No drilling mud or mud pits were observed in the immediate vicinity of the post-shot hole.

4.3.2 Site History

Historical information for this study states that both the north and south forks of White Alice Creek were significantly impacted by drilling mud spills. The following excerpts regarding spills and releases at the Cannikin site were extracted from Chapter 14 of the document *The Environment of Amchitka Island, Alaska* (Valdez et. al., 1977).

> "Similar, but more frequent, contamination of White Alice Creek, near the Cannikin site, occurred from summer 1968 until just before the Cannikin event of November 1971. These spills were a result of normal drilling operations, not event-induced ground motion.
>
> Both branches of White Alice Creek, one northwest and the other southeast of the Cannikin site, were contaminated with frequent small spills. Larger spills in 1970 reduced both macroinvertebrate and fish populations to near zero downstream from sites of contamination. Although the populations of both fish and macroinvertebrates were completely eliminated by the spills, recovery was initiated by immigrants from unaffected areas.
>
> An inspection in June 1970 revealed that the bottom of White Alice Creek was covered with caked and peeling mud and silt, and the odor of oil was very apparent. Large sheets of old and used plastic were strewn along the stream and its banks. Two live fish were observed during an inspection of the entire length of the stream, but no fish were captured by electrofishing in selected areas. No live macroinvertebrates were found.
>
> In mid-July 1970 there was evidence of spills of supernatant liquid from five locations at site C. At least four of the five locations were intentional releases since two originated

from drain pipes installed in sump walls and two others from trenches cut through these walls. One source was flowing about 0.0056 m^3/sec (0.2 ft^3/sec) during the time of inspection. Since the mean flow of White Alice Creek was 0.054 m^3/sec (1.92 ft^3/sec), the flow in one branch adjacent to the drill site was less than half this amount, or less than 0.027 m^3 sec. This resulted in a contamination concentration of about 21%, a concentration demonstrated to be lethal to both Dolly Varden and threespine sticklebacks by use of bioassays. All fish downstream from the spill point were likely killed as a result of the toxic liquid. Evidence indicated that spills of similar or larger magnitude also occurred in the southeast branch of White Alice Creek."

4.3.3 Characterization Activities

Initial investigation activities at the Cannikin site consisted of brief reconnaissance of the drill site to verify site features, and reconnaissance and sampling at the western mud pit. Surface water and sediment samples were collected from three locations in the mud pit. In addition, discretionary investigation and sampling were conducted at the two exploratory hole mud pits southeast of the Cannikin site. Sediment and surface water samples were collected from two locations in each of these mud pits. The two disturbed areas near Cannikin SGZ that appear to be former mud pits were measured and photographed but not sampled. All mud pit samples were collected from representative locations that were spaced evenly throughout each mud pit. Mud pit sample locations are shown in Figures 4.3-1 and 4.3-3.

Surface water and sediment samples were collected from three locations in Cannikin Lake that appeared likely to receive drainage from the Cannikin site. The samples were collected in shallow water from 20 to 40 feet offshore (Figure 4.3-2), in order to evaluate the potential for releases from the Cannikin site upslope to the west of Cannikin Lake.

Detailed reconnaissance of White Alice Creek was performed at both its upper reaches near SGZ and its lower reaches downstream of Cannikin Lake. The reconnaissance was performed to observe the stream's ecology and select sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along the stream. Bioassay, benthic macroinvertebrates. and fish samples were collected from three of these stations. Stream sampling locations are shown in Figure 4.3-2. The samples collected from the Cannikin northwest mud pit, exploratory hole mud pits, Cannikin Lake, and White Alice Creek were shipped to off-site laboratories for testing. The types of tests performed and their results are discussed in the following sections.

4.3.4 Observations and Analytical Results

4.3.4.1 Mud Pits

The Cannikin mud pit that was part of the initial scope of work is located about 200 feet west of the Cannikin SGZ monument. The mud pit appears to have been constructed by scraping the surface soil off the bedrock surface and forming low berms with the resulting soil. Some sandy gravel fill also appears to have been used. The pit was constructed below grade. At the time of the field work, the water surface elevation in the pit was lower than the surrounding ground surface. No surface water drainage from the pit was observed. A section of pipe that extends beneath the water surface is visible on the east wall of the mud pit. The pipe runs over the berm at an elevation above the water surface. It does not appear to represent a potential drainage path, but may have been a suction inlet pipe when the pit was operational. The mud pit berms appeared to be relatively stable, with no observed areas of significant erosion or collapse.

The mud pit is rectangular with dimensions of approximately 120 by 170 feet. This field measurement differs from the mud pit dimensions of approximately 120 by 300 feet measured in 1969 air photos. It appears that the east end of the mud pit was backfilled during the AEC demobilization. The remaining portion of the mud pit contained water with a surface elevation approximately 2 to 4 feet lower than the tops of the surrounding berms.

The depth of water in the pit ranged from 2.0 to 3.0 feet at the sampling locations. Sediment in the mud pit consisted of cohesive, gray bentonite that contained some sand and gravel-sized particles assumed to be drill cuttings. The bentonite had a slight diesel odor and was 4.2 to 5.2 feet thick. Based on these measurements, an estimated volume of 3,000 cubic yards of drilling mud remaining in the mud pit. This volume estimate is based on the mud exposed in the open pit and does not include mud that might be covered in the backfilled portion of the mud pit. The estimated volume of water in the mud pit (at the time of field work) was 364,000 gallons. The assumptions made and methods used to make these estimates are explained in Section 2.4.3.1.3.

As previously discussed, two low-lying areas were observed at the Cannikin site that appeared to the remnants of former mud pits. The locations of these apparent former mud pits are shown in Figure 4.3-1. Both of the pits contained gray bentonite mixed with sand and gravel. The soil in both pits had a faint to moderate diesel smell. The pit located southwest of Cannikin SGZ is approximately 100 by 100 feet in size. The soil depth of 4.5 to 6 feet in the pit was estimated by probing with a steel rod until refusal was met (assumed to be bedrock). The pit located southeast of Cannikin SGZ is approximately 120 by 200 feet in size, with an apparent soil depth of 8.5 to 10 feet. Drainage of surface water was observed to be very slowly eroding the soil at the surface of the pits and carrying it downslope toward Cannikin Lake.

The two exploratory hole mud pits are located near the top of a low ridge approximately 2,000 feet south of the Cannikin site. The mud pits were constructed in mined-out areas of a former gravel pit to the north of the exploratory hole marker (Photos 4.3-2 and 4.3-3) and appear to be

situated on bedrock. The gravel pit walls surrounding the mud pits are composed of gravelly soils that appeared stable. The south mud pit is located uphill of the north mud pit and is about 5 feet higher in elevation. The water surface elevations in both mud pits are below the surrounding ground surface outside the gravel pit. No surface water was observed draining from the mud pits. No eroded channels were observed in the berms that would suggest the mud pits had overflowed.

The dimensions of the south and north mud pits are approximately 60 by 85 feet and 42 by 78 feet, respectively. The water in the south mud pit was approximately 1 foot deep at the sampling locations, while the water in the north mud pit ranged from 1.1 to 1.5 feet deep. The drilling mud was 1.5 to 3.0 feet thick in the south pit and 1.2 to 1.4 feet in the north pit. Based on these measurements, the estimated volume of drilling mud is 355 cubic yards in the south pit and 133 cubic yards in the north pit. The estimated volume of water (at the time of field work) was 36,000 gallons in the south pit, and 27,000 gallons in the north pit. The assumptions and methods used to make these estimates are explained in Section 2.4.3.1.3.

Descriptions and field screening results for samples collected from the Cannikin mud pits are provided in the following table.

Mud Pit Sample Descriptions, Cannikin Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Northwest (SGZ) Mud Pit	2.7	4.8	1013-SW		Surface Water		
			1016-SD	0-1.5	Gray Bentonite	Slight diesel odor	PID=3
			1017-SD	3.5-4.5	Gray, gravelly Bentonite	Slight diesel odor	PID=2
	3.0	5.2	1014-SW		Surface Water		
			1018-SD	0-1.0	Gray Bentonite	Slight diesel odor	PID=2
			1019-SD	4.0-5.0	Gray, gravelly Bentonite	Slight diesel odor	PID=4
	2.0	4.2	1015-SW		Surface Water		
			1020-SD 1021-SD (dup)	0-1.0	Gray Bentonite	Slight diesel odor	PID=5
			1022-SD	3.0-4.0	Gray, gravelly Bentonite	Slight diesel odor	PID=1
Exploratory Hole South Mud Pit	1.0	1.5	1106-SW 1107-SW (dup)		Surface Water		
	1.0	3.5	1108-SW		Surface Water		
			1109-SD 1110-SD (dup)	0-1.0	Gray, gravelly Bentonite		PID=0

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Exploratory Hole South Mud Pit (cont.)	1.0	3.5	1111-SD	2.0-3.0	Bentonite, Sand, and Gravel mixture	Strong diesel odor and sheen	PID=0
Exploratory Hole North Mud Pit	1.5	1.2	1112-SW		Surface Water		
			1114-SD	0-1.0	Bentonite, Sand, and Gravel mixture	Strong diesel odor and sheen	PID=9
	1.1	1.4	1113-SW		Surface Water		
			1115-SD	0-1.0	Bentonite, Sand, and Gravel mixture	Strong diesel odor and sheen	PID=13

* Sample depth measured from mud surface

4.3.4.1.1 Surface Water

The mud pit surface water samples were analyzed for VOCs, DRO, PAHs, PCBs, and metals. The results of these analyses are summarized in Table 4.3-1. All of the mud pit surface water samples contained DRO at concentrations ranging from 146 to 286 ug/L. The laboratory method blanks associated with these water samples also contained 82.7 and 55.5 ug/L of DRO. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples could have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. However, because the mud pits are known to have contained diesel, these DRO results have been "B"-flagged to indicate the presence of DRO in the method blanks. It is possible that the reported values of DRO are due to some combination of diesel fuel from the drilling mud, laboratory contamination, and/or biogenic hydrocarbons.

Methylene chloride and toluene are the only VOCs detected in mud pit surface waters. Methylene chloride (at concentrations of 2.03 to 12.2 ug/L) is a suspected laboratory contaminant. Toluene was detected only in one sample from the south exploratory hole mud pit at a concentration of 1.06 ug/L. This toluene concentration is far below its ERBSC and also flagged by the laboratory as a suspected laboratory contaminant. No PAHs were detected in the samples.

The Cannikin mud pit water samples contained 14 metals, most at levels well below background concentrations for surface water from lowland streams. Exceptions were arsenic, calcium, nickel, and strontium in the SGZ mud pit, and cobalt and nickel in the south exploratory hole mud pit. There is no background concentration for arsenic; it was detected in one SGZ mud pit sample at 1.57 ug/L, which is well below its ERBSC. Nickel was also not detected in the lowland reference stream samples but was detected in two SGZ mud pit and two south exploratory hole mud pit samples. The maximum concentration of nickel detected in these

the background value by about 10 percent. No ERBSC is available for calcium, which is considered an essential nutrient in most organisms and not likely to result in significant ecological effects. Strontium values were at most 3 percent above background, but well below its ERBSC. In the south exploratory hole mud pit two of the three water samples contained about twice as much cobalt as the lowland background streams, but these concentrations were less than the cobalt ERBSC.

Surface water quality parameters measured in the Cannikin mud pits during the 1998 Drill Site Investigation sampling events are presented in the following table.

Surface Water Parameters for Mud Pits, Cannikin Site

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1013-SW (SGZ pit)	9.1	10.0	11.9	110	0
1014-SW (SGZ pit)	8.7	10.0	13.4	110	10
1015-SW (SGZ pit)	8.5	10.0	12.3	110	10
1106-SW (South EH)	5.6	9.8	9.9	121	0
1108-SW (South EH)	6.2	10.0	12.2	82	0
1112-SW (North EH)	7.4	11.9	11.2	80	0
1113-SW (North EH)	6.12	13.0	10.2	80	0

4.3.4.1.2 Sediment

The mud pit sediment samples were analyzed for DRO, VOCs, PAHs, PCBs, and metals. The results of these analyses are summarized in Table 4.3-2. All of the sediment samples contained DRO. Concentrations in the SGZ mud pit ranged from 66.1 to 14,000 mg/kg, with an average of 5,400 mg/kg. DRO concentrations averaged about 1,700 mg/kg in the south exploratory hole mud pit and 5,500 mg/kg in the north exploratory hole mud pit.

Since the mud was as much as 5 feet thick, two mud samples were analyzed at most sample locations: one from the mud surface and one from the bottom of the mud layer. At two locations in the SGZ mud pit, DRO concentrations in the deeper sample were an order of magnitude higher than the concentration in the shallow sample. At the third sample location this trend was reversed. The south exploratory mud pit had lower DRO concentrations at depth; no deep samples were collected from the north pit, where the mud was only 1.4 feet deep. All of the sediment samples contained bentonite drilling mud; the deeper samples from the SGZ mud pit

contained higher proportions of sand and gravel drill cuttings. Most of the samples from the exploratory hole mud pits were a mixture of bentonite, sand, and gravel, reflecting either a higher concentration of cuttings, or mixing with the gravels that form the berms around the pits.

As many as nine alkylated benzenes were present in the drilling mud samples at total concentrations as high as about 26 mg/kg (an average of 0.05 percent of the DRO concentration). Several samples also contained acetone or carbon disulfide, which are suspected laboratory contaminants, at maximum concentrations of 0.83 and 0.018 mg/kg, respectively. The samples also contained between five and ten PAHs at total concentrations ranging from 0.22 to 35.9 mg/kg (an average of 0.17 percent of the DRO concentration). One mud sample from the north exploratory hole mud pit contained VOC and PAH concentrations (relative to the DRO concentration) that were significantly higher than the other Cannikin mud samples.

Twenty-four metals were detected in the samples from the Cannikin mud pits. Thirteen metals, listed below, exceeded background stream sediment levels for at least one of the twelve samples (including two duplicates). An asterisk indicates metals for which sample concentrations also exceeded project ERBSCs.

Boron	Cadmium*	Calcium	Cerium	Cesium	Chromium*
Copper*	Magnesium	Nickel*	Potassium	Strontium	Thorium
Uranium					

Of the instances where both background and ERBS concentrations were exceeded, there was one sample for cadmium, ten samples for chromium, twelve for copper, and eight for nickel. Other metals listed either did not exceed the ERBSCs or no value was available.

Test results revealed differences in metals concentrations between the SGZ mud pit and the exploratory hole mud pits. For instance, the exploratory mud pits showed higher average concentrations of aluminum, barium, and nickel than the SGZ mud pit. Arsenic, boron, and chromium concentrations were higher in the SGZ mud pit. These differences in chemistry suggest that a different mud composition was used for the two holes.

Following the discovery of low levels of PCBs in sediment from sediments in Cannikin Lake (see Section 4.3.4.3.2), PCBs were analyzed in all Cannikin drilling-mud samples. Although the analyses were performed about 3½ months after the samples were collected, it was felt that PCBs are persistent enough in the environment that analysis of a sediment sample stored at 4°C (a temperature cooler than field conditions on Amchitka) would produce valid, estimated data.

PCBs were found at low levels in two drilling mud samples, both from the mud pit near SGZ. Aroclor 1248 was reported at 0.095 and 0.215 mg/kg, and Aroclor 1260 was reported at 0.27 and 0.31 mg/kg. Total PCB concentrations were 0.40 and 0.49 mg/kg, respectively. Concentrations of both aroclors exceeded sediment ERBSCs (0.023 mg/kg for Aroclor 1248 and 0.005 mg/kg for Aroclor 1260). No PCBs were reported in the other mud pit samples, with reporting limits ranging from 0.05 to 0.455 mg/kg, depending on the solids content of the sample. Solids content

for the mud pit samples ranged from 71 to 11 percent, the latter value corresponding to the highest reporting limit.

4.3.4.2 White Alice Creek

White Alice Creek begins to the west of Cannikin SGZ and flows east-northeast to the Bering Sea (Figure 4.3-2). White Alice Creek is divided into an upper and lower section interrupted by Cannikin Lake. The creek was altered as a result of the nuclear detonation, which caused significant ground subsidence and resulted in the creation of Cannikin Lake. The creek originally had a north and south fork. The south fork is now primarily submerged beneath Cannikin Lake, as is a short (300-foot long) section of the north fork. The 1998 investigation examined the north fork above Cannikin Lake as well as the portion of the stream below Cannikin Lake. The studied portion of the stream is approximately 8,000 feet long with an overall gradient of 2.7 percent. There are at least two waterfalls that pose a barrier to fish, one about 3 feet high on upper White Alice Creek a short distance upstream of Cannikin Lake, and the other a 15-foot-high waterfall about 100 feet upstream of the beach.

Field activities at White Alice Creek included reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). Surface water and sediment samples were collected at each of five sampling stations along the length of the creek. At Stations 2, 3, 4, and 5, benthic macroinvertebrates, sediment samples for bioassays, and fish samples were also collected. An additional fish sample was collected at Station 4 for radionuclide analysis. Samples collected from Cannikin Lake are discussed in Section 4.3.4.3.

The following table lists the sample numbers for each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.3-2.

Sample Numbers and Station Coordinates for White Alice Creek, Cannikin Site

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 28' 10.9"	179° 05' 52.7"	190	4109-SW 4110-SD
2	51° 28' 14.3"	179° 05' 59.7"	170	4107-SW 4108-SD 4132-FS 4133-IN
3	51° 28' 21.7"	179° 06' 24.7"	130	4105-SW 4106-SD 4130-FS 4131-IN

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
4	51° 28' 23.9"	179° 06' 56.8"	109	4103-SW 4104-SD 4127-FS 4128-FS (rad) 4129-IN
5	51° 28' 33.6"	179° 07' 19.2"	70	4101-SW 4102-SD 4125-FS 4126-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.3.4.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, White Alice Creek was divided into five stream reaches (Figure 4.3-2). Reach 1 begins along the main tributary of upper White Alice Creek (the north fork). Upper White Alice Creek is shown in Photo 4.3-4. Three tributaries come together in Reach 1, with the main tributary contributing about 50 percent and the other two roughly 25 percent each to the overall stream discharge. Reach 1 ends shortly downstream of where the third tributary enters. Reach 2 consists of an incised, tightly curving channel in the upper portion of the reach, with Ice Box Lake in the lower portion. Reach 3 begins at the mouth of Ice Box Lake and ends at the mouth of Cannikin Lake. Reach 3 is defined to include Cannikin Lake for convenience; however, no sampling was conducted in this part of the lake in 1998. Reach 4 begins at the mouth of Cannikin Lake and ends shortly upstream of a steep-sided canyon. Reach 5 lies within the incised canyon and flows to the Bering Sea. The following table summarizes reach characteristics for White Alice Creek.

Reach Characteristics for White Alice Creek, Cannikin Site

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,000	2.0	Few bends	Peat
2	1,700	2.3	Many bends	Peat
3	2,000	1.6	Few bends	Peat with sand
4	2,500	1.5	Many bends	Peat with silt
5	800	8.7	Few bends	Sand and gravel Lower reach - bedrock

Reach 1

Reach 1 lies within a broad, relatively flat valley that is about 1,000 feet wide and 30 feet deep (at Station 1). Valley vegetation consists mainly of sedge tundra on the upper slopes and grass with marsh marigolds, fern, and sedges along the stream banks. The stream consists of multiple, braided channels, each about 6 to 12 inches wide by 3 to 6 inches deep. These channels are incised and vertical to undercut. The banks are generally low (4 to 8 inches). The stream bottom consists of firm peat. Station 1 is located about 200 feet upstream of the boundary between Reaches 1 and 2. Photo 4.3-5 shows the terrain and multiple channels at Station 1 (Ice Box Lake is visible in the background).

Reach 2

Reach 2 of White Alice Creek is a narrower (300-foot wide) reach of the valley with numerous ground subsidence features such as scarps and slumps. The stream channel averages 2 feet wide by 1 foot deep and has numerous tight meanders and 8- to 24-inch drops with associated pools. The stream bottom consists of soft peat with some sand and gravel superimposed. In-stream vegetation consisting of moss and grass covers about 30 percent of the bottom. Ice Box Lake is included within Reach 2. The lake is approximately 500 feet long by 250 feet wide. Its depth is unknown but probably less than 10 feet. Station 2 is located 400 feet upstream of Ice Box Lake.

Reach 3

Reach 3 begins at the outfall of Ice Box Lake. As with Reach 2, there are numerous ground subsidence features such as blocks of peat that are slumping into the stream. The valley continues to be relatively narrow (about 200 feet wide). The channel is incised up to 10 feet through peat banks but averaging about 4 feet deep. The stream itself ranges from 6 to 12 inches deep and 2 to 3 feet wide. There are numerous 12-inch waterfalls along the reach and one 3-foot-high waterfall about 50 feet upstream of Cannikin Lake. The stream bottom is comprised of firm silty peat with some sand and gravel superimposed. Station 3 is located about halfway between Ice Box and Cannikin Lakes.

Reach 4

Reach 4 begins at the outfall of Cannikin Lake and continues for about 2,500 feet downstream. The upper portion of this reach is characterized by abundant amphipods and Dolly Varden and favorable habitat for both. The stream is 1 to 3 feet wide and 2 to 6 feet deep. In the deeper areas the channel bottom is hard mud; in shallow, depositional areas the bottom is gravelly sand. The upper portion of this reach lies within a broad valley, while the lower portion flows through a narrow valley and has a steeper gradient. There are active landslides on both sides of the valley in the lower reach; the toe of these slides is continuously eroded by White Alice Creek. Station 4 is located about 500 feet downstream of Cannikin Lake. A tributary from a small lake enters this reach shortly upstream of Station 4 and contributes about 10 percent to the overall discharge.

Reach 5

Reach 5 is about 800 feet long with an overall gradient of 8.7 percent. This reach is characterized by higher velocities and numerous runs and chutes. Upper Reach 5 is shown in

Photo 4.3-6. The channel bottom consists of sand, gravel, and cobbles, with bare bedrock along the lower portion of the reach. The channel, including pools, is 2 to 8 feet wide and 1 to 6 feet deep. There are scarps along the valley slopes. A 15-foot-high, near-vertical waterfall lies about 100 feet upstream of the high tide zone along the beach. This prevents anadromous fish from migrating upstream. Station 5 is located about 350 feet upstream of the beach in a large pool just upstream of a sheet metal weir and a small foot bridge.

4.3.4.2.2 Surface Water

Five surface water samples were collected from White Alice Creek, one at each sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.3-3.

DRO was reported in all five surface water samples at concentrations of 65.6 to 95.3 ug/L. These concentrations are comparable to the 92 ug/L average DRO detected in about half the samples from lowland reference streams, so some portion of the reported DRO may be of biogenic origin.

The only VOC detected in the surface water samples was methylene chloride, which was reported in four samples at concentrations of 5.14 to 5.59 ug/L. This substance is a common laboratory contaminant, and these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

Fourteen metals were detected in the surface water samples from White Alice Creek. The concentrations of these metals were compared to background concentrations for lowland reference streams. The following five metals exceeded their respective background concentration at one or more stations. The asterisk denotes metals which also exceeded the ERBSC.

Arsenic* Boron* Calcium Selenium Vanadium

All of the background exceedances were in samples from Stations 4 and 5 downstream of Cannikin Lake, with the exception of calcium, which was also slightly elevated at Stations 1 and 2. Boron was detected at concentrations of 424 and 386 ug/L and arsenic at concentrations of 4.78 and 6.24 ug/L, while the background concentrations for these metals were nondetect at detection limits of 50 ug/L and 1 ug/L, respectively. The vanadium concentration at Stations 4 and 5 was only slightly greater than the background concentration (4.94 compared with 4.43 ug/L). Calcium concentrations were as much as 28 percent higher than background. The 1.1 ug/L of selenium detected at Station 4 was the only occurrence of this metal in water from any site-related stream, and none was detected in background samples with a detection limit of 1 ug/L.

Metals that exceeded background values in White Alice Creek surface water were compared with metals that exceeded background values in sediment (see Section 4.3.4.2.3). Arsenic and calcium concentrations exceeded both sediment and water background concentrations. Boron was not detected in sediment samples; however, the sediment detection limits were somewhat elevated. Selenium and vanadium were present in sediment but at concentrations below background.

Those metals found in White Alice Creek water samples that exceeded background concentrations were compared to project ERBSCs. The ERBSC for boron (1.6 ug/L) is exceeded over 200 times by the maximum White Alice Creek water sample. The lowest ERBSC for arsenic in water is 3.1 ug/L. The maximum exceedance for arsenic, at Station 4, was about twice this. The maximum selenium, and vanadium concentrations did not exceed their ERBSCs. No ERBSC is available for calcium, which is considered an essential nutrient and unlikely to result in any toxic effects.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented below. The conductivity measured at Stations 4 and 5, which are downstream of Cannikin Lake, are considerably higher than at other stations on this or any other stream investigated in 1998. Cannikin Lake water had equally high conductivities (Section 4.3.4.3.1).

Surface Water Parameters for White Alice Creek, Cannikin Site

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	7.5	7.7	13.1	179	Clear
2	7.6	7.3	13.1	175	Clear
3	8.1	9.9	11.8	125	Clear
4	8.1	10.1	11.1	618	Clear
5	8.7	9.9	10.9	592	Clear

4.3.4.2.3 Sediment

One sediment sample was collected at each of five stations on White Alice Creek. All sediment samples were analyzed for DRO, PAHs, PCBs, TOC, AVS/SEM, and metals. Only one sediment sample (from Station 2) was analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.3-4.

DRO was detected in all five samples, at concentrations ranging from 32.6 to 116 mg/kg. These DRO concentrations are greater than those found in sediment samples from lowland reference streams (as discussed in Section 2.3.2.5). However, as explained in Section 2.3.2.6, concentrations of DRO as high as 184 mg/kg were found in Corps background sediment samples during the Phase I RI. Thus, it is possible that some portion of the DRO reported in the sediment

samples from White Alice Creek is from biogenic sources. No VOCs were detected in the one sediment sample analyzed for these parameters. No PAHs were detected in the White Alice Creek sediment samples.

Analysis of the sediment samples for PCBs was not part of the original scope of work. Following the discovery of low levels of PCBs in sediment from the bottom of Cannikin Lake (see Section 4.3.4.3.2), PCBs were analyzed in all five sediment samples from White Alice Creek. No PCBs were detected, although detection ranged from 0.19 to 0.59 mg/kg due to solids contents as low as 9 percent.

A total of 19 metals were detected in the various White Alice Creek sediment samples. Concentrations of these metals were compared to background concentrations for lowland reference streams. The following ten metals exceeded background concentrations (an asterisk indicates that ERBSCs were also exceeded).

Aluminum	Arsenic*	Calcium	Cerium
Chromium*	Copper*	Magnesium	Nickel*
Potassium	Strontium		

With two exceptions, the background exceedances occurred at Stations 3, 4, and 5.

The four metals that exceeded background levels by the highest percentages were chromium, copper, magnesium, potassium, and strontium. Chromium and copper concentrations exceeded the background concentration at three stations by up to 2.3 times. Arsenic exceeded background levels only slightly at one station (100 vs. 109 mg/kg).

Metals that exceeded background concentrations in White Alice Creek sediment samples were then compared to project ERBSCs. Arsenic, chromium, copper, and nickel exceeded both their respective background concentrations and ERBSCs. Although the background concentration for arsenic in lowland streams is 100 mg/kg, the ERBSC for arsenic is only 6 mg/kg. Only one sample exceeded background for arsenic; however, four samples exceeded the arsenic ERBSC. Similarly, the copper ERBSC is 16 mg/kg, while the background concentration is 71.7 mg/kg. All five samples exceed the ERBSC for copper, but only three exceed background. The ERBSC for nickel is close to the background value; the same three samples exceeded both the nickel ERBSC and background concentrations. All of the samples exceeded the background value for chromium, but only one sample (Station 1) exceeded the ERBSC. Background values for iron, manganese, and zinc were not exceeded; however, the ERBSCs for these metals are less than background concentrations, and the ERBSCs were generally exceeded at Stations 2, 3, 4, and 5. No ERBSCs are available for the other metals exceeding background.

AVS and SEM concentrations in sediment samples from White Alice Creek are presented in the following table. The ratios of SEM to AVS were 0.21 and 0.02 at Stations 3 and 4, respectively. No AVS was detected at the other three stations. This suggests that there are sufficient acid

volatile sulfides present to limit the availability of the SEM metals to organisms at Stations 3 and 4.

AVS and SEM Concentrations for White Alice Creek, Cannikin Site

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4110-SD	0	2.8	NA
2	4108-SD	0	18.5	NA
3	4106-SD	13.4	2.81	0.21
4	4104-SD	123	2.51	0.02
5	4102-SD	0	3.11	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations. Organic content was also determined for all samples. No grain-size gradation was performed due to insufficient mineral soil content. The results are presented in the following table.

Sediment Characteristics for White Alice Creek, Cannikin Site

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4110-SD	158,000	-	Brown PEAT
2	4108-SD	70,000	28.8	Brown, silty fine SAND with organics
3	4106-SD	8,250	31.1	Brown, fine sandy SILT with organics
4	4104-SD	126,000	41.9	Brown, silty PEAT
5	4102-SD	113,000	32.1	Brown, silty PEAT

DOE collected analytical samples along White Alice Creek in 1993 and 1997 (Appendix B and Figure 4.3-2). In 1993 two surface water samples were collected from upper White Alice Creek that were close to sampling stations in 1998. Specifically, the locations of SW-IB and SW-WAC were near Stations 2 and 3 (upstream of Cannikin lake), so the results were compared. Metals concentrations in the surface water samples from 1993 and 1998 were similar without exception. It was reported that toluene was detected at an estimated 2 ug/L in SW-WAC.

In 1997 three sediment samples were collected on lower White Alice Creek near locations sampled in 1998. Specifically, the sediment sample CN-2A was collected near Station 4, and samples CN-3C and CN-4A were collected at the stream mouth, downstream of Station 5. The DOE results for metals were similar to the 1998 results at these sites, with two exceptions:

copper concentrations were generally twice as high in 1998, while manganese concentrations were lower in 1998 than 1997.

4.3.4.2.4 Benthos

Benthic samples were collected at Stations 2, 3, 4, and 5 on White Alice Creek. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. An evaluation of the data is presented in the report *Triad Analysis of Drill Site and Test Stream Sediments* (see Appendix F).

Benthic Invertebrates in White Alice Creek, Cannikin Site

Class	Order	Family	Common Name	Life Stage	Individuals per Station			
					WA2	WA3	WA4	WA5
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult		80	8	8
Gastropoda	Mesogastropoda	Planorbidae	snail	adult				8
Peleycopoda	Spaeracea	Sphaeriidae	clam	juvenile			36	48
Collembola	Collembola	Isotomidae	springtail	adult	2	8		
Insecta	Ephemeroptera	Baetidae (Pseudocloeon sp.)	mayfly	nymph		8		
	Trichoptera	Limniphilidae	caddisfly	larva	38	24		24
	Lepidoptera		moth	larva		1		8
	Diptera	Chironomidae	midge	larva	138		96	1088
		Diamesinae	midge	larva		48		
		Tanypodinae	midge	larva		248		
		Simulidae	blackfly	larva	2	240	72	112
Crustacea	Amphipoda	Gammaridae	scud	adult			2040	920
				Total	**180**	**657**	**2252**	**2216**
				Family Biotic Index	5.57	6.27	4.23	5.19
				EPT Relative Abundance	21.1%	4.9%	0.0%	1.1%
				Species Diversity	0.63	1.41	0.42	1.04

4.3.4.2.5 Sediment Toxicity Tests

Sediment samples collected from the same four stations as the benthic invertebrate samples were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. An evaluation of the following data is provided in the report *Triad Analysis of Drill Site and Test Site Stream Sediments* prepared by IT Corporation (see Appendix F).

Sediment Toxicity Results, White Alice Creek, Cannikin Site

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
2	92.50%	104.23%	0.567	112.50%	5.21	116.30%
3	77.50%	81.58%	0.345	66.10%	2.60	52.70%
4	32.50%	36.60%	0.606	120.20%	1.97	44.00%
5	87.50%	98.59%	0.499	99.00%	4.24	94.60%

4.3.4.2.6 Fish

Fish samples were collected at Stations 2, 3, 4, and 5 on White Alice Creek. An additional sample was collected at Station 4 for radionuclide analyses. Fish in White Alice Creek are resident Dolly Varden, landlocked by a 15-foot waterfall near the mouth. It has been documented that the larger anadromous Dolly Varden were introduced into Cannikin Lake in the past. In general, the fish sampled from White Alice Creek were larger than fish in other streams, due to the influence of the lake. Specific data on fish sampling, such as the size and weight of individual fish, are presented in the field fish collection forms in Appendix J.

Fish Sample Descriptions for White Alice Creek, Cannikin Site

Station	Sample Number	Length (inches)	Number of fish	Total Sample Weight (grams)	Average Weight per Fish (grams)	Electroshock Time (seconds)
2	4132-FS	1 - 10.5	4	350	87.5	235
2 (dup)	4148-FS	3 - 11	12	450	37.5	229
3	4130-FS	2 - 8	18	350	19.4	986
4	4127-FS	3 - 9	5	350	70.0	371
4 (rad)	4128-FS	15 - 16	3	2150	716.7	709
5	4125-FS	2 - 9	8	500	62.5	29

Fish tissue samples from White Alice Creek were analyzed for total metals, inorganic arsenic, PAHs, PCBs, percent lipids, and radionuclides. Analytical results are presented in Table 4.3-5 and summarized in the following subsections.

4.3.4.2.6.1 Chemicals

Twenty-one metals were detected in the fish tissue samples from White Alice Creek. Concentrations were compared to background concentrations determined for fish from lowland reference streams and to EPA Region III RBCs for fish consumption. Arsenic and copper in the

fish sample from Station 5 exceeded the background concentrations by about 6 and 9 percent, respectively. No total metals concentrations in fish from White Alice Creek exceeded their respective RBCs, with the exception of inorganic arsenic.

Only the inorganic arsenic concentration for the fish sample from Station 5 exceeded its background concentration; however, inorganic arsenic concentrations exceeded the RBC for all samples (including background samples), with the exception of the original sample from Station 2. Inorganic arsenic concentrations for fish from Stations 2, 3, and 4 were 16 to 67 percent of the background concentration.

The PCB Aroclor 1260 was detected in samples from all four stations, including the duplicate sample. Aroclor 1260 concentrations ranged from 0.0115 to 0.0394 mg/kg, exceeding the 0.0016 mg/kg RBC for fish consumption by humans. No PAHs were detected in the fish tissue from White Alice Creek.

The percentage of lipids by weight of fish from Station 5 was 5.67.

4.3.4.2.6.2 Radionuclides

During fish sampling at Station 4 of White Alice Creek numerous landlocked Dolly Varden were observed of the size range found in Cannikin Lake, which is located just upstream. There were sufficient fish present to obtain a sample for radionuclide testing (see previous table for sample description). The fish were frozen and shipped whole to the laboratory. The fish were gutted At the laboratory. Fish and removed guts were analyzed separately. The test results are shown in the following table.

Radionuclide Concentrations in Fish from Station 4 of White Alice Creek, Cannikin Site

Isotope	Gutted Fish			Fish Guts		
	Flag	Result (pCi/g)	Detection Limit	Flag	Result (pCi/g)	Detection Limit
Americium-241	U	-0.000487 ±0.00472	0.0238	U	0.000645 ±0.00129	0.00435
Plutonium-238	U	-0.00453 ±0.00379	0.0270	U	-0.000402 ±0.000807	0.00884
Plutonium-239/240	U	0.00477 ±0.00917	0.0195	U	0.00127 ±0.00345	0.00882
Cesium-137		0.130 ±0.0352	0.0325	J	0.0999 ±0.0825	0.0486

U = analyte was not detected at a concentration greater than the detection limit.
J = analyte was present at a concentration greater than the detection limit but less than the reporting limit (0.100 pC1/g).

These results are similar to the analytical results obtained for Cannikin Lake fish, as expected. Based on the stream setting and fish size, it is apparent that fish travel readily between the lake and the stream. The first three listed isotopes were below the detection limit in these and

background fish samples. For cesium-137 the results from White Alice Creek fish were slightly higher but comparable to background values (Section 2.3.3.2).

4.3.4.3 Cannikin Lake

The locations of the three Cannikin Lake surface water and sediment samples are shown in Figure 4.3-2. The samples were collected 20 to 40 feet offshore, downslope from the Cannikin site. The southernmost surface water and sediment sample (sample numbers 1102-SW and 1105-SD) were collected near the outlet of a small ephemeral stream. The water depth at the sampling locations ranged from 3.3 to 7 feet. The surficial lake sediments at the sampling locations consisted of 0.5 feet to 0.8 feet of drilling mud (bentonite) or drilling mud mixed with silty sand. These sediments were underlain by brown peat, which is assumed to represent the former ground surface. As only three locations were sampled, the extent of the drilling mud on the bottom of Cannikin Lake is unknown. Descriptions and field screening results for the Cannikin Lake surface water and sediment samples are provided in the following table.

Surface Water and Sediment Sample Descriptions for Cannikin Lake, Cannikin Site

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Cannikin Lake	3.3	0.5	1100-SW		Surface Water		
			1103-SD	0-1.0	Black, organic, silty Sand	Trace bentonite, brown Peat in lower 0.5 feet	PID=3
	4.5	0.7	1101-SW		Surface Water		
			1104-SD	0 –1.0	Gray, gravelly Bentonite	Strong diesel odor and heavy sheen, brown Peat in lower 0.3 feet	PID=49
	7.0	0.8	1102-SW		Surface Water		
			1105-SD	0-0.8	Gray, sandy, gravelly Bentonite	Moderate diesel odor and sheen, peat in tip of sample	PID=NA

* Sample depth measured from the sediment surface

4.3.4.3.1 Surface Water

The Cannikin Lake surface water samples were analyzed for DRO, GRO, VOCs, PAHs, metals, and PCBs. These samples were analyzed for an expanded list of COPCs at the request of the USFWS field representative due to the nature of the potential contaminant source, which was a suspected landfill (although no evidence of a landfill was found during 1998 reconnaissance activities). Laboratory results are summarized in Table 4.3-6. All three surface water samples

contained DRO at concentrations ranging from 57.8 to 72.2 ug/L. These reported concentrations of DRO are below the 92 ug/L average concentration of DRO reported in water from half of the lowland reference stream samples, as explained in Section 2.3.1.5. Thus it is possible that the DRO reported in the Cannikin Lake surface water is of biogenic origin.

With the exception of one suspected laboratory contaminant (methylene chloride at concentrations of 2.03 to 5.34 ug/L), no VOCs or PAHs were detected. No PCBs were detected in the water samples.

The Cannikin Lake water samples contained 14 metals. The following six metals were present at levels exceeding the background concentrations for lowland streams (an asterisk indicates that ERBSCs were also exceeded).

Arsenic* Boron* Calcium Cobalt Nickel Vanadium.

Arsenic, boron, and nickel were not detected in the lowland reference stream water samples but were detected in one or more lake water samples at concentrations up to 7.53, 468, and 1.2 ug/L, respectively. Occurrences of both arsenic and boron in water samples during the 1998 investigation were limited to these three Cannikin Lake samples, two White Alice Creek samples downstream of Cannikin Lake, and two samples from Clevenger Creek. Concentrations of arsenic and boron are comparable in Cannikin Lake and White Alice Creek, while the Clevenger Creek concentrations are lower. The single occurrence of nickel at 1.2 ug/L in Cannikin Lake is one of many occurrences at or near the 1 ug/L detection limit in the 1998 samples. Nickel did not exceed its lowest project ERBSC. The boron detections, ranging from 429 to 468 ug/L, greatly exceeded the lowest ERBSC (1.6 ug/L based on the EPA Tier II secondary chronic value) but are well below the human health RBC of 3,300 ug/L (Table 2-8). Arsenic exceeded its lowest ERBSC in each sample by a slight amount.

Calcium, cobalt, and vanadium concentrations in Cannikin Lake water exceeded their respective background values by about 20 to 40 percent. Neither cobalt nor vanadium exceeded their respective ERBSCs. No ERBSC is available for calcium, which is considered an essential nutrient in most organisms and not likely to result in significant ecological effects.

Surface water quality parameters measured in Cannikin Lake during the 1998 Drill Site Investigation are presented below. The conductivity results are significantly higher than those found in surface water from other streams and lakes on Amchitka, except for lower White Alice Creek, which had comparable readings. In general, higher conductivity correlates with higher total dissolved solids or salts.

Surface Water Parameters for Cannikin Lake, Cannikin Site

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1100-SW	7.7	11.1	11.7	570	0
1101-SW	8.1	11.3	10.7	562	0
1102-SW	6.6	11.3	10.7	561	0

DOE collected two water samples from Cannikin Lake (one from the north end and one from the south end) in 1993 and analyzed them for metals. Concentrations were similar to those in the 1998 samples with the exception of calcium, magnesium, vanadium, and zinc. Calcium was present at about a 30 percent greater concentration in the 1993 samples, magnesium was about 50 percent greater, and vanadium was about 60 percent greater. Zinc was detected at 16 and 32 ug/L in 1993 but not detected in 1998 (with a 10 ug/L detection limit).

4.3.4.3.2 Sediment

The Cannikin Lake sediment samples were tested for DRO, GRO, VOCs, PAHs, metals, and PCBs. The results of these analyses are summarized in Table 4.3-7. All three sediment samples contained DRO at concentrations of 110, 2,240, and 4,710 mg/kg. The two samples with the higher DRO concentrations consisted primarily of bentonite drilling mud and exhibited a diesel odor and sheen upon disturbance. GRO was reported in one sample at 25.9 mg/kg, but this low concentration probably represents the light end of the diesel range that overlaps the gasoline range and is reported as GRO.

Five and eight alkylated benzenes, respectively, were present in the two sediment samples that consisted primarily of drilling mud. Total alkylated benzene concentrations were as high as about 9.3 mg/kg (which was 0.2 percent of the DRO concentration). The two samples consisting of drilling mud also contained seven PAHs at a maximum total of 21.2 mg/kg (an average of 0.5 percent of the DRO concentration). This drilling mud contained lower DRO concentrations than the mud from the Cannikin mud pits, with the exception of the mud from the south exploration hole mud pit, which had a comparable DRO concentration. Average VOC concentrations in the mud in Cannikin Lake were higher and PAH concentrations lower (relative to the DRO concentration) than they were in the mud from the Cannikin mud pits.

VOC and PAH concentrations in the Cannikin Lake sediment samples were compared with available ERBSCs. ERBSCs are available for only two of the detected alkylated benzenes, ethylbenzene and xylenes. These were exceeded by a factor of 2 and 50, respectively. PAH ERBSCs that were exceeded by a significant amount included: acenaphthene (6 times), fluorene (26 times), naphthalene (23 times), and phenanthrene (36 times).

PCBs were present at low levels in the two Cannikin Lake sediment samples that consisted primarily of drilling mud. The sample with the highest DRO concentration contained 0.107

mg/kg of Aroclor 1260. The sample with the lower DRO concentration contained 0.104 mg/kg of Aroclor 1260 and 0.185 mg/kg of Aroclor 1248. Concentrations of both aroclors exceeded the sediment ERBSCs (0.023 mg/kg for Aroclor 1248 and 0.05 mg/kg for Aroclor 1260). PCBs were not detected in the third lake sediment sample.

The distribution of metals was different between the single sample that was primarily lake bottom sediment and the two samples that contained drilling mud. The following twelve metals were elevated above background concentrations for lowland reference streams in the samples that contained drilling mud (an asterisk indicates that ERBSCs were also exceeded).

Aluminum	Boron	Cadmium*	Calcium
Cerium	Cesium	Chromium*	Copper*
Magnesium	Nickel*	Strontium	Thorium

The concentrations of these metals were compared with their respective ERBSCs. Cadmium and nickel concentrations in the mud-containing sediment only slightly exceeded their ERBSCs; chromium and copper concentrations were about ten times higher than their ERBSCs. No ERBSCs are available for the other metals. Calcium and magnesium are considered essential nutrients in most organisms and not likely to result in significant ecological effects. The approximate 250 mg/kg chromium concentration in these two samples from Cannikin Lake resembles the average 382 mg/kg chromium in the SGZ drilling mud more than it does the 89 mg/kg in the mud pits near the exploratory hole.

Metals that exceeded lowland background values in the third sediment sample (without bentonite) included boron, chromium, magnesium, and nickel. Except for nickel, none of these exceeded available ERBSCs. The nickel concentration (an estimated value) was about five times higher than background and about four times higher than its ERBSC. Nickel was not significantly elevated in the drilling-mud samples, so it does not appear that the mud caused the exceedance in the third sediment sample.

4.3.4.3.3 Fish

Nineteen Dolly Varden were collected from Cannikin Lake for chemical and radionuclide testing. These fish were collected using hook and line rather than by electroshocking. The fish were primarily caught at the southeast end of the lake near an access road that approaches the lake. Fish in the lake were typically larger than stream fish. This may be due to better habitat and food supply than is found in the streams. Descriptions of fish samples are provided in the following table; test results are presented in the following sections.

Fish Sample Descriptions for Cannikin Lake, Cannikin Site

Sample Number	Matrix	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight per Fish (grams)
4146-FS	Whole fish	14	1	500	500
4147-FS (dup)	Whole Fish	7 – 9	2	600	300
5001-FS	Gutted fish	12 - 13.5	7	2,435	399
5002-FS	Innards of 5001			358	
5003-FS	Gutted fish	11 - 16.5	5	2,229	508
5004-FS	Innards of 5003			312	
5005-FS	Gutted fish	13.7 - 16	4	2,171	610
5006-FS	Innards of 5005			271	

4.3.4.3.3.1 Chemicals

One fish sample and a duplicate were collected for chemical analysis. These samples were analyzed for PCBs, PAHs, and metals (excluding inorganic arsenic). Percent lipids were also determined. Results are presented in Table 4.3-5. No PAHs were detected in either the sample or duplicate. Lipids were 7 and 5.75 percent by weight for the original fish sample and duplicate.

Aroclor 1260 was detected in both samples at 0.0248 and 0.019 mg/kg. These values are comparable to PCB results in fish from White Alice Creek. The higher result is about 15 times higher than the RBC of 0.0016 mg/kg.
The following five metals exceeded background concentrations for fish from lowland reference streams, in one or both of the samples.

Arsenic* Cadmium Copper Nickel Thallium

Of these, only arsenic exceeded the RBC for fish consumption.

4.3.4.3.3.2 Radionuclides

A total of sixteen Dolly Varden were collected from Cannikin Lake for radionuclide analysis. The fish were gutted in the field, and fish bodies and innards were analyzed separately. The first following table provides sample descriptions, and the second table presents the analytical findings.

As with other project fish samples including background, Cesium-137 was detected in each sample from Cannikin Lake, while the other three radionuclides were below their detection

limits. The cesium-137 values for Cannikin Lake fish were slightly higher than but comparable to background samples (see Section 2.3.3.2).

Radionuclide Concentrations in Fish for Cannikin Lake, Cannikin Site

Isotope	Gutted Fish			Fish Guts		
	Flag	Result (pCi/g)	DL	Flag	Result (pCi/g)	DL
	CANN-5001-FS			CANN-5002-FS		
Americium-241	U	-0.000205 ±0.000832	0.0142	U	0.00276 ±0.00452	0.0258
Plutonium-238	U	0.00 ±0.00	0.00636	U	0.00177 ±0.00719	0.0212
Plutonium-239/240	U	0.00211 ±0.00424	0.00634	U	0.00176 ±0.00717	0.0211
Cesium-137	J	0.0967 ±0.0372	0.0276		0.145 ±0.0696	0.0631
	CANN-5003-FS			CANN-5004-FS		
Americium-241	U	0.00314 ±0.00515	0.0130	U	0.00543 ±0.00986	0.0287
Plutonium-238	U	0.0126 ±0.0161	0.0240	U	0.00542 ±0.0147	0.0376
Plutonium-239/240	U	0.00345 ±0.00936	0.0239	U	-0.00171 ±0.00343	0.0376
Cesium-137		0.133 ±0.0507	0.0479		0.180 ±0.0564	0.0628
	CANN-5005-FS			CANN-5006-FS		
Americium-241	U	0.00421 ±0.00746	0.0200	U	0.00308 ±0.00723	0.0248
Plutonium-238	U	0.00332 ±0.00955	0.0241	U	0.00338 ±0.0128	0.0342
Plutonium-239/240	U	-0.00229 ±0.00268	0.0221	U	-0.00506 ±0.000463	0.0341
Cesium-137		0.154 ±0.0534	0.0447		0.223 ±0.0673	0.0702

DL = detection limit
U = analyte was not detected at a concentration greater than the detection limit.
J = analyte was present at a concentration greater than the detection limit but less than the reporting limit (0.100 pC1/g).

4.3.5 Summary

Reconnaissance of the Cannikin test site identified four mud pits in addition to the open mud pit west of the SGZ that was identified for sampling during the planning stage of this project. Two of these additional mud pits are dry, filled pits located near the SGZ. The other two are located several hundred yards to the south in an old borrow pit, and were apparently used during drilling of a nearby exploratory drill hole. These latter two pits contained ponded water, and have no drainage outlet. The reconnaissance also identified scattered debris from the Cannikin facilities, but no evidence was found of a landfill that had been suspected by U.S. Fish and Wildlife personnel. As a result of these findings, the scope of work for the site was expanded to address potential contamination from the additional sources. Specifically, the additional work included collecting samples from two exploratory drill hole mud pits, and Cannikin Lake sampling for a broad suite of parameters to evaluate the potential for contamination from an unknown source or sources at the Cannikin site. After PCBs were identified in bentonite-rich sediment samples from Cannikin Lake, analysis for PCBs was also added to the scope for all of the mud pit and fish samples.

The three mud pits sampled at the Cannikin site contain an estimated total quantity of 3,490 cubic yards of diesel-contaminated drilling mud. The DRO levels in the drilling mud (66.1 to 14,000 mg/kg) are similar to what was detected in the drilling mud from the majority of the drill sites. Eleven of the twelve reported DRO levels detected in the drilling mud exceed the ADEC cleanup standard for DRO in soil. The surface water in the mud pits is only slightly contaminated with DRO, with detected levels all below the ADEC drinking water standards. Since analytical samples were not collected from the two filled mud pits near Cannikin SGZ, no conclusions can be made regarding the contaminant levels (if any) in those mud pits.

The mud pit immediately west of Cannikin SGZ is located below grade in a relatively level area. Based on the site topography, the drilling mud in the pit appears to be relatively well contained. The risk that the drilling mud could be released, either catastrophically or by gradual erosion, to White Alice Creek sometime in the future appears to be small. The two mud pits near the exploratory drill hole are located at the bottom of a gravel pit and are very well contained. The two dry mud pits near Cannikin SGZ are also located below grade and drilling mud within them is apparently well contained. Although these pits are not as isolated from erosive forces, the erosion and sediment transport that is occurring at their surfaces appears to be minimal and does not appear to pose a significant risk to Cannikin Lake, about 600 feet downslope at its closest approach.

The southwestern margin of Cannikin Lake where the sediment samples were collected locally contains 0.5 to 0.8 feet of drilling mud overlying the former ground surface. A review of 1969 air photos (before the Cannikin detonation) shows clear drainage paths from the drill site (which was under construction at the time) to the south fork of White Alice Creek. The Cannikin Lake sediment samples appear to have been collected from within or near those drainage paths. Therefore, the drilling mud observed on the lake bottom may have originated from releases into the south fork of White Alice Creek, which was subsequently submerged below the lake water. The DRO levels detected in the drilling mud (110 to 4,710 mg/kg) are somewhat lower than was detected in the Cannikin mud pits. The quantity of drilling mud remaining on the lake floor is unknown. DRO levels in surface water and normal sediment from the lake are comparable with background levels.

PAHs and VOCs were present in the mud pit sediment samples and drilling mud from Cannikin Lake, in some cases above ERBSCs. However, they were not detected in any sediment samples from White Alice Creek. Drilling mud that reportedly was spilled into the streams has probably been that flushed by water action to a large extent, while that which was deposited in what is now the lake remains in place.

The PCBs Aroclor 1260 and Aroclor 1248 were detected in two drilling mud samples from the SGZ mud pit. Aroclor 1260 was also detected in the two Cannikin Lake sediment samples that contained drilling mud, and in each of the fish samples collected from the stream and lake. The most likely source of PCBs in these fish appears to be past releases of drilling mud from the SGZ pit into White Alice Creek and what is now Cannikin Lake. The concentrations of Aroclor 1260 in lake and stream fish ranged from 10.4 to 24.8 mg/kg. Although the concentrations detected

decrease with distance downstream, this may be coincidental since fish from Stations 4 and 5 of White Alice Creek are able to migrate to and from the lake.

Boron concentrations were uniformly high (386 to 468 ug/L) in surface water from Cannikin Lake and from downstream of the lake, at Stations 4 and 5 of White Alice Creek. In contrast, neither surface water from upstream of the lake nor mud pit water samples contained detectable levels of boron. Boron was not detected in stream sediment and was slightly above background levels in lake sediment. Although its source is unknown, the elevated boron clearly is associated with the lake. These high values are likely to be related to high conductivity measured in lake water and at downstream stations. For an unknown reason, a higher than normal level of dissolved compounds, including compounds with boron, are present in the lake and downstream waters. No other metals exceeded both background and ERBSCs in surface water from either the mud pits, streams, or lake.

Chromium and copper were elevated in the lake sediment samples that contained drilling mud. Copper was also elevated in sediment downstream of Cannikin Lake.

The Triad Analysis Report (see Appendix F) presents an evaluation of the relative sediment quality with respect to sediment habitat for 22 locations investigated on the lowland streams. Using a system that combines benthic, sediment chemistry, and sediment toxicity rankings, the overall rankings for White Alice Creek are as follows:

White Alice Creek

Station 2	7th
Station 3	8th
Station 4	21st
Station 5	11th

This overall ranking combines benthic, sediment chemistry, and sediment toxicity rankings, with the highest rank (lowest number) representing the best overall sediment habitat. Taken as a whole, the mean chemistry ranking for White Alice Creek is poor, but the benthic and toxicological rankings are average and within the range of the lowland reference streams. The results from Station 2 indicate relatively good sediment quality, whereas Station 3 had poor sediment chemistry but overall sediment quality within the range of the reference streams. The poor ranking of Station 4 reflects a relatively poor ranking in all three Triad components, and was one of only four lowland stream stations that had Triad rankings that were worse than the reference locations. However, these results appear to be anomalous since investigators noted abundant amphipods and favorable fish habitat at this location, better than was seen in most other lowland stream settings. The downstream Station 5 had a very good toxicological ranking and an overall rank within the range of the reference stations.

TABLE 4.3-2
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration[1]	98DOE-CANN-1016-SD	98DOE-CANN-1017-SD	98DOE-CANN-1018-SD	98DOE-CANN-1019-SD	98DOE-CANN-1020-SD	98DOE-CANN-1021-SD (Duplicate)	98DOE-CANN-1022-SD	98DOE-CANN-1109-SD	98DOE-CANN-1110-SD (Duplicate)	98DOE-CANN-1111-SD	98DOE-CANN-1114-SD	98DOE-CANN-1115-SD
			mud pit							S discretionary mud pit			N discretionary mud pit	
		Depth (feet)	0-1.5	3.5-4.5	0-1.5	4-5	0-1	0-1	3-4	0-1	0-1	2-3	0-1	0-1
Petroleum Hydrocarbons														
Diesel Range Hydrocarbons	AK 102	-	2,030	14,000	1,980	11,900	3,330	4,430	66.1	2,940	1,770	273	3,100	7,940
Volatile Organic Compounds														
1,2,4-Trimethylbenzene	EPA 8260B	-	0.354 J	0.113 J	0.305	0.687 J	ND(0.0524) UJ	ND(0.0455) UJ	0.0733 J	ND(0.703)	ND(1.1)	ND(0.125)	0.319	16.7
1,3,5-Trimethylbenzene	EPA 8260B	-	0.0774 J	0.0316 J	0.078	0.185 J	ND(0.0524) UJ	ND(0.0455) UJ	0.0182 J	ND(0.703)	ND(1.1)	ND(0.125)	0.297	4.53
Acetone	EPA 8260B	-	0.318 J	ND(0.0882) UJ	0.833	ND(0.325) UJ	ND(0.381) UJ	ND(0.455) UJ	ND(0.5) UJ	ND(17.6)	ND(27.4)	ND(3.13)	ND(2.75)	ND(18.7)
Carbon disulfide	EPA 8260B	-	ND(0.0455) UJ	0.0182 UJ	ND(0.0664)	0.0136 UJ	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(3.51)	ND(5.49)	ND(0.625)	ND(0.55)	ND(3.74)
Ethylbenzene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0261 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	ND(0.11)	ND(0.749)
Isopropylbenzene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0184 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	ND(0.11)	ND(0.749)
m,p-Xylene	EPA 8260B	-	ND(0.0455) UJ	0.0178 J	ND(0.0664)	0.0141 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(1.41)	ND(2.19)	ND(0.25)	ND(0.22)	ND(1.5)
Methylene chloride	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	ND(0.00575) UJ	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(3.51)	ND(5.49)	ND(0.625)	ND(0.55)	ND(3.74)
n-Butylbenzene	EPA 8260B	-	0.0558 J	ND(0.0147) UJ	0.0691	0.0788 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	0.508	1.39
n-Propylbenzene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0455 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	0.284	1.45
Naphthalene	EPA 8260B	-	ND(0.0455) UJ	0.0101 J	0.187	0.045	ND(0.0524) UJ	0.0582 J	0.0657 J	ND(0.703)	ND(1.1)	ND(0.125)	1.84	5.74
o-Xylene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0585 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	ND(0.11)	ND(0.749)
p-Isopropyltoluene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0592 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	0.299	0.947
sec-Butylbenzene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	ND(0.00575) UJ	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	0.212	0.761
Toluene	EPA 8260B	-	ND(0.0455) UJ	ND(0.0147) UJ	ND(0.0664)	0.0315 J	ND(0.0524) UJ	ND(0.0455) UJ	ND(0.00625) UJ	ND(0.703)	ND(1.1)	ND(0.125)	ND(0.11)	ND(0.749)
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	EPA 8270C	-	0.109	0.0545 J	0.0886	0.0449 J	0.0953	0.154	0.0174	0.277	0.201	0.0854	0.936	3.34
Acenaphthylene	EPA 8270C	-	ND(0.455)	ND(0.588)	ND(0.443)	ND(0.5)	ND(0.238)	ND(0.607)	ND(0.0033)	ND(0.148)	ND(0.128)	0.0258	ND(0.5)	ND(1.94)
Anthracene	EPA 8270C	-	ND(0.03)	0.0433	ND(0.0886)	0.0876 J	ND(0.0953)	ND(0.121)	ND(0.0033)	ND(0.0489)	ND(0.0321)	0.0149	ND(0.2)	ND(0.777)
Benzo(a)anthracene	EPA 8270C	-	ND(0.03)	0.0137	ND(0.0292)	ND(0.0165)	ND(0.0157)	ND(0.02)	ND(0.0033)	ND(0.0489)	ND(0.0212)	ND(0.0033)	ND(0.033)	ND(0.128)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.03)	0.0118	ND(0.0292)	ND(0.0165)	ND(0.0157)	ND(0.02)	ND(0.0033)	ND(0.0489)	ND(0.0212)	ND(0.0033)	ND(0.033)	ND(0.128)
Chrysene	EPA 8270C	-	ND(0.03)	0.0137	ND(0.0292)	ND(0.0165)	ND(0.0157)	ND(0.02)	ND(0.0033)	ND(0.0489)	ND(0.0212)	ND(0.0033)	ND(0.033)	ND(0.128)
Fluoranthene	EPA 8270C	-	0.0788 J	0.0176	0.065 J	0.0238 J	0.0635	0.0101 J	0.00544	ND(0.0489)	0.0257	0.0119	ND(0.033)	0.0116 J
Fluorene	EPA 8270C	-	0.0358 J	0.0447	0.284	0.0354 J	0.0372	0.636	0.0491 J	0.81	0.599	0.0239	2.99	12.6
Naphthalene	EPA 8270C	-	0.0364 J	0.0431 J	ND(0.0292)	0.0224 J	0.0191	ND(0.02)	ND(0.0033)	0.119	0.0214	0.0139	0.0281	0.0518

TABLE 4.3-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Background Concentration	98DOE-CANN-1016-SD	98DOE-CANN-1017-SD	98DOE-CANN-1018-SD	98DOE-CANN-1019-SD	98DOE-CANN-1020-SD	98DOE-CANN-1021-SD (Duplicate)	98DOE-CANN-1022-SD	98DOE-CANN-1100-SD	98DOE-CANN-1110-SD (Duplicate)	98DOE-CANN-1111-SD	98DOE-CANN-1114-SD	98DOE-CANN-1115-SD
			mud pit							S discretionary mud pit			N discretionary mud pit	
		Depth (feet)	0-1.5	3.5-4.5	0-1.5	4.5	0-1	0-1	3-4	0-1	0-1	2-3	0-1	0-1
Phenanthrene	EPA 8270C	-	0.135	0.591	0.143	0.292	0.159	0.242	0.138	0.154	0.104	0.0458	0.0462	0.109
Pyrene	EPA 8270C	-	0.145	0.308	0.142	0.0462	0.146	0.239	0.0098	0.0593	0.0471	0.0219	0.14	0.0821
Polychlorinated Biphenyls														
Aroclor 1248	EPA 8082	-	ND(0.455) UJ	0.215	ND(0.443) UJ	0.0951	ND(0.238) UJ	ND(0.304) UJ	ND(0.05) UJ	ND(0.148)	ND(0.16)	ND(0.05)	ND(0.05) UJ	ND(0.194) UJ
Aroclor 1260	EPA 8082	-	ND(0.455) UJ	0.271	ND(0.443) UJ	0.0808	ND(0.238) UJ	ND(0.304) UJ	ND(0.05) UJ	ND(0.148)	ND(0.16)	ND(0.05)	ND(0.05) UJ	ND(0.194) UJ
Metals														
Aluminum	EPA 6010B	45,400	18,000	32,400	16,200	30,200	20,000	21,500	20,700	33,200	31,800	35,400	40,300	33,500
Arsenic	EPA 6020	5.001	ND(4.55)	4.84	5.92	4.96	6.91	20.2	5.86	2.81	2.67	1.13	0.969	3.06
Barium	EPA 6020	469	124	177	166	115	148	166	92.7	335	305	88.9	100	248
Boron	EPA 6010B	7.18 [b]	ND(22.7) UJ	ND(7.35) UJ	ND(22.1) UJ	**69.2 J**	**46.7 J**	**81.7 J**	**58.9 J**	ND(7.41) UJ	ND(8.02) UJ	2.51 J	3.12 J	ND(9.71) UJ
Cadmium	EPA 6020	0.608 [b]	ND(4.55)	ND(1.47)	ND(4.43)	ND(0.5)	ND(2.38)	ND(3.04)	ND(0.5)	ND(1.48) UJ	1.64 J	ND(0.5) UJ	ND(0.5)	ND(1.94)
Calcium	EPA 6010B	7,300	**44,400**	**43,200**	**36,300**	**35,700**	**102,000**	**133,000**	**18,700**	**23,100**	**17,200**	**11,100**	5,720	**10,500**
Cerium	EPA 6020	14.2	**38.2**	**22.8**	**48.4**	**18.5**	**21.4**	**27.7**	**19.9**	**22.2**	**23.1**	11.5	11.6 J	**35 J**
Cesium	EPA 6020	ND	ND(4.55)	ND(1.47)	ND(4.43)	ND(0.5)	ND(2.38)	ND(3.04)	**0.917**	ND(1.48) UJ	ND(1.6) UJ	ND(0.5) UJ	**0.664**	ND(1.94)
Chromium	EPA 6020	11.8	455 J	236 J	1010 J	148 J	326 J	483 J	**17.9 J**	140 J	158 J	**19.4**	ND(25)	126
Cobalt	EPA 6020	43.7	11.4	17.6	10.2	14	10.5	11.6	11.2	10.9 J	10.7 J	13.7 J	31.9 J	23.1 J
Copper	EPA 6020	74.1	42	149	165	138	149	263	151	113 J	124 J	98.4 J	474	515
Iron	EPA 6010B	55,000	27,600	63,000	12,900	43,800	29,500	24,700	46,300	38,200	35,300	31,000	40,900	40,000
Lithium	EPA 6020	48.8	9.09	15.3	10	10.6	8.22	10	9.07	8.26	8.32	7.02	7.05	10.2
Magnesium	EPA 6010B	9,320	**10,900**	**24,200**	**9,360**	**17,000**	**9,520**	**10,500**	**10,900**	**22,300**	**16,900**	**15,300**	**25,800**	**22,100**
Manganese	EPA 6020	20,700	572 J	864 J	860	806 J	507 J	492 J	586 J	1,270	1,300	1,270	1,060	1,690
Nickel	EPA 6020	13.6	**14.1**	12.4	24.7	10.1	25.5	28.2	4.25	45.5 J	51.2 J	17.7 J	125 J	59.6 J
Potassium	EPA 6010B	1,390	971	1,260	1,080	946	667	667	1,330	**2,410 J**	**2,020 J**	**1,970 J**	**1,780**	**2,130**
Selenium	EPA 6020	5.44 [b]	ND(4.55)	ND(1.47)	ND(4.43)	0.658	ND(2.38)	ND(3.04)	0.531	ND(1.48) UJ	ND(1.6) UJ	ND(0.5) UJ	ND(0.5) UJ	ND(1.94) UJ
Strontium	EPA 6020	164	**198**	**346**	**288**	**270**	**181**	**170**	**236**	**308**	**332**	**184**	117	**165**
Thallium	EPA 6020	1 [b]	ND(4.55)	ND(1.47)	ND(4.43)	ND(0.5)	ND(2.38)	ND(3.04)	ND(0.5)	ND(1.48)	ND(1.6)	ND(0.5)	ND(0.5)	ND(1.94)
Thorium	EPA 6020	0.5 [b]	**12.7 J**	**4.59 J**	**16.8 J**	**2.58 J**	**5.8 J**	**7.62 J**	**1.91 J**	**6.12**	**6.84**	**1.27**	**0.665**	**10.5**
Titanium	EPA 6020	3,010	1,230 J	1,190 J	825 J	1,290 J	905 J	1,160 J	1,330 J	546	815	541	750	591

TABLE 4.3-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Background Concentration[a] / Lowland Stream	98DOE-CANN-1016-SD	98DOE-CANN-1017-SD	98DOE-CANN-1018-SD	98DOE-CANN-1019-SD	98DOE-CANN-1020-SD	98DOE-CANN-1021-SD (Duplicate)	98DOE-CANN-1022-SD	98DOE-CANN-1109-SD	98DOE-CANN-1110-SD (Duplicate)	98DOE-CANN-1111-SD	98DOE-CANN-1114-SD	98DOE-CANN-1115-SD
			mud pit							S discretionary mud pit			N discretionary mud pit	
		Depth (feet)	0-1.5	3.5-15	0-15	4.5	0-1	0-1	3-4	0-1	0-1	2-3	0-1	0-1
Uranium	EPA 6020	4.13 [b]	ND(4.55) UJ	1.68 J	**5.19 J**	1.08 J	2.46 J	3.48 J	0.766 J	2.4	2.5	0.566	ND(0.5)	3.38
Vanadium	EPA 6020	734	66.5	138	36.7	117	69.4	64.6	101	72.1	85.1	84.5	107	66.2
Zinc	EPA 6020	134	120	81.5	166	72	108	159	42.7	57.9	57.1	31.2	43.7	69.8

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
\- sample not analyzed for this parameter
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations
Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.3-3
SURFACE WATER ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration *	98DOE-CANN-4109-SW	98DOE-CANN-4107-SW	98DOE-CANN-4105-SW	98DOE-CANN-4103-SW	98DOE-CANN-4101-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	72.9	66.1	95.3	90.1	65.6
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Acetone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	5.28 U	5.14 U	5.59 U	5.31 U	ND(2)
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Chrysene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)

TABLE 4.3-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-CANN-4109-SW Station 1	98DOE-CANN-4107-SW Station 2	98DOE-CANN-4105-SW Station 3	98DOE-CANN-4103-SW Station 4	98DOE-CANN-4101-SW Station 5
Metals							
Aluminum	EPA 6020	269	ND(50)	74.9	97.4	73.2	80
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	6.42	4.78
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	424	386
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	**4,390**	**4,870**	3,280	**5,550**	**5,490**
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	3.35	1.15	1.39	1.54	1.09	1.27
Copper	EPA 6020	10.8	1.2	1.71	1.43	1.81 J	2.01
Iron	EPA 6010B	993	ND(150)	150	266	190	208
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	2,920	3,090	2,200	1,880	2,010
Manganese	EPA 6020	267	7.3	21.5	10.3	7.81	12.9
Nickel	EPA 6020	ND(1)	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1)	ND(1) UJ
Potassium	EPA 6010B	2,620	494 J	564 J	217 J	546	425 J
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	**1.1**	ND(1)
Strontium	EPA 6020	36.1	33	31.8	22.4	28.8	28.5
Thallium	EPA 6020	7.07 [b]	ND(1)	ND(1)	ND(1)	ND(1) UJ	ND(1)
Thorium	EPA 6020	ND(1)	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ
Titanium	EPA 6020	6.13	1.41 J	2.73 J	2.51 J	2.59 J	2.96 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	ND(1)	1.34	1.16	**4.8**	**4.94**
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

TABLE 4.3-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE
(concentrations in micrograms per liter)

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.3-4
SEDIMENT ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-CANN-4110-SD	98DOE-CANN-4108-SD	98DOE-CANN-4106-SD	98DOE-CANN-4104-SD	98DOE-CANN-4102-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Petroleum Hydrocarbons								
Diesel Range Hydrocarbons	AK 102	mg/kg	-	48.7	36.9	116	32.6	38
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
1,3,5-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Acetone	EPA 8260B	mg/kg	-	-	ND(8.91)	-	-	-
Carbon disulfide	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Ethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Isopropylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
m,p-Xylene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Methylene chloride	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
n-Butylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
n-Propylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Naphthalene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
o-Xylene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
p-Isopropyltoluene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
sec-Butylbenzene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-
Toluene	EPA 8260B	mg/kg	-	-	ND(0.078)	-	-	-

TABLE 4.3-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE

Analyte	Analytical Method	Units	Background Concentration	98DOE-CANN-4110-SD Station 1	98DOE-CANN-4108-SD Station 2	98DOE-CANN-4106-SD Station 3	98DOE-CANN-4104-SD Station 4	98DOE-CANN-4102-SD Station 5
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Acenaphthylene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Anthracene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Benzo(a)anthracene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Benzo(b)fluoranthene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Chrysene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Fluoranthene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Fluorene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Naphthalene	EPA 8270C	mg/kg	-	ND(0.0387) R	ND(0.0221) R	ND(0.0125) R	ND(0.0222) R	ND(0.0217) R
Phenanthrene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Pyrene	EPA 8270C	mg/kg	-	ND(0.0387)	ND(0.0221)	ND(0.0125)	ND(0.0222)	ND(0.0217)
Polychlorinated Biphenyls								
Aroclor 1248	EPA 8082	mg/kg	-	ND(0.586) UJ	ND(0.335) UJ	ND(0.19) UJ	ND(0.336) UJ	ND(0.329) UJ
Aroclor 1260	EPA 8082	mg/kg	-	ND(0.586) UJ	ND(0.335) UJ	ND(0.19) UJ	ND(0.336) UJ	ND(0.329) UJ
Metals								
Aluminum	EPA 6010B	mg/kg	45,400	6,480	41,000	**60,100**	**68,300**	**48,400**
Arsenic	EPA 6020	mg/kg	100	ND(5.86)	48.4	15.4	**109**	57.7

TABLE 4.3-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-CANN-4110-SD Station 1	98DOE-CANN-4108-SD Station 2	98DOE-CANN-4106-SD Station 3	98DOE-CANN-4104-SD Station 4	98DOE-CANN-4102-SD Station 5
Barium	EPA 6020	mg/kg	469	ND(58.6)	377	ND(948)	249	150
Boron	EPA 6010B	mg/kg	7.18 [b]	ND(29.3)	ND(16.8)	ND(9.48)	ND(16.8)	ND(16.5)
Cadmium	EPA 6020	mg/kg	0.608 [b]	ND(5.86)	ND(3.35)	ND(1.9)	ND(3.36)	ND(3.29)
Calcium	EPA 6010B	mg/kg	7,300	5,540	5,960	**7,940**	6,370	**10,800**
Cerium	EPA 6020	mg/kg	14.2	ND(5.86)	13.3	13.5	**20.9**	9
Cesium	EPA 6020	mg/kg	ND	ND(5.86)	ND(3.35)	ND(1.9)	ND(3.36)	ND(3.29)
Chromium	EPA 6020	mg/kg	11.8	**27.5**	**19.3**	**24.4**	**20.1**	**13.1**
Cobalt	EPA 6020	mg/kg	43.7	ND(5.86)	38.2	28.1	16.2	15
Copper	EPA 6020	mg/kg	71.1	28.7	54.8	**74.1**	**127**	**168**
Iron	EPA 6010B	mg/kg	155,000	6,900	96,800	70,600	59,800	67,600
Lithium	EPA 6020	mg/kg	48.8	ND(5.86)	8.86	20.1	22.7	19.2
Magnesium	EPA 6010B	mg/kg	9,320	1,530	9,180	**15,600**	**25,400**	**36,600**
Manganese	EPA 6020	mg/kg	20,700	442	9,390	10,300	1,360	2,570
Nickel	EPA 6020	mg/kg	13.6	6.22	**22.1**	**17.2**	**24.9**	10.4
Potassium	EPA 6010B	mg/kg	1,390	249	527	1,310	791	**3,880**
Selenium	EPA 6020	mg/kg	5.44 [b]	ND(5.86)	4.52	2.21	ND(3.36)	ND(3.29)
Strontium	EPA 6020	mg/kg	164	49.5	106	**531**	94.9	**547**
Thallium	EPA 6020	mg/kg	1 [b]	ND(5.86)	ND(3.35)	ND(1.9)	ND(3.36)	ND(3.29)

TABLE 4.3-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-CANN-4110-SD	98DOE-CANN-4108-SD	98DOE-CANN-4106-SD	98DOE-CANN-4104-SD	98DOE-CANN-4102-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Thorium	EPA 6020	mg/kg	0.5 [b]	ND(5.86)	ND(3.35)	ND(1.9)	ND(3.36)	ND(3.29)
Titanium	EPA 6020	mg/kg	3,010	228	1,140	1,390	2,010	1,860
Uranium	EPA 6020	mg/kg	4.13 [b]	ND(5.86)	ND(3.35)	ND(1.9)	ND(3.36)	ND(3.29)
Vanadium	EPA 6020	mg/kg	734	40.6	645	239	175	210
Zinc	EPA 6020	mg/kg	434	ND(58.6)	248	167	71.4	94
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	158,000	70,000	8,250	126,000	113,000
Acid Volatile Sulfide	Titration	umol/g	-	ND(0.0586)	ND(0.0335)	13.4	123	ND(0.0329)
Simultaneously Extracted Metals	Summation	umol/g	-	2.8	18.5	2.81	2.51	3.11

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

mg/kg milligrams per kilogram

umol/g micromoles per gram

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

R result rejected due to quality control considerations

TABLE 4.3-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR WHITE ALICE CREEK, CANNIKIN SITE

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.3-5
FISH ANALYTICAL RESULTS FOR CANNIKIN SITE

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-CANN-4132-FS	98DOE-CANN-4148-FS (Duplicate)	98DOE-CANN-4130-FS	98DOE-CANN-4127-FS	98DOE-CANN-4125-FS	98DOE-CANN-4146-FS	98DOE-CANN-4147-FS
					White Alice Creek					Cannikin Lake	
					Station 2B	Station 2	Station 3	Station 4	Station 5		
Polycyclic Aromatic Hydrocarbons											
Acenaphthene	SW8270 SIM	mg/kg	81.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0223)	ND(0.0223)
Acenaphthylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0223)	ND(0.0223)
Anthracene	SW8270 SIM	mg/kg	405.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Benzo(a)anthracene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Benzo(a)pyrene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Benzo(b)fluoranthene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Benzo(ghi)perylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Benzo(k)fluoranthene	SW8270 SIM	mg/kg	0.043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Chrysene	SW8270 SIM	mg/kg	0.43	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Dibenzo(a,h)anthracene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Fluoranthene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.446)	ND(0.223)
Fluorene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0223)	ND(0.0223)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)
Naphthalene	SW8270 SIM	mg/kg	27.0	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0223)	ND(0.0223)
Phenanthrene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.446)
Pyrene	SW8270 SIM	mg/kg	40.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.223)	ND(0.223)

TABLE 4.3-5 (cont.)
FISH ANALYTICAL RESULTS FOR CANNIKIN SITE

Analyte	Analytical Method	Unit	EPA Region III RBC Consumption	Low Land Stream Background Concentration	98DOE-CANN-4132-FS	98DOE-CANN-4148-FS (Duplicate)	98DOE-CANN-4130-FS	98DOE-CANN-4127-FS	98DOE-CANN-4125-FS	98DOE-CANN-4146-FS	98DOE-CANN-4147-FS
					White Alice Creek					Cannikin Lake	
					Station 2	Station 2	Station 3	Station 4	Station 5		
Polychlorinated Biphenyls											
Aroclor 1016	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.025) UJ	ND(0.025) UJ
Aroclor 1221	SW8081	mg/kg	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.05) UJ	ND(0.05) UJ
Aroclor 1232	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.025) UJ	ND(0.025) UJ
Aroclor 1242	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.025) UJ	ND(0.025) UJ
Aroclor 1248	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.025) UJ	ND(0.025) UJ
Aroclor 1254	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.025) UJ	ND(0.025) UJ
Aroclor 1260	SW8081	mg/kg	0.0016	-	0.0394 J	0.0215 J	0.0178 J	0.0115 J	0.0116 J	0.0248 J	0.019 J
Metals											
Aluminum	SW6010A/ 6020	mg/kg	1351.9	475	10.6 J	15.9 J	55.5 J	13.8 J	99.3 J	ND(2.50)	66.5
Arsenic (total)	SW6020	mg/kg	0.21	0.127	ND(0.0250) UJ	0.0415 J	0.0593 J	0.088 J	**0.135 J**	0.12	**0.564**
Arsenic (inorganic)	EPA Draft 1632	mg/kg	0.0021	0.0208	ND(0.000158)	0.0033	0.00874	0.0139	**0.0457**	-	-
Barium	SW6020	mg/kg	94.6	1.03	0.053	0.0963	0.135	0.115	0.129	0.1	0.365
Beryllium	SW6020	mg/kg	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0500)	ND(0.0500)
Boron	SW6020	mg/kg	121.7	28.6	10.6 UJ	13.6 UJ	9.08 UJ	37.2 UJ	11.4 UJ	6.6	3.53
Cadmium	SW6020	mg/kg	1.4	0.0373 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	**0.0535**	ND(0.0500)

TABLE 4.3-5 (cont.)
FISH ANALYTICAL RESULTS FOR CANNIKIN SITE

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-CANN-4132-FS	98DOE-CANN-4148-FS (Duplicate)	98DOE-CANN-4130-FS	98DOE-CANN-4127-FS	98DOE-CANN-4125-FS	98DOE-CANN-4146-FS	98DOE-CANN-4147-FS
					White Alice Creek					Cannikin Lake	
					Station 2	Station 2	Station 3	Station 4	Station 5		
Calcium	SW6010A/ 6020	mg/kg	NA	19,200	6,000	5,150	5,730	3,680	3,850	3,080	1,850
Cerium	SW6020	mg/kg	NA	0.0280 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Cesium	SW6020	mg/kg	NA	0.0258 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Chromium	SW6020	mg/kg	4.1	1.03	0.327 J	0.358 J	0.298 J	0.426 J	0.289 J	0.499	0.226
Cobalt	SW6020	mg/kg	81.1	0.0780 [b]	ND(0.0500) UJ	ND(0.0500) UJ	ND(0.0500) UJ	ND(0.0500) UJ	0.0508 J	ND(0.0500)	ND(0.0500)
Copper	SW6020	mg/kg	54.1	1.20 [b]	0.664	0.662	0.912	0.0857 U	**1.31**	**1.22**	**1.86**
Iron	SW6010A/ 6020	mg/kg	405.6	310	17 J	25.5 J	110 J	11.9 J	99.3 J	8.3	104
Lithium	SW6020	mg/kg	27.0	0.0993 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.0368	ND(0.0500)	ND(0.0500)
Magnesium	SW6010A/ 6020	mg/kg	NA	408	305	318	338	260	383	290	295
Manganese	SW6020	mg/kg	189.3	160	2.22	4.82	7.41	2.82	5.67	2	18.2
Molybdenum	SW6020	mg/kg	6.8	0.173 [b]	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(1.00)	ND(1.00)
Nickel	SW6020	mg/kg	27.0	ND	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	**0.117**	**0.21**
Potassium	SW6010A/ 6020	mg/kg	NA	4,780 [b]	3,550	3,630	3,680	3,430	3,350	3,330	3,550
Selenium	SW6020	mg/kg	6.8	0.936	0.569	0.596	0.553	0.446	0.686	0.717	0.72
Strontium	SW6020	mg/kg	811.1	22.1	7.29 J	6.73 J	10.6 J	7.09 J	8.26 J	7.6	5.18

TABLE 4.3-5 (cont.)
FISH ANALYTICAL RESULTS FOR CANNIKIN SITE

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration [a]	98DOE-CANN-4137-FS	98DOE-CANN-4148-FS (Duplicate)	98DOE-CANN-4130-FS	98DOE-CANN-4127-FS	98DOE-CANN-4125-FS	98DOE-CANN-4146-FS	98DOE-CANN-4147-FS
					White Alice Creek					Cannikin Lake	
					Station 2	Station 2	Station 3	Station 4	Station 5		
Thallium	SW6020	mg/kg	0.09	0.0283 [b]	ND(0.0250) UJ	ND(0.0250) UJ	ND(0.0250) UJ	ND(0.0250) UJ	ND(0.0250) UJ	**0.05**	ND(0.0500)
Thorium	SW6020	mg/kg	NA	3.43 [b]	ND(2.50) UJ,B	ND(2.50) UJ,B	ND(2.50) UJ,B	ND(2.50) UJ,B	ND(2.50) UJ,B	ND(0.500)	ND(0.500)
Titanium	SW6020	mg/kg	5407.4	32.1	0.241 J	0.409 J	1.64 J	0.321 J	1.36 J	3.18	5.48
Uranium	SW6020	mg/kg	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	mg/kg	9.5	1.05	0.148	0.242	0.45	0.215	0.545	0.166	0.475
Zinc	SW6020	mg/kg	405.6	48.8	28.1	29.6	24.6	23.9	26.8	22	23.2
% Lipids	Lipids	% by Weight	-	-	-	-	-	-	5.67	7	5.75

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

mg/kg milligrams per kilogram

B analyte detected in method blank

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank or laboratory contamination; result considered nondetect

TABLE 4.3-5 (cont.)
FISH ANALYTICAL RESULTS FOR CANNIKIN SITE

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.

TABLE 4.3-6
SURFACE WATER ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Streams Background Concentration	98DOE-CANN-1100-SW	98DOE-CANN-1101-SW	98DOE-CANN-1102-SW
Diesel Range Hydrocarbons	AK 102	-	72.2	57.8	60.2
Volatile Organic Compounds					
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Acetone	EPA 8260B	-	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	5.34 U	2.03 U	5.16 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Chrysene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Polychlorinated Biphenyls					
Aroclor 1248	EPA 8082	-	ND(0.5)	ND(0.5)	ND(0.5)

TABLE 4.3-6 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration[a]	98DOE-CANN-1100-SW	98DOE-CANN-1101-SW	98DOE-CANN-1102-SW
Aroclor 1260	EPA 8082	-	ND(0.5)	ND(0.5)	ND(0.5)
Metals					
Aluminum	EPA 6020	269	92 J	102 J	77.8 J
Arsenic [c]	EPA 6020	ND(1)	6.81	7.25	7.53
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	429	468	439
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	**5,500**	**5,360**	**5,250**
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	2.25 [b]	2 J	1.91 J	2.05 J
Cobalt	EPA 6020	3.35	**3.46**	ND(1)	**4.81**
Copper	EPA 6020	10.8	2.5 J	1.72 J	1.66 J
Iron	EPA 6010B	993	223	242	222
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	4,690 [b]	1,890	1,890	1,840
Manganese	EPA 6020	267	28.2 J	28.2 J	17.4 J
Nickel	EPA 6020	ND(1)	ND(1)	ND(1)	**1.2**
Potassium	EPA 6010B	2,620	715	773	689
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	29.8	29	28.8
Thallium	EPA 6020	707 [b]	ND(1) UJ	1.27 J	ND(1) UJ
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	3.52 J	4.1 J	2.81 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	**5.31**	**5.3**	**5.04**
Zinc	EPA 6020	50.3 [b]	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

TABLE 4.3-6 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in micrograms per liter)

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.3-7
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-CANN-1103-SD	98DOE-CANN-1104-SD	98DOE-CANN-1105-SD
		Depth (feet)	0-1	0-1	0-0.8
Petroleum Hydrocarbons					
Gasoline Range Hydrocarbons	AK 101/8021B	-	ND(15.5)	ND(5) UJ	25.9 J
Diesel Range Hydrocarbons	AK 102	-	110	4,710	2,240
Volatile Organic Compounds					
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.493)	5.16	0.622
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.493)	1.21	ND(0.15)
Acetone	EPA 8260B	-	ND(12.3)	ND(3.5)	ND(3.75)
Carbon disulfide	EPA 8260B	-	ND(2.47)	ND(0.7)	ND(0.75)
Ethylbenzene	EPA 8260B	-	ND(0.493)	0.186	ND(0.15)
Isopropylbenzene	EPA 8260B	-	ND(0.493)	ND(0.14)	ND(0.15)
m,p-Xylene	EPA 8260B	-	ND(0.986)	0.836	ND(0.3)
Methylene chloride	EPA 8260B	-	ND(2.47)	ND(0.7)	ND(0.75)
n-Butylbenzene	EPA 8260B	-	ND(0.493)	0.495	0.311
n-Propylbenzene	EPA 8260B	-	ND(0.493)	0.369	0.15
Naphthalene	EPA 8260B	-	ND(0.493)	5.53	ND(0.15)
o-Xylene	EPA 8260B	-	ND(0.493)	0.498	ND(0.15)
p-Isopropyltoluene	EPA 8260B	-	ND(0.493)	0.304	0.282
sec-Butylbenzene	EPA 8260B	-	ND(0.493)	0.233	0.202
Toluene	EPA 8260B	-	ND(0.493)	ND(0.14)	ND(0.15)
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	EPA 8270C	-	ND(0.00798)	1.89	0.42
Acenaphthylene	EPA 8270C	-	ND(0.00798)	ND(1)	ND(0.25)
Anthracene	EPA 8270C	-	ND(0.00798)	0.403	0.144
Benzo(a)anthracene	EPA 8270C	-	ND(0.00798)	ND(0.033)	ND(0.0165)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.00798)	ND(0.033)	ND(0.0165)
Chrysene	EPA 8270C	-	ND(0.00798)	ND(0.033)	ND(0.0165)
Fluoranthene	EPA 8270C	-	ND(0.00798)	0.227	0.0591
Fluorene	EPA 8270C	-	ND(0.00798)	4.87	1.31
Naphthalene	EPA 8270C	-	ND(0.00798)	1.4	0.046
Phenanthrene	EPA 8270C	-	ND(0.00798)	12.1	4.35

TABLE 4.3-7 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Lowland Stream Background Concentration[a]	98DOE-CANN-1103-SD	98DOE-CANN-1104-SD	98DOE-CANN-1105-SD
		Depth (feet)	0-1	0-1	0-0.8
Pyrene	EPA 8270C	-	ND(0.00798)	0.34	0.151
Polychlorinated Biphenyls					
Aroclor 1248	EPA 8082	-	ND(0.121)	ND(0.05)	0.185
Aroclor 1260	EPA 8082	-	ND(0.121)	0.107	0.104
Metals					
Aluminum	EPA 6010B	45,400	29,300	**47,400**	**55,900**
Arsenic	EPA 6020	100	20.4	9.15	13.2
Barium	EPA 6020	469	60	120	198
Boron	EPA 6010B	7.18 [b]	**11 J**	7.01 J	**15.6 J**
Cadmium	EPA 6020	0.608 [b]	ND(1.21) UJ	ND(0.5) UJ	**0.876 J**
Calcium	EPA 6010B	7,300	3,300	**10,800**	**25,900**
Cerium	EPA 6020	14.2	4.73	**16.7**	**21.1**
Cesium	EPA 6020	ND	ND(1.21) UJ	ND(0.5) UJ	**1.11 J**
Chromium	EPA 6020	11.8	**13.8**	257	**253**
Cobalt	EPA 6020	43.7	8.62 J	17.7 J	21.6 J
Copper	EPA 6020	71.1	65.6 J	157 J	**203 J**
Iron	EPA 6010B	155,000	36,900	53,400	**55,900**
Lithium	EPA 6020	48.8	15.8	14.7	15.4
Magnesium	EPA 6010B	9,320	**11,400**	**23,300**	**22,800**
Manganese	EPA 6020	20,700	357	924	**956**
Nickel	EPA 6020	13.6	66.9 J	18.6 J	**17.5 J**
Potassium	EPA 6010B	1,390	379 J	964 J	1,290 J
Selenium	EPA 6020	5.44 [b]	1.64 J	0.707 J	0.937 J
Strontium	EPA 6020	164	32.3	149	**251**
Thallium	EPA 6020	1 [b]	ND(1.21)	ND(0.5)	ND(0.5)
Thorium	EPA 6020	0.5 [b]	ND(1.21)	**2.81**	**2.41**
Titanium	EPA 6020	3,010	798	1,070	1,360
Uranium	EPA 6020	4.13 [b]	ND(1.21)	1.23	1.32
Vanadium	EPA 6020	734	118	143	164
Zinc	EPA 6020	434	53.9	67.1	78.9

TABLE 4.3-7 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR CANNIKIN LAKE
(concentrations in milligrams per kilogram)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

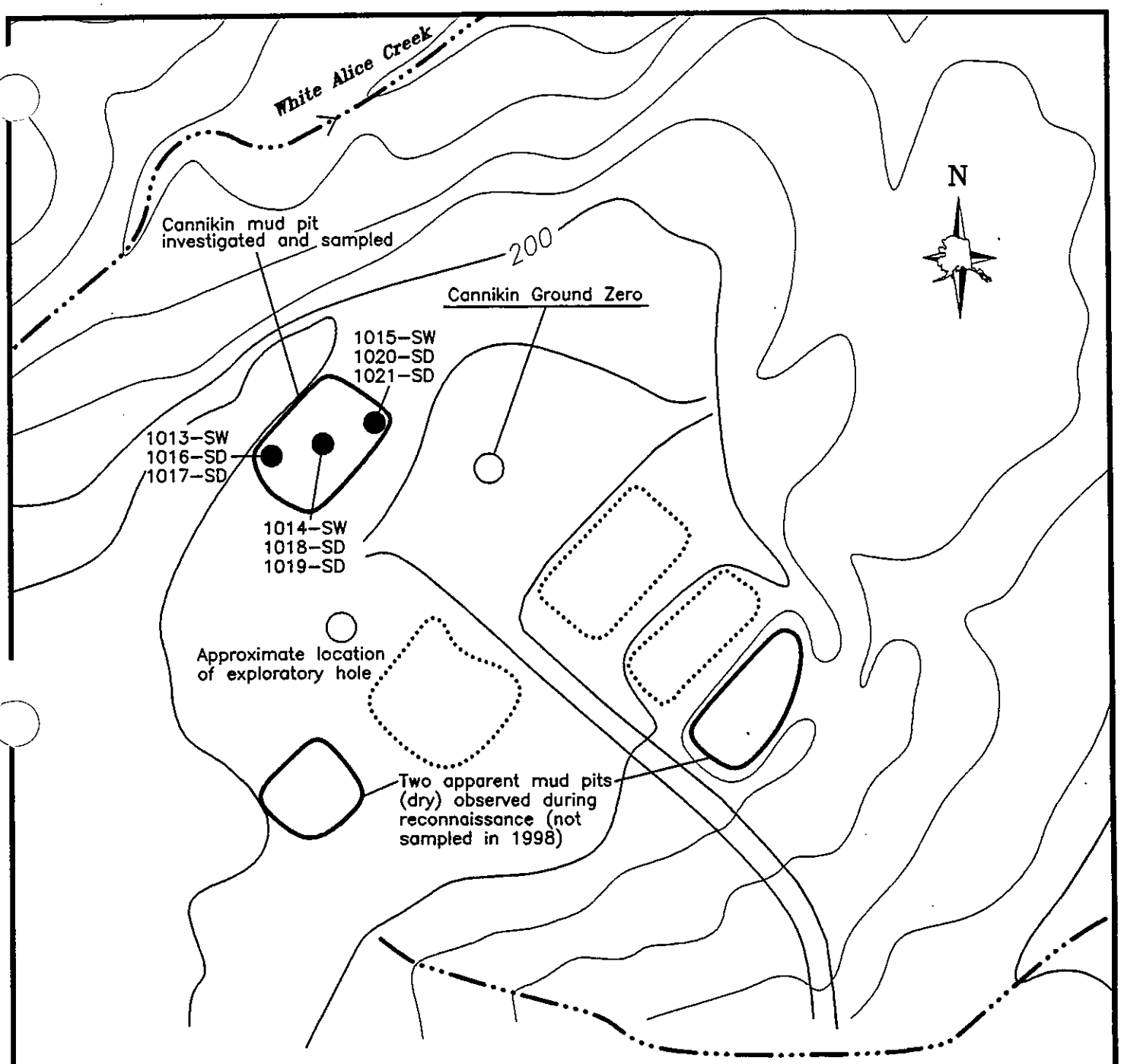
\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.



LEGEND

1013–SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE–CANN").

Stream

Approximate Former Location of Mud Pit

APPROXIMATE SCALE (FEET)

0 200 400

Contour Interval= 10 feet

Reference: Drawing Based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

CANNIKIN SITE

September 1999
Revision Number: 0

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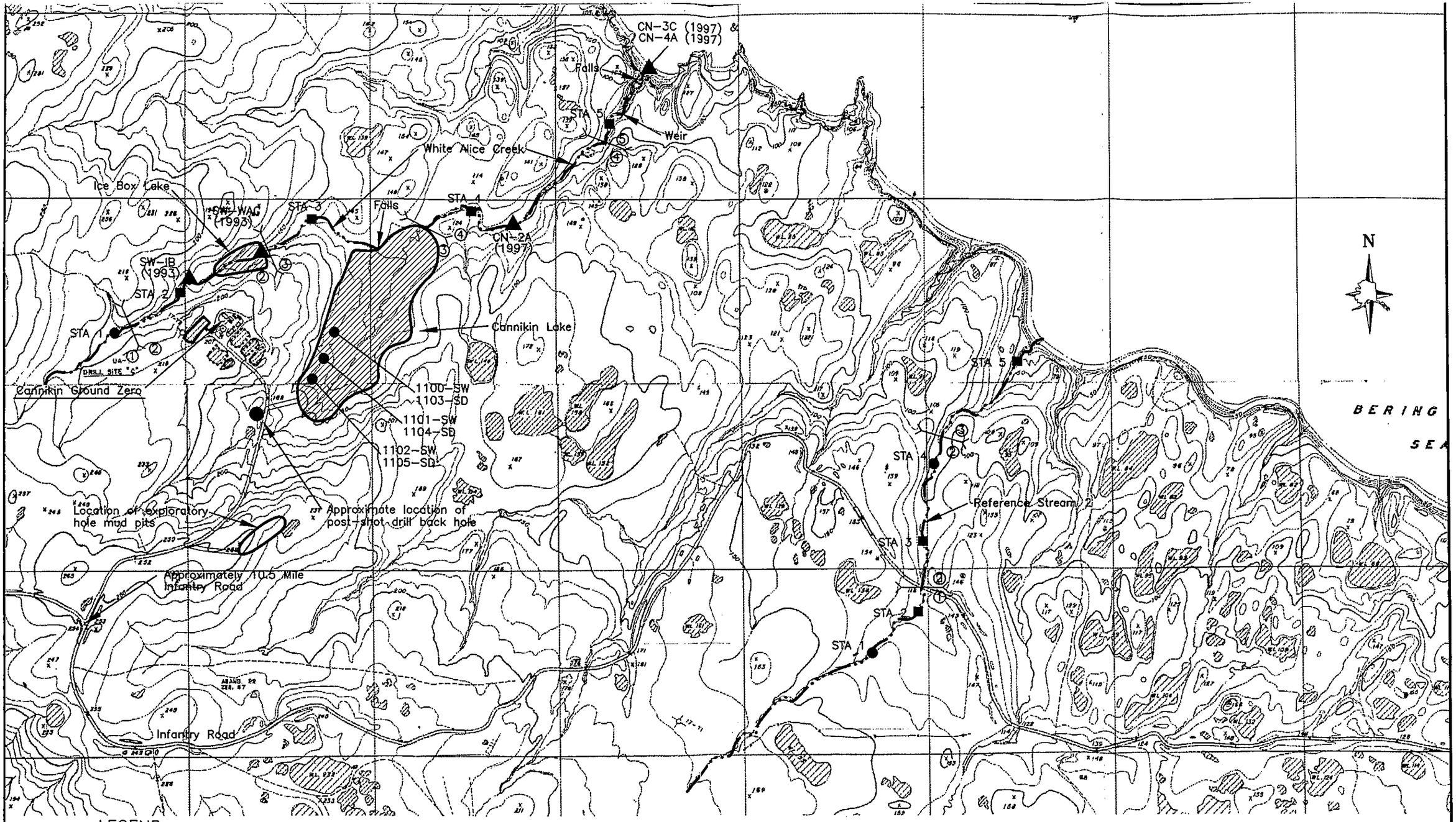
FIG. 4.3–1

FILE:



LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Sections 4.3.4.2 and 4.9.2 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and Benthic Invertebrate Sampling. (See Sections 4.3.4.2 and 4.9.2 for Sample Numbers.)

② Reach Number

Reach Boundary

▲ Locations of Chemical Samples Collected by DOE in 1993 and 1997

1100-SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE-CANN").

Investigated Stream Course

Existing Lake

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

CANNIKIN SITE STREAM AND REFERENCE STREAM 2

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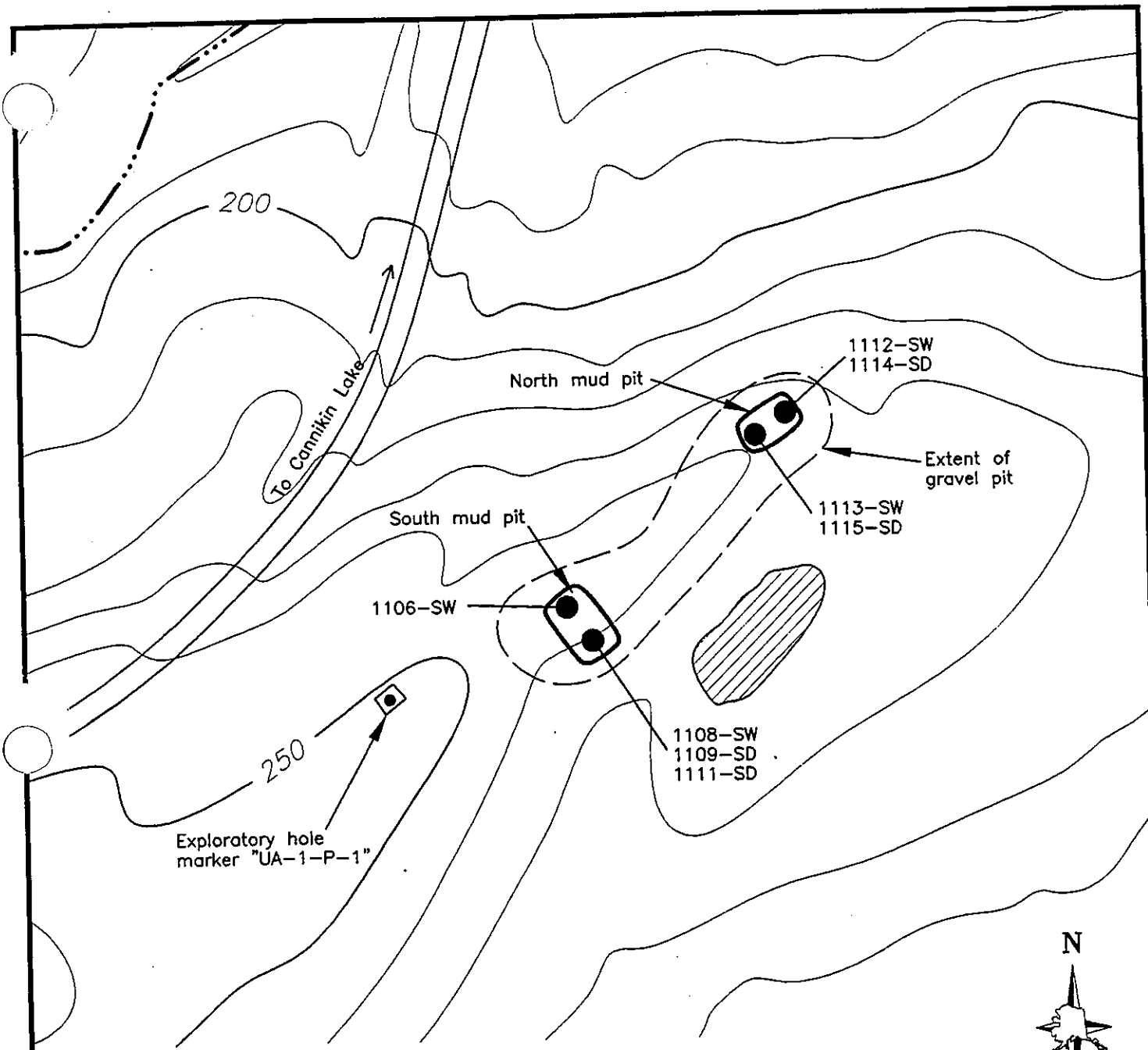
FIG. 4.3-2

FILE: Cannikin



LEGEND

1113–SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE–CANN").

Stream

Existing Mud Pit Investigated

Lake

APPROXIMATE SCALE (FEET)

0 200 400

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

CANNIKIN EXPLORATORY HOLE MUD PITS

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Revision Number: 0

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FIG. 4.3–3

FILE:

Photo 4.3-1: Post-shot reentry hole located southeast of surface ground zero. Cannikin Lake is shown at right edge of the photo. View is to the northeast.

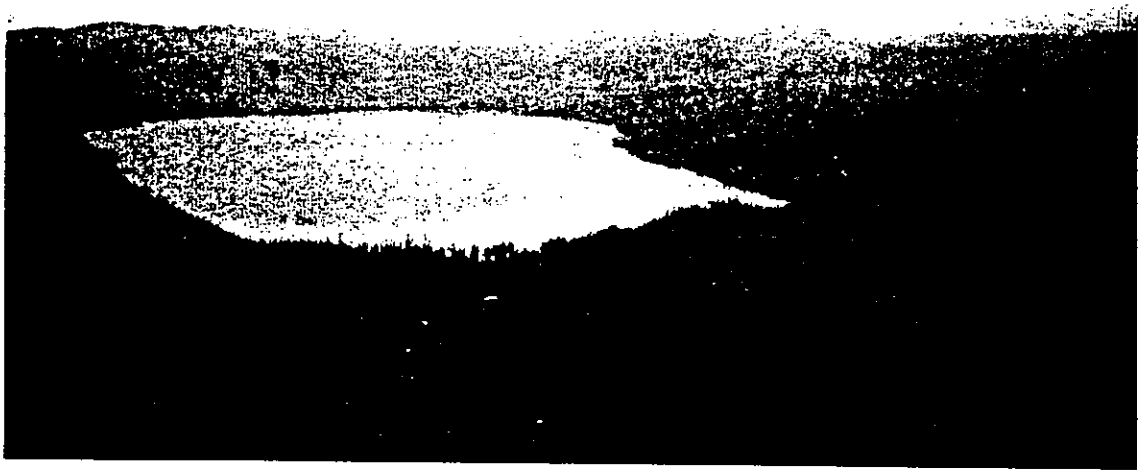


Photo 4.3-2: Exploratory hole north mud pit, facing north.

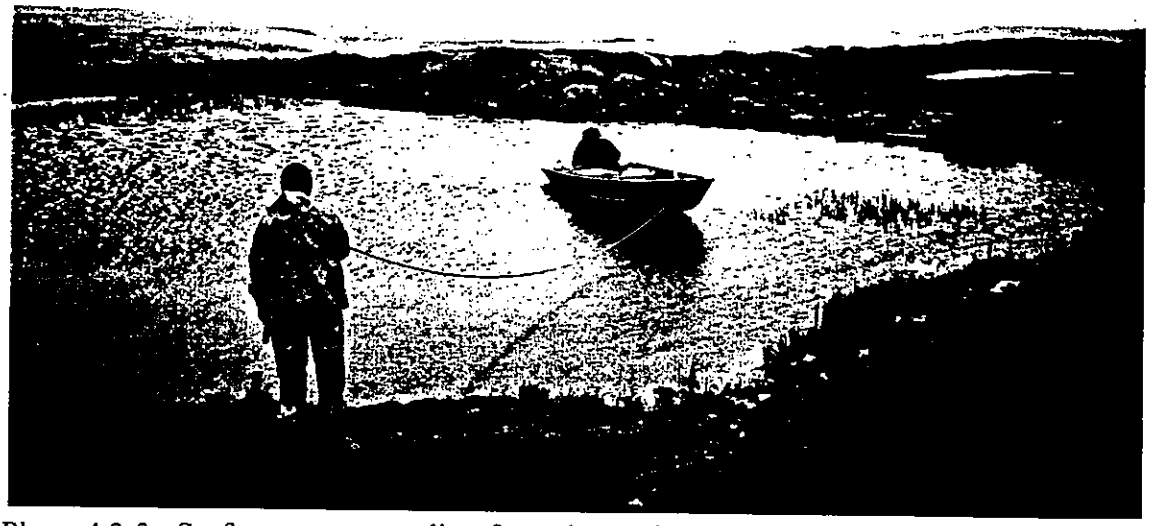


Photo 4.3-3: Surface water sampling from the exploratory hole south mud pit, facing north with Cannikin Lake and the north mud pit shown in the background.

Photo 4.3-4: Upper White Alice Creek basin with Cannikin Lake on right side of photo.

Photo 4.3-5: The view downstream from Reach 1 of White Alice Creek. Ice Box Lake is in the center of the photo.

Photo 4.3-6: Upper end of Reach 5, White Alice Creek, facing downstream and north.

4.4 MILEPOST 13 LAKE

4.4.1 Site Description and History

Historical data indicate that the AEC built a pipeline along Infantry Road from Cannikin to Drill Site D to facilitate the transfer of drilling mud between the sites. Two lakes along Infantry Road, one at Milepost 13 and one at Milepost 14, were apparently used as temporary drilling-mud storage facilities in conjunction with the pipeline. The mileposts refer to the designations used at the time of AEC occupancy of the island; subsequent changes to the road resulted in a slightly different current milepost measurement for these lakes. Weekly reports of AEC activities on the island during site restoration and demobilization indicate that the drilling mud was removed from both of these lakes before the AEC left the island.

According to an AEC construction drawing of the site provided by the DOE, the Milepost 13 Lake was approximately 6 feet deep and oblong-shaped, with dimensions of approximately 200 feet by 500 feet. The best information available at the time the August 1998 *Management Plan* was prepared indicated that the "Milepost 13 Lake" was located about 200 feet north of Infantry Road in the vicinity of Milepost 13.5 (Figure 2-1). It was immediately south of a larger lake with a water surface elevation of 254 feet (Figure 4.4-1). The available air photos (1968) of the area show a dry depression, roughly circular, with a diameter of approximately 200 feet in the suspected location of Milepost 13 Lake.

4.4.2 Observations

Reconnaissance of Milepost 13 Lake was performed as part of the 1998 Drill Site Investigation. The site contained a roughly rectangular, bermed area with dimensions of approximately 170 feet by 200 feet. The bermed area was dry except for one 8-foot-diameter puddle at its bottom. The surface soils within the bermed area consisted of silty, sandy gravel with cobbles. These surface soils, which were probed with a steel rod at numerous locations, were uniformly hard and resisted penetration. No drilling mud was evident in the bermed area, nor was there any indication that the area had been used to store drilling mud.

Reconnaissance of the surrounding area revealed no other evidence of drilling mud, impacts from drilling mud, or remnants of piping used to transport mud. The exception was two small areas of drilling mud, about 2 feet by 4 feet each, observed near the edge of Infantry Road. The drilling mud in these two areas did not appear to be impacted by diesel, although it contained what appeared to be a lightweight fibrous additive. Since the site did not appear to have been used to store drilling mud, the surface water and sediment samples planned for the site were not collected.

All parties present in the field during the 1998 investigation agreed that the area reconnoitered for the Milepost 13 Lake was the area identified in the *Management Plan*. However, the field observations of a dry, gravelly area were more indicative of a former borrow pit than a drilling-mud storage pit. This conclusion, reached after the field teams had returned from Amchitka, prompted reexamination of available site data. Based on that review it appears that the lake shown in Figure 4.4-1 with a water surface elevation of 192, about 1,400 feet southeast of the reconnoitered area, may be a more likely location for Milepost 13 Lake. Note that this water surface elevation is an apparent misprint on the Holmes & Narver base map, since the surrounding area is at an elevation of 250 to 280 feet. The AEC construction drawing indicates the water surface should be about elevation 275.

The revised possible location is outside the radius searched during the 1998 investigation. The findings at Milepost 14 Lake (discussed in the following section) either confirm that drilling mud was removed from that lake, or it was never used for mud storage. The same could be true for the Milepost 13 Lake. In addition, the revised possible location for the Milepost 13 Lake appears to be in a closed depression with no outlet stream (which would have been a logical choice for a lake used for mud storage). Thus, even if some mud remains in the lake, there should be no pathway for migration of mud constituents beyond the local area.

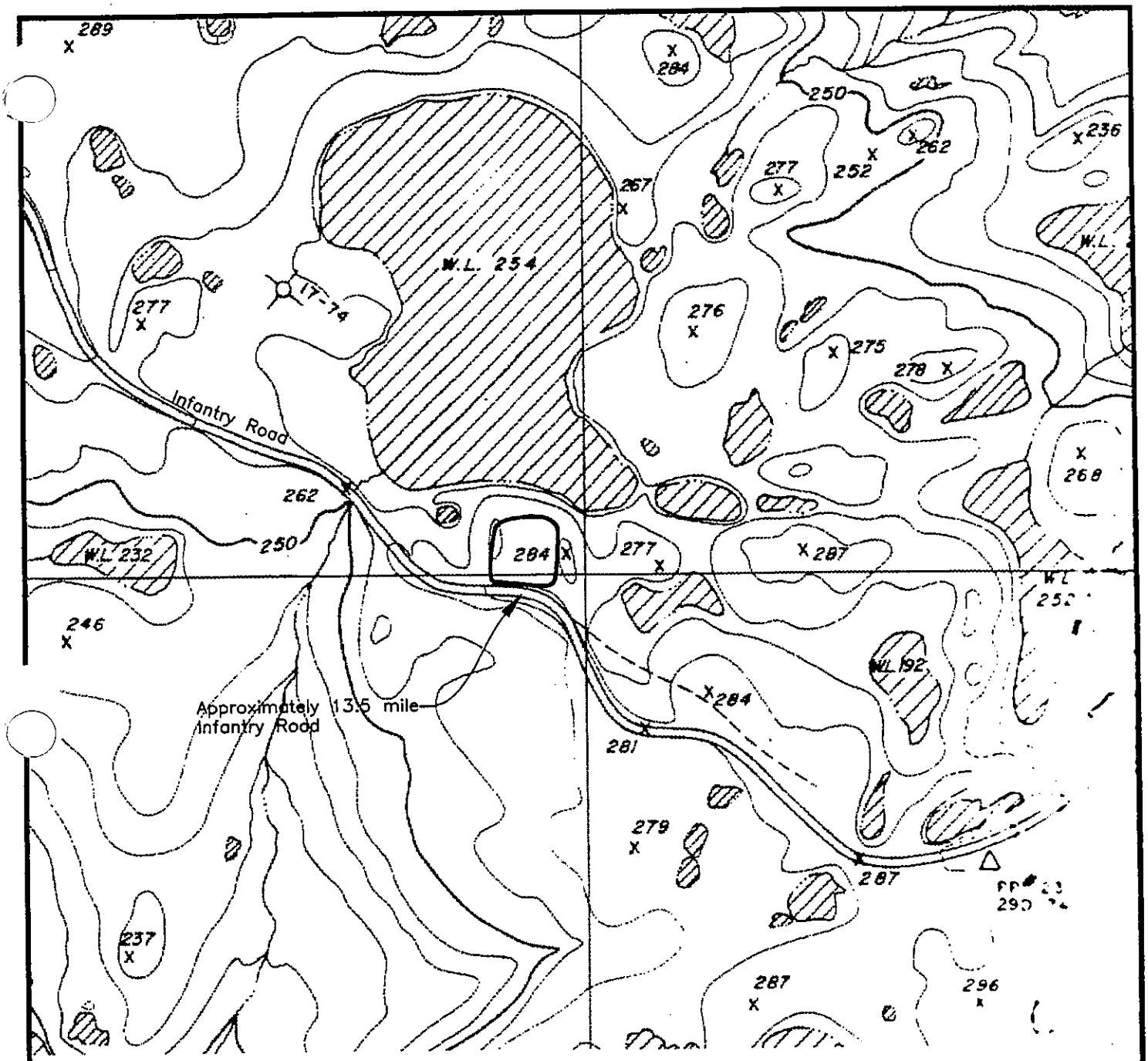
4.5 MILEPOST 14 LAKE

4.5.1 Site Description and History

As discussed above, Milepost 14 Lake was also reportedly used for drilling-mud storage. The title "Milepost 14 Lake" is again a misnomer. The lake is actually located about 100 feet east of Infantry Road near Mile 15.7, which places it approximately 1,800 feet northeast of Drill Site D (Figure 4.6-2). AEC construction drawings for this site furnished by the DOE match the lake designated "MP14 Lake" in Figure 4.6-2.

4.5.2 Observations

A reconnaissance of Milepost 14 Lake was performed as part of the 1998 Drill Site Investigation. The lake was circular in shape with a diameter of approximately 150 feet. Water depth ranged from 1 to 6 feet. The soils at the lake's shoreline and bottom consisted of brown, silty, sandy gravel with cobbles. These soils were probed in numerous locations using a steel rod. The probing was performed on foot near shore and from a skiff in the deeper parts of the lake. The results of the probing indicated that the soils were uniformly hard and resistant to penetration. The soils adhering to the tip of the probe were observed for evidence of drilling mud. No drilling mud or indicators of drilling mud (diesel odor, sheen, etc.) were observed during the probing. A reconnaissance of the area surrounding Milepost 14 Lake revealed no evidence of drilling mud, impacts from drilling mud, or remnants of piping used to transport mud. Since the



LEGEND

Location of MP13 Lake

APPROXIMATE SCALE (FEET)

0 500 1000

Contour interval= 10 feet

N

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

MP13 LAKE

September 1999
Revision Number: 0

X-0926

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FIG. 4.4-1

FILE:

site had no apparent impacts from drilling mud, the surface water and sediment samples planned for the site were not collected.

As in the case of Milepost 13 Lake, all parties present in the field during the 1998 investigation agreed that the area reconnoitered for the Milepost 14 Lake was the area identified in the *Management Plan.* Post field-season review confirmed that the correct location was investigated. Thus, it is possible that the AEC conducted a very thorough cleanup, or else the Milepost 14 Lake was never put into service for mud storage.

4.6 DRILL SITE D

4.6.1 Site Description

Drill Site D is located approximately 1,000 feet south of Infantry Road in the vicinity of Milepost 15.9 (Figure 1-2). This site was developed by the AEC for an underground nuclear test, but was not used. The AEC drilled a 4,550-foot-deep, 10-foot-diameter emplacement hole, and two 7,000-foot-deep exploratory holes at the site. Drilling took place between February 1968 and March 1971. The locations of the emplacement hole and one of the exploratory holes are marked by concrete pads with steel posts in their centers. The site also contains three relatively large drilling mud pits that have not been backfilled. A piping manifold used in the transfer of the drilling mud is located on a concrete pad near the northeast mud pit. Detailed site features are shown in Figure 4.6-1.

A topographic map showing the site vicinity is presented in Figure 4.6-2. The site, which is located in an area of steeply sloping terrain, drains to the southeast toward an unnamed lake. This lake is drained by Falls Creek, which empties into the Pacific Ocean approximately 8,000 feet south of the drill site.

4.6.2 Site History

The emplacement hole and one of the exploratory holes were filled with drilling mud before they were sealed and abandoned by the AEC. The second exploratory hole was left open for the purpose of long-term monitoring. The two holes full of drilling mud were sealed with 10-foot cement plugs and welded steel caps prior to abandonment. DOE records indicate that drilling mud was mixed at Drill Site D and piped to other drill sites for use. Weekly reports of AEC activities on the island during site restoration and demobilization indicate that the drilling mud was removed from the mud pits before the AEC left the island; however, the mud pits were left open with the concurrence of the BSF&W.

Historical information indicates that Falls Creek and possibly the unnamed lake at the head of the creek were impacted by drilling-mud spills and releases. The following excerpt regarding spills and releases at Drill Site D was taken from *The Environment of Amchitka Island, Alaska* (Valdez et. al., 1977).

> "Although some drilling mud may have splashed out of holding ponds at the time of the Milrow test, cracking and failure of pond walls at site D during Cannikin were far more serious. Drilling mud residue and silt from pond walls covered the bed and banks of Falls Creek. A subsequent intentional release of 20,000 to 25,000 barrels caused further damage to this stream. Downstream, where colonization from an uncontaminated branch of the stream could occur, Dolly Varden and some macroinvertebrates (simulids, chironomids, and trichopterans) were found. Absent, however, were the mayflies (ephemeropterans), whose presence is usually associated with clean well-aerated water. The upper portion of Falls Creek was devoid of fish and macroinvertebrates where heavy deposits of silt undoubtedly retarded their recovery".

Fuller and Kirkwood (1997) describe the release from Drill Site D during the Cannikin detonation:

> "... ground motion from Cannikin breached a dike around a holding pond, allowing some 4,800 m^3 (30,000 barrels) of water and mud to drain into falls creek ..."

4.6.3 Characterization Activities

Investigation activities at Drill Site D consisted of a detailed reconnaissance of the drill site to verify and record site features, and a reconnaissance and sampling effort at the three mud pits, the unnamed lake downslope from the mud pits, and Falls Creek. Five locations were selected in each mud pit and the lake for the collection of sediment samples. The sampling locations were selected in representative areas of the mud pits and lake and were generally evenly spaced. An exception is that one sediment sample in the lake was intentionally located in an apparent impacted area (sample number 1086-SD). Surface water samples were collected at three sediment sample locations in each mud pit and the lake. Sampling locations in the mud pits and unnamed lake are shown in Figure 4.6-1.

A detailed reconnaissance of Falls Creek was performed to observe the stream's ecology and select sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along the stream. Invertebrate, bioassay, and fish samples were collected from three of these stations. Stream sampling locations are shown in Figure 4.6-2. The samples collected from the mud pits, lake, and Falls Creek were shipped to off-site laboratories for testing. The types of tests performed and their results are described in the following sections.

4.6.4 Observations and Analytical Results

4.6.4.1 Mud Pits

The three mud pits at Drill Site D are located south of the emplacement hole drill pad and appear to have been constructed on bedrock following the removal of the surficial peaty soils. The mud pits are surrounded by relatively high berms, ranging from 3 feet to 15 feet in height (measured from the surface of the water in the mud pits). The berms appear to have been constructed of sandy gravel fill with cobbles and boulders. It was apparent that blasting was used to excavate bedrock in portions of the mud pits. These observations generally concur with the specifications shown on a grading plan provided by the DOE for Drill Site D. Due to their construction on sloping terrain, the downslope sides of the mud pits have the highest berms. The tops of the berms on the upslope sides of the mud pits are generally at the same elevation as the surrounding ground surface. The northeast mud pit contained the remains of two wooden baffles that extended across the mud pit and were apparently constructed to screen drill cuttings.

No areas of significant erosion or collapse were observed in the berms, and they appeared to be stable. Notable exceptions are two channels (or trenches) in the berms at the southern mud pit. As shown in Figure 4.6-1, the first of these trenches is located in the berm separating the south and northwest mud pits (Photo 4.6-1). A small stream of water was flowing through the trench from the northwest mud pit into the south mud pit at the time of our reconnaissance. The trench, which is approximately 3 feet deep, equalizes the water levels in the two mud pits. The second trench is located in the southeast wall of the south mud pit. A small stream of water was observed flowing in the approximately 5-foot-deep trench (Photo 4.6-2). The water level in the south mud pit was at approximately the same elevation as the base of the trench. The stream of water flowed a short distance into the nearby lake. A hydrocarbon sheen and staining were observed in this stream near the lake. It could not be determined whether the trenches had been excavated purposely or were the result of erosion from water overtopping the mud pit berms. Two 18-inch-diameter culverts were observed in the berm between the northwest and the northeast mud pits. These culverts, which were approximately 1 foot below the surface of the water in the two pits, apparently provide a conduit for water flow between the pits.

Water depth and the thickness of the drilling mud was measured at each sampling location. The sediment at the base of the mud pits was cohesive, gray bentonite. The bentonite contained some sand- and gravel-sized particles assumed to be drill cuttings. The bentonite also typically exhibited a slight diesel odor and produced a slight sheen on the water surface when disturbed. The thickness of the drilling mud ranged from 0.1 to 7.3 feet. Mud thickness was greatest in the northwest pit (average 6.6 feet) and least in the south pit (average 1.2 feet). The northeast pit contained an average of 3.4 feet of mud.

The depth of water in the mud pits ranged from 2.5 to 10.5 feet, with the greatest depth in the south pit. Based on the field measurements, the estimated total volume of drilling mud and water (at the time of the field work) in the mud pits was:

South pit	2,350 cy drilling mud	3,125,500 gal. water
Northwest pit	7,820 cy drilling mud	780,300 gal. water
Northeast pit	4,870 cy drilling mud	1,684,750 gal. water

The assumptions and methods used to make these estimates are explained in Section 2.4.3.1.3.

Sample descriptions and field screening results for samples collected from the mud pits are provided in the following table.

Mud Pit Sample Descriptions, Drill Site D

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth (feet)	Description	Observations	Screening Results (ppm)
South Mud Pit	5.0	0.5	1037-SW		Surface Water		
			1048-SD	0-0.3	Gray Bentonite		PID=4
	9.2	0.4	1038-SW		Surface Water		
			1046-SD	0-0.3	Gray Bentonite		PID=7
	10.5	2.4	1039-SW		Surface Water		
			1044-SD	0-0.3	Gray Bentonite		PID=5
	10.1	2.7	1045-SD	0-0.3	Gray Bentonite		PID=2
	5.3	0.1	1047-SD	0-0.1	Gray Bentonite		PID=6
Northwest Mud Pit	3.3	6.8	1040-SW		Surface Water		
			1069-SD	0-0.7	Gray Bentonite	Moderate diesel sheen and odor	PID=12
			1070-SD	5.7-6.7	Black Gravel in a bentonite matrix		PID=1
	4.0	5.8	1041-SW		Surface Water		
			1049-SD	0-1.0	Gray Bentonite	Slight sheen	PID=8
			1050-SD	4.5-5.5	Gray Bentonite	Trace sheen	PID=7
	3.5	6.6	1042-SW		Surface Water		
			1051-SD 1052-SD (dup)	0-1.0	Gray Bentonite	Slight diesel sheen and odor	PID=13
			1053-SD	5.5-6.5	Gray, gravelly Bentonite	Slight diesel sheen and odor	PID=12
	3.0	6.5	1071-SD	0-0.8	Gray Bentonite		PID=1
			1072-SD	5.5-6.5	Gray Bentonite	Slight diesel sheen and odor, bottom 3 inches gravel	PID=2
	2.5	7.3	1073-SD	0-0.8	Gray Bentonite	Slight diesel sheen and odor	PID=2
			1074-SD	6.1-7.1	Gray, gravelly Bentonite	Strong diesel odor and sheen	PID=1
Northeast Mud Pit	6.5	3.1	1079-SW		Surface Water		
			1091-SD	0-1.0	Gray Bentonite	Slight diesel odor and sheen	PID=0

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Northeast Mud Pit (cont.)	6.5	3.1	1092-SD	2.0-3.0	Gray, gravelly Bentonite	Slight diesel odor and sheen	PID=0
	5.8	4.3	1080-SW 1081-SW (dup)		Surface Water		
			1096-SD	0-1.0	Gray Bentonite	Slight diesel odor, 6 inches gravel in tip	PID=0
			1097-SD	3.2-4.2	Gray Bentonite	Slight diesel odor, gravel in tip	PID=0
	5.0	5.1	1082-SW		Surface Water		
			1098-SD	0-1.0	Gray Bentonite	Slight diesel odor	PID=0
			1099-SD	4.0-5.0	Brown , gravelly Bentonite	Slight diesel odor	PID=0
	5.8	1.2	1093-SD	0-1.2	Gray Bentonite	Slight diesel odor	PID=0
	6.0	3.3	1094-SD	0-1.0	Gray Bentonite	Slight diesel odor and sheen	PID=0
			1095-SD	2.0-3.0	Gray Bentonite	Slight diesel odor	PID=0

* Sample depth measured from mud surface

A piping manifold was observed near and downslope from the northeast mud pit (Figure 4.6-1, Photo 4.6-3). The location of the piping manifold corresponds to an area on the DOE construction drawing labeled "pump sump concrete pad." The piping manifold consists of a steel pipe approximately 20 feet long and 2 feet in diameter. The manifold rests on an approximate 20-foot-square concrete pad. The manifold has six large gate valves welded along one side; the valves were all closed. A 20-inch-diameter steel pipe extends from the manifold into the side of the mud pit berm and appears to connect the northeast mud pit to the manifold. The DOE construction drawing, which shows a "suction" pipe extending from the pump sump pad to the northeast mud pit, supports this observation. The invert elevation for the pipe shown in the drawing is 0.5 feet higher than the elevation of the bottom of the mud pit.

The exterior of the manifold was rusted but appeared relatively intact. However, one of the gate valves was leaking two small streams of water (Photo 4.6-4). The water was squirting out from the valve, indicating it was under pressure. The water had no apparent diesel odor or sheen. Based on the construction drawing, it appears the leaking water is coming from the northeast mud pit. The water trickled off of the concrete pad and was absorbed into the ground surface. A small rivulet (much larger than the flow of water leaking from the valve) was also observed flowing from the fill beneath the concrete pad supporting the manifold. It is likely that this water is seeping from the mud pit through the backfill used in the suction pipe trench. This rivulet

flowed into a small puddle of water located just downslope of the concrete pad. A sheen was generated on this puddle when the sediment was disturbed. The puddle drains via a small stream into the lake located immediately downhill from the mud pits.

4.6.4.1.1 Surface Water

The mud pit surface water samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.6-1. Eight of the ten surface water samples contained DRO at concentrations of 57.3 to 125 ug/L (an average of 76 ug/L).

No VOCs were reported in the Drill Site D mud pit water samples except methylene chloride, a suspected laboratory contaminant, which was reported in three of ten samples. No PAHs were detected in any of the water samples.

Thirteen metals were present in one or more of the water samples from the Drill Site D mud pits. The only exceedances of the upland reference stream background concentrations were single occurrences of aluminum, chromium, molybdenum, nickel, and two occurrences of thorium and titanium. In each case the exceeding concentration was slightly over background.

The metals that exceeded background were compared to project ERBSCs. The 92 ug/L occurrence of aluminum slightly exceeded its ERBSC of 87 ug/L, which equals the upland aluminum background concentration. Chromium did not exceed its ERBSC. No ERBSC are available for thorium or titanium.

Surface water quality parameters measured in the Drill Site D mud pits during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Mud Pits, Drill Site D

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1037-SW (S pit)	8.7	11.0	10.6	140	10
1038-SW (S pit)	8.5	11.0	10.8	141	10
1039-SW (S pit)	8.4	11.1	10.6	140	10
1040-SW (NW pit)	8.8	11.8	10.4	130	10
1041-SW (NW pit)	8.9	11.5	10.5	130	10
1042-SW (NW pit)	8.8	11.6	10.4	130	10
1079-SW (NE pit)	6.8	9.5	11.7	170	1
1080-SW (NE pit)	6.9	9.6	11.7	170	1
1082-SW (NE pit)	6.8	9.4	11.7	170	1

4.6.4.1.2 Sediment

The drilling mud samples were initially analyzed for DRO, VOCs, PAHs, and metals. Following the discovery of low levels of PCBs in two samples from Cannikin Lake and two samples from the Cannikin SGZ mud pit, a portion of the drilling mud samples from Drill Site D were also analyzed for PCBs. Analytical results are summarized in Table 4.6-2.

Each sample contained DRO at concentrations ranging from 45.7 mg/kg to 2.420 mg/kg. Average DRO concentrations in the three pits are as follows:

South pit	497 mg/kg
Northwest pit	756 mg/kg
Northeast pit	526 mg/kg

Two alkylated benzenes were present in several of the drilling mud samples at total concentrations of up to 0.66 mg/kg (0.2 percent of the DRO concentration). Four to eleven PAH compounds were present in each sample at total concentrations ranging from 0.07 to 27.6 mg/kg (0.02 to 5.8 percent of the DRO concentration). Average VOC and PAH concentrations in the three mud pits are as follows:

	VOCs	PAHs
South pit	0.00 mg/kg	0.44 mg/kg (0.14% DRO)
Northwest pit	0.33 mg/kg (0.13%DRO)	8.08 mg/kg (1.41% DRO)
Northeast pit	0.38 mg/kg (0.09% DRO)	1.50 mg/kg (0.42% DRO)

A total of 15 of the drilling mud samples from the three mud pits at Drill Site D were analyzed for PCBs. The analyses were performed about 4 months after the samples were collected. However, it was felt that PCBs are persistent enough in the environment that analysis of these sediment samples, which had been stored at 4°C (cooler than field conditions on Amchitka), would produce valid estimated data. Drill Site D samples were chosen for PCB analysis because drilling mud was mixed at Drill Site D and then pumped to the other sites. Five of the 15 mud pit samples from Drill Site D analyzed for PCBs contained low levels of Aroclor 1260, ranging from 0.055 to 0.2 mg/kg. For about half of the samples where no PCBs were detected, the reporting limits were elevated (maximum 0.329 mg/kg) due to the low percent solids (high moisture content) typical of samples of bentonite clay-based drilling mud. Four of the samples reported to contain PCBs were from the northeast mud pit and the other from the northwest mud pit. The southern Drill Site D mud pit samples did not contain any detected PCBs.

Twenty-seven metals were detected in the mud pit samples. Metals concentrations from the samples of each mud pit were compared to background concentrations from upland reference stream sediment. In the south mud pit samples, ten metals exceeded background concentrations for at least one of the five samples analyzed. Of these, thorium and uranium were detected in each of the five south pit samples but not detected in the background. Cerium and chromium

exceeded background in all five samples by up to 4.5 and 11 times, respectively. Boron exceeded background in two south pit samples.

In the northwest mud pit there were fourteen metals that exceeded background in at least one of the ten mud samples. Of these metals, calcium, chromium, thallium, and uranium exceeded background in each of the ten samples. For chromium the maximum reported concentration was 57 times greater than background (1,090 vs. 18.9 mg/kg). Thorium and uranium were not detected in reference streams, while the maximum thorium and uranium concentrations were 9.5 and 4.34 mg/kg, respectively. Six metals (cerium, cesium, copper, potassium, strontium, and titanium) exceeded background sediment concentrations in six to eight of the ten samples.

In the northeast mud pit fourteen metals exceeded background in at least one of the nine samples. Similar to the other mud pits, calcium, cerium, chromium, thorium, and uranium all exceeded background in every sample. The maximum concentration of chromium was 70 times background. Copper, potassium, and strontium exceeded background in six to eight samples from the northeast pit with maximum concentrations up to twice background (approximately).

Of the metals that exceeded background concentrations, chromium and copper also exceeded their respective ERBSCs. In the case of chromium, all the samples exceeded the ERBSC of 26 mg/kg by a significant margin. With copper, not all samples exceeded the ERBSC. Other metals that exceeded background did not have available ERBSC values for comparison.

4.6.4.2 ~~Unnamed~~ Maxwell Lake

The unnamed lake located near the southeast edge of the mud pits was the subject of both a reconnaissance and a sampling effort. An overview of the lake is shown in Photo 4.6-5. The lake is approximately 520 feet long and 140 feet wide. At the time of the field work the lake was receiving surface drainage from the south and northeast mud pits (via two small streams). A sheen and staining were observed in both of these streams. During the investigation, the shoreline of the lake was searched for signs of contamination. A sheen was caused on the water surface in several areas after sediment near the shoreline was disturbed. The location for sediment sample 1086-SD was specifically chosen in such an area. The sheens were observed along an approximately 200-foot length of shoreline near the inlet of the small stream draining from the south mud pit. No sheen was caused when sediment at the outlet stream from the northeast mud pit was disturbed.

The sediment near the shoreline of the lake was mainly silt, peat, and sand. Lake sediment at the sampling locations was either stained sandy gravel, white to gray bentonite, or gray sand. The sediment samples were collected from within the top 0.3 feet of the lake bottom using an Eckman dredge. Sediment at locations where drilling mud was found was not explored to greater depths. The only additional information gathered at these locations was the total thickness of sediment, based on probing with a steel rod. Thus, the sediment below 0.3 foot was not visually classified; it may not consist entirely of drilling mud (some native sediment may be

present). For this reason, no estimate of the volume of drilling mud in the lake was made. Sample descriptions and field screening results for samples collected in the lake are provided in the following table:

Lake Sample Descriptions, Drill Site D

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Drill Site D Lake	0.8	-	1083-SW		Surface Water		
			1086-SD	0-0.3	Sandy Gravel	Stained, heavy sheen	PID=3
	2.5	1.5**	1084-SW		Surface Water		
			1088-SD	0-0.3	Gray Bentonite	No diesel odor	PID=7
	2.1	-	1085-SW		Surface Water		
			1090-SD	0-0.2	Gray Sand		PID=1
	2.2	2.3**	1087-SD	0-0.3	Gray Bentonite	No diesel odor	PID=5
		1.5	1089-SD	0-0.2	White Bentonite and gray sand	No diesel odor	PID=0

* Sample depth measured from lake bottom
** Thickness of sediments based on depth of probe refusal. Sediments may not all be bentonite.
\- Drilling mud not observed

4.6.4.2.1 Surface Water

The lake surface water samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.6-3. All three surface water samples contained DRO, at concentrations of 56.2 to 119 ug/L (an average of 83 ug/L). This is somewhat higher than the average 61 ug/L DRO present in about half of the upland reference stream water samples.

No VOCs were reported in the lake water samples except 3.2 to 4.4 ug/L of methylene chloride, a suspected laboratory contaminant reported in all three samples. No PAHs were detected in any of the water samples.

Thirteen metals were present in one or more of the water samples from the Drill Site D lake. Concentrations of the following seven metals exceeded the upland reference stream background values (an asterisk indicates ERBSCs were also exceeded):

Aluminum*	Chromium*	Lithium	Nickel
Potassium	Titanium	Vanadium	

Lithium, nickel, vanadium, and two of the titanium concentrations were only slightly higher than background (maximum exceedance of 15 percent). Aluminum and potassium concentrations were about twice background; one titanium result was four times background. At a maximum of 11.5 ug/L, chromium concentrations were about three times the 3.49 ug/L background concentration. This group of exceedances is different, both in number of compounds and magnitude of exceedances, than the exceedances in the mud pit water that contributes water to the lake; more exceedances of a greater magnitude were recorded in the lake.

These background exceedances were compared to project ERBSCs. The maximum occurrence of aluminum was about twice its ERBSC of 87 ug/L. The 11.5 ug/L of chromium only slightly exceeded the 11 ug/L ERBSC for chromium (VI), but not the 74 ug/L ERBSC for chromium (III); chromium species was not determined for samples collected for this project. No ERBSC is available for titanium. No ERBSC is available for potassium, but this metal is considered an essential nutrient and unlikely to result in any toxic effects. Neither lithium, nickel, nor vanadium exceeded their respective ERBSCs.

4.6.4.2.2 Sediment

The lake sediment samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.6-4. All five sediment samples contained DRO at concentrations ranging from 66.2 to 146 mg/kg. Sample 1086-SD, whose location was intentionally selected to correspond to a place where a sheen was caused by disturbance of the sediment, contained 125 mg/kg DRO. DRO inferred to be biogenic in origin was reported in half the sediment samples from upland reference streams, at an average concentration of 49 mg/kg. Thus, it is possible that some portion of the DRO reported in these lake sediment samples could be of biogenic origin.

The only VOCs reported in sediment samples from the Drill Site D lake are suspected laboratory contaminants. Carbon disulfide was reported in four of the five samples at 0.025 to 0.20 mg/kg. One sample contained 2-butanone (MEK) at 0.050 mg/kg.

Four of the sediment samples contained one to four PAH compounds at total concentrations ranging from 0.006 to 0.31 mg/kg. The maximum total PAH occurrence corresponds to 0.2 percent of the DRO concentration in that sample. Only one of the individual PAHs, fluorene, exceeded its ERBSC in one sample (by about 25 percent).

Twenty metals were present in the sediment samples from the Drill Site D lake. The following nine of these metals exceeded the background values for upland reference streams in one or more samples (an asterisk indicates that ERBSCs were also exceeded).

Barium	Calcium	Cerium	Chromium*
Copper*	Potassium	Thorium	Titanium
Uranium			

The most exceedances of background and the highest metals concentrations generally occurred in samples 1087-SD and 1088-SD. Concentrations of barium, calcium, copper, potassium, and titanium exceeded background by 10 to 57 percent. Thorium (maximum 16.8 mg/kg in lake sediment) and uranium (maximum 6.2 mg/kg) were not detected in reference stream sediment samples. Cerium (maximum 61.4 mg/kg) exceeded background by five times. The greatest exceedance of background was chromium (695 mg/kg maximum, compared to a background value of 18.9 mg/kg). The chromium concentrations in four of the five lake sediment samples were comparable to the concentrations in the Drill Site D mud pits. The concentration in the fifth lake sample did not exceed background. This sample (1086-SD) was the location selected because a sheen was generated upon disturbance of the sediment.

Metals that exceeded background were then compared to ERBSCs. Four of the five chromium occurrences greatly exceeded their 26 mg/kg ERBSC. All of the copper occurrences (25.7 to 98.3 mg/kg) exceeded the ERBSC of 16 mg/kg, as does the upland reference stream background value for copper of 82.4 mg/kg. No ERBSCs are available for the other metals that exceeded background. However, calcium and potassium are considered essential nutrients and unlikely to result in any toxic effects.

4.6.4.3 Falls Creek

Falls Creek is the primary drainage stream of the Drill Site D watershed. Approximately 6,000 feet long, it is located south of the site and flows south-southwest to the Pacific Ocean (Figure 4.6-2). As described in Section 4.6.2, portions of Falls Creek were inundated with drilling mud during the Cannikin event. Fish and benthic invertebrates were reported to have been severely impacted in much of the stream following the mud deposition. However, significant recovery has taken place since then.

Field activities at Falls Creek included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). Surface water and sediment samples were collected at each of five sampling stations along the length of the creek. At Stations 1, 2, and 4, benthic macroinvertebrates and sediment samples for bioassays were also collected. Fish samples were collected at Stations 1 and 4 but could not be collected from Station 2, because the stream flows underground in this vicinity.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ± 100 feet. Station elevations were interpolated from contours in Figure 4.6-2.

Sample Numbers and Station Coordinates for Falls Creek, Drill Site D

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 30.792'	179° 1.414'	275	3005-SW 3005-SD 3028-IN 3007-FS
2	51° 30.508'	179° 1.190'	220	3004-SW 3004-SD 3027-IN
3	51° 30.301'	179° 1.210	150	3003-SW 3003-SD
4	51° 30.071'	179° 1.032	80	3002-SW 3002-SD 3026-IN 3006-FS
5	51° 30.023'	179° 0.807'	45	3001-SW 3001-SD

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss laboratory results for surface water, sediment, benthos, and fish samples.

4.6.4.3.1 Stream Characteristics

Based on observations during the initial reconnaissance, Falls Creek was divided into three stream reaches (Figure 4.6-2). The upper reach, Reach 1, begins at the unnamed lake immediately southeast of the mud pits and about 1,100 feet south of Infantry Road and ends at the point of a significant increase in stream gradient. Reach 2 begins at this point and ends downstream at a major decrease in stream gradient. Reach 3 extends from the end of Reach 2 downstream to the Pacific Ocean. In general, the upper and lower reaches have flatter gradients than the middle reach, which is more incised and has a higher stream velocity. No significant fish barriers such as waterfalls were observed along the stream. The following table summarizes reach characteristics for Falls Creek.

Reach Characteristics for Falls Creek, Drill Site D

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,100	1.0	Few bends	Sand overlying peat at headwaters, then silty peat and some gravel (in channel)
2	2,900	4.5	Many small bends	Cobbles and gravel mixed evenly with, and sometimes overlying silty peat
3	2,000	3.0	Many small bends	Cobbles and gravel mixed evenly with, and overlying peat, grading toward gravel and cobbles with sparse peaty silt

Reach 1

Reach 1 is roughly 1,100 feet long. It meanders through a small sedge-covered wetland meadow of approximately 5 acres with numerous areas of shallow (1 to 8 inches deep) open water (see Photo 4.6-6). The streambed becomes more distinct in the downstream portion of this reach as the gradient increases. The overall gradient averages 1 percent. The stream typically ranges from less than 1 foot to 3 feet wide and 4 inches to 3 feet deep, with few bends. The dominant streambed substrate is soft organic muck (silty peat). However, in the first 100 feet of the stream as it exits the unnamed lake the streambed substrate was sand and a vermiculite-like substance overlying silty peat. The dominant aquatic vegetation in Reach 1 was sedges (*Carex* spp.).

Station 1 was located in Reach 1 about 20 feet downstream of the unnamed lake. Amphipods and fingernail clams were common in the sandy substrate. Field observations suggested that Station 1 had a higher density and abundance of benthic macroinvertebrates than stations located downstream. The invertebrate population data are presented in Section 4.6.4.3.4.

A large sheen and petroleum odor were noticed upon disturbance of the sediments at Station 1 and within much of the upstream portion of Reach 1. Farther downstream, where the stream is channelized, the sheen and odor were not found. A pocket of vermiculite-type material was observed at Station 1 overlying a deeper peat layer. This was believed to be a residual from the drilling mud.

Reach 2

Reach 2 is roughly 2,900 feet long with a gradient of approximately 4 to 5 percent. The small valley associated with the stream is relatively straight. The channel is incised 4 to 6 feet into the tundra and is underground along more than 90 percent of the length of the reach (Photo 4.6-7). Where the stream could be seen and probed, the bottom substrate consists of cobbles and gravel over peat. The stream channel is typically less than 3 feet wide, and water depth varies from 4 inches to 3 feet deep. Aquatic vegetation consisted primarily of moss (*Fontinalus* sp.).

Station 2 was located in the upper part of Reach 2. Both here and at Station 3 sampling was conducted through holes in the nearly continuous ground cover over the stream. The diversity

and density of benthic macroinvertebrates were very low. Station 3 was located in the downstream portion of Reach 3.

Reach 3

Reach 3 is roughly 2,000 feet long, with an overall gradient of about 3 percent, which is gentler than Reach 2 but slightly steeper than Reach 1. The stream contains more and larger bends than are found upstream, but remains almost completely subterranean until the confluence with a similar-sized tributary that flows from the east. This confluence is approximately 1,200 feet upstream from the Pacific Ocean. At the beginning of Reach 3 the stream valley becomes a broad, flat grass and sedge meadow leading to a bluff over the ocean. As the stream nears the ocean the meanders increase, as it cuts a narrow valley through the bluff and enters the ocean as a low waterfall (Photo 4.6-8). The dominant stream channel substrate consists of cobbles and gravel. The average stream width varies from 6 inches to 6 feet, and the range in depth is similar. The only tributary entering Falls Creek contributes nearly 50 percent to the flow during periods of medium flow. The stream meets the tidal zone at a boulder and cobble beach strewn with ocean debris above the high-water line.

Station 4 was located just below the confluence with the eastern tributary. The observed diversity and density of benthic macroinvertebrates at Station 4 were low, even though the cobble and gravel substrate was adequate habitat. *Fontinalus* was the dominant aquatic vegetation type, with patchy coverage. Station 5 was located at an old gauging station and associated weir. The surface water and sediment samples were collected from the pool created by the weir.

4.6.4.3.2 Surface Water

Five surface water samples were collected from Falls Creek, one per sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.6-5.

DRO was reported in three (Stations 1, 4, and 5) of the five surface water samples, at concentrations ranging from 72.4 to 84.9 ug/L. However, 71 ug/L of DRO was also present in the laboratory method blank associated with this batch of samples. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991) these samples have been qualified as nondetects at detection limits corresponding to their values, because they are less than five times the method blank concentration. The reported concentrations of DRO are also comparable to the 61 ug/L average concentration of DRO reported in about half the water samples from upland reference streams.

The only VOC detected was methylene chloride, a laboratory contaminant; these occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples collected from Falls Creek.

Fifteen metals were detected in the surface water samples from Falls Creek. Nine of these were present in samples from each of the five stations, while the other metals were detected only at one or a few stations. The concentrations of these metals were compared to the background concentrations for upland reference streams. Six metals exceeded their respective background concentration at one or more stations. This group of metals included:

Chromium*	Lithium	Molybdenum	Potassium
Vanadium	Zinc		

Chromium exceeded its background concentration at Station 5, the only station where it was detected. The chromium concentration exceeded background by nearly 4 times. The remaining metals each were less than 2 times their respective background concentrations.

Of the metals that exceeded background concentrations in Falls Creek, water, chromium, and zinc also exceeded background values in Falls Creek sediment samples (see Section 4.6.4.3.3).

Metals found in Falls Creek water samples that exceeded background concentrations were then compared to the lowest (i.e. most conservative) of the project ERBSCs. The chromium concentration in surface water from Station 5 slightly exceeded the ERBSC for chromium VI. However, the chromium in water is more likely to be in the form of chromium III. The chromium III ERBSC was not exceeded. None of the other site-related metals concentrations in water exceeded background concentrations and their respective ERBSCs. An ERBSC was not available for potassium, but this metal is considered an essential nutrient and unlikely to results in any toxic effects.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Falls Creek, Drill Site D

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	6.72	12.3	11.4	190	-10
2	6.17	9.2	10.23	175	-10
3	5.74	8.6	10.49	175	-10
4	6.0	7.6	11.81	168	-10
5	5.82	7.3	11.46	167	-10

4.6.4.3.3 Sediment

One sediment sample was collected at each of five stations on Falls Creek. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. Sediment samples from Stations

2, 3, 4, and 5 were analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.6-6.

DRO was detected at 176 mg/kg in one sediment sample collected from Station 1. Petroleum sheen and odor were noted at this station during sampling. As this value is below the maximum DRO concentration detected in the upland reference streams (See Section 2.3.2.6), it is possible that some portion of the DRO is from biogenic sources.

No VOCs were detected in the sediment samples. PAHs were detected only at Station 1. Twelve PAHs were detected in this sample, with a combined concentration was 0.49 mg/kg. The concentrations of PAHs were compared to the lowest of the project ERBSCs. The benzo(b)fluoranthene concentration at Station 1 exceeded its respective ERBSC by a factor of 3; the other PAHs were all below project ERBSCs.

Twenty-one metals were detected in the Falls Creek sediment samples. The concentrations of these metals were compared to the background concentrations determined for these metals in upland reference stream sediment samples. Eight of the detected metals concentrations exceeded their respective background concentrations, as follows (an asterisk indicates that ERBSCs were also exceeded):

Boron	Cerium	Chromium*	Copper*	Magnesium
Titanium	Uranium	Zinc*		

Boron and chromium exceeded their respective upland stream background concentrations at all five stations. Boron concentrations in sediment exceeded the background concentration by factors ranging from nearly four at Station 1 to as much as 25 at Station 5. Station 1 had the highest chromium concentration (226 mg/kg), which was 12 times the background concentration Chromium concentrations at the other stations were all less than two times background. Copper, magnesium, and titanium only slightly exceeded their background concentrations at Station 5 Cerium slightly exceeded background at Station 1. Zinc was elevated above background at Stations 3 and 5.

The only detection of uranium in Falls Creek sediment was from Station 1 at a concentration of 2.49 mg/kg, which is just above its detection limit. Uranium was not detected in upland reference streams or site-related streams, but it was detected in three lowland reference stream samples at up to 4.13 ug/L.

The drilling mud samples from the mud pits at Drill Site D had the highest average chromium concentration of all the drill sites, with individual samples containing as much as 1,090 mg/kg of chromium. It is likely that the elevated chromium concentration in the stream sediment at Station 1 is the result of the known historical releases of mud to Falls Creek.

Of the eight metals found in Falls Creek sediment that exceeded background concentrations, chromium, copper, and zinc also exceeded project ERBSCs. Chromium exceeded its ERBSC at

Stations 1, 4, and 5. The ERBSCs for copper and zinc are both below the background concentrations for these metals. ERBSCs are not available for boron, cerium, magnesium, titanium, and uranium.

In addition to the total metals results discussed above, AVS and SEM were analyzed to provide information on the bioavailability of metals. AVS and SEM concentrations in the sediment samples from Falls Creek are presented in the following table. At the two stations where AVS were detected, the data suggest there are sufficient sulfides present to bind the SEM metals and limit their bioavailability. At stations where AVS was not detected it is not clear whether the metals are bioavailable or not.

AVS and SEM Concentrations for Falls Creek, Drill Site D

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	3005-SD	170	1.03	0.01
2	3004-SD	ND	0.553	NA
3	3003-SD	ND	1.05	NA
4	3002-SD	105	1.47	0.01
5	3001-SD	ND	1.51	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, if necessary, and comparison of the substrate at the various stations. Organic content was also determined for the three samples collected at stations where benthos and bioassay samples were collected. The TOC and organic content results are presented in the following table.

Sediment Characteristics for Falls Creek, Drill Site D

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	3005-SD	11,600	10.1/12	Grey sand, and "vermiculite"-like substance overlying dark brown silty peat
2	3004-SD	18,600	17.2/18.3	Dark brown silty peat
3	3003-SD	50,200	-	Dark brown silty peat
4	3002-SD	82,700	21.3	Dark brown silty peat
5	3001-SD	26,600	-	Dark brown peaty silt

In 1997 DOE collected four sediment samples from the downstream portion of an "unnamed reference area creek" that crosses Infantry Road approximately at Mile 16.5. This stream is the next drainage west of Falls Creek. The DOE sample locations are shown in a DOE figure in

Appendix B and in Figure 4.6-2. Two of these four samples were analyzed for TOC and metals as shown in the accompanying table, Appendix B. The 1998 investigation did not sample along this stream, thus no comparison of results can be made.

4.6.4.3.4 Benthos

Benthic samples were collected at Stations 1, 2, and 4 on Falls Creek. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Falls Creek, Drill Site D

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	4
Turbellaria	Tricladida	Planariidae	flatworm	adult		7	2
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult	8	8	29
Peleycopoda	Spaeracea	Sphaeriidae	clam	juvenile	96		
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph			1
	Trichoptera	Limniphilidae	caddisfly	larva	48	9	2
	Diptera	Chironomidae	midge	larva	152	10	10
		Simulidae	blackfly	larva		1	
Crustacea	Amphipoda	Gammaridae	scud	adult	128		
		Talitridae (genus Hyalella sp.)	scud	adult	360		
				Total	**792**	**35**	**44**
				Family Biotic Index	6.73	5.54	7.09
				EPT Relative Abundance	6.1%	25.7%	6.8%
				Species Diversity	1.44	1.47	0.98

4.6.4.3.5 Sediment Toxicity Tests

Sediment samples collected from the same three stations as the benthic invertebrate samples were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation.

Measurements of toxicity include survival (the percentage of initial seed organisms surviving to the end of the test), growth (average dry weight of surviving organisms), and biomass (total dry weight of surviving organisms). Since the toxicity tests were conducted in three batches, the data were control normalized in order to make appropriate comparisons. Normalization consisted of expressing the results as a percentage of the average laboratory control response for

the laboratory control sample tested concurrently with the particular sample. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Sediment Toxicity Results, Falls Creek, Drill Site D

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	46.25%	49.35%	1.367	185.1%	6.37	92.2%
2	26.25%	27.99%	1.005	136.0%	2.30	33.2%
4	53.75%	57.35%	0.748	101.3%	4.00	57.9%

4.6.4.3.6 Fish

Fish samples were collected at Stations 1 and 4. An attempt was made to collect a third sample at Station 2, but the stream channel was mostly underground and could not be sampled. Specific data on fish sampling are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish.

Fish Sample Descriptions for Falls Creek, Drill Site D

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	3007-FS	2.6 - 7.5	10	350	35	2,770
4	3006-FS	1.6 - 6.3	33	325	9.8	1,695

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.6-7 and summarized below.

Eighteen metals were detected in the fish tissue samples. Concentrations were compared to background concentrations determined for fish from upland reference streams and to EPA Region III RBCs for fish consumption. No metals in fish from Falls Creek exceeded their respective RBCs with the exception of inorganic arsenic, discussed below. Chromium in the sample from Station 1 exceeded the background concentration of chromium in fish from reference streams by about 11 percent. The chromium concentration in the fish sample from Station 4 was only about half as great and within the range of concentrations found in background samples. Barium and titanium exceeded background by 1 and 3 percent in the sample from Station 4, and by 27 and 28 percent in the sample from Station 1. Nickel was

reported in both samples at 0.142 and 0.184 mg/kg; nickel was not reported in any of the reference stream fish samples, with a reporting limit of 0.125 mg/kg.

The inorganic arsenic concentration in the two fish samples from Falls Creek, at 4.11 and 3.79 ug/kg, was about twice the RBC but only about one-tenth the background concentration.

The PCB Aroclor 1260 was detected in both fish samples from Falls Creek. The sample from Station 1 contained 0.183 mg/kg, and the sample from Station 4 contained 0.0325 mg/kg. These were the two highest concentrations of PCBs reported in any of the fish tissue samples from the 1998 Drill Site Investigation. Both occurrences exceed the 0.0016 mg/kg RBC for fish consumption by humans.

No PAHs were detected in the fish tissue samples from Falls Creek.

4.6.5 Summary

The three mud pits at Drill Site D contain a total of about 15,000 cubic yards of drilling mud. Portions of the mud pits are located above grade, especially the eastern ends of the northeast and south mud pits which are perched above an unnamed lake. The culverts, trenches, and piping manifold located in the mud pit berms act to regulate the level of water in the pits, thus preventing the water level in the pits from rising and overtopping the berms. The mud pits do not appear to have eroded significantly to date. However, if some force or event (such as an earthquake or significant erosion) caused the mud pit berms to rupture, drilling mud in the pits could flow into the unnamed lake and Falls Creek, causing ecological impacts. The drilling mud encountered at the drill sites was moderately to very stiff, and would not flow easily unless it was eroded and transported by water. A failure of the manifold downslope from the northeast mud pit could result in rapid release of much of the water in the pits. However, since the intake of the pipe in the pit is at about the elevation of the top of the mud, it is likely that only a relatively small amount of mud would be released in the event of such a failure.

The drilling mud in the Drill Site D mud pits contains elevated levels of DRO and associated PAHs, PCBs, cadmium, chromium, and copper. Low levels of volatiles were also detected, and several other metals were detected at higher average concentrations than in samples from other mud pits on the island. The DRO concentrations ranged from 58.3 to 2,420 mg/kg, and the total PAHs associated with the DRO ranged from 0.07 to 27.6 mg/kg. The PCB Aroclor 1260 was detected in drilling mud samples at concentrations of 0.055 to 0.2 mg/kg from one third of the samples analyzed, primarily from the northeast mud pit. The water samples from the mud pits had very few contaminants detected above reference stream levels. DRO concentrations ranged from not detected to 125 mg/kg, which is generally within the range detected in the reference streams. No volatiles or PAHs were detected, and only aluminum, in a single sample, slightly exceeded the upland reference stream concentration and ERSBC.

Relatively few compounds were detected at elevated levels in the sediment and surface water samples from the lake immediately downslope of the mud pits. DRO in the lake sediment was above that detected in the reference streams. The only other constituents that were detected at concentrations above both reference stream levels and ERBSCs were chromium and copper in sediment, and aluminum and chromium in surface water. As with the mud pits, the concentrations of several other metals detected in sediment, including barium, calcium, cerium, potassium, and thorium, were elevated relative to the sediment from the upland reference streams.

Sediment and water samples from the five Falls Creek stream sampling stations show an impact from the mud pits only at Station 1, a short distance downstream from the northeast mud pit and lake. Evidence of diesel at Station 1 included a faint odor and oily sheen observed in disturbed stream sediment. Sediment from Station 1 contained DRO at concentrations that are up to twice the level of biogenic DRO detected in the upland reference stream sediments. Low levels of associated PAHs were also detected in Station 1 sediment, as was an elevated concentration of chromium. Downstream from Station 1, DRO, PAHs, and elevated metals were generally not detected in sediment. The elevated sediment constituents at Station 1 appear to be remnants from the extensive mud releases to this stream that occurred about 30 years ago. It is likely that flushing and dilution has reduced the concentrations of these compounds farther downstream from the source area (mud pits).

DRO concentrations in the Falls Creek surface water samples are relatively low, and are comparable to the concentrations of biogenic DRO in surface water samples from the reference streams. No VOCs or PAHs were detected in any of the surface water samples from the stream, and the only metal detected at an elevated concentration was chromium, at Station 5. Although this detection is about three times the chromium concentration found in the upland reference streams, it only slightly exceeds the ERBSC.

Neither of the two fish samples collected from Falls Creek exceeded the EPA Region III RBCs for human consumption for any constituents except inorganic arsenic and PCBs. The arsenic concentrations, however, were only about one tenth of the concentration detected in upland reference streams and therefore cannot be attributed to site-related activities. The fish samples contained PCBs at concentrations of 0.183 mg/kg at Station 1 and 0.0325 mg/kg at Station 4. It appears likely that drilling mud is the source of PCBs in fish since the fish were resident and presumably could not have been exposed to PCBs in the ocean. PCBs were probably introduced to the stream environment during historic mud spill events, where they have persisted. Based on our field observations, there does not appear to be an existing mechanism for PCBs to migrate to the stream. Although overflow water drains from pits, the drilling mud that contains the PCBs remains in the bottom of the pits. Since PCBs have a very low solubility in water, they tend to adhere to solid particles, and would only migrate to the stream by sediment transport. Therefore, PCBs in the mud pits would tend to remain in place under current conditions.

The Triad Analysis (see Appendix F) provided an overall evaluation the sediment quality of Falls Creek relative to 15 locations on the upland streams investigated. The overall rankings for the

Falls Creek stations, based on a combination of benthic, sediment chemistry, and sediment toxicity rankings, are as follows:

Falls Creek	
Station 1	7th
Station 2	5th
Station 4	12th

This system assigns the highest rank (or lowest number) to the station with the best sediment quality. The rankings for Falls Creek were better than for several of the upland reference stream stations, and the mean for the stream as a whole ranks within the range of the reference streams. Station 1, which was the only location where mud pit-related chemicals were detected at elevated levels, had the lowest rank (15th) in terms of sediment chemistry, but nevertheless had the highest rank for toxicity. Station 2 had overall sediment quality that was good relative to the comparable locations along the reference streams, whereas Station 4 ranked lower than the corresponding reference stream locations.

In summary, Falls Creek has experienced significant recovery since the historic mud spills occurred. PCBs are present in the fish collected from Falls Creek and therefore the stream's ecological system. Presumably, the PCBs entered the system during historic mud spills. In their current condition, Drill Site D mud pits are unlikely to allow transport of additional drilling mud to Falls Creek. Other compounds discussed above including metals, DRO, and PAHs do not appear to be accumulating in fish tissue or to be adversely impacting benthic invertebrates Aluminum exceeded the background concentration and its ERBSC for surface water in the mud pits and the unnamed lake, but was not detected in stream water samples. There were no metals that exceeded background and corresponding ERBSCs in surface water from Falls Creek.

TABLE 4.6-1
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1037-SW	98DOE-DRSD-1038-SW	98DOE-DRSD-1039-SW	98DOE-DRSD-1040-SW	98DOE-DRSD-1041-SW	98DOE-DRSD-1042-SW	98DOE-DRSD-1079-SW	98DOE-DRSD-1080-SW	98DOE-DRSD-1081-SW (Duplicate)	98DOE-DRSD-1082-SW
			S mud pit			NW mud pit			NE mud pit			
Diesel Range Hydrocarbons	AK 102	-	ND(50)	ND(50)	66.4	57.3	79.5	61.4	71	77.7	125	68.3
Volatile Organic Compounds												
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	4.87 U	4.92 U	6.28 U	ND(2)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons												
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(ghi)perylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Chrysene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)

TABLE 4.6-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1037-SW	98DOE-DRSD-1038-SW	98DOE-DRSD-1039-SW	98DOE-DRSD-1040-SW	98DOE-DRSD-1041-SW	98DOE-DRSD-1042-SW	98DOE-DRSD-1079-SW	98DOE-DRSD-1080-SW	98DOE-DRSD-1081-SW (Duplicate)	98DOE-DRSD-1082-SW
			S mud pit			NW mud pit			NE mud pit			
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals												
Aluminum	EPA 6020	87.1 [b]	64.4	75.8	86.3	ND(50)	ND(50)	57.7	70.6	83.3	75.3	92
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	8,810 [b]	2,070	2,130	2,190	2,410	2,450	2,410	3,000	3,060	3,030	2,980
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	2.82	3.68	2.8	3.45
Cobalt	EPA 6020	9.52	4.27	4.44	4.49	4.28	4.36	4.46	4.82	ND(1)	ND(1)	2.24
Copper	EPA 6020	13.4 [b]	2.78	2.67	2.81	2.17	2.38	2.37	1.43 J	1.64	1.31 J	1.74

TABLE 4.6-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSD-037-SW	98DOE-DRSD-038-SW	98DOE-DRSD-039-SW	98DOE-DRSD-040-SW	98DOE-DRSD-041-SW	98DOE-DRSD-042-SW	98DOE-DRSD-079-SW	98DOE-DRSD-080-SW	98DOE-DRSD-081-SW (Duplicate)	98DOE-DRSD-082-SW
			S mud pit			NW mud pit			NE mud pit			
Iron	EPA 6010B	2,830 [b]	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	1,600	1,610	1,600	1,470	1,450	1,450	1,700	1,790	1,750	1,770
Manganese	EPA 6020	2.748	14.4	14.9	16.9	14.2	14.5	15	15.5	3.41	3.17	9.27
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	**1.05**	ND(1)
Nickel	EPA 6020	1.69 [b]	1.48	1.49	1.52	1.31	1.51	1.56	1.21	ND(1) UJ	ND(1)	**2.1 J**
Potassium	EPA 6010B	1,190 [b]	622	831	902	713	ND(200)	892	987	753 J	989	940 J
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	16.6	16.4	16.9	18.1	17.5	17.9	20.9	21.7	21	21.3
Thallium	EPA 6020	2.13 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1) UJ	ND(1)	1.62 J	ND(1)
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1) UJ	ND(1) UJ	**1.15 J**	**1.55 J**
Titanium	EPA 6020	2.37 [b]	1.21	**3**	**2.41**	ND(1)	ND(1)	1.05	ND(1) UJ	1.02 J	ND(1) UJ	1.11 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Zinc	EPA 6020	12.8 [b]	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

TABLE 4.6-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in micrograms per liter)

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.6-2
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1044-SD	98DOE-DRSD-1045-SD	98DOE-DRSD-1046-SD	98DOE-DRSD-1047-SD	98DOE-DRSD-1048-SD	98DOE-DRSD-1049-SD	98DOE-DRSD-1050-SD
			S mud pit					NW mud pit	
		Depth (feet)	0-0.25	0-0.25	0-0.25	0-0.1	0-0.25	0-1	4.5-5.5
Diesel Range Hydrocarbons	AK 102	-	138	58.3	100	1,800	393	468	101
Volatile Organic Compounds									
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.018) UJ	ND(0.0199) UJ	ND(0.0217) UJ	ND(0.0411) UJ	ND(0.0248) UJ	0.242	0.166
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.018) UJ	ND(0.0199) UJ	ND(0.0217) UJ	ND(0.0411) UJ	ND(0.0248) UJ	0.245	ND(0.125)
2-Butanone	EPA 8260B	-	ND(0.036) UJ	ND(0.0398) UJ	ND(0.0433) UJ	ND(0.0821) UJ	ND(0.0495) UJ	ND(4.5)	ND(3.13)
Carbon disulfide	EPA 8260B	-	ND(0.018) UJ	ND(0.0199) UJ	ND(0.0217) UJ	ND(0.0411) UJ	ND(0.0248) UJ	ND(0.45)	ND(0.313)
Methylene chloride	EPA 8260B	-	ND(0.018) UJ	ND(0.0199) UJ	ND(0.0217) UJ	ND(0.0411) UJ	ND(0.0248) UJ	ND(0.9)	ND(0.625)
Naphthalene	EPA 8260B	-	ND(0.018) UJ	ND(0.0199) UJ	ND(0.0217) UJ	ND(0.0411) UJ	ND(0.0248) UJ	0.278	0.266
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	0.105	ND(0.0163)	0.291	0.0508
Anthracene	EPA 8270C	-	0.024	0.0159	0.0231	ND(0.131)	0.0198	0.196	0.0134
Benzo(a)anthracene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)
Benzo(a)pyrene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	0.00885	ND(0.0033)
Benzo(ghi)perylene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Inland Stream Background Concentration	98DOE-DRSD-1044-SD	98DOE-DRSD-1045-SD	98DOE-DRSD-1046-SD	98DOE-DRSD-1047-SD	98DOE-DRSD-1048-SD	98DOE-DRSD-1049-SD	98DOE-DRSD-1050-SD
		Depth (feet)	S mud pit					NW mud pit	
			0-0.25	0-0.25	0-0.25	0-0.1	0-0.25	0-1	4.5-5.5
Chrysene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)
Fluoranthene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	0.0701	ND(0.0163)	0.0464	0.00575
Fluorene	EPA 8270C	-	0.0745	0.0451	0.0664	0.386	0.0198	0.996	0.155
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	ND(0.0033)	ND(0.0033)
Naphthalene	EPA 8270C	-	ND(0.0119)	ND(0.0131)	ND(0.0143)	ND(0.0217)	ND(0.0163)	0.232	0.0555
Phenanthrene	EPA 8270C	-	0.144	0.0928	0.0751	0.837	0.0264	3.6	0.55
Pyrene	EPA 8270C	-	0.024	ND(0.0131)	ND(0.0143)	0.127	ND(0.0163)	0.0874	0.00958
Polychlorinated Biphenyls									
Aroclor 1260	EPA 8082	-	ND(0.18) UJ	ND(0.199) UJ	ND(0.217) UJ	ND(0.329) UJ	ND(0.248) UJ	-	ND(0.05) UJ
Metals									
Aluminum	EPA 6010B	47,500	19,100	16,100	26,400	16,900	20,500	32,800	40,500
Arsenic	EPA 6020	30.5	3.21 J	4.48 J	4.24 J	3.82 J	2.82 J	7.15 J	2.94 J
Barium	EPA 6020	468	122	99.2	175	181	126	356	140
Beryllium	EPA 6020	ND	ND(1.8) UJ	**1.99 J**	ND(2.17) UJ	ND(3.29) UJ	ND(2.48) UJ	ND(0.5)	ND(2.5)
Boron	EPA 6010B	6.42 [b]	**34**	ND(9.94)	ND(10.8)	**37.5**	ND(12.4)	3.45	ND(2.5)
Cadmium	EPA 6020	ND	ND(1.8) UJ	ND(1.99) UJ	ND(2.17) UJ	ND(3.29) UJ	ND(2.48) UJ	**0.604 J**	ND(0.5) UJ
Calcium	EPA 6010B	7,720	7,660	6,570	**12,800**	**10,400**	**9,050**	**21,500**	**21,300**

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1044-SD	98DOE-DRSD-1045-SD	98DOE-DRSD-1046-SD	98DOE-DRSD-1047-SD	98DOE-DRSD-1048-SD	98DOE-DRSD-1049-SD	98DOE-DRSD-1050-SD
		Depth (feet)	S mud pit					NW mud pit	
			0-0.25	0-0.25	0-0.25	0-0.1	0-0.25	0-1	4.5-5.5
Cerium	EPA 6020	13	**29.6**	**26.7**	**51.6**	**59.3**	**58.4**	**28.2**	11.1
Cesium	EPA 6020	ND	ND(1.8) UJ	**2.17 J**	ND(2.17) UJ	ND(3.29) UJ	ND(2.48) UJ	**1.04 J**	ND(0.5) UJ
Chromium	EPA 6020	18.9	**124**	**107**	**160**	**206**	**166**	**491**	**203**
Cobalt	EPA 6020	37.3	7.38	7.94	11	8.13	8.28	9.64	15.8
Copper	EPA 6020	82.4	**56.9**	**55.8**	**92.2**	**60**	**63.6**	**186**	**119**
Iron	EPA 6010B	123,000	15,600	10,900	24,300	18,600	17,400	44,400	40,800
Lithium	EPA 6020	21.7	5.68	6.58	7.81	7.41	5.23	9	14
Magnesium	EPA 6010B	17,000	4,290	3,530	6,900	6,220	6,310	11,000	**20,800**
Manganese	EPA 6020	26,500	272	222	698	380	397	1,030	856
Molybdenum	EPA 6020	ND	ND(1.8)	**2.39**	ND(2.17)	ND(3.29)	ND(2.48)	ND(10) UJ	ND(0.5) UJ
Nickel	EPA 6020	23.8	15.2 J	14.7 J	18.8 J	12.6 J	16.8 J	5.64	**25.9**
Potassium	EPA 6010B	1,290	708 J	529 J	1,240 J	1,120 J	911 J	**3,380 J**	**2,590 J**
Selenium	EPA 6020	3.15 [b]	ND(1.8) UJ	ND(1.99) UJ	ND(2.17) UJ	ND(3.29) UJ	ND(2.48) UJ	0.91	ND(0.5)
Strontium	EPA 6020	207	80.9	68.6	122	149	103	**280**	**364**
Thallium	EPA 6020	ND	ND(1.8) UJ	**2.31 J**	ND(2.17) UJ	ND(3.29) UJ	ND(2.48) UJ	ND(0.5) UJ	ND(0.5) UJ
Thorium	EPA 6020	ND	**7.86**	**7.08**	**16**	**21.3**	ND(2.48)	**4.4 J**	**1.33 J**
Titanium	EPA 6020	1,480	682	628	1,320	913	629	**2,350**	280

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1044-SD	98DOE-DRSD-1045-SD	98DOE-DRSD-1046-SD	98DOE-DRSD-1047-SD	98DOE-DRSD-1048-SD	98DOE-DRSD-1049-SD	98DOE-DRSD-1050-SD
		Depth (feet)	S mud pit					NW mud pit	
			0-0.25	0-0.25	0-0.25	0-0.1	0-0.25	0-1	4.5-5.5
Uranium	EPA 6020	ND	**2.81**	**2.46**	**5.97**	**5.99**	**6.72**	**1.84 J**	**0.555 J**
Vanadium	EPA 6020	336	54.9	42.7	75.4	47.1	49	92	156
Zinc	EPA 6020	185	49.7	40.8	79.2	48.8	55.9	73.2	53.1

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1051-SD	98DOE-DRSD-1052-SD (Duplicate)	98DOE-DRSD-1053-SD	98DOE-DRSD-1069-SD	98DOE-DRSD-1070-SD	98DOE-DRSD-1071-SD	98DOE-DRSD-1072-SD	98DOE-DRSD-1073-SD	98DOE-DRSD-1074-SD
			NW mud pits								
		Depth (feet)	0-1	0-1	5.5-6.5	0-0.7	5.7-6.7	0-0.8	5.5-6.5	0-0.8	6-7
Diesel Range Hydrocarbons	AK 102	-	475	1,080	1,970	911	285	644	2,420	357	62.2
Volatile Organic Compounds											
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.18)	ND(0.366)	ND(0.464)	ND(0.12)	ND(0.1)	0.146 J	ND(0.18)	ND(0.12)	ND(0.14)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.18)	ND(0.366)	ND(0.464)	ND(0.12)	ND(0.1)	ND(0.12)	ND(0.18)	ND(0.12)	ND(0.14)
2-Butanone	EPA 8260B	-	ND(4.5)	ND(9.14)	ND(11.6)	ND(3)	ND(2.5)	ND(3)	ND(4.5)	ND(3)	ND(3.5)
Carbon disulfide	EPA 8260B	-	ND(0.45)	ND(0.914)	ND(1.16)	ND(0.6)	ND(0.5)	ND(0.6)	ND(0.9)	ND(0.6)	ND(0.7)
Methylene chloride	EPA 8260B	-	ND(0.9)	ND(1.83)	ND(2.32)	ND(0.6)	ND(1)	ND(0.6)	ND(0.9)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	0.533	0.682	ND(0.464)	ND(0.12)	ND(0.1)	0.411	ND(0.18)	ND(0.12)	ND(0.14)
Polycyclic Aromatic Hydrocarbons											
Acenaphthene	EPA 8270C	-	1.34	0.413	0.71	0.0887	0.109	0.189	0.207	0.0719	0.0225
Anthracene	EPA 8270C	-	ND(0.0033)	0.312	ND(0.412)	0.0459	0.0546	0.0787	ND(0.1)	0.045	0.00721
Benzo(a)anthracene	EPA 8270C	-	0.018	ND(0.00862)	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Benzo(a)pyrene	EPA 8270C	-	ND(0.0033)	ND(0.00862)	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Benzo(b)fluoranthene	EPA 8270C	-	0.054	0.0174	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Benzo(ghi)perylene	EPA 8270C	-	0.00771	ND(0.00862)	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1051-SD	98DOE-DRSD-1052-SD (Duplicate)	98DOE-DRSD-1053-SD	98DOE-DRSD-1069-SD	98DOE-DRSD-1070-SD	98DOE-DRSD-1071-SD	98DOE-DRSD-1072-SD	98DOE-DRSD-1073-SD	98DOE-DRSD-1074-SD
			NW mud pit								
		Depth (feet)	0-1	0-1	5.5-6.5	0-0.7	5.7-6.7	0-0.8	5.5-6.5	0-0.8	6-7
Benzo(k)fluoranthene	EPA 8270C	-	0.00642	ND(0.00862)	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Chrysene	EPA 8270C	-	0.027	0.00871	ND(0.0068)	0.00641	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Fluoranthene	EPA 8270C	-	0.243	0.0975	0.0412	0.0299	0.01	0.0192	ND(0.0165)	0.012	0.00541
Fluorene	EPA 8270C	-	4.83	1.54	2.35	0.433	0.319	0.647	0.719	0.23	0.0577
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	0.0218	ND(0.00862)	ND(0.0068)	ND(0.0033)	ND(0.0033)	ND(0.0033)	ND(0.0165)	ND(0.0033)	ND(0.0033)
Naphthalene	EPA 8270C	-	0.862	0.152	0.151	0.0214 R	0.0583 R	0.15 R	0.0382 R	0.033 R	0.0171 R
Phenanthrene	EPA 8270C	-	19.7	6.3	7.37	0.853	0.863	1.86	1.53	0.638	0.194
Pyrene	EPA 8270C	-	0.437	0.178	0.0797	0.0534	0.0209	0.0374	ND(0.0165)	0.023	0.00631
Polychlorinated Biphenyls											
Aroclor 1260	EPA 8082	-	-	-	-	-	0.0669 J	ND(0.05) UJ	-	ND(0.05) UJ	ND(0.05) UJ
Metals											
Aluminum	EPA 6010B	47,500	25,800	22,200	28,100	25,100	40,100	22,700	16,500	34,000	19,000
Arsenic	EPA 6020	30.5	6.71 J	6.41 J	4.07 J	5.37	7.24	6.45	1.96	8.85	2.02
Barium	EPA 6020	468	298	279	102	399	132	335	89.9	614	73.6
Beryllium	EPA 6020	ND	ND(0.5)	ND(1.31)	ND(1.03)	ND(0.5)	ND(10)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)
Boron	EPA 6010B	6.42 [b]	ND(2.5)	ND(6.53)	ND(5.15)	ND(2.5)	ND(2.5)	3.87	ND(2.5)	3.71	ND(2.5)
Cadmium	EPA 6020	ND	ND(0.5) UJ	ND(1.31) UJ	1.03 J	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	0.642	ND(0.5)

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1051-SD	98DOE-DRSD-1052-SD (Duplicate)	98DOE-DRSD-1053-SD	98DOE-DRSD-1069-SD	98DOE-DRSD-1070-SD	98DOE-DRSD-1071-SD	98DOE-DRSD-1072-SD	98DOE-DRSD-1073-SD	98DOE-DRSD-1074-SD
		Depth (feet)	NW mud pit								
			0-1	0-1	5.5-6.5	0-0.7	5.7-6.7	0-0.8	5.5-6.5	0-0.8	6-7
Calcium	EPA 6010B	7,720	26,400	24,500	13,100	16,500	22,500	20,500	8,410	22,300	12,900
Cerium	EPA 6020	13	27.7	32.9	22.5	39.4	23	26.6	11	36.4	12.1
Cesium	EPA 6020	ND	0.731 J	ND(1.31) UJ	1.16 J	1.38 J	0.666 J	0.578 J	ND(0.5) UJ	1.51 J	ND(0.5) UJ
Chromium	EPA 6020	18.9	1,040	1,020	133	419	238	1,090	112	161	93.8
Cobalt	EPA 6020	37.3	10.6	10.6	8.91	9.42	20.3	10	10.1	10.9	7.96
Copper	EPA 6020	82.4	142	130	61.3	114	239	135	76	186	105
Iron	EPA 6010B	123,000	39,100	31,600	19,900	35,000	52,000	36,800	18,700	48,600	21,300
Lithium	EPA 6020	21.7	9.58	8.35	4.11	9.33	10.4	8.82	5.76	10.8	8.87
Magnesium	EPA 6010B	17,000	11,800	10,500	3,980	9,250	13,200	10,600	7,630	10,600	9,940
Manganese	EPA 6020	26,500	852	842	336	1,050	1,100	685	319	1,310	450
Molybdenum	EPA 6020	ND	0.676 J	ND(1.31) UJ	4.53 J	ND(10)	ND(10)	ND(10)	2.32	ND(10)	ND(0.5)
Nickel	EPA 6020	23.8	8.17	9.23	15.7	9.11	10.7	6.92	17.8	4.87	7.53
Potassium	EPA 6010B	1,290	3,000 J	2,680 J	753 J	2,670	4,340	2,860	920	4,050	1,260
Selenium	EPA 6020	3.15 [b]	0.706	ND(1.31)	ND(1.03)	0.619	0.595	0.684	ND(0.5)	0.759	ND(0.5)
Strontium	EPA 6020	207	198	189	108	267	327	218	111	298	125
Thallium	EPA 6020	ND	ND(0.5) UJ	ND(1.31) UJ	1.16 J	ND(0.5) UJ	ND(0.5) UJ	ND(0.5) UJ	ND(0.5) UJ	ND(0.5) UJ	ND(0.5) UJ
Thorium	EPA 6020	ND	5.3 J	7.74 J	6.86 J	9.56 J	1.84 J	5.62 J	2.42 J	5.48 J	1.76 J

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-051-SD	98DOE-DRSD-052-SD (Duplicate)	98DOE-DRSD-053-SD	98DOE-DRSD-069-SD	98DOE-DRSD-070-SD	98DOE-DRSD-071-SD	98DOE-DRSD-072-SD	98DOE-DRSD-073-SD	98DOE-DRSD-074-SD
			NW mud pit								
		Depth (feet)	0-1	0-1	5.5-6.5	0-0.7	5.7-6.7	0-0.8	5.5-6.5	0-0.8	6-7
Titanium	EPA 6020	1,480	1,870	1,670	771	2,240 J	3,020 J	1,870 J	15,400 J	3,200 J	812 J
Uranium	EPA 6020	ND	2.17 J	2.99 J	2.78 J	4.34 J	0.907 J	2.21 J	0.87 J	2.53 J	0.65 J
Vanadium	EPA 6020	336	86.3	82.2	60.7	78.8	211	78.7	59.1	115	78.4
Zinc	EPA 6020	185	68.6	69.4	37.2	65.6	68.7	63.3	34.8	82.9	38.7

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1091-SD	98DOE-DRSD-1092-SD	98DOE-DRSD-1093-SD	98DOE-DRSD-1094-SD	98DOE-DRSD-1095-SD	98DOE-DRSD-1096-SD	98DOE-DRSD-1097-SD	98DOE-DRSD-1098-SD	98DOE-DRSD-1099-SD
			NE mud pit								
		Depth (feet)	0-1	2-3	0.2-12	0-1	2-3	0-1	3.1-4.1	0-1	4-5
Diesel Range Hydrocarbons	AK 102	-	372	45.7	543	210	711	457	243	444	342
Volatile Organic Compounds											
1,2,4-Trimethylbenzene	EPA 8260B	-	0.247	ND(0.22) UJ	ND(0.501)	ND(0.291)	0.449	ND(0.364)	ND(0.272)	ND(0.787)	0.658
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.125)	ND(0.22) UJ	ND(0.501)	ND(0.291)	ND(0.278)	ND(0.364)	ND(0.272)	ND(0.787)	ND(0.317)
2-Butanone	EPA 8260B	-	ND(3.13)	ND(5.5) UJ	ND(12.5)	ND(7.29)	ND(6.95)	ND(9.1)	ND(6.81)	ND(19.7)	ND(7.92)
Carbon disulfide	EPA 8260B	-	ND(0.625)	ND(1.1) UJ	ND(2.51)	ND(1.46)	ND(1.39)	ND(1.82)	ND(1.36)	ND(3.94)	ND(1.58)
Methylene chloride	EPA 8260B	-	ND(0.625)	ND(1.8) UJ	ND(2.51)	ND(1.46)	ND(1.39)	ND(1.82)	ND(1.36)	ND(3.94)	ND(1.58)
Naphthalene	EPA 8260B	-	0.284	ND(0.22) UJ	0.613	0.488	0.912	ND(0.364)	ND(0.272)	ND(0.787)	0.509
Polycyclic Aromatic Hydrocarbons											
Acenaphthene	EPA 8270C	-	0.104	0.0263	0.0835	0.106	0.248	0.0503	0.11	0.0827	0.0451
Anthracene	EPA 8270C	-	0.0361	ND(0.01)	0.0425	0.0456	0.1	0.027	0.0378	0.035	0.0197
Benzo(a)anthracene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Benzo(a)pyrene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	0.00927	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1091-SD	98DOE-DRSD-1092-SD	98DOE-DRSD-1093-SD	98DOE-DRSD-1094-SD	98DOE-DRSD-1095-SD	98DOE-DRSD-1096-SD	98DOE-DRSD-1097-SD	98DOE-DRSD-1098-SD	98DOE-DRSD-1099-SD
			NE mud pit								
		Depth (feet)	0-1	2-3	0.2-1.2	0-1	2-3	0-1	3.1-4.1	0-1	4-5
Benzo(ghi)perylene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Chrysene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Fluoranthene	EPA 8270C	-	0.00899	ND(0.0033)	0.00911	0.0101	0.0278	ND(0.0089)	0.0131	ND(0.0157)	ND(0.00697)
Fluorene	EPA 8270C	-	0.303	0.0874	0.251	0.304	0.79	0.18	0.383	0.238	0.123
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.0033)	ND(0.0033)	ND(0.00752)	ND(0.00836)	ND(0.00918)	ND(0.0089)	ND(0.00719)	ND(0.0157)	ND(0.00697)
Naphthalene	EPA 8270C	-	0.103	0.0232	0.0607	0.0845	0.236	0.0216	0.113	0.0763	0.0437
Phenanthrene	EPA 8270C	-	0.763	0.27	0.783	0.882	2.28	0.482	1.15	0.741	0.372
Pyrene	EPA 8270C	-	0.017	0.00527	0.0182	0.0186	0.0501	0.0126	0.0247	0.0254	0.00845
Polychlorinated Biphenyls											
Aroclor 1260	EPA 8082	-	0.0553 J	0.0904 J	ND(0.114) UJ	-	-	-	0.146 J	-	0.201 J
Metals											
Aluminum	EPA 6010B	47,500	20,100	11,900	17,100	14,500	27,200	29,200	29,800	20,900	29,200
Arsenic	EPA 6020	30.5	4.59 J	3.22 J	4.53 J	5.62 J	7.49 J	4.81 J	7 J	5.55 J	1.38 J
Barium	EPA 6020	468	314	120	326	210	439	255	304	690	221
Beryllium	EPA 6020	ND	ND(2.5)	ND(0.5)	ND(1.14)	ND(1.27)	ND(6.95)	ND(1.35)	ND(1.09)	ND(2.38)	ND(1.06)

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland/Stream Background Concentration	98DOE-DRSD-1091-SD	98DOE-DRSD-1092-SD	98DOE-DRSD-1093-SD	98DOE-DRSD-1094-SD	98DOE-DRSD-1095-SD	98DOE-DRSD-1096-SD	98DOE-DRSD-1097-SD	98DOE-DRSD-1098-SD	98DOE-DRSD-1099-SD
			NE mud pits								
		Depth (feet)	0-1	2-3	0.2-1.2	0-1	2-3	0-1	3.1-4.1	0-1	4-5
Boron	EPA 6010B	6.42 [b]	**6.68 J**	**7.63 J**	**6.84 J**	ND(6.34) UJ	**12 J**	ND(6.74) UJ	ND(5.45) UJ	ND(11.9) UJ	ND(5.28) UJ
Cadmium	EPA 6020	ND	0.888	ND(0.5)	ND(1.14)	ND(1.27)	ND(1.39)	ND(1.35)	ND(1.09)	ND(2.38)	ND(1.06)
Calcium	EPA 6010B	7,720	**17,300**	**32,700**	**22,700**	**20,900**	**31,200**	**15,900**	**33,000**	**31,200**	**20,500**
Cerium	EPA 6020	13	**23.8**	**16.1**	**31.8**	**28.9**	**34.4**	**30.9**	**27.9**	**49.9**	**31**
Cesium	EPA 6020	ND	**0.546**	ND(0.5)	ND(1.14)	ND(1.27)	ND(1.39)	ND(1.35)	ND(1.09)	ND(2.38)	ND(1.06)
Chromium	EPA 6020	18.9	404 J	240 J	549 J	574 J	912 J	418 J	676 J	773 J	**545 J**
Cobalt	EPA 6020	37.3	18.1 J	6.78 J	8.99 J	8.3 J	18.5 J	16 J	15.3 J	12.8 J	8.91 J
Copper	EPA 6020	82.4	180 J	56.5 J	88 J	74.3 J	172 J	114 J	168 J	113 J	51 J
Iron	EPA 6010B	103,000	36,900	10,100	24,300	18,600	38,800	36,600	40,600	26,900	22,700
Lithium	EPA 6020	21.7	6.83	3.52	6.95	6.22	10.4	3.72	9.42	8.63	12.2
Magnesium	EPA 6010B	17,000	11,300	5,460	9,230	7,130	15,600	10,200	15,000	11,300	8,270
Manganese	EPA 6020	26,500	1,020	360	886	612	1,150	915	1,060	1,160	527
Molybdenum	EPA 6020	ND	ND(1)	ND(0.5)	ND(11.4)	ND(6.34)	ND(27.8)	ND(6.74)	ND(10.9)	ND(11.9)	ND(1.06)
Nickel	EPA 6020	23.8	9.88	11.1	8.8	11.9	18.4	29.9	15.9	14.1	22.8
Potassium	EPA 6010B	1,290	**2,460 J**	930 J	**2,160 J**	**1,610 J**	**3,150 J**	**1,510 J**	**2,820 J**	**3,000 J**	**1,640 J**
Selenium	EPA 6020	3.15 [b]	0.705	ND(0.5)	ND(1.14)	ND(1.27)	ND(1.39)	ND(1.35)	ND(1.09)	ND(2.38)	ND(1.06)
Strontium	EPA 6020	207	**217 J**	**226 J**	**269 J**	**245 J**	**412 J**	**268 J**	**412 J**	**412 J**	170 J

TABLE 4.6-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Uplands Stream Background Concentration[a]	98DOE-DRSD-1091-SD	98DOE-DRSD-1092-SD	98DOE-DRSD-1093-SD	98DOE-DRSD-1094-SD	98DOE-DRSD-1095-SD	98DOE-DRSD-1096-SD	98DOE-DRSD-1097-SD	98DOE-DRSD-1098-SD	98DOE-DRSD-1099-SD
			NE mud pit								
		Depth (feet)	0-1	2-3	0.2-1.2	0-1	2-3	0-1	3.1-4.1	0-1	4-5
Thallium	EPA 6020	ND	ND(0.5)	ND(0.5)	ND(1.14)	ND(1.27)	ND(1.39)	ND(1.35)	ND(1.09)	ND(2.38)	ND(1.06)
Thorium	EPA 6020	ND	**2.92**	**3.68**	**9.38**	**9.05**	**8.19**	**6.63**	**5.63**	**15.3**	**8.22**
Titanium	EPA 6020	1,480	1,460 J	741 J	1,240 J	849 J	**2,680 J**	419 J	**2,590 J**	407 J	297 J
Uranium	EPA 6020	ND	**1.12**	**1.43**	**3.44**	**3.3**	**3.51**	**2.45**	**2.12**	**5.51**	**2.96**
Vanadium	EPA 6020	336	128 J	74.1 J	88.6 J	77.4 J	202 J	128 J	162 J	126 J	44.8 J
Zinc	EPA 6020	185	84.6 J	35.2 J	64.1 J	57.3 J	97.4 J	75.3 J	96.5 J	90.5 J	65 J

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

R result rejected due to quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.6-3
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration[a]	98DOE-DRSD-1083-SW	98DOE-DRSD-1084-SW	98DOE-DRSD-1085-SW
Diesel Range Hydrocarbons	AK 102	-	119	56.2	74
Volatile Organic Compounds					
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	4.1 U	3.17 U	4.42 U
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(ghi)perylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Chrysene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Metals					
Aluminum	EPA 6020	87.1[b]	146	ND(50)	186
Arsenic[c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	8,810[b]	4,740	4,700	5,700

TABLE 4.6-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSD-1083-SW	98DOE-DRSD-1084-SW	98DOE-DRSD-1085-SW
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	**10.5**	**11.5**	**10.5**
Cobalt	EPA 6020	9.52	5.01	5.18	4.66
Copper	EPA 6020	13.4 [b]	3.63	3.54	3.33 J
Iron	EPA 6010B	2,830 [b]	ND(150)	ND(150)	ND(150)
Lithium	EPA 6020	ND(1)	**1.13**	**1.12**	**1.18**
Magnesium	EPA 6010B	5,250	4,230	4,220	4,340
Manganese	EPA 6020	748	21.1	17.2	28.9
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	1.69 [b]	**1.87 J**	**1.92 J**	1.6
Potassium	EPA 6010B	1,190 [b]	**2,080 J**	**1,310 J**	**1,890**
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	38.5	38.4	39.9
Thallium	EPA 6020	2.13 [b]	ND(1)	ND(1)	ND(1) UJ
Thorium	EPA 6020	1.14 [b]	ND(1) UJ	ND(1) UJ	ND(1) UJ
Titanium	EPA 6020	2.37 [b]	**2.83 J**	**2.46 J**	**8.83 J**
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	1.44	**1.65**	**1.52**
Zinc	EPA 6020	12.8 [b]	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

TABLE 4.6-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in micrograms per liter)

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.6-4
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1086-SD	98DOE-DRSD-1087-SD	98DOE-DRSD-1088-SD	98DOE-DRSD-1089-SD	98DOE-DRSD-1090-SD
		Depth (feet)	0-0.3	0-0.3	0-0.3	0-0.3	0-0.3
Diesel Range Hydrocarbons	AK 102	-	125	130	146	97.3	66.2
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.005)	ND(0.0228)	ND(0.018)	ND(0.0248)	ND(0.0199)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.005)	ND(0.0228)	ND(0.018)	ND(0.0248)	ND(0.0199)
2-Butanone	EPA 8260B	-	ND(0.01)	ND(0.0456)	ND(0.036)	ND(0.0495)	0.0496 J
Carbon disulfide	EPA 8260B	-	0.0253 UJ	0.0379 UJ	ND(0.018)	0.0332 UJ	0.197 UJ
Methylene chloride	EPA 8260B	-	ND(0.005)	ND(0.0228)	ND(0.018)	ND(0.0248)	ND(0.0199)
Naphthalene	EPA 8260B	-	ND(0.005)	ND(0.0228)	ND(0.018)	ND(0.0248)	ND(0.0199)
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Anthracene	EPA 8270C	-	ND(0.0033)	ND(0.015)	0.0216	ND(0.0163)	ND(0.0131)
Benzo(a)anthracene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Benzo(a)pyrene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Benzo(ghi)perylene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Chrysene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Fluoranthene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)

TABLE 4.6-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentrations	98DOE-DRSD-1086-SD	98DOE-DRSD-1087-SD	98DOE-DRSD-1088-SD	98DOE-DRSD-1089-SD	98DOE-DRSD-1090-SD
		Depth (feet)	0-0.3	0-0.3	0-0.3	0-0.3	0-0.3
Fluorene	EPA 8270C	-	ND(0.0033)	0.0243	0.0432	ND(0.0163)	ND(0.0131)
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.0033)	ND(0.015)	ND(0.0119)	ND(0.0163)	ND(0.0131)
Naphthalene	EPA 8270C	-	ND(0.0033) R	ND(0.015) R	ND(0.0119) R	ND(0.0163) R	ND(0.0131) R
Phenanthrene	EPA 8270C	-	0.00588	0.0213	0.207	ND(0.0163)	0.0609
Pyrene	EPA 8270C	-	ND(0.0033)	ND(0.015)	0.036	ND(0.0163)	0.0212
Polychlorinated Biphenyls							
Aroclor 1260	EPA 8082	-	-	-	-	-	-
Metals							
Aluminum	EPA 6010B	47,500	21,900	20,700	22,000	18,200	14,400
Arsenic	EPA 6020	30.5	ND(0.5)	4.82	5.08	3.01	3.38
Barium	EPA 6020	468	38.1	**515**	**484**	424	371
Beryllium	EPA 6020	ND	ND(0.5)	ND(2.28)	ND(1.8)	ND(2.48)	ND(1.99)
Boron	EPA 6010B	6.42 [b]	ND(2.5)	ND(11.4)	ND(9.01)	ND(12.4)	ND(9.93)
Cadmium	EPA 6020	ND	ND(0.5)	ND(2.28)	ND(1.8)	ND(2.48)	ND(1.99)
Calcium	EPA 6010B	7,720	6,710	**9,530**	**10,500**	**9,270**	**8,480**
Cerium	EPA 6020	13	9.45	**44.3**	**42.1**	**61.4**	**23.6**
Cesium	EPA 6020	ND	ND(0.5)	ND(2.28)	ND(1.8)	ND(2.48)	ND(1.99)
Chromium	EPA 6020	18.9	16.1	564	695	421	406

TABLE 4.6-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSD-1086-SD	98DOE-DRSD-1087-SD	98DOE-DRSD-1088-SD	98DOE-DRSD-1089-SD	98DOE-DRSD-1090-SD
		Depth (feet)	0-0.3	0-0.3	0-0.3	0-0.3	0-0.3
Cobalt	EPA 6020	37.3	2.63	9.66	9.83	7.23	5.65
Copper	EPA 6020	82.4	25.7	96.6	98.3	76.5	64.7
Iron	EPA 6010B	123,000	32,700	27,900	27,900	26,000	21,600
Lithium	EPA 6020	21.7	1.83	6.27	6.15	5.68	6.31
Magnesium	EPA 6010B	17,000	881	7,110	8,370	6,790	4,890
Manganese	EPA 6020	26,500	98.7	525	593	783	748
Molybdenum	EPA 6020	ND	ND(0.5) UJ	ND(2.28) UJ	ND(3.6) UJ	ND(2.48) UJ	ND(1.99) UJ
Nickel	EPA 6020	23.8	5.78	15.1	14.4	15.9	11.7
Potassium	EPA 6010B	1,290	216	**1,850**	**2,020**	**1,930**	**1,530**
Selenium	EPA 6020	3.15 [b]	ND(0.5)	ND(2.28)	ND(1.8)	ND(2.48)	ND(1.99)
Strontium	EPA 6020	207	59.4	182	200	163	146
Thallium	EPA 6020	ND	ND(0.5)	ND(2.28)	ND(1.8)	ND(2.48)	ND(1.99)
Thorium	EPA 6020	ND	**0.91**	**8.81**	**8.76**	**16.8**	**3.51**
Titanium	EPA 6020	1,480	416	**1,950**	**1,640**	1,290	1,170
Uranium	EPA 6020	ND	ND(0.5)	**3.57**	**3.96**	**6.22**	**2**
Vanadium	EPA 6020	336	32	99.7	83.2	73.6	57.3
Zinc	EPA 6020	185	13.6	73.4	71.8	68.1	55.8

TABLE 4.6-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE D LAKE
(concentrations in milligrams per kilogram)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

R result rejected due to quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.6-5
SURFACE WATER ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration[a]	98DOE-DRSD-3005-SW	98DOE-DRSD-3004-SW	98DOE-DRSD-3003-SW	98DOE-DRSD-3002-SW	98DOE-DRSD-3001-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	80 U	ND(50)	ND(50)	84.9 U	72.4 U
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
2-Butanone	EPA 8260B	-	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	ND(2)	3.03 U	4.95 U	ND(2)	ND(2)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(a)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(b)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(ghi)perylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Benzo(k)fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Chrysene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Indeno(1,2,3-cd)pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals							
Aluminum	EPA 6020	87.1[b]	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Arsenic[c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Beryllium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)

TABLE 4.6-5 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSD-3005-SW	98DOE-DRSD-3004-SW	98DOE-DRSD-3003-SW	98DOE-DRSD-3002-SW	98DOE-DRSD-3001-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Calcium	EPA 6010B	8,810 [b]	3,850	3,980	4,060	3,740	4,990
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	ND(1)	ND(1)	ND(1)	ND(1)	**12**
Cobalt	EPA 6020	9.52	3.01	2.83	3.05	3.55	4.59
Copper	EPA 6020	13.4 [b]	ND(1) UJ	1.41 J	1.4 J	1.23 J	3.3 J
Iron	EPA 6010B	2,830 [b]	ND(150)	199	171	174	ND(150)
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	**1.04**	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	3,650	3,690	3,750	3,690	4,350
Manganese	EPA 6020	748	10.4	15.7	14.3	14.8	17.1
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	**1.01**	ND(1)
Nickel	EPA 6020	1.69 [b]	ND(1)	ND(1)	ND(1)	1.13	1.59
Potassium	EPA 6010B	1,190 [b]	**1,990 J**	**1,980 J**	**2,040 J**	**1,910 J**	**2,270 J**
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	31.9	35.2	34.1	33.2	36.9
Thallium	EPA 6020	2.13 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	2.37 [b]	1.31 J	1.25 J	1.42 J	1.51 J	2.37 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	**1.62 J**	**1.74 J**	**1.74 J**	**1.92 J**	**2.37 J**
Zinc	EPA 6020	12.8 [b]	**23.3 J**	12.3 J	11.2 J	11 J	**14 J**

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

c Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

TABLE 4.6-5 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D
(concentrations in micrograms per liter)

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.6-6
SEDIMENT ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSD-3005-SD Station 1	98DOE-DRSD-3004-SD Station 2	98DOE-DRSD-3003-SD Station 3	98DOE-DRSD-3002-SD Station 4	98DOE-DRSD-3001-SD Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	176	ND(4)	ND(14.1)	ND(17.3)	ND(12.3)
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.6)	ND(1.94)	ND(1.73)	ND(1.39)
1,3,5-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.6)	ND(1.94)	ND(1.73)	ND(1.39)
2-Butanone	EPA 8260B	mg/kg	-	-	ND(15)	ND(48.5)	ND(43.4)	ND(34.6)
Carbon disulfide	EPA 8260B	mg/kg	-	-	ND(3)	ND(9.7)	ND(8.67)	ND(6.93)
Methylene chloride	EPA 8260B	mg/kg	-	-	ND(3)	ND(12.3)	ND(8.67)	ND(6.93)
Naphthalene	EPA 8260B	mg/kg	-	-	ND(0.6)	ND(1.94)	ND(1.73)	ND(1.39)
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	EPA 8270C	mg/kg	-	ND(0.00885)	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Anthracene	EPA 8270C	mg/kg	-	0.0161	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Benzo(a)anthracene	EPA 8270C	mg/kg	-	0.034	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Benzo(a)pyrene	EPA 8270C	mg/kg	-	0.0501	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Benzo(b)fluoranthene	EPA 8270C	mg/kg	-	0.0876	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Benzo(ghi)perylene	EPA 8270C	mg/kg	-	0.0143	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Benzo(k)fluoranthene	EPA 8270C	mg/kg	-	0.0322	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Chrysene	EPA 8270C	mg/kg	-	0.0215	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Fluoranthene	EPA 8270C	mg/kg	-	0.0232	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)

TABLE 4.6-6 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSD-3005-SD Station 1	98DOE-DRSD-3004-SD Station 2	98DOE-DRSD-3003-SD Station 3	98DOE-DRSD-3002-SD Station 4	98DOE-DRSD-3001-SD Station 5
Fluorene	EPA 8270C	mg/kg	-	0.0125	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Indeno(1,2,3-cd)pyrene	EPA 8270C	mg/kg	-	0.0197	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Naphthalene	EPA 8270C	mg/kg	-	ND(0.00885)	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Phenanthrene	EPA 8270C	mg/kg	-	0.125	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Pyrene	EPA 8270C	mg/kg	-	0.0554	ND(0.0033)	ND(0.0116)	ND(0.0143)	ND(0.0102)
Polychlorinated Biphenyls								
Aroclor 1260	EPA 8082	mg/kg	-	-	-	-	-	-
Metals								
Aluminum	EPA 6010B	mg/kg	47,500	11,900	9,490	15,700	17,500	38,200
Arsenic	EPA 6020	mg/kg	30.5	1.62 J	4.05 J	4.24 J	10 J	8.5 J
Barium	EPA 6020	mg/kg	468	86.9	53	61.3	139	181
Beryllium	EPA 6020	mg/kg	ND	ND(1.34)	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Boron	EPA 6010B	mg/kg	6.42 [b]	**17.2 J**	**45 J**	**29 J**	**149 J**	**163 J**
Cadmium	EPA 6020	mg/kg	ND	ND(1.34)	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Calcium	EPA 6010B	mg/kg	7,720	4,160	1,700	2,510	2,720	7,410
Cerium	EPA 6020	mg/kg	13	**14.6**	3.71	7.45	8.19	10.6
Cesium	EPA 6020	mg/kg	ND	ND(1.34)	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Chromium	EPA 6020	mg/kg	18.9	**226**	**23.1**	**20.6**	**36.2**	**31.2**

TABLE 4.6-6 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSD-3005-SD Station 1	98DOE-DRSD-3004-SD Station 2	98DOE-DRSD-3003-SD Station 3	98DOE-DRSD-3002-SD Station 4	98DOE-DRSD-3001-SD Station 5
Cobalt	EPA 6020	mg/kg	37.3	4.62	7.76	9.82	17.9	23.5
Copper	EPA 6020	mg/kg	82.4	44.5	21.5	55	21.7	**93.1**
Iron	EPA 6010B	mg/kg	123,000	8,960	20,200	14,900	68,600	**85,500**
Lithium	EPA 6020	mg/kg	21.7	2.51 J	2.89 J	3.9 J	4.6 J	16.6 J
Magnesium	EPA 6010B	mg/kg	17,000	2,610	1,660	1,760	2,010	**17,300**
Manganese	EPA 6020	mg/kg	26,500	256	1,430	1,490	2,310	2,080
Molybdenum	EPA 6020	mg/kg	ND	ND(1.34)	**0.555**	ND(1.76)	ND(2.17)	ND(1.54)
Nickel	EPA 6020	mg/kg	23.8	15.5	11.4	13.8	18	21.9
Potassium	EPA 6010B	mg/kg	1,290	442	175	248	415	1,060
Selenium	EPA 6020	mg/kg	3.15 [b]	ND(1.34)	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Strontium	EPA 6020	mg/kg	207	35.2	19.8	31.3	38.1	93.7
Thallium	EPA 6020	mg/kg	ND	ND(1.34) UJ	ND(0.5) UJ	ND(1.76) UJ	ND(2.17) UJ	ND(1.54) UJ
Thorium	EPA 6020	mg/kg	ND	ND(1.34)	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Titanium	EPA 6020	mg/kg	1,480	650 J	376 J	506 J	755 J	**1,590 J**
Uranium	EPA 6020	mg/kg	ND	**2.49**	ND(0.5)	ND(1.76)	ND(2.17)	ND(1.54)
Vanadium	EPA 6020	mg/kg	336	49.2	60.9	116	205	247
Zinc	EPA 6020	mg/kg	185	82 J	104 J	**256 J**	106 J	**231 J**
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	11,600	18,600	50,200	82,700	26,600

TABLE 4.6-6 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSD-3005-SD	98DOE-DRSD-3004-SD	98DOE-DRSD-3003-SD	98DOE-DRSD-3002-SD	98DOE-DRSD-3001-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Acid Volatile Sulfide	Titration	umol/g	-	170	ND(0.005)	ND(0.0176)	105	ND(0.0154)
Simultaneously Extracted Metals	Summation	umol/g	-	1.03	0.553	1.05	1.47	1.51

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

mg/kg milligrams per kilogram

umol/g micromoles per gram

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.6-7
FISH ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBCs	Upland Stream Background Concentration *	98DOE-DRSD-3007-F1	98DOE-DRSD-3006-F1
				Station 1	Station 4
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	SW8270 SIM	81.1	-	ND(0.0335)	ND(0.0067)
Acenaphthylene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0067)
Anthracene	SW8270 SIM	405.6	-	ND(0.0335)	ND(0.0335)
Benzo (a) anthracene	SW8270 SIM	0.0043	-	ND(0.168)	ND(0.0335)
Benzo (a) pyrene	SW8270 SIM	0.00043	-	ND(0.168)	ND(0.0335)
Benzo (b) fluoranthene	SW8270 SIM	0.0043	-	ND(0.168)	ND(0.0335)
Benzo (ghi) perylene	SW8270 SIM	NA	-	ND(0.168)	ND(0.0335)
Benzo (k) fluoranthene	SW8270 SIM	0.043	-	ND(0.168)	ND(0.0335)
Chrysene	SW8270 SIM	0.43	-	ND(0.168)	ND(0.0335)
Dibenzo (a,h) anthracene	SW8270 SIM	0.00043	-	ND(0.168)	ND(0.0335)
Fluoranthene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0335)
Fluorene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0067)
Indeno (1,2,3-cd) pyrene	SW8270 SIM	0.0043	-	ND(0.168)	ND(0.0335)
Naphthalene	SW8270 SIM	27.0	-	ND(0.0335)	ND(0.0067)
Phenanthrene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)
Pyrene	SW8270 SIM	40.6	-	ND(0.168) UJ	ND(0.0335)
Polychlorinated Biphenyls					
Aroclor 1016	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	-	-	ND(0.02) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1242	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1248	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1260	SW8081	0.0016	-	**0.183 J**	**0.0325 J**
Metals					
Aluminum	SW6020	1351.9	38.8	23.4	23.9
Arsenic (total)	SW6020	0.21	26.9	0.038	0.0485
Arsenic (inorganic)	EPA Draft 1632	0.0021	0.0456	0.00411	0.00379
Barium	SW6020	94.6	0.567	**0.722**	**0.571**
Beryllium	SW6020	2.7	ND	ND(0.0250)	ND(0.0250)
Boron	SW6020	121.7	24.1	9.4 UJ	9.04 UJ
Cadmium	SW6020	1.4	ND	ND(0.0250)	ND(0.0250)
Calcium	SW6020	NA	10,300	5,650	8,270
Cerium	SW6020	NA	ND	ND(0.0250)	ND(0.0250)
Cesium	SW6020	NA	ND	ND(0.0250)	ND(0.0250)

TABLE 4.6-7 (cont.)
FISH ANALYTICAL RESULTS FOR FALLS CREEK, DRILL SITE D
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBCs	Upland Stream Background Concentration[a]	98DOE-DRSD-3007-FI1 Station 1	98DOE-DRSD-3006-FI1 Station 4
Chromium	SW6020	4.1	0.684	**0.758**	0.312
Cobalt	SW6020	81.1	0.0510 [b]	ND(0.0500)	ND(0.0500)
Copper	SW6020	54.1	3.40	1.12 U	0.928 U
Iron	SW6020	405.6	73.6	66.5	51
Lithium	SW6020	27.0	ND	ND(0.0250)	ND(0.0250)
Magnesium	SW6020	NA	349	285	288
Manganese	SW6020	189.3	164	3.84	4.71
Molybdenum	SW6020	6.8	0.150 [b]	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	27.0	ND	**0.142**	**0.184**
Potassium	SW6020	NA	4,310	4,180	4,230
Selenium	SW6020	6.8	2.08	0.51	0.803
Strontium	SW6020	811.1	12.1 [b]	10.3	11.2
Thallium	SW6020	0.09	0.0755 [b]	ND(0.0250)	ND(0.0250)
Thorium	SW6020	NA	4.67 [b]	2.51 J, B	ND(2.50) UJ, B
Titanium	SW6020	5,407.4	0.834	**1.07**	**0.857**
Uranium	SW6020	4.1	ND	ND(0.500)	ND(0.500)
Vanadium	SW6020	9.5	0.289	0.236	0.244
Zinc	SW6020	405.6	78.0	32.9	38.5

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

B analyte detected in method blank

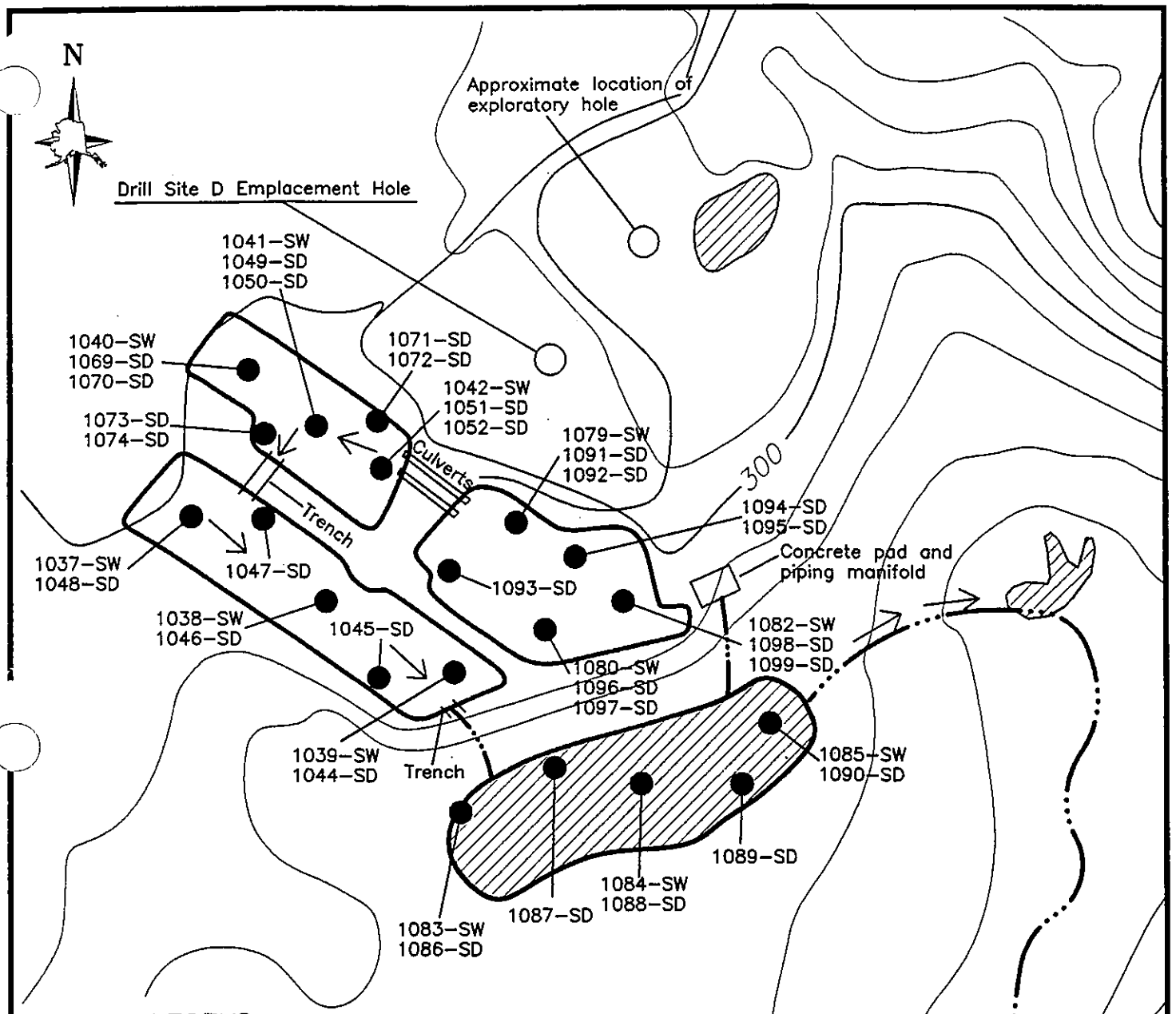
J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank or laboratory contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.



LEGEND

1037–SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE–DRSD").

Stream

Existing Mud Pit or Lake Investigated

Lake or Pond

Surface Water Flow

APPROXIMATE SCALE (FEET)

0 200 400

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968, and 1968 Air Photos

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE D

September 1999
Revision Number: 0

X–0926

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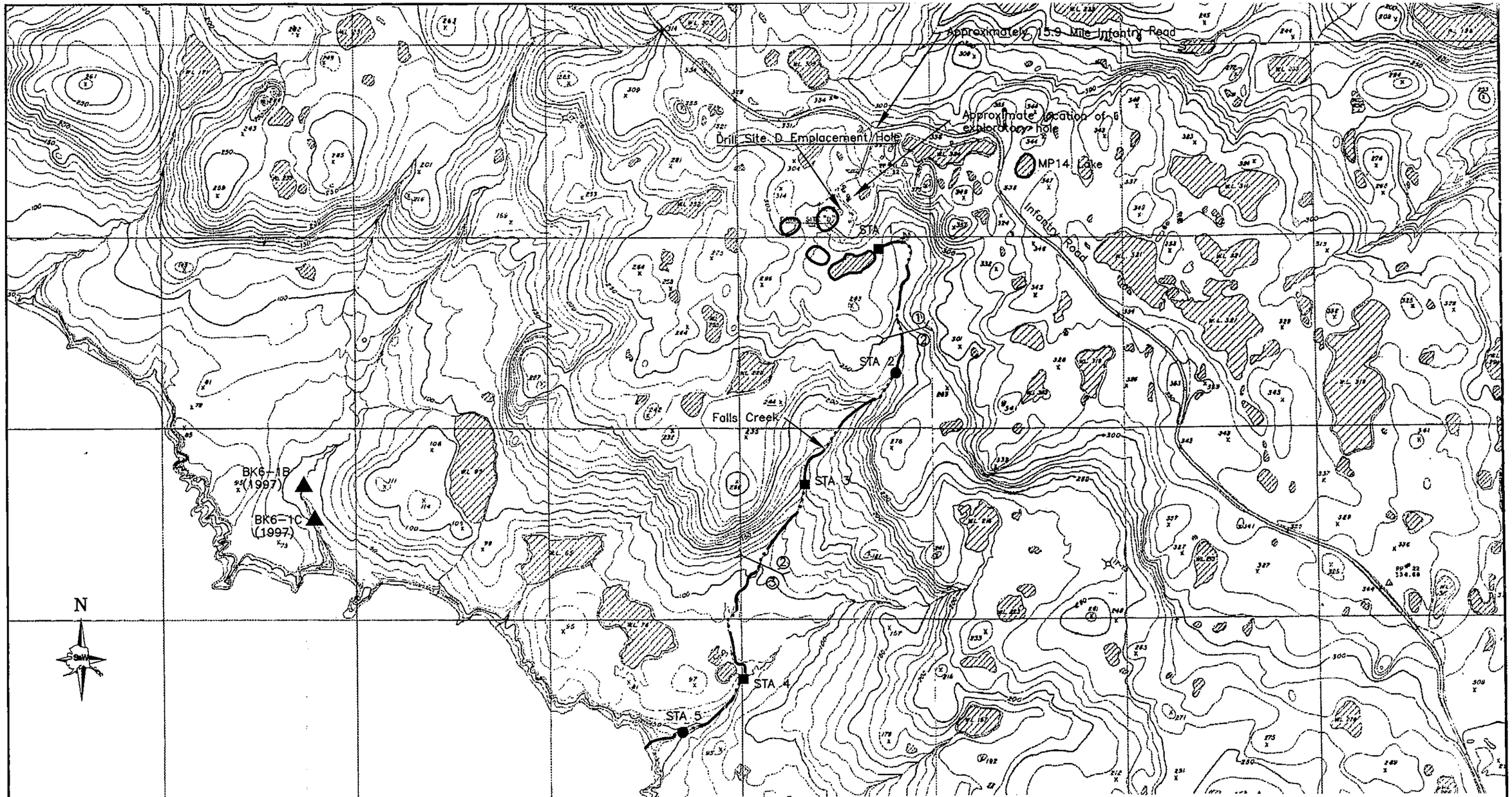
FIG. 4.6–1

FILE: P



LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Section 4.6.4.3 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and Benthic Invertebrate Sampling. (See Section 4.6.4.3 for Sample Numbers.)

② Reach Number

Reach Boundary

▲ Locations of Chemical Samples Collected by DOE in 1997

Investigated Stream Course

Existing Mud Pit or Lake

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

Reference: Drawing based on Amchitka Island Map Atlas Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE D STREAM

September 1999
Revision Number: 0

X-0926

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4.6-2

FILE: DrillSiteD

Photo 4.6-1: Water flowing through a trench into the south mud pit at Drill Site D. Water in the trench comes from the northwest mud pit. View is to the south.

Photo 4.6-2: Water exiting the south mud pit through a trench in the east wall. This water flows towards the unnamed lake at Drill Site D (not pictured). View is to the south.

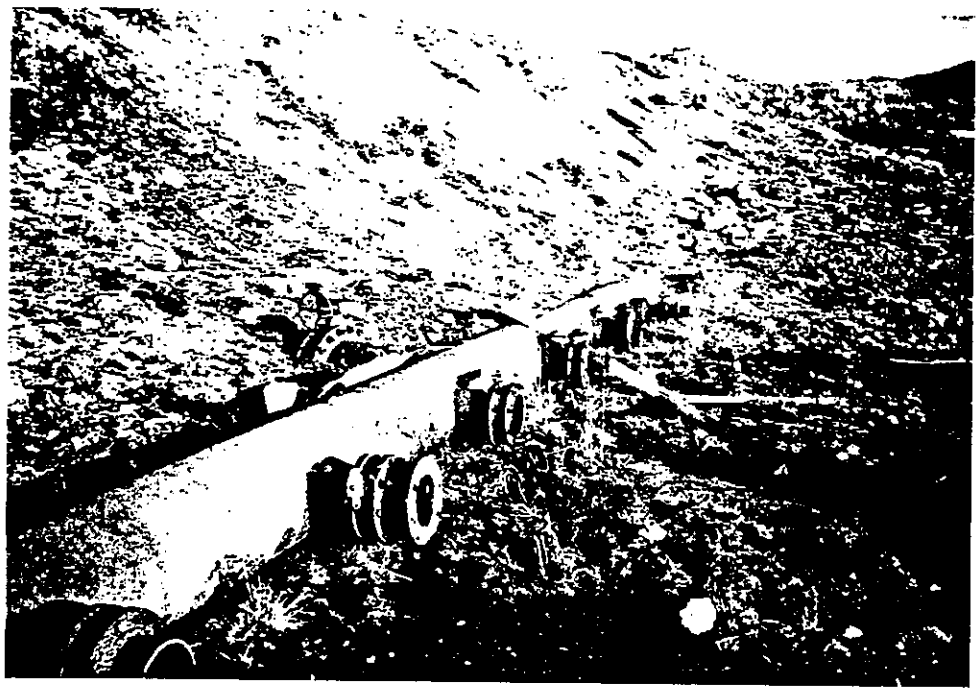


Photo 4.6-3: Piping manifold located near the northeast mud pit (location shown in Figure 4.6-1). Manifold pipe is approximately 20 feet long by 2 feet in diameter and rests on a 20-foot-square concrete pad. The manifold has six large gate valves that were all closed, though one leaked (see photo below). A 20-inch-diameter pipe runs from the manifold into the side of the northeast mud pit berm (shown at back edge of manifold, midway along the pipe).

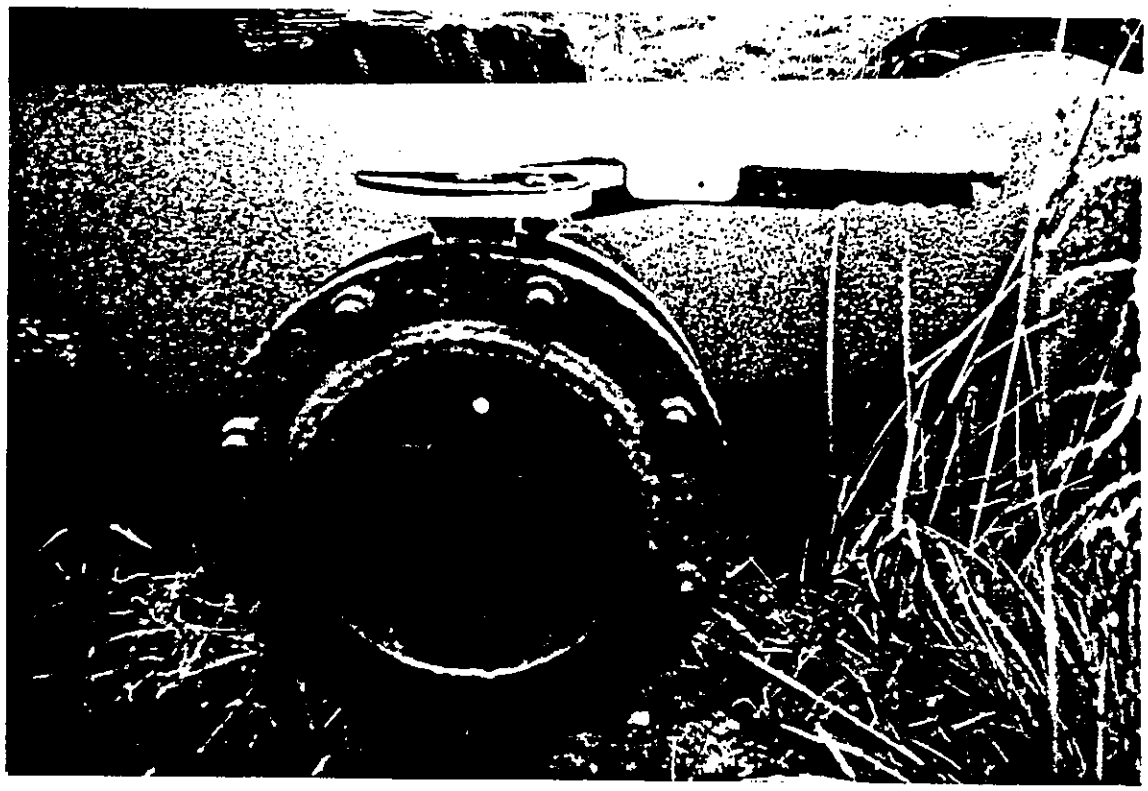


Photo 4.6-4: This photo shows water leaking from one of the valve gates. The water had no apparent sheen or odor.

Photo 4.6-5: Surface water sampling in unnamed lake at Drill Site D.

Photo 4.6-6: Southern part of Reach 1, Falls Creek, Drill Site D. Facing upstream, to the north.

Photo 4.6-7: Middle portion of Reach 2, Falls Creek, Drill Site D. Facing south and downstream.

Photo 4.6-8: Mouth of Falls Creek, facing east.

4.7 DRILL SITE F

4.7.1 Site Description

Drill Site F was developed by the AEC for an underground nuclear test but was not used. The site is located approximately 1,500 feet south of Infantry Road in the vicinity of Mile 18.7 (Figure 1-2). In preparation for the test, the AEC drilled a 7,012-foot-deep exploratory hole and began a 7.5-foot-diameter emplacement hole, but only extended it to 531 feet. Drilling was performed between July 1967 and January 1968. Prior to demobilizing from the island, the AEC backfilled the holes with drilling mud and abandoned them. The holes were sealed with 10-foot cement plugs and welded steel caps prior to abandonment. The location of each hole is marked with a concrete pad and steel post. The site originally contained four drilling mud pits. Currently only one mud pit remains, and it is partially backfilled. The other three mud pits have been completely backfilled. The area where the backfilled mud pits are located is graded and sparsely vegetated. A plan showing site features is presented in Figure 4.7-1.

The topography of Drill Site F and vicinity is shown in Figure 4.7-2. The drill site drains southeastward toward Limpet Creek, which flows approximately 10,000 feet between the site and the Pacific Ocean. A large lake and stream to the west of the drill site also were suspected to have been impacted by drilling mud and therefore were included in the site reconnaissance. As discussed in Section 4.7.4.3, the reconnaissance identified no evidence that either the lake or the stream were impacted.

4.7.2 Site History

The historical information obtained for this study indicates that drilling mud spilled from the mud pits impacted Limpet Creek. The historical information also states that an additional stream was impacted by drilling mud. According to the AEC planning document (AEC/NV, 1972):

> "These stream beds have been polluted by drilling mud overflowing or leaking from sumps or pits during AEC operations. ... Streams [two] ... near Site F ... suffered pollution from mud escaping from the sumps at these sites."

The two impacted streams referred to are shown on a map in the planning document. The first stream is Limpet Creek. The second stream drains a large lake located west of the drill site. Based on this information, a reconnaissance was conducted for both the Limpet Creek drainage and the upper portion of the second stream, including the lake at its headwaters.

4.7.3 Characterization Activities

Investigation activities at Drill Site F consisted of a detailed reconnaissance of the drill site to verify and record site features, and investigations of the mud pit, the western lake and stream, and Limpet Creek. Three sediment samples were collected from representative locations in the mud pit. Surface water samples were also collected at the three sediment sample locations. Mud pit sampling locations are shown in Figure 4.7-1.

The large lake located west of the drill site and the upper section of its drainage stream were observed visually for the presence of drilling mud or impacts associated with drilling mud. The lake bottom sediments on the side nearest the drill site were also probed using a hand auger. No samples were collected from the lake for laboratory analysis. This site is discussed further in Section 4.7.4.3.

A detailed reconnaissance was performed of Limpet Creek and the drainage pathways leading to it from the drill site, to observe the stream's ecology and select sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along the stream. Invertebrate, bioassay, and fish samples were collected from three of these stations. Stream sampling locations are shown in Figure 4.7-2. The samples collected from the mud pit and Limpet Creek were shipped to off-site laboratories for testing. The types of tests performed and their results are discussed in the section below.

4.7.4 Observations and Analytical Results

4.7.4.1 Mud Pit

The mud pit at Drill Site F has been partially backfilled with sandy gravel; two portions still contain standing water (Figure 4.7-1). Based on site observations, the mud pit was originally about 400 feet long and 50 feet wide. The largest remaining portion of the mud pit that has not been backfilled is approximately 200 feet long and 25 feet wide (Photo 4.7-1). A smaller portion of the mud pit that has also not been backfilled is located at the east end of the original mud pit; this area is about 20 feet long by 10 feet wide (Photo 4.7-2). The mud pit is located on a moderate slope and appears to have been constructed on bedrock after the native peaty soils were removed. The mud pit was constructed with a 6- to 8-foot-tall sandy gravel berm on its downhill side; the sides of the berm slope at approximately 1.5 horizontal to 1 vertical. The uphill side of the mud pit is level with the original ground surface. No areas of significant erosion or failure were observed in the berm, and it appeared to be relatively stable. Two 8-inch-diameter wood-stave pipes were observed buried at a depth of about 1 foot below the top of the berm on the downhill side of the mud pit (Photo 4.7-3). These pipes provide a drainage pathway and prevent the water in the mud pit from overtopping the berm. No surface water was draining from the pipes (which were at an elevation higher than the water surface in the mud pit) or any other portion of the mud pit at the time of the investigation.

The two portions of the mud pit not backfilled contained water about 0.5 to 1.0 foot deep. The sediment in these two areas consisted of gray, gravelly bentonite that had no noticeable diesel odor and did not generate a sheen when disturbed. Based on field measurements (including explorations with a steel probe in areas where no samples were collected) the bentonite in the west portion of the mud pit ranges from 0.5 foot to 6 feet thick. The bentonite in the east portion of the pit is 0.3 to 1 foot thick. The estimated total volume of drilling mud remaining in both open portions of the mud pit is 310 cubic yards. The estimated total volume of water in both portions of the mud pit at the time of field work is 20,300 gallons. Note that the mud volume estimate is based on the mud that was visible in the pit and does not include mud that might be present below backfill (see Section 2.4.3.1.3). Sample descriptions and field screening results for samples collected from the mud pit are summarized in the following table.

Mud Pit Sample Descriptions, Drill Site F

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
East Portion	0.8	1.0	1023-SW		Surface Water		
			1026-SD	0-1.0	Gray, gravelly Bentonite	No odor or sheen	PID=1
West Portion	1.0	4.0	1024-SW		Surface Water		
			1027-SD	0-1.0	Gray, gravelly Bentonite	No odor or sheen	PID=2
			1028-SD	3.0-4.0	Gray, gravelly Bentonite	No odor or sheen	PID=3
	0.8	3.2	1025-SW		Surface Water		
			1029-SD	0-1.0	Gray, gravelly Bentonite	No odor or sheen	PID=2
			1030-SD	2.0-3.0	Gray, gravelly Bentonite	No odor or sheen	PID=1

* Sample depth measured from mud surface

4.7.4.1.1 Surface Water

The mud pit surface water samples were analyzed for DRO, VOCs, PAHs, and metals; results are summarized in Table 4.7-1. All three surface water samples contained DRO at concentrations of 73.5 to 129 ug/L. However, two laboratory method blanks associated with these water samples also contained DRO at 71 and 82.7 ug/L. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples could have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. However, in this case this approach has not been taken, since the samples are from a mud pit known to contain diesel (based on the sediment results presented in Section 4.7.4.1.1). Accordingly, these DRO results

have been "B"-flagged. It is possible the reported values of DRO in the Drill Site F mud pit water could be due to drilling mud, laboratory contamination, and/or biogenic material.

With the exception of methylene chloride, which is a common laboratory contaminant, no VOCs or PAHs were detected in the mud pit surface water samples.

Sixteen metals were detected in mud pit water samples. Of these, the following eight metals were detected at concentrations that exceeded the background concentrations in upland stream water samples (an asterisk indicates that ERBSCs were also exceeded).

Aluminum*	Copper*	Molybdenum	Nickel	
Potassium	Selenium	Titanium	Vanadium	Zinc

These metals concentrations were then compared to the corresponding project ERBSCs. Of the metals that exceeded background, only aluminum and copper exceeded their respective ERBSCs. No ERBSC is available for titanium or potassium.

Surface water quality parameters measured in the Drill Site F mud pit during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Mud Pits, Drill Site F

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1023-SW (E portion)	9.0	10.8	10.5	127	10
1024-SW (W portion)	9.16	9.9	13.3	131	11
1025-SW (W portion)	9.0	10.6	11.4	110	12

4.7.4.1.2 Sediment

The mud pit sediment samples were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.7-2. The four drilling-mud samples from the west portion of the mud pit contained 975 to 12,800 mg/kg DRO. The sample from the east portion of the mud pit contained only 142 mg/kg DRO.

Ten to eleven alkylated benzenes were present in each drilling-mud sample from the western portion of the mud pit, at total concentrations ranging from 0.69 to 3.75 mg/kg (0.03 to 0.07 percent of the DRO concentration). The 0.0058 mg/kg benzene reported in sample 1030-SD was the only reported occurrence of benzene in this project. Carbon disulfide, a suspected laboratory

contaminant, was also detected in the western portion of the mud pit at a concentration 0.0255 mg/kg.

Three to seven PAH compounds were present in each sample, at total concentrations ranging from 0.16 to 22.1 mg/kg (0.11 to 0.30 percent of the DRO concentration).

Twenty-three metals were detected in the samples from the Drill Site F mud pits. The following eight metals were detected at concentrations that exceeded the upland stream sediment background concentrations (an asterisk indicates that ERBSCs were also exceeded).

Boron	Calcium	Cerium	Cesium
Chromium*	Thorium	Uranium	

A comparison of the metals that exceeded background was made to ERBSCs for stream sediment. Of these metals, only chromium has an ERSBC for sediment; it was exceeded in all of the mud pit samples by a range of slightly over one to about ten times.

4.7.4.2 Limpet Creek

Limpet Creek is the primary stream of the watershed where Drill Site F is located. Its headwaters are located northeast of the drill site. The stream flows eastward near its headwaters, then curves to the south around the site, and finally turns west and flows into the Pacific Ocean (Figure 4.7-2). It is approximately 10,000 feet long. As noted in Section 4.7.2, drilling mud reportedly was spilled into Limpet Creek in the late 1960s. Significant recovery appears to have taken place since then.

Field activities at Limpet Creek included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). Surface water and sediment samples were collected at each of five sampling stations along the length of the creek. At Stations 1, 3, and 5, fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.7-2.

Sample Numbers and Station Coordinates for Limpet Creek, Drill Site F

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 32.121'	178° 59.230'	400	3013-SW 3013-SD 3016-FI 3031-IN
2	51° 31.876'	178° 59.427'	250	3012-SW 3012-SD
3	51° 31.560'	178° 59.289'	190	3011-SW 3011-SD 3015-FI 3030-IN
4	51° 31.334'	178° 58.986'	110	3010-SW 3010-SD
5	51° 31.478'	178° 58.386'	30	3009-SW 3009-SD 3014-FI 3029-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss laboratory results for surface water, sediment, benthos, and fish samples.

4.7.4.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, Limpet Creek was divided into three stream reaches (Figure 4.7-2). Reach 1 begins approximately 750 feet northeast of the Drill Site F emplacement hole and about 750 feet southwest of Infantry Road. This uppermost reach extends 1,500 feet down to, and across, a flat plateau. Reach 2 begins at the southern edge of the plateau, where the stream gradient increases. It extends about 4,500 feet downstream to a point where the stream gradient decreases as the stream turns westward toward the ocean. Reach 3 extends from the end of Reach 2, about 4,000 feet downstream to the Pacific Ocean. In general, the upper and lower reaches have flatter gradients than the middle reach, which has a more incised channel and a higher stream velocity. No significant fish barriers such as waterfalls were observed along the stream. The following table summarizes reach characteristics for Limpet Creek.

Reach Characteristics for Limpet Creek, Drill Site F

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,800	1	Few Bends	Silty peat
2	4,700	3 – 4	Few Bends	Cobbles and gravel mixed evenly with, and sometimes overlying, silty peat. Some bedrock
3	3,500	2	Few Bends	Cobbles and gravel

Reach 1

Reach 1 is approximately 1,800 feet long. The headwaters of Limpet Creek within Reach 1 are characterized by many short rivulets flowing toward the center of a 300-foot-wide by 75-foot-deep U-shaped valley. The rivulets converge into a fairly well-defined stream channel near the end of this 800-foot-long valley as it opens into a flat, 8- to 10-acre wet meadow dominated by grasses and sedges. The stream meanders through the meadow, forming several shallow (1 to 8 inches deep) open water areas (See Photo 4.7-4). The stream channel becomes more distinct in the downstream portion of this reach. The overall gradient averages about 1 percent. The stream typically ranges from less than 1 foot to 3 feet wide, and 4 inches to 1 foot deep. The dominant streambed substrate is soft, organic muck (silty peat). The dominant aquatic vegetation in Reach 1 was sedge (*Carex* spp.).

Station 1 was located in the downstream portion of Reach 1 about 150 feet upstream of the beginning of Reach 2. Resident Dolly Varden were readily found in the stream channel and open water areas.

Reach 2

Reach 2 is roughly 4,700 feet long with a gradient of approximately 3 to 4 percent. The valley associated with the stream in this reach is broad and flat. It is slightly narrower in the upstream portion of Reach 2, then opens up until just before the end of Reach 2, where it begins to narrow considerably with relatively steep sides. The channel is consistently incised into the tundra to a depth of 4 to 6 feet and is underground along approximately 10 percent of the length the reach (Photo 4.7-5). The bottom substrate consists of some cobbles but mostly intermixed gravel and peat. Typically, the cobbles and gravel overlie the peat. The stream channel ranged from less than 1.5 to 6 feet wide, and water depth varied from 4 inches to nearly 6 feet in a few pools. Aquatic vegetation consisted primarily of moss (*Fontinalus* sp.) that was patchy in the middle portion and more continuous in the lower portions of the reach.

Station 2 was located at a shallow pool in the middle portion of Reach 2. The substrate was dark brown silty peat. Station 3 was located in the downstream portion of Reach 2, immediately downstream from a tributary that enters Limpet Creek from the west. The tributary originates from a 1- to 2-acre lake about 200 feet away from Limpet Creek. The tributary adds about 30 percent to the volume of Limpet Creek.

Reach 3

Reach 3 is roughly 3,500 feet long with an overall gradient of about 2 percent, which is flatter than Reach 2 but steeper than Reach 1. The stream channel in Reach 3 becomes broader and less incised, with an average width of 6 feet and depth of 3 feet. However, the valley in the upstream portion of Reach 3 is steeply incised; it is about 100 feet wide at the top and 75 to 100 feet deep (Photo 4.7-6). This valley opens up dramatically at the midpoint of the reach to a broad U-shaped valley that remains open until the last 200 feet of the stream, where it cuts a small valley through the 50- to 75-foot-high bluff at the ocean shore. The stream meets the tidal zone at a boulder and cobble beach strewn with ocean debris including driftwood and miscellaneous garbage. A tributary enters Reach 3 from the north approximately 1,000 feet upstream from the Pacific Ocean. This tributary adds approximately 15 percent to the volume of Limpet Creek. The stream substrate within Reach 3 is predominantly cobbles and gravel, with some sand and silt in depositional areas.

Station 4 was located in the upstream portion of Reach 3 within the steeply incised valley. Station 5 was located 200 feet below the confluence of the tributary from the north.

4.7.4.2.2 Surface Water

Five surface water samples were collected from Limpet Creek, one per sampling station. Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.7-3.

Neither DRO nor PAHs were detected in any of the surface water samples collected from Limpet Creek. The only VOC detected was methylene chloride, which is a common laboratory contaminant. Its occurrence is not believed to be site-related (see Section 2.3.1.5).

Twelve metals were detected in the surface water samples from Limpet Creek. The concentrations of these metals were compared to the background concentrations for upland reference streams. Potassium, vanadium, and zinc exceeded their respective background concentration at one or more stations.

The metals that exceeded background concentrations in Limpet Creek water were compared to metals that also exceeded background in Limpet Creek sediment (see Section 4.7.4.2.3). Only zinc also exceeded background in sediment samples. However, the sediment exceedance was at Station 5, while the surface water exceedances were at Stations 1 and 4.

Metals found in Limpet Creek water samples that exceeded background concentrations were also compared to the lowest (i.e. most conservative) of the project ERBSCs. Neither vanadium nor zinc exceeded their respective ERBSCs. An ERBSC was not available for potassium.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Limpet Creek, Drill Site F

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	5.75	10.2	10.25	144	0
2	6.25	8.7	10.26	150	0
3	6.08	9.2	10.91	146	0
4	6.07	8.1	11.65	160	0
5	5.8	8.0	11.76	167	0

4.7.4.2.3 Sediment

One sediment sample was collected at each of five stations on Limpet Creek. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. One sediment sample at Station 2 was analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.7-4.

Neither DRO nor PAHs were detected in any sediment samples from Limpet Creek. The only VOC detected in the sediment samples was carbon disulfide at a concentration of 0.043 mg/kg. According to the laboratory, this is suspected to be cross-contamination from the sample containers (see Section 2.3.1.5).

Twenty-one metals were detected in the Limpet Creek sediment samples. Of these metals, only boron, molybdenum, and zinc exceeded their respective background concentrations. Boron exceeded its upland stream background concentrations at Stations 2, 3, and 4 by factors ranging from 3 to 14 times. Molybdenum was detected at Station 3 at 1.63 mg/kg but not detected in upland reference streams; however, it was found in lowland reference streams at concentrations over three times that found in the single Limpet Creek sample where it was detected. The zinc concentration at Station 5 exceeded background by a factor of less than 2.

Those metals found in Limpet Creek sediment samples at concentrations that exceeded background concentrations were then compared to ERBSCs. Zinc exceeded its ERBSC, since the ERBSC for zinc is below the background concentration. Boron and molybdenum did not have ERBSCs for comparison.

In addition to the total metals results discussed above, AVS and SEM were analyzed to provide information on the bioavailability of metals. AVS and SEM concentrations in the Limpet Creek sediment samples are presented in the following table. At the one station where AVS were detected, the data suggest there are sufficient sulfides present to bind the SEM metals and limit their bioavailability. At the other stations where AVS was not detected it is not clear whether the metals are bioavailable or not.

AVS and SEM Concentrations for Limpet Creek, Drill Site F

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	3013-SD	ND	0.79	NA
2	3012-SD	ND	0.84	NA
3	3011-SD	ND	0.813	NA
4	3010-SD	ND	1.94	NA
5	3009-SD	11.3	1.86	0.16

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, if necessary, and comparison of the substrate at the various stations. Organic content was also determined for all five samples. Grain-size analyses were only performed on the samples from Stations 1, 4, and 5 that had a sufficient mineral soil content. The TOC and organic content results are presented in the following table, and the grain-size gradations are plotted in Figure 4.7-3.

Sediment Characteristics for Limpet Creek, Drill Site F

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	3013-SD	44,900	17.1/13.7	Dark brown silty peat
2	3012-SD	72,500	24.3	Dark brown silty peat
3	3011-SD	29,300	17.1/23.2	Dark brown silty peat
4	3010-SD	26,500	70.3	Dark brown silty peat
5	3009-SD	19,200	13.9	Dark brown peaty silt and gray sand

Visual classification of the sediment sample from Station 3 (3011-SD) after it had been oven-dried in the laboratory revealed a small quantity of light buff-colored material mixed in with brown silt and peat. This material had the appearance of bentonite and matched a field observation of a pocket of fine-grained sediment, speculated to be drilling mud. This finding is notable since it is one of very few direct observations of drilling mud in the streams during 1998. It is also interesting to note that the chemistry results do not suggest any elevated concentrations that might be attributable to drilling mud in this sample.

4.7.4.2.4 Benthos

Benthic samples were collected at Stations 1, 3, and 5 on Limpet Creek. The samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the

Triad Analysis of Drill Site and Test Site Stream Sediments (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Limpet Creek, Drill Site F

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	3	5
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult		60	32
Gastropoda	Mesogastropoda	Lymnaidae	snail	juvenile	8		
Peleycopoda	Spaeracea	Sphaeriidae	clam	juvenile	280		
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph			4
	Trichoptera	Limniphilidae	caddisfly	larva	8	8	6
	Diptera	Chironomidae	midge	larva	32		
		Simulidae	blackfly	larva		4	
Crustacea	Amphipoda	Talitridae (genus Hyalella sp.)	scud	adult	272		2
				Total	**600**	**72**	**44**
				Family Biotic Index	7.84	7.44	7.09
				EPT Relative Abundance	1.3%	11.1%	22.7%
				Species Diversity	0.99	0.56	0.86

4.7.4.2.5 Sediment Toxicity Tests

Sediment samples collected from Stations 1, 3, and 5 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed under subcontract to IT Corporation by American Aquatic Testing in Allentown, Pennsylvania. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of this data.

Sediment Toxicity Test Results for Limpet Creek, Drill Site F

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	57.50%	61.33%	0.776	105.08%	4.49	65.0%
2	47.50%	50.67%	0.859	116.2%	3.79	54.8%
4	62.50%	66.68%	0.681	92.2%	4.00	57.9%

4.7.4.2.6 Fish

Fish samples consisting of resident Dolly Varden were collected at Stations 1, 3, and 5 on Limpet Creek. At Station 5 samples were collected using a combination of electroshocker and minnow traps. The minnow traps were used in accordance with the scientific collection permit, after a salmon was found among the shocked fish and released alive. The fish collected at each station were composited into one sample and submitted for whole body tissue analysis. Specific data, such as the size of individual fish, are presented in the field fish-collection forms in Appendix J. The following table summarizes the size and weight of the fish samples.

Fish Sample Descriptions for Limpet Creek, Drill Site F

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	3016-FI	2 - 6.5	27	360	13.3	1103
3	3015-FI	4 - 10	8	350	43.7	512
5	3014-FI	3 - 6	24	250	10.4	11,434

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. The sample from Station 3 was also tested for percent lipids. Analytical results are presented in Table 4.7-5 and summarized below.

The PCB Aroclor 1260 was detected in fish samples from Stations 3 and 5 at concentrations of 0.0101 and 0.0204 mg/kg, respectively, or slightly above the detection limit. The corresponding RBC for this compound is 0.0016 mg/kg. In other words, the sample concentrations were approximately 6 and 12 times higher than the RBC. No other PCBs were detected. No PAHs were detected in the samples.

Eighteen metals were detected in the samples. Of these, the following eight metals exceeded the background concentrations for fish in at least one sample:

Barium	Cobalt	Iron	Potassium	Strontium
Thorium	Titanium	Vanadium		

The sample concentrations were compared to the project RBCs for fish consumption. None of the sample concentrations that exceeded background levels also exceeded the RBCs.

Total arsenic at Station 3 had a concentration in excess of the RBC, but below background levels. Inorganic arsenic was detected in the three fish samples from Limpet Creek. The three sample concentrations were below the background concentration. The sample from Station 5 (with 0.00442 mg/kg) exceeded the RBC (0.0021 mg/kg) by a factor of two.

The fish sample from Station 3 had 2.98 percent lipids by weight.

4.7.4.3 Western Drainage

The field investigation at Drill Site F included reconnaissance at the lake located to the west of the drill site. The reconnaissance also included the upper portion of the lake's drainage stream. The sediments on the shore and bottom of the lake consisted of sand and large cobbles. These sediments were probed at several offshore locations on the side nearest the drill site using a hand auger. The probed lake sediments consisted of approximately 1 foot of sandy gravel overlying bedrock. The sediment in the bottom of the outlet stream consisted of a thin layer of sand overlying bedrock. No drilling mud or impact from drilling mud was observed during the reconnaissance of the lake and stream. The area between the drill site and the lake was observed for possible connecting drainage pathways. It was concluded that surface water drainage from the vicinity of the drill site, including its western side, ultimately flows eastward toward Limpet Creek. Based on the reconnaissance, the western drainage (including the lake and stream) does not appear to have been impacted by drilling mud.

4.7.5 Summary

The features observed at Drill Site F during the field work were similar to those identified during the project's planning phase. Therefore, the original scope of work planned for the drill site was considered adequate to meet the project objectives. Only one of the four original mud pits remains exposed, and it is partially backfilled. This pit is estimated to contain an estimated 311 cubic yards of drilling mud that contains DRO at an average concentration of 5,461 mg/kg. Several VOCs and PAHs were also detected in the mud samples at concentrations above their respective ERBSCs, and chromium was detected routinely at concentrations that exceed both its background concentration and ERBSC. Approximately 20,300 gallons of surface water containing low levels (73.5 to 129 ug/L) of DRO was present in the mud pit. The DRO in the surface water may be due to diesel in the drilling mud, DRO cross-contamination at the laboratory, or biogenic material. The mud pit water also contained aluminum and copper at concentrations that exceeded both the surface water background levels and ERBSCs.

The mud pit at Drill Site F is located above grade on a sloping hillside. If some force or event (such as an earthquake or severe erosion) caused the mud pit berm to fail, much of the drilling mud in the pit could flow into the Limpet Creek drainage. The mud pit berm does not appear to have eroded significantly to date, and wood-stave pipes in the mud pit's berm appear to prevent the water level in the mud pit from overtopping and eroding the berm.

The water quality and sediment quality in Limpet Creek generally do not appear to be adversely impacted from past drilling mud releases. No DRO, volatiles, or PAHs were detected in water or sediment samples. No metals exceeded both background and ERBSCs in either water or sediment with the exception of zinc at one station.

The PCB Aroclor 1260 was detected in two of three fish samples at concentrations of 0.010 and 0.0204 mg/kg. These concentrations exceed the EPA Region III RBC for PCBs in fish (0.0016 mg/kg). The source of the PCBs is not known since drilling mud samples at Drill Site F were not tested for PCBs. However, it is likely that the PCBs detected in the fish are from the stream environment since the sampled fish were resident and not likely exposed to the ocean environment where PCBs could potentially be present. It is possible that drilling mud released historically into Limpet Creek contained PCBs that have persisted in the stream environment. PCBs have been have detected in the mud samples from elsewhere on the island, and could also be present at Drill Site F.

No PAHs were detected in fish, and none of the metals detected in fish samples were found to exceed both the RBCs and background concentrations.

Results from the Triad Analysis (Appendix F) indicated that the sediment quality in Limpet Creek ranked high relative to 15 upland reference streams. Limpet Creek stations ranked as follows, out of a total of 15 upland stream locations:

Limpet Creek	
Station 1	7th
Station 3	9th
Station 5	4th

This overall ranking combines benthic, sediment chemistry, and sediment toxicity rankings, with the lowest number representing the best overall habitat. These results are consistent with the general lack of evidence for current impact from the mud pits at Drill Site F.

In summary, the stream environment along Limpet Creek has experienced significant recovery since mud spills occurred in the late 1960s. PCBs are present in the fish of Limpet Creek, and presumably entered the stream system as a result of the historic mud spills. Other compounds discussed above, including metals, DRO, and PAHs do not appear to be adversely impacting the stream environment. In its current condition, the Drill Site F mud pit is unlikely to release additional mud to Limpet Creek.

TABLE 4.7-1
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE F MUD PIT
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSF-1023-SW	98DOE-DRSF-1024-SW	98DOE-DRSF-1025-SW
Diesel Range Hydrocarbons	AK 102	-	129 B	73.5 B	96.3 B
Volatile Organic Compounds					
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Benzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	3.35 U	2.62 U	3.67 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)
Metals					
Aluminum	EPA 6020	87.1 [b]	167	480	468
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)
Calcium	EPA 6010B	8,810 [b]	4,610	3,900	2,700

TABLE 4.7-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE F MUD PITS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland/Stream Background Concentration[a]	98DOE-DRSF-1023-SW	98DOE-DRSF-1024-SW	98DOE-DRSF-1025-SW
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	ND(1)	2.78	1.32
Cobalt	EPA 6020	9.52	5.35	4.97	5.28
Copper	EPA 6020	13.4 [b]	219 J	6.75 J	22.9 J
Iron	EPA 6010B	2,830 [b]	230	674	494
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	2,300	2,200	2,230
Manganese	EPA 6020	748	45	19.3	22.2
Molybdenum	EPA 6020	ND(1)	ND(1)	**1.31**	ND(1)
Nickel	EPA 6020	1.69 [b]	**1.71**	**3.01**	1.4
Potassium	EPA 6010B	1,190 [b]	**1,780 J**	**1,350 J**	**1,580 J**
Selenium	EPA 6020	ND(1)	ND(1)	**1.53**	ND(1)
Strontium	EPA 6020	44.1 [b]	26.9	24.5	24.1
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	2.37 [b]	**7.35 J**	**40.2 J**	**25.5 J**
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	ND(1) UJ	**3.84 J**	**3.41 J**
Zinc	EPA 6020	12.8 [b]	**77.8 J**	**54.4 J**	12.7 J

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

B analyte detected in method blank

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

TABLE 4.7-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR DRILL SITE F MUD PITS
(concentrations in micrograms per liter)

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.7-2
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE F MUD PIT
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSF-1026-SD	98DOE-DRSF-1027-SD	98DOE-DRSF-1028-SD	98DOE-DRSF-1029-SD	98DOE-DRSF-1030-SD
		Depth (ft)	0-1	0-1	3-4	0-1	2.2-3
Diesel Range Hydrocarbons	AK 102	-	142	12,800	975	7,300	6,090
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(0.0221) UJ	1.86	0.345 J	2.37	1.06
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.532 J	0.0627 J	0.165 J	0.0198 J
Benzene	EPA 8260B	-	ND(0.0221) UJ	ND(0.00625) UJ	ND(0.005) UJ	ND(0.005)	0.00584 J
Carbon disulfide	EPA 8260B	-	0.0255 UJ	0.0209 UJ	ND(0.005) UJ	ND(0.005)	ND(0.005) UJ
Ethylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.0653 J	0.0348 J	0.0453 J	0.147 J
Isopropylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.0628 J	0.0255 J	0.0626 J	0.142 J
m,p-Xylene	EPA 8260B	-	ND(0.0221) UJ	0.343 J	0.0516 J	0.0549 J	0.134 J
Methylene chloride	EPA 8260B	-	ND(0.0221) UJ	ND(0.00625) UJ	ND(0.005) UJ	ND(0.005)	ND(0.005) UJ
n-Butylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.122 J	0.0314 J	0.441	0.353 J
n-Propylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.128 J	0.0498 J	0.139 J	0.281 J
Naphthalene	EPA 8260B	-	ND(0.0221) UJ	0.13 J	0.196 J	0.313 J	ND(0.005) UJ
o-Xylene	EPA 8260B	-	ND(0.0221) UJ	0.168 J	0.037 J	0.196 J	0.0303 J
p-Isopropyltoluene	EPA 8260B	-	ND(0.0221) UJ	0.087 J	0.0277 J	0.39 J	0.128 J
sec-Butylbenzene	EPA 8260B	-	ND(0.0221) UJ	0.0628 J	0.0212 J	0.0674 J	0.11 J
Toluene	EPA 8260B	-	ND(0.0221) UJ	0.0182 J	ND(0.005) UJ	ND(0.005)	ND(0.005) UJ

TABLE 4.7-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE F MUD PIT
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSF-1026-SD	98DOE-DRSF-1027-SD	98DOE-DRSF-1028-SD	98DOE-DRSF-1029-SD	98DOE-DRSF-1030-SD
		Depth (feet)	0-1	0-1	3-4	0-1	2.2-3
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	EPA 8270C	-	0.0143	0.683	0.128	1.22	0.833
Anthracene	EPA 8270C	-	ND(0.00884)	0.369	0.0314	0.493	0.6
Fluoranthene	EPA 8270C	-	ND(0.00884)	0.0992	0.00878	0.122	0.0962
Fluorene	EPA 8270C	-	0.05	3.84	0.3855	5.58	3.9
Naphthalene	EPA 8270C	-	ND(0.00884)	0.187	0.112	0.094	ND(0.0165)
Phenanthrene	EPA 8270C	-	0.0947	9.86	0.926	14.3	9.95
Pyrene	EPA 8270C	-	ND(0.00884)	0.187	0.0151	0.244	0.188
Metals							
Aluminum	EPA 6010B	47,500	29,700	23,300	34,800	22,100	21,600
Arsenic	EPA 6020	30.5	ND(1.34)	3.58	1.48	2.3	15.6
Barium	EPA 6020	468	93.9	91.1	44.7	87.6	81.4
Boron	EPA 6010B	6.42 [b]	**38.2 J**	**36.8 J**	**35 J**	**33.4 J**	**33.2 J**
Calcium	EPA 6010B	7,720	7,280	**21,000**	3,990	**8,380**	7,650
Cerium	EPA 6020	13	**13.8**	**19.5**	**15.1**	**17.1**	**16.1**
Cesium	EPA 6020	ND	ND(1.34)	ND(0.5)	ND(0.5)	ND(0.5)	**0.632**
Chromium	EPA 6020	18.9	**28.3 J**	**296 J**	**33.5 J**	**145 J**	**90.1 J**
Cobalt	EPA 6020	37.3	6.39	6.3	7.01	6.57	7.5

TABLE 4.7-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE F MUD PIT
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration[a]	98DOE-DRSF-026-SD	98DOE-DRSF-027-SD	98DOE-DRSF-028-SD	98DOE-DRSF-029-SD	98DOE-DRSF-030-SD
		Depth (feet)	0-1	0-1	3-4	0-1	2.2-3
Copper	EPA 6020	82.4	45	50.8	46.6	48.1	45.4
Iron	EPA 6010B	123,000	28,900	28,300	27,000	25,200	22,500
Lithium	EPA 6020	21.7	2.88	4.15	5.3	2.93	2.94
Magnesium	EPA 6010B	17,000	2,490	4,280	1,700	3,600	3,820
Manganese	EPA 6020	26,500	188 J	439 J	239 J	343 J	301 J
Molybdenum	EPA 6020	ND	ND(0.134) UJ	ND(0.25) UJ	ND(0.05) UJ	ND(0.25) UJ	ND(0.25) UJ
Nickel	EPA 6020	23.8	3.88	5.52	4.44	5.86	6.91
Potassium	EPA 6010B	1,290	582	885	364	526	528
Selenium	EPA 6020	3.15 [b]	ND(1.34)	0.602	1.15	ND(0.5)	ND(0.5)
Strontium	EPA 6020	207	40.1	130	27.4	75.2	65.3
Thorium	EPA 6020	ND	ND(1.34) UJ	**4.58 J**	**1.21 J**	**2.84 J**	**2.02 J**
Titanium	EPA 6020	1,480	1,250 J	655 J	941 J	1,020 J	696 J
Uranium	EPA 6020	ND	ND(1.34) UJ	**1.81 J**	ND(0.5) UJ	**1.06 J**	**0.832 J**
Vanadium	EPA 6020	336	61.5	41.1	75.6	45.7	51.9
Zinc	EPA 6020	185	37.1	45	31.7	35.3	33

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

TABLE 4.7-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE F MUD PIT
(concentrations in milligrams per kilogram)

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.7-3
SURFACE WATER ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSF-3013-SW	98DOE-DRSF-3012-SW	98DOE-DRSF-3011-SW	98DOE-DRSF-3010-SW	98DOE-DRSF-3009-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Benzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Carbon disulfide	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Ethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Isopropylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
m,p-Xylene	EPA 8260B	-	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)
Methylene chloride	EPA 8260B	-	3.64 U	2.32 U	ND(2)	2.76 U	4.83 U
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
n-Propylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
o-Xylene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
sec-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Toluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals							
Aluminum	EPA 6020	87.1 [b]	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)

TABLE 4.7-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSF-3013-SW	98DOE-DRSF-3012-SW	98DOE-DRSF-3011-SW	98DOE-DRSF-3010-SW	98DOE-DRSF-3009-SW
			Station 1	Station 2	Station 3	Station 4	Station 5
Calcium	EPA 6010B	8,810 [b]	3,510	3,160	3,180	3,540	3,500
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	9.52	4.91	3.74	3.44	4.68	ND(1)
Copper	EPA 6020	13.4 [b]	1.73 J	1.13	ND(1)	1.85 J	ND(1) UJ
Iron	EPA 6010B	2,830 [b]	154	ND(150)	ND(150)	ND(150)	165
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	2,700	2,940	2,890	3,110	3,330
Manganese	EPA 6020	748 [b]	21.3	13.5	11.6	15	2.92
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	1.69 [b]	1.44	1.47	1.64	1.11	ND(1)
Potassium	EPA 6010B	1,190 [b]	**1,210**	**1,320**	**1,280**	1,160	**1,640**
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	33.4	33.8	32.8	35.7	35.8
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	2.37 [b]	1.89 J	1.41	1.16	1.67 J	2.29 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	1.17	ND(1)	1.25	1.42	**2.02**
Zinc	EPA 6020	12.8 [b]	**60.8**	11.7	10.1	**16.2**	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

TABLE 4.7-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F
(concentrations in micrograms per liter)

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.7-4
SEDIMENT ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSF-3013-SD	98DOE-DRSF-3012-SD	98DOE-DRSF-3011-SD	98DOE-DRSF-3010-SD	98DOE-DRSF-3009-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	ND(19.8)	ND(15)	ND(10.3)	ND(12.9)	ND(10.5)
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
1,3,5-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Benzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Carbon disulfide	EPA 8260B	mg/kg	-	-	0.0426 UJ	-	-	-
Ethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Isopropylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
m,p-Xylene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Methylene chloride	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
n-Butylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
n-Propylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Naphthalene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
o-Xylene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
p-Isopropyltoluene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
sec-Butylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-
Toluene	EPA 8260B	mg/kg	-	-	ND(0.0244) UJ	-	-	-

TABLE 4.7-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSF-3013-SD Station 1	98DOE-DRSF-3012-SD Station 2	98DOE-DRSF-3011-SD Station 3	98DOE-DRSF-3010-SD Station 4	98DOE-DRSF-3009-SD Station 5
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Anthracene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Fluoranthene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Fluorene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Naphthalene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Phenanthrene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Pyrene	EPA 8270C	mg/kg	-	ND(0.0163)	ND(0.0124)	ND(0.00849)	ND(0.0107)	ND(0.00867)
Metals								
Aluminum	EPA 6010B	mg/kg	47,500	16,000	25,100	15,500	22,200	18,000
Arsenic	EPA 6020	mg/kg	30.5 [a]	ND(2.47) UJ	4.16 J	3.73 J	3.33 J	2.49
Barium	EPA 6020	mg/kg	468	58.9	56.3	36.8	52.9	93.1
Boron	EPA 6010B	mg/kg	6.42 [b]	ND(12.4)	**89.3**	**30.6**	**22.4**	ND(6.57)
Calcium	EPA 6010B	mg/kg	7,720	3,710	3,360	5,440	7,300	5,770
Cerium	EPA 6020	mg/kg	13	6.27	8.92	6.71	12.9	5.55
Cesium	EPA 6020	mg/kg	ND	ND(2.47) UJ	ND(1.88) UJ	ND(1.29) UJ	ND(1.61) UJ	ND(1.31)
Chromium	EPA 6020	mg/kg	18.9	7.66	9.01	9.81	9.57	9.74
Cobalt	EPA 6020	mg/kg	37.3	15.7	16.6	6.67	12.4	7.88
Copper	EPA 6020	mg/kg	82.4	16.8	23.3	18.3	57.6	22.5

TABLE 4.7-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSF-3013-SD	98DOE-DRSF-3012-SD	98DOE-DRSF-3011-SD	98DOE-DRSF-3010-SD	98DOE-DRSF-3009-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Iron	EPA 6010B	mg/kg	123,000	64,800	38,300	13,300	10,400	24,200
Lithium	EPA 6020	mg/kg	21.7	4.08	5.59	4.47	4.6	5.47
Magnesium	EPA 6010B	mg/kg	17,000	839	750	859	2,190	3,340
Manganese	EPA 6020	mg/kg	26,500	1,250	239	284	91.2	218
Molybdenum	EPA 6020	mg/kg	ND	ND(2.47)	ND(1.88)	**1.63**	ND(1.61)	ND(1.31)
Nickel	EPA 6020	mg/kg	23.8	5.46 J	6.42 J	4.74 J	7.71 J	6.64
Potassium	EPA 6010B	mg/kg	1,290	236 J	201 J	202 J	224 J	260
Selenium	EPA 6020	mg/kg	3.15 [b]	ND(2.47) UJ	**2.52 J**	**2.31 J**	**2.18 J**	ND(1.31)
Strontium	EPA 6020	mg/kg	207	30.3	26.3	25	23.6	37.4
Thorium	EPA 6020	mg/kg	ND	ND(2.47)	ND(1.88)	ND(1.29)	ND(1.61)	ND(1.31)
Titanium	EPA 6020	mg/kg	1,480	1,150	1,370	1,030	1,110	865
Uranium	EPA 6020	mg/kg	ND	ND(2.47)	ND(1.88)	ND(1.29)	ND(1.61)	ND(1.31)
Vanadium	EPA 6020	mg/kg	336	165	157	102	148	92.5
Zinc	EPA 6020	mg/kg	185	65	66.6	39.2	61	**257**
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	44,900	72,500	29,300	26,500	19,200
Acid Volatile Sulfide	Titration	umol/g	-	ND(0.0247)	ND(0.0188)	ND(0.0129)	ND(0.0161)	11.3
Simultaneously Extracted Metals	Summation	umol/g	-	0.79	0.84	0.813	1.91	1.86

TABLE 4.7-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

mg/kg milligrams per kilogram

umol/g micromoles per gram

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.7-5
FISH ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration	98DOE-DRSF-3016-F1	98DOE-DRSF-3015-F1	98DOE-DRSF-3014-F1
					Station 1	Station 3	Station 5
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	SW8270 SIM	mg/kg	81.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Acenaphthylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Anthracene	SW8270 SIM	mg/kg	405.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)anthracene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)pyrene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(b)fluoranthene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(ghi)perylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(k)fluoranthene	SW8270 SIM	mg/kg	0.043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Chrysene	SW8270 SIM	mg/kg	0.43	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Dibenzo(a,h)anthracene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluoranthene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluorene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Naphthalene	SW8270 SIM	mg/kg	27.0	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Phenanthrene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Pyrene	SW8270 SIM	mg/kg	40.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Polychlorinated Biphenyls							
Aroclor 1016	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	mg/kg	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1242	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1248	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1260	SW8081	mg/kg	0.0016	-	ND(0.01) UJ	0.0204 J	0.0101 J
Metals							
Aluminum	SW6020	mg/kg	1,351.9	38.8	36	10.3	20.4
Arsenic (total)	SW6020	mg/kg	0.21	26.9	0.076	1.37	0.0665
Arsenic (inorganic)	EPA Draft 1632	mg/kg	0.0021	0.0456	0.00172	0.0019	0.00442
Barium	SW6020	mg/kg	94.6	0.567	**0.83**	**0.636**	**0.742**
Beryllium	SW6020	mg/kg	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)

TABLE 4.7-5 (cont.)
FISH ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration[a]	98DOE-DRSF-3016-F1	98DOE-DRSF-3015-F1	98DOE-DRSF-3014-F1
					Station 1	Station 3	Station 5
Boron	SW6020	mg/kg	121.7	24.1	11.4 UJ	11.9 UJ	11.5 UJ
Cadmium	SW6020	mg/kg	1.4	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Calcium	SW6020	mg/kg	NA	10,300	9,330	6,680	9,480
Cerium	SW6020	mg/kg	NA	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Cesium	SW6020	mg/kg	NA	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Chromium	SW6020	mg/kg	4.1	0.684	0.462	0.534	0.365
Cobalt	SW6020	mg/kg	81.1	0.0510 [b]	**0.0523**	ND(0.0500)	ND(0.0500)
Copper	SW6020	mg/kg	54.1	3.40	1.34 U	1.04 U	0.736 U
Iron	SW6020	mg/kg	405.6	73.6	**101**	14.1	28.3
Lithium	SW6020	mg/kg	27.0	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Magnesium	SW6020	mg/kg	NA	349	340	325	305
Manganese	SW6020	mg/kg	189.3	164	3.58	1.45	2.77
Molybdenum	SW6020	mg/kg	6.8	0.150 [b]	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	mg/kg	27.0	ND	ND(0.125)	ND(0.125)	ND(0.125)
Potassium	SW6020	mg/kg	NA	4,310	3,900	**4,450**	4,180
Selenium	SW6020	mg/kg	6.8	2.08	1.1	0.69	0.669
Strontium	SW6020	mg/kg	811.1	12.1 [b]	**20.2**	**17.7**	**15.9**
Thallium	SW6020	mg/kg	0.09	0.0755 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)
Thorium	SW6020	mg/kg	NA	4.67 [b]	ND(2.50) UJ, B	ND(2.50) UJ, B	**4.98 J, B**
Titanium	SW6020	mg/kg	5407.4	0.834	**1.25**	0.242	0.743
Uranium	SW6020	mg/kg	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	mg/kg	9.5	0.289	**0.409**	0.169	0.189
Zinc	SW6020	mg/kg	405.6	78.0	43.8	34.5	38.3
% Lipids	Lipids	% by Weight	-	-	-	2.98	-

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

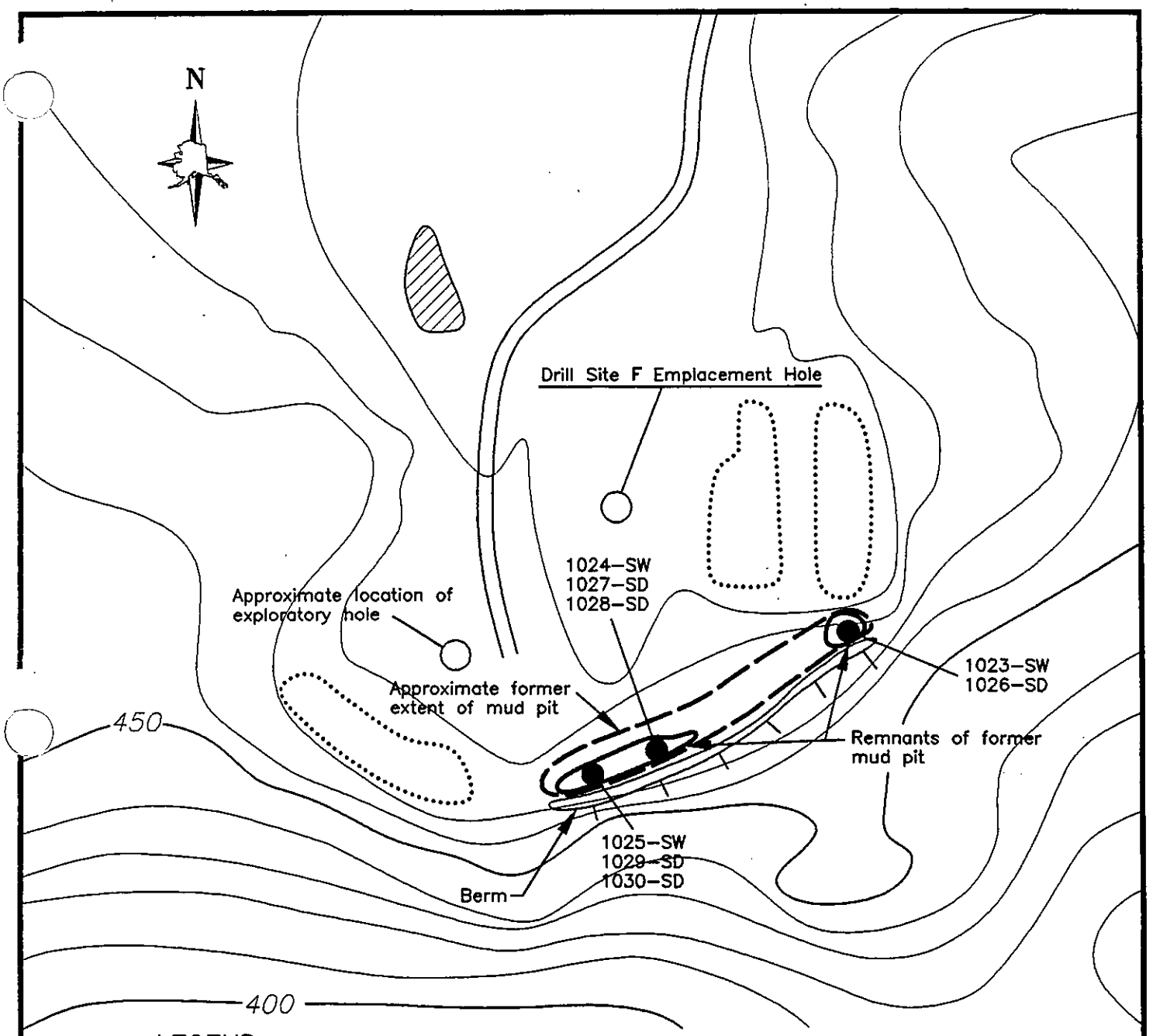
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

TABLE 4.7-5 (cont.)
FISH ANALYTICAL RESULTS FOR LIMPET CREEK, DRILL SITE F

-	sample not analyzed for this parameter
mg/kg	milligrams per kilogram
B	analyte detected in method blank
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U	analyte concentration attributed to blank or laboratory contamination; result considered nondetect
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.



LEGEND

1025–SW ● Surface Water and/or Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE–DRSF").

Existing Mud Pit Investigated

Approximate Former Location of Mud Pit

Lake or Pond

APPROXIMATE SCALE (FEET)

0 200 400

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE F

September 1999
Revision Number: 0

X–0926

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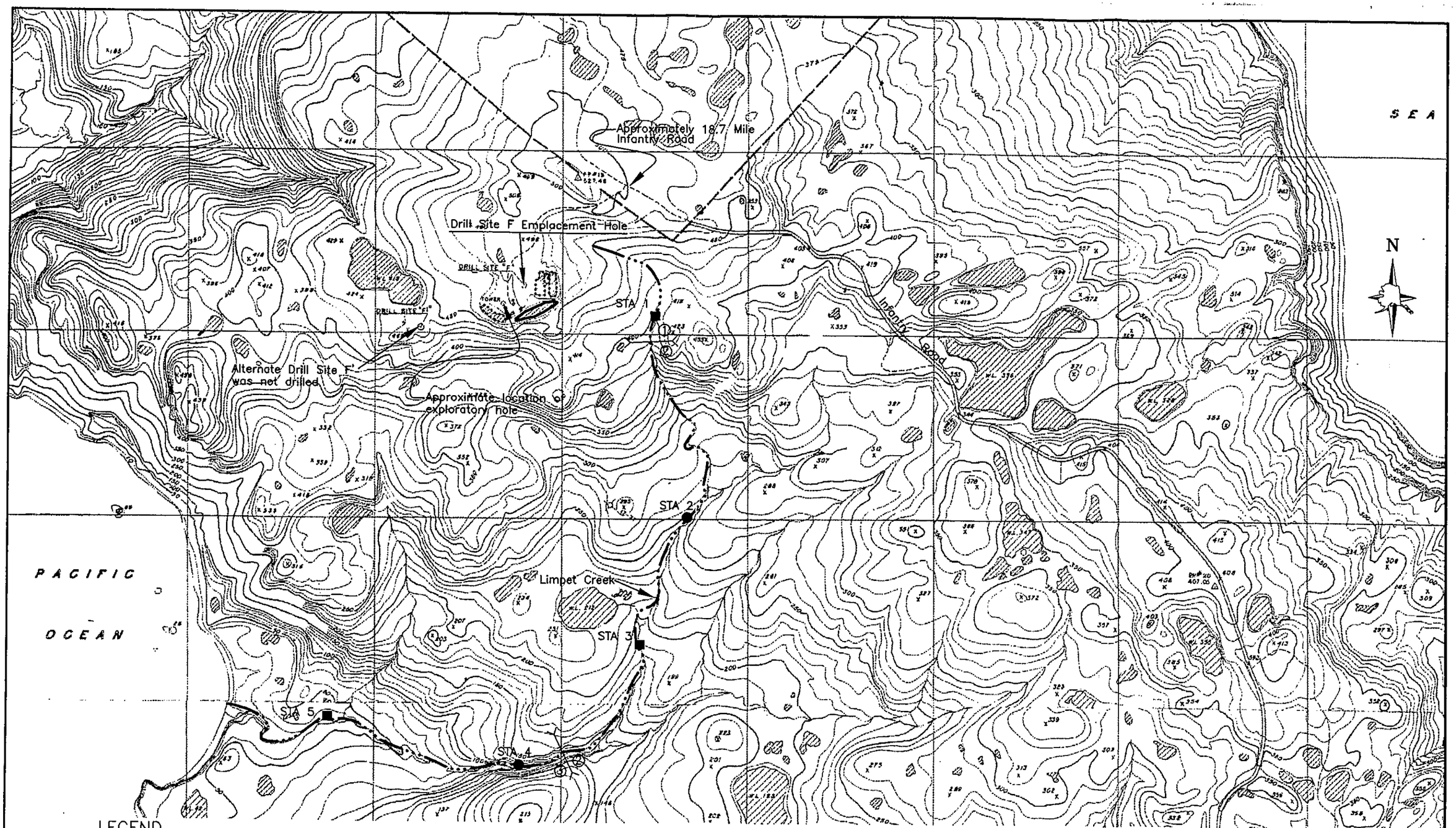
FIG. 4.7–1

FILE: Drill



LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Section 4.7.4.2 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and Benthic Invertebrate Sampling. (See Section 4.7.4.2 for Sample Numbers.)

② Reach Number

Reach Boundary

Investigated Stream Course

Existing Lake

Former Location of Mud Pit

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas**
Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE F STREAM

September 1999
Revision Number: 0

X-0926

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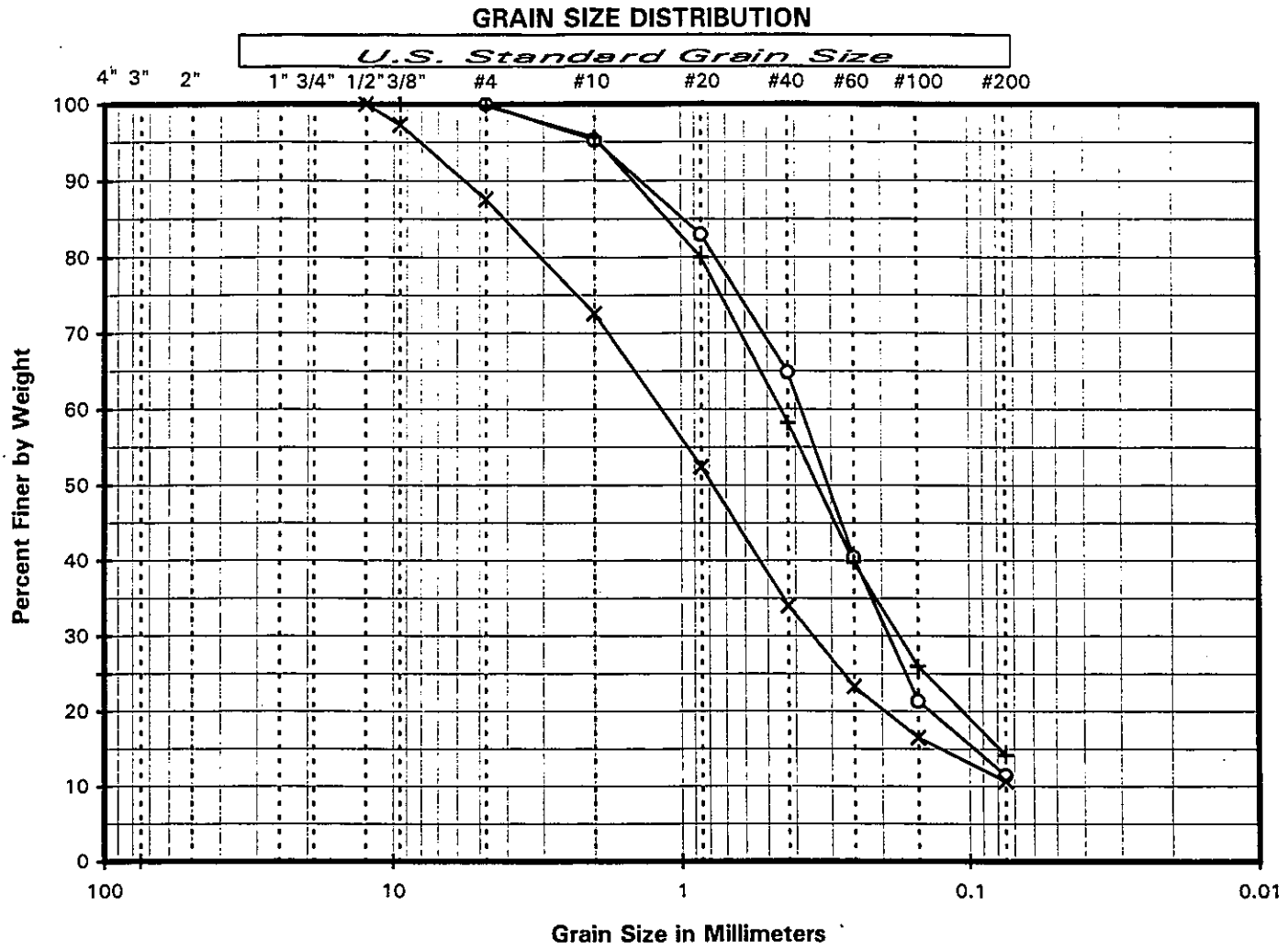
FIG. 4.7-2

FILE: DrillSiteF



Marker	Sample ID	Percent Passing by Dry Weight — U.S. Standard Sieve Size: 4"	3"	2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.02m	USC Soil Class
O	98DOE-DRSF-3013-SD								100	95	83	65	41	21	12		SP-SM
X	98DOE-DRSF-3010-SD						100	97	88	73	52	34	23	17	11		SP-SM
+	98DOE-DRSF-3009-SD							100	100	96	80	58	40	26	14		SM

1998 Drill Site Investigation
Amchitka Island

GRAIN SIZE DISTRIBUTION CURVES
Stations 1, 4, and 5, Limpet Creek, Drill Site F

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Figure 4.7-3

Photo 4.7-1: Largest remaining portion of the mud pit at Drill Site F that has not been backfilled. The approximate dimensions are 200 by 25 feet.

Photo 4.7-2: Smaller portion of the mud pit that has not been backfilled, located east of pit shown above. This portion is approximately 10 by 20 feet.

Photo 4.7-3: Berm on downhill side of mud pit, consisting of sandy gravel. Note the 8-inch-diameter wood stave pipe emerging from the berm. The pipe was not draining, as the inlet was higher than the water level in the mud pit.

Photo 4.7-4: Electroshocking for fish on Reach 1 of Limpet Creek, where the channel meanders through a broad meadow with numerous pools 1 to 8 inches deep.

Photo 4.7-5: Lower Reach 2, Limpet Creek, facing upstream and north.

Photo 4.7-6: Upper Reach 3, Limpet Creek, facing downstream and west.

4.8 DRILL SITE E

4.8.1 Site Description

Drill Site E was partially developed by the AEC as an underground nuclear test site but not used. The drill site is located approximately 1,500 feet south of Infantry Road in the vicinity of Milepost 21 (Figure 1-2). The AEC began drilling an emplacement hole at the site, but abandoned the operation after reaching a depth of 10 feet. They also drilled one 7,495-foot-deep exploratory hole at the site, which was left open for use in the Long Term Hydrologic Monitoring Program. Drilling was performed between June 1968 and February 1969. The site currently contains two large concrete pads (Figure 4.8-1), one with a steel post in its center affixed with a brass marker labeled "UA-7." Evidently the post marks the location of the emplacement hole.

The historical information gathered for this study indicates that the site once contained a single mud pit. The mud pit was reportedly no longer present at the site because, due to unstable foundation soils, it had slid into the nearby stream. However, two small pits were observed at the site during the 1998 reconnaissance, which may have been the remnants of mud pits. In order to characterize these two possible mud pits, a sampling effort at the pits was added to the project scope of work.

Figure 4.8-2 shows a topographic map of the vicinity of Drill Site E. As depicted in the figure, the site is located in steep terrain with grades as high as 20 percent. Based on the site topography and observations made during the reconnaissance, the drill site is located at the headwaters of a stream that flows southward to the Pacific Ocean. The stream, labeled "Stream E" in the figure, traverses a distance of approximately 7,000 feet between the site and the Pacific Ocean.

4.8.2 Site History

The historical information obtained for this study indicates that the unnamed stream at Drill Site E was significantly impacted by drilling mud. According to the AEC planning document (AEC/NV, 1972):

> "These stream beds have been polluted by drilling mud overflowing or leaking from sumps or pits during AEC operations. ... and the stream below Site E suffered pollution from mud escaping from the sumps at these sites.
>
> "The mud sumps near Site E were located on a lobe or mounds of jelly-like, wet soils containing loose material. Lobes of this type are common in Alaskan regions and, since these "thixotropic" soils have the property of yielding under stress, they tend to become

fluid, especially when shaken. This results in a slow creeping movement of the entire lobe down a slope. During the course of construction at Site E the soil in the lobe went liquid and approximately 15,000 yards flowed into the drainage system. Some of this liquid soil traveled as far as the ocean."

The following excerpt was taken from the document *The Environment of Amchitka Island, Alaska* (Valdez et. al., 1977):

> "A mud slide at Site E in 1968 resulted in substantial and persistent damage to the stream valley. Sumps were constructed on what proved to be unstable soil, which gave way under the weight of the liquid contents, causing a massive slide of semiliquid soil down the stream bed. As a result of this slide, the upper two-thirds of the stream course, about 1300 m (4300 foot) long, was grossly altered. Streamside vegetation was killed or severely damaged by the smothering effect of the muddy residue. This allowed the stream to deepen and widen its channel so that it no longer resembles the narrow grass-overhung lower part of the stream, which was little affected by the slide. The gross morphological changes in the upper stream course will persist for a very long time since much of the peat substrate that formerly maintained the integrity of the stream channel has eroded away (R.G.F., personal observation, 1975)."

4.8.3 Characterization Activities

Investigation activities at Drill Site E consisted of an initial reconnaissance of the drill site to identify site features. It was during this reconnaissance that the two small mud pits were discovered. A sampling effort was added to the scope of work to characterize these mud pits. The added sampling effort consisted of the collection of one surface water and one sediment sample from each mud pit. Mud pit sampling locations are shown in Figure 4.8-1.

A reconnaissance was also performed to determine apparent drainage pathways and identify the upstream extent of impact in the stream. The stream was then investigated to observe its ecology and select sampling locations. Sediment and surface water samples for chemical analysis were collected from five stations along the stream. Invertebrate, bioassay, and fish samples were collected from three of these stations. Stream sampling locations are shown in Figure 4.8-2. The samples collected from the mud pits and the stream were shipped to off-site laboratories for testing. The types of tests performed and their results are discussed in the following sections.

4.8.4 Observations and Analytical Results

4.8.4.1 Mud Pits

The two mud pits are located 400 to 500 feet downhill (southwest) of the emplacement hole (Figure 4.8-1). Both of the mud pits are relatively small and, in general, not typical of the mud pits observed at the other drill sites. The southern mud pit, with dimensions of approximately 40 by 80 feet, was the most typical mud pit. This pit was encircled by low berms 2 to 3 feet high, which were constructed of sandy gravel (Photo 4.8-1). The pit was full of water that averaged about one foot deep. No water was flowing from the pit, but a shallow channel was observed that had been eroded into a low section of the south wall of the pit's berm. This channel is probably the pathway for water that overflows the pit during periods of high water. In addition, a culvert located approximately 100 feet west of the pit may also drain the area. The culvert, which extended from the side of a stream bank, had a small stream of water flowing from it at the time of the reconnaissance. The small stream emptied into the larger drainage stream that flows southward from the site. Based on the location of the culvert, it is possible that some of the water draining from the culvert was water that had infiltrated into the subsurface soil from the pit.

The sediment at the bottom of the southern mud pit consisted of light gray, sandy bentonite. The thickness of the bentonite was measured using a steel probe at several locations around the pit's perimeter. Based on these measurements, the bentonite ranges from 1.5 to 8 feet thick. Measurements could not be made in the center of the mud pit since the site was not accessible to a skiff. Based on the measurements, the estimated volume of drilling mud remaining in the pit is 415 cubic yards. The estimated volume of water in the pit at the time of the field work is 20,100 gallons.

The northern pit is located at the base of a deep, excavated area with steep sides approximately up to 15 feet high (Photos 4.8-2). The excavated area appears to have been constructed as some sort of sump or drainage collection area. Two culverts, which did not have water flowing from them, were observed extending into the excavated area from the northeast (the direction of the emplacement hole). About one-half of the base of the excavated area was submerged. This area, with dimensions of approximately 40 by 20 feet, was considered to be the possible mud pit. The remaining half of the bottom of the excavated area was heavily vegetated with moss and aquatic plants. This pit is drained by a small stream that flows southward through a steep-walled trench. This stream joins a larger stream a short distance downstream, which also flows southward. These streams constitute the headwaters of the site's drainage stream.

The sediment at the bottom of the northern mud pit consisted of a thin layer of black, organic silt overlying a thin layer of gray, sandy bentonite. The total thickness of the silt and bentonite in the mud pit averaged 0.1 to 0.2 foot. The average depth of water in the pit was about 0.7 foot. Based on these measurements, the estimated volume of bentonite remaining in the mud pit (including the organic silt) is 3.7 cubic yards. The estimated volume of water present at the time

of the field work is 3,200 gallons. Sample descriptions and field screening results for the samples collected from the mud pits are presented in the following table

Mud Pit Sample Descriptions, Drill Site E

Sampling Location	Water Depth (feet)	Mud Thickness (feet)	Sample No.	Sample Depth* (feet)	Description	Observations	Screening Results (ppm)
Southern Mud Pit	0.9	8.0	1116-SW		Surface Water		
			1117-SD	0-1.0	Light gray, sandy Bentonite	Slight diesel odor	-
Northern Mud Pit	0.7	0.2	1118-SW		Surface Water		
			1119-SD	0-0.2	Black, organic silt, and gray, sandy Bentonite	Slight diesel odor and sheen	-

* Sample depth measured from mud surface
- Sample not field screened

4.8.4.1.1 Surface Water

The surface water samples from the two Drill Site E mud pits were analyzed for DRO, VOCs, PAHs, and metals. The results of these analyses are summarized in Table 4.8-1.

The two water samples contained DRO at concentrations of 117 and 132 ug/L. The laboratory method blank associated with the sample from the southern pit also contained DRO at 55.5 ug/L. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), this sample could have been qualified as a nondetect at a detection limit corresponding to the reported value, because it is less than five times the method blank concentration. However, this approach is not necessarily appropriate when used on a sample from a mud pit known to contain diesel. Accordingly, this DRO result has been "B"-flagged in the table. The reported concentrations of DRO are also comparable to the 61 ug/L average concentration of DRO reported in water from half of the upland reference stream samples, as explained in Section 2.3.1.5. It is possible that the reported values of DRO could be due to, or some combination of, diesel fuel from the drilling mud, laboratory contamination, or biogenic materials. With the exception of one suspected laboratory contaminant (methylene chloride), no VOCs or PAHs were detected in the samples.

Twelve metals were detected in the water samples. With the exception of magnesium, potassium, and strontium in the northern mud pit, all occurrences were at concentrations below background levels for upland streams. Magnesium barely exceeded background; potassium and strontium were about 2.4 and 1.2 times higher than background, respectively. The metals that exceeded background were compared to their corresponding project ERBSCs. Strontium was well below its ERBSC (1,500 ug/L). No ERBSCs are available for magnesium or potassium, but these

metals are considered essential nutrients in most organisms and not likely to result in significant ecological effects.

Surface water parameters measured in the Drill Site E mud pit during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Mud Pits, Drill Site E

Sample Number	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1116-SW (S pit)	6.2	10.5	10.4	85	1
1118-SW (N pit)	6.5	10.5	8.8	222	0

4.8.4.1.2 Sediment

The sediment samples were analyzed for DRO, VOCs, PAHs, and metals; results are summarized in Table 4.8-2. The northern and southern mud pit samples contained 214 and 10,600 mg/kg of DRO, respectively. The DRO concentration in the sample from the southern mud pit is among the highest concentrations from all of the mud pits. Four alkylated benzenes were present in this sample, at a total concentration of 4.7 mg/kg (0.04 percent of the DRO concentration). Five to eight PAH compounds were present in the two drilling-mud samples, at total concentrations ranging from 0.31 to 28.9 mg/kg (0.15 to 0.27 percent of the DRO concentration).

Twenty-two metals were detected in the two mud pit sediment samples from the Drill Site E. Of these, eleven metals exceeded background concentrations in at least one sample. These are listed below, with an asterisk if ERBSCs were also exceeded.

Calcium	Cerium	Cesium	Chromium*	Cobalt	Copper*
Nickel*	Strontium	Thorium	Uranium	Zinc*	

Chromium, copper, and nickel exceeded background and the ERBSC in both mud samples, while zinc exceed the two criteria in the north mud pit only.

4.8.4.2 Unnamed Stream at Drill Site E

An unnamed stream (or Stream E) provides the primary drainage of the Drill Site E watershed. Its headwaters are north-northwest of the exploratory hole. The stream flows immediately adjacent to the concrete drilling pad, and small drainages flow across the site or originate in remnants of former mud pits. The stream flows south past the drill site, then curves south-

southwest at the confluence of the first major side-stream, and continues in this direction to the Pacific Ocean (Figure 4.8-2). The stream is approximately 8,200 feet long. As noted in Section 4.8.2, the upper two-thirds of the stream was severely impacted in the past by large volumes of drilling mud that inundated the stream channel. Fuller and Kirkwood (1977) noted long-term impacts resulted from the collapse of a large mud pit adjacent to the drill site. They predicted significant recovery would take place over time, but permanent morphological changes to the stream channel had been caused by the spills.

Field activities at the unnamed stream at Drill Site E included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden). One surface water and sediment sample was collected at each of five sampling stations spaced along the length of the creek. Fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected at Stations 1, 2, and 4.

The following table lists the sample numbers for each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.8-2.

Sample Numbers and Station Coordinates for Unnamed Stream, Drill Site E

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 33.431'	178° 57.475'	500	3037-SW 3037-SD 3042-FI 3043-IN
2	51° 33.201'	178° 57.474'	290	3036-SW 3036-SD 3040-FI 3041-IN
3	51° 32.950'	178° 57.349'	170	3034-SW/3035-SW 3035-SD
4	51° 32.641'	178° 57.169'	80	3033-SW 3033-SD 3039-FI 3038-IN
5	51° 32.621'	178° 57.046'	40	3032-SW 3032-SD

The following subsections present observations made during the reconnaissance and sampling activities and discuss laboratory results for surface water, sediment, benthos, and fish samples.

4.8.4.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, Stream E was divided into three stream reaches (Figure 4.8-2). Reach 1 begins 1,000 feet north-northwest of the drill site emplacement hole and about 750 feet southwest of Infantry Road. This uppermost reach extends from these headwaters 2,500 feet downstream to a slight decrease in gradient just above the confluence with the only major tributary, which flows from the north-northeast. Reach 2 begins where the stream gradient decreases slightly, and extends 4,000 feet downstream to a point where the stream gradient decreases again as it reaches a plateau. Reach 3 extends from there downstream to the Pacific Ocean. Each subsequent downstream reach has a flatter gradient. There is a 6-foot waterfall at the mouth of the stream that is most likely a barrier to anadromous fish passage. There is also a 3-foot waterfall in the middle of Reach 2. The following table summarizes reach characteristics for the stream at Drill Site E.

Reach Characteristics for the Unnamed Stream, Drill Site E

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	2,500	4 – 5	Few bends	Boulders, cobbles, gravel, sand, and bedrock
2	4,000	3 – 4	Few bends	Cobbles, gravel, sand, boulders, and bedrock
3	1,700	1 – 2	Many bends	Cobbles, gravel, and sand

Reach 1

Reach 1 is approximately 2,500 feet long with an overall gradient of 4 to 5 percent. The headwaters at Drill Site E are a series of braided, partially underground, rivulets that come together in a manmade channel that directs the drainage around the drill site. A small drainage flows from the area immediately upgradient of the concrete pad associated with the drill site. This drainage joins the stream above the manmade channel. Another drainage begins in a former mud pit with a large breach in its surrounding berm. This second drainage joins Reach 1 downstream of the manmade channel. The stream channel is very straight and has been severely scoured throughout most of Reach 1. The stream substrate is boulders, cobbles, and gravel. The stream is about 3 feet wide, and 4 inches to 1 foot deep. There is moss in the slow-flowing water in the manmade channel, but the rest of Reach 1 contains no in-stream vegetation. Some clumps of grass have become established in the scoured area adjacent to the stream channel.

Station 1 was located in the middle portion of Reach 1, downstream of the manmade channel and about 1,500 feet upstream of the beginning of Reach 2. Dolly Varden were scarce in this reach except within the slower moving waters of the manmade channel.

Reach 2
Reach 2 is roughly 4,000 feet long with a gradient of approximately 3 to 4 percent. The valley along this reach is shallow and broad (Photo 4.8-3). The stream channel appears somewhat scoured but not as obviously as in Reach 1. The stream substrate is similar to Reach 1 with fewer boulders and includes cobbles, gravel, and sand. The stream channel is typically less than 3 feet wide, and water depth varies from 4 inches to nearly 2 feet in a few pools. There was no aquatic vegetation within Reach 2.

Station 2 was located about 200 feet below the beginning of Reach 2 and 200 feet upstream from the confluence of the only major tributary along the stream (which enters from the north-northeast). This tributary contributes about 40 percent to the water volume in Stream E. The stream substrate was cobbles, gravel, and sand. However, some fine-grained sediment consisting of dark brown peat was observed in depositional areas and along the edges of the stream. Station 3 was located in the middle portion of Reach 2, 100 feet upstream of the 3-foot waterfall.

Reach 3
Reach 3 is roughly 1,700 feet long with an overall gradient of 1 to 2 percent, which is flatter than both Reaches 1 and 2. The stream channel in Reach 3 becomes broader, but the substrate remains dominated by cobbles and gravel. Some gravelly sand is present in depositional areas. The average width and depth are 4 feet and 1 foot, respectively. Some of the pools in Reach 3 are as deep as 5 feet. The broad valley along Reach 2 opens up to a flat open meadow in Reach 3 (Photo 4.8-4). The open meadow continues until the stream cuts a small valley through the 75- to 100-foot-high bluff at the ocean shore. The stream meets the tidal zone at a boulder and cobble beach strewn with ocean debris including driftwood and miscellaneous garbage.

Station 4 was located at the change in gradient that defines the downstream extent of Reach 2 and the upstream extent of Reach 3. Some moss (*Fontinalis*) was noted at Station 4. Station 5 was located approximately 700 feet upstream of the mouth, where the stream begins to cut through the ocean-front bluff. There was no moss in the vicinity of Station 5.

4.8.4.2.2 Surface Water

Five surface water samples were collected from the unnamed stream at Drill Site E, one for each sampling station (a duplicate sample was also collected at Station 3). Each sample was analyzed for DRO, VOCs, PAHs, and metals. A summary of analytical results is presented in Table 4.8-3.

DRO was reported in five of the six surface water samples, at concentrations ranging from 52.7 to 104 ug/L. These concentrations are comparable to the average of 61 ug/L DRO detected in upland reference stream samples (as explained in Section 2.3.1.5).

The only VOC detected was methylene chloride, which is a common laboratory contaminant. These occurrences are not believed to be site-related (see Section 2.3.1.5). No PAH compounds were detected in the water samples.

Thirteen metals were detected in the surface water samples from the Stream E. The concentrations of these 13 metals were compared to the background concentrations for upland reference streams. Five metals (aluminum, potassium, titanium, vanadium, and zinc) exceeded their respective background concentrations at one or more stations.

The list of metals that exceeded background concentrations was compared with the list of metals that also exceeded background in the sediment from this stream (see Section 4.8.4.2.3). Although the five metals listed above were detected in the sediment samples, none were present at concentrations that exceeded background values.

Metals found in water samples from Stream E that exceeded background concentrations were also compared to the project ERBSCs. Aluminum concentrations at Stations 4 and 5 slightly exceeded the ERBSC (by a factor of 1.1 and 1.2 times, respectively). The ERBSCs for vanadium and zinc were not exceeded. No ERBSCs are available for potassium or titanium. Potassium is considered an essential nutrient for most organisms, and is unlikely to result in any toxic effects.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented below.

Surface Water Parameters for Unnamed Stream, Drill Site E

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	6.29	7.5	11.9	118	1
2	6.08	7.5	11.55	123	0
3	6.45	7.4	11.72	122	0
4	6.19	10.2	10.95	88	0
5	5.45	9.9	10.71	87	0

4.8.4.2.3 Sediment

One sediment sample was collected at each of five stations on the Stream E. All sediment samples were analyzed for DRO, PAHs, TOC, AVS/SEM, and metals. One sediment sample from Station 2 was analyzed for VOCs. Analytical results for sediment samples are summarized in Table 4.8-4.

DRO was only detected in one sediment sample (from Station 2) at a concentration of 22.1 mg/kg. This relatively low concentration may be attributed to biogenic sources. No VOCs were

detected. Four PAHs were detected in the sediment sample from Station 1 at a total concentration of 0.12 mg/kg. None of these PAH compound exceeded their respective project ERBSCs.

Twenty metals were detected in the sediment samples. The concentrations of these metals were compared to background concentrations in upland reference streams. Five metals (cerium, chromium, molybdenum, nickel, and selenium) exceeded background values in one or two samples each.

Molybdenum was not detected in upland reference stream samples; it was present at a concentration near the detection limit (1.02 mg/kg) in a single sample from Stream E. Station 1 had two metals (cerium and nickel) that exceeded background; Stations 2, 3, and 5 each had one metal that exceeded background. The detected concentrations were relatively low, exceeding the background values by factors of 1.05 to 2.2 times.

Of the five metals results exceeding background, only chromium and nickel exceeded the project ERBSCs. The ERBSC for chromium (26 mg/kg) was exceeded in the sample from Station 2, which contained chromium at 41.1 mg/kg. A second background exceedance of chromium in the sample from Station 5 did not exceed the ERBSC. The nickel concentration of 32.5 mg/kg in the sample from Station 1 exceeded the nickel ERBSC of 15.9 mg/kg.

ERBSCs were not available for the other three metals (cerium, molybdenum, and selenium). The unnamed stream at Drill Site E had the highest cerium concentrations in sediment of any of the upland site-related streams. Station 1 had the highest nickel concentration of any site-related stream.

AVS and SEM concentrations in the sediment samples from the unnamed stream at Drill Site E are presented in the following table. No AVS was detected at any of the stations. This absence of AVS indicates that the SEM metals may be bioavailable in this stream.

AVS and SEM Concentrations for Unnamed Stream, Drill Site E

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	3037-SD	0	6.12	NA
2	3036-SD	0	3.56	NA
3	3035-SD	0	0.886	NA
4	3033-SD	0	0.922	NA
5	3032-SD	0	0.951	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, if necessary, and comparison of the substrate at the various stations. Organic content was also determined for three samples collected at stations where

benthos and bioassay samples were collected. Grain-size analyses were performed only on two samples with a sufficient mineral soil content (rather than peat and other organics, whose lighter specific gravity render a grain-size analysis invalid). The TOC and organic content results are presented in the following table, and the grain-size gradations are plotted in Figure 4.8-3.

Sediment Characteristics for Unnamed Stream, Drill Site E

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	3037-SD	25,600	8.8	Dark brown silty peat and gray sand
2	3036-SD	103,000	29.4	Dark brown silty peat
3	3035-SD	27,900	-	Dark brown silty peat and gray sand
4	3033-SD	22,800	10.3	Dark brown silty peat and gray sand
5	3032-SD	10,300	-	Dark brown silty peat and gray sand

4.8.4.2.4 Benthos

Benthic samples were collected at Stations 1, 2, and 4 on the unnamed stream at Drill Site E. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Unnamed Stream, Drill Site E

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	4
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult			2
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph	5	54	
	Trichoptera	Limniphilidae	caddisfly	larva	12	3	4
	Diptera	Chironomidae	midge	larva		26	
		Chironominae	midge	larva	4		
		Diamesinae	midge	larva	3		
Arachnoidea	Arachnida		spider	adult	1		
				Total	**25**	**83**	**6**
				Family Biotic Index	4.38	4.63	5.33
				EPT Relative Abundance	70.8%	68.7%	66.7%
				Species Diversity	1.23	0.76	0.64

4.8.4.2.5 Sediment Toxicity Tests

Sediment samples collected from Stations 1, 2, and 4 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are presented in the following table. Refer to the Triad Report, Appendix F, for an evaluation of the data.

Sediment Toxicity Results, Unnamed Stream, Drill Site E

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	85.00%	89.47%	0.406	77.8%	3.32	67.3%
2	83.75%	94.37%	0.291	57.7%	2.38	53.1%
4	85.00%	95.79%	0.280	55.6%	2.37	52.9%

4.8.4.2.6 Fish

Fish samples consisting of resident Dolly Varden were collected at Stations 1, 2, and 4 on Stream E. The fish collected at each station were composited into one sample per station and submitted for whole body tissue analysis. Specific data, such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish samples.

Fish Sample Descriptions for Unnamed Stream, Drill Site E

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	3042-FI	3 – 6	26	310	11.9	761
2	3040-FI	3 – 6	29	305	10.5	979
4	3039-FI	3 - 6	36	350	9.7	800

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.2-5 and summarized below.

Twenty-one metals were detected in the samples. Concentrations were compared to background concentrations determined for fish from lowland reference streams, and to EPA Region III RBCs for fish consumption. The following seven metals exceeded background in at least one sample:

Barium	Cadmium	Calcium	Cesium	Cobalt
Nickel	Strontium			

None of the metals listed above exceeded the RBC, though no criteria are available for calcium or cesium.

Inorganic arsenic was detected in each of the three fish samples from Stream E. The sample from Station 2 exceeded the fish consumption RBC but was below background levels. The other two samples were below the RBC and background. Note that the background level of inorganic arsenic in lowland stream fish is almost ten times higher than the corresponding RBC.

Neither PAHs nor PCBs were detected in the fish samples from Stream E.

4.8.5 Summary

The two mud pits found at Drill Site E were not anticipated during the project's planning phase. and the original scope of work planned for the drill site was expanded to include a sampling effort at these pits.

The northern mud pit contains less than 4 cubic yards of diesel-contaminated drilling mud and soil. The DRO concentration detected in this drilling mud/soil was also relatively low (214 mg/kg). Approximately 3,200 gallons of surface water containing low levels (117 to 132 ug/L) of DRO was present in the north pit during the field work. This mud pit has been trenched to drain freely into the site's drainage stream. Based on the small volume of drilling mud observed in the mud pit, it appears that the potential for future impacts to the stream by releases from the mud pit is negligible.

The southern mud pit contains an estimated 415 cubic yards of drilling mud that has DRO concentrations as high as 10,600 mg/kg. Low levels of VOCs and PAHs were also present in this drilling mud. The southern mud pit is located is on a sloping hillside, with the bottom of the pit below grade. However, if some force or event (such as an earthquake or erosion) caused the mud pit berm to fail, much of the drilling mud in the pit could be transported into the nearby stream. No provision has been made for pit drainage, and surface water in the pit apparently overtops the berm on occasion, based on the presence of a small channel that is eroded at the top of a low portion of the berm.

Stream water and sediment quality appeared to show a slight impact at Station 1, nearest the drill site, but impacts farther downstream could not be discerned. Whereas stream water had slightly elevated DRO at Station 1 (104 mg/kg), samples from the downstream locations were comparable to the average DRO in upland reference streams. Diesel was not detected in stream sediment except in one station at a low level (22 mg/kg). Low levels of four PAHs were detected in sediment at Station 1 only, but at concentrations that were below project ERBSCs. No metals concentrations in stream water exceeded both background and ERBSCs. In sediment,

nickel exceeded both the background concentration and the ERBSC at Station 1, and chromium exceeded background and the ERBSC at Station 2.

The fish tissue analyses (from Stations 1, 2, and 4) detected no PAHs or PCBs, nor were metals detected in excess of both background and ERBSC values.

Results from the Triad Analysis (Appendix F) indicate that the overall sediment quality in the creek that drains Drill Site E ranked high relative to the upland reference streams. The stations along this creek ranked as follows, out of a total of 15 upland stream locations:

Stream E	
Station 1	2nd
Station 2	11th
Station 4	3rd

This overall ranking combines benthic, sediment chemistry, and sediment toxicity rankings, with the highest rank (lowest number) representing the best overall habitat. These results are consistent with the general lack of chemical evidence for current impact from the mud pits at Drill Site E.

In summary, the mud pits at Drill Site E do not appear to be adversely impacting the stream ecology, despite the direct connection between the northern pit and the stream. Stream E apparently has undergone significant recovery since the mud releases that occurred about three decades ago.

TABLE 4.8-2
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE E MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSE-1117-SD	98DOE-DRSE-1119-SD
			S mud pit	N mud pit
		Depth (feet)	0-1	0-0.2
Diesel Range Hydrocarbons	AK 102	-	10,600	214
Volatile Organic Compounds				
1,2,4-Trimethylbenzene	EPA 8260B	-	2.96	ND(0.1)
1,3,5-Trimethylbenzene	EPA 8260B	-	0.767	ND(0.1)
Methylene chloride	EPA 8260B	-	ND(1.54)	ND(0.5)
n-Butylbenzene	EPA 8260B	-	0.62	ND(0.1)
Naphthalene	EPA 8260B	-	2.99	ND(0.1)
p-Isopropyltoluene	EPA 8260B	-	0.315	ND(0.1)
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	EPA 8270C	-	1.58	0.0207
Acenaphthylene	EPA 8270C	-	0.601	ND(0.0103)
Anthracene	EPA 8270C	-	0.751	0.0186
Fluoranthene	EPA 8270C	-	1.02	ND(0.0103)
Fluorene	EPA 8270C	-	0.658	0.058
Naphthalene	EPA 8270C	-	0.275	ND(0.0103)
Phenanthrene	EPA 8270C	-	18.4	0.197
Pyrene	EPA 8270C	-	0.525	0.0166
Metals				
Aluminum	EPA 6010B	47,500	29,100	47,500
Arsenic	EPA 6020	30.5	14.4	1.83
Barium	EPA 6020	468	105	164
Cadmium	EPA 6020	ND	ND(0.5)	ND(1.55)
Calcium	EPA 6010B	7,720	**20,800**	**8,710**
Cerium	EPA 6020	13	**16.8 J**	**30.3 J**
Cesium	EPA 6020	ND	**0.723**	ND(1.55)
Chromium	EPA 6020	18.9	123	37.7
Cobalt	EPA 6020	37.3	**37.4 J**	ND(31.1) UJ
Copper	EPA 6020	82.4	106	128
Iron	EPA 6010B	123,000	23,500	35,600

TABLE 4.8-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR DRILL SITE E MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	Upland Stream Background Concentration[a]	98DOE-DRSE-1117-SD	98DOE-DRSE-1119-SD
			S mud pit	N mud pit
		Depth (feet)	0-1	0-0.2
Lithium	EPA 6020	21.7	7.03	9.91
Magnesium	EPA 6010B	17,000	6,500	9,470
Manganese	EPA 6020	26,500	673	1,877
Molybdenum	EPA 6020	ND	ND(5) UJ	ND(31.1) UJ
Nickel	EPA 6020	23.8	26.7 J	48 J
Potassium	EPA 6010B	1,290	613	1,270
Selenium	EPA 6020	3.15 [b]	0.758 J	ND(1.55) UJ
Strontium	EPA 6020	207	159	**208**
Thorium	EPA 6020	ND	**2.02**	**1.96**
Titanium	EPA 6020	1,480	664	1,010
Uranium	EPA 6020	ND	**1**	ND(1.55)
Vanadium	EPA 6020	336	99.7	142
Zinc	EPA 6020	185	92.1	198

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.8-3
SURFACE WATER ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSE-3037-SW	98DOE-DRSE-3036-SW	98DOE-DRSE-3034-SW	98DOE-DRSE-3035-SW (Duplicate)	98DOE-DRSE-3033-SW	98DOE-DRSE-3032-SW
			Station 1	Station 2	Station 3	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	104	65.4	ND(50)	54.3	52.7	66.3
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,3,5-Trimethylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Methylene chloride	EPA 8260B	-	7.94 U	ND(2)	5.94 U	6.56 U	ND(2)	2.1 UJ
n-Butylbenzene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Naphthalene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
p-Isopropyltoluene	EPA 8260B	-	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Acenaphthylene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Anthracene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluoranthene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Fluorene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Naphthalene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Phenanthrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Pyrene	EPA 8270C	-	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)

TABLE 4.8-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-DRSE-3037-SW Station 1	98DOE-DRSE-3036-SW Station 2	98DOE-DRSE-3034-SW Station 3	98DOE-DRSE-3035-SW (Duplicate) Station 3	98DOE-DRSE-3033-SW Station 4	98DOE-DRSE-3032-SW Station 5
Metals								
Aluminum	EPA 6020	87.1 [b]	54.6 J	ND(50)	85.8 J	52.4 J	105 J	99 J
Arsenic [c]	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	8,810 [b]	2,970	3,750	3,780	3,570	2,370	2,140
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cesium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium [c]	EPA 6020	3.49 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	9.52	4.01	4.55	4.63	ND(1)	4.74	4.28
Copper	EPA 6020	13.4 [b]	ND(1) UJ	1.57	2.85 J	1.1 J	1.54 J	1.69 J
Iron	EPA 6010B	2,830 [b]	ND(150)	ND(150)	150	ND(150)	ND(150)	ND(150)
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	2,610	2,850	2,830	2,780	1,830	1,690
Manganese	EPA 6020	748 [b]	12.9	19	19.9	8.09	17.1	17.9
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	1.69 [b]	1.12	1.47 J	1.65	ND(1)	1.4	1.44

TABLE 4.8-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration [a]	98DOE-DRSE-3037-SW Station 1	98DOE-DRSE-3036-SW Station 2	98DOE-DRSE-3034-SW Station 3	98DOE-DRSE-3035-SW (Duplicate) Station 3	98DOE-DRSE-3033-SW Station 4	98DOE-DRSE-3032-SW Station 5
Potassium	EPA 6010B	1,190 [b]	**1,510**	947 J	**1,220**	**1,330**	**1,610**	**1,270**
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	28.4	29.5	29.3	28.5	19.9	18.7
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1) UJ	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	2.37 [b]	ND(1) UJ	**6.31 J**	**7.7 J**	1.05 J	1.96 J	2.28 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	1.44 [b]	**2.25**	ND(1)	ND(1)	1.31	**1.77**	ND(1)
Zinc	EPA 6020	12.8 [b]	ND(10)	10.6	11.6	ND(10)	ND(10)	**13.7**

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

[c] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

TABLE 4.8-3 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E
(concentrations in micrograms per liter)

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-8.

TABLE 4.8-4
SEDIMENT ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSE-3037-SD	98DOE-DRSE-3036-SD	98DOE-DRSE-3035-SD	98DOE-DRSE-3033-SD	98DOE-DRSE-3032-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	ND(10.3)	22.1	ND(4)	ND(8.5)	ND(8.41)
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
1,3,5-Trimethylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
Methylene chloride	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
n-Butylbenzene	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
Naphthalene	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
p-Isopropyltoluene	EPA 8260B	mg/kg	-	-	ND(0.0641)	-	-	-
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	EPA 8270C	mg/kg	-	0.0103	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Acenaphthylene	EPA 8270C	mg/kg	-	ND(0.00848)	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Anthracene	EPA 8270C	mg/kg	-	ND(0.00848)	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Fluoranthene	EPA 8270C	mg/kg	-	ND(0.00848)	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Fluorene	EPA 8270C	mg/kg	-	0.0274	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Naphthalene	EPA 8270C	mg/kg	-	0.0154 R	ND(0.0176) R	ND(0.0033) R	ND(0.00701)	ND(0.00694)
Phenanthrene	EPA 8270C	mg/kg	-	0.0702	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Pyrene	EPA 8270C	mg/kg	-	ND(0.00848)	ND(0.0176)	ND(0.0033)	ND(0.00701)	ND(0.00694)
Metals								
Aluminum	EPA 6010B	mg/kg	47,500	25,100	17,000	11,700	19,500	21,700

TABLE 4.8-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E

Analyte	Analytical Method	Units	Upland Stream Background Concentration	98DOE-DRSE-3037-SD	98DOE-DRSE-3036-SD	98DOE-DRSE-3035-SD	98DOE-DRSE-3033-SD	98DOE-DRSE-3032-SD
				Station 1	Station 2	Station 3	Station 4	Station 5
Arsenic	EPA 6020	mg/kg	30.5	3.64	3.44	1.51	1.25 J	1.7 J
Barium	EPA 6020	mg/kg	468	76.7	36.5	61.6	49.9	64.2
Cadmium	EPA 6020	mg/kg	ND	ND(1.28)	ND(2.67)	ND(0.5)	ND(1.06) UJ	ND(1.05) UJ
Calcium	EPA 6010B	mg/kg	7,720	3,400	2,710	1,950	4,860	5,370
Cerium	EPA 6020	mg/kg	13	**19.7**	10.3	8.03	9.82	11.5
Cesium	EPA 6020	mg/kg	ND	ND(1.28) UJ	ND(2.67) UJ	ND(0.5) UJ	ND(1.06) UJ	ND(1.05) UJ
Chromium	EPA 6020	mg/kg	18.9	18.9	**41.1**	9.49	11.4	**22**
Cobalt	EPA 6020	mg/kg	37.3	18.5	4.03	7.66	11.5	15.1
Copper	EPA 6020	mg/kg	82.4	68	29.9	20.6	29.7	34.6
Iron	EPA 6010B	mg/kg	123,000	23,000	31,000	13,700	23,000	30,300
Lithium	EPA 6020	mg/kg	21.7	7.89	3.03	4.04	6.08	8.74
Magnesium	EPA 6010B	mg/kg	17,000	5,320	1,310	3,110	4,980	6,950
Manganese	EPA 6020	mg/kg	26,500	748	350	82.5	840	1,260
Molybdenum	EPA 6020	mg/kg	ND	ND(1.28)	ND(2.67)	**1.02**	ND(1.06) UJ	ND(1.05) UJ
Nickel	EPA 6020	mg/kg	23.8	32.5	6.28	11	12.4	16.9
Potassium	EPA 6010B	mg/kg	1,290	556	123	187	345 J	434 J
Selenium	EPA 6020	mg/kg	3.15 [b]	1.66	**3.31**	1.42	ND(1.06)	ND(1.05)
Strontium	EPA 6020	mg/kg	207	38.2	47.9	24.6	43.4	51.4
Thorium	EPA 6020	mg/kg	ND	ND(1.28) UJ	ND(2.67) UJ	ND(0.5) UJ	ND(1.06) UJ	ND(1.05) UJ

TABLE 4.8-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E

Analyte	Analytical Method	Units	Upland Stream Background Concentration[a]	98DOE-DRSE-3037-SD Station 1	98DOE-DRSE-3036-SD Station 2	98DOE-DRSE-3035-SD Station 3	98DOE-DRSE-3033-SD Station 4	98DOE-DRSE-3032-SD Station 5
Titanium	EPA 6020	mg/kg	1,480	940 J	715 J	471 J	937	1,010
Uranium	EPA 6020	mg/kg	ND	ND(1.28) UJ	ND(2.67) UJ	ND(0.5) UJ	ND(1.06) UJ	ND(1.05) UJ
Vanadium	EPA 6020	mg/kg	336	90.6	89.5	63.3	79.9	88.1
Zinc	EPA 6020	mg/kg	185	56.9	ND(26.7)	36.1	50.7	59.3
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	25,600	103,000	27,900	22,800	10,300
Acid Volatile Sulfide	Titration	umol/g	-	ND(0.0128)	ND(0.0267)	ND(0.005)	ND(0.0106)	ND(0.0105)
Simultaneously Extracted Metals	Summation	umol/g	-	6.12	3.56	0.886	0.922	0.951

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

- sample not analyzed for this parameter

mg/kg milligrams per kilogram

umol/g micromoles per gram

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

R result rejected due to quality control considerations

TABLE 4.8-4 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR UNNAMED STREAM, DRILL SITE E

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.
Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-9.

TABLE 4.8-5
FISH ANALYTICAL RESULTS FOR UNNAMED STREAM DRILL SITE E
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration	98DOE-DRSE-3042-F1	98DOE-DRSE-3040-F1	98DOE-DRSE-3039-F1
				Station 1	Station 2	Station 4
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	SW8270 SIM	81.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Acenaphthylene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Anthracene	SW8270 SIM	405.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo (a) anthracene	SW8270 SIM	0.0043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Benzo (a) pyrene	SW8270 SIM	0.00043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Benzo (b) fluoranthene	SW8270 SIM	0.0043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Benzo (ghi) perylene	SW8270 SIM	NA	-	ND(0.134)	ND(0.134)	ND(0.0335)
Benzo (k) fluoranthene	SW8270 SIM	0.043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Chrysene	SW8270 SIM	0.43	-	ND(0.134)	ND(0.134)	ND(0.0335)
Dibenzo (a,h) anthracene	SW8270 SIM	0.00043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Fluoranthene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluorene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Indeno (1,2,3-cd) pyrene	SW8270 SIM	0.0043	-	ND(0.134)	ND(0.134)	ND(0.0335)
Naphthalene	SW8270 SIM	27.0	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Phenanthrene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)
Pyrene	SW8270 SIM	40.6	-	ND(0.134)	ND(0.134)	ND(0.0335)
Polychlorinated Biphenyls						
Aroclor 1016	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1242	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1248	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1260	SW8081	0.0016	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Metals						
Aluminum	SW6020	1351.9	38.8	21.4	18.2	21.5
Arsenic (total)	SW6020	0.21	26.9	0.0548	0.0518	0.047
Arsenic (inorganic)	EPA Draft 1632	0.0021	0.0456	0.00176	0.00508	0.00111
Barium	SW6020	94.6	0.567	**1.08**	**0.635**	**0.714**

TABLE 4.8-5 (cont.)
FISH ANALYTICAL RESULTS FOR UNNAMED STREAM DRILL SITE E
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration[a]	98DOE-DRSE-3042-F1	98DOE-DRSE-3040-F1	98DOE-DRSE-3039-F1
				Station 1	Station 2	Station 4
Beryllium	SW6020	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Boron	SW6020	121.7	24.1	7.35 UJ	7.09 UJ	8.92 UJ
Cadmium	SW6020	1.4	ND	ND(0.0250)	ND(0.0250)	**0.0288**
Calcium	SW6020	NA	10,300	10,000	9,650	**10,800**
Cerium	SW6020	NA	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Cesium	SW6020	NA	ND	**0.036**	**0.026**	**0.033**
Chromium	SW6020	4.1	0.684	0.373	0.423	0.377
Cobalt	SW6020	81.1	0.0510 [b]	**0.118**	**0.15**	**0.0718**
Copper	SW6020	54.1	3.40	0.838 U	0.973 U	0.833 U
Iron	SW6020	405.6	73.6	36	35.8	36
Lithium	SW6020	27.0	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)
Magnesium	SW6020	NA	349	328	318	343
Manganese	SW6020	189.3	164	4.14	5.93	4.54
Molybdenum	SW6020	6.8	0.150 [b]	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	27.0	ND	ND(0.125)	**0.132**	ND(0.125)
Potassium	SW6020	NA	4,310	3,500	4,200	3,930
Selenium	SW6020	6.8	2.08	1.05	0.933	0.918
Strontium	SW6020	811.1	12.1 [b]	**13.4**	8.94	10.1
Thallium	SW6020	0.09	0.0755 [b]	ND(0.0250)	ND(0.0250)	0.0453
Thorium	SW6020	NA	4.67 [b]	ND(2.50) UJ, B	ND(2.50) UJ, B	ND(2.50) UJ, B
Titanium	SW6020	5407.4	0.834	0.418	0.671	0.579
Uranium	SW6020	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	9.5	0.289	0.22	0.21	0.195
Zinc	SW6020	405.6	78.0	54.2	43.4	53.5

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

TABLE 4.8-5 (cont.)
FISH ANALYTICAL RESULTS FOR UNNAMED STREAM DRILL SITE E
(concentrations in milligrams per kilogram)

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

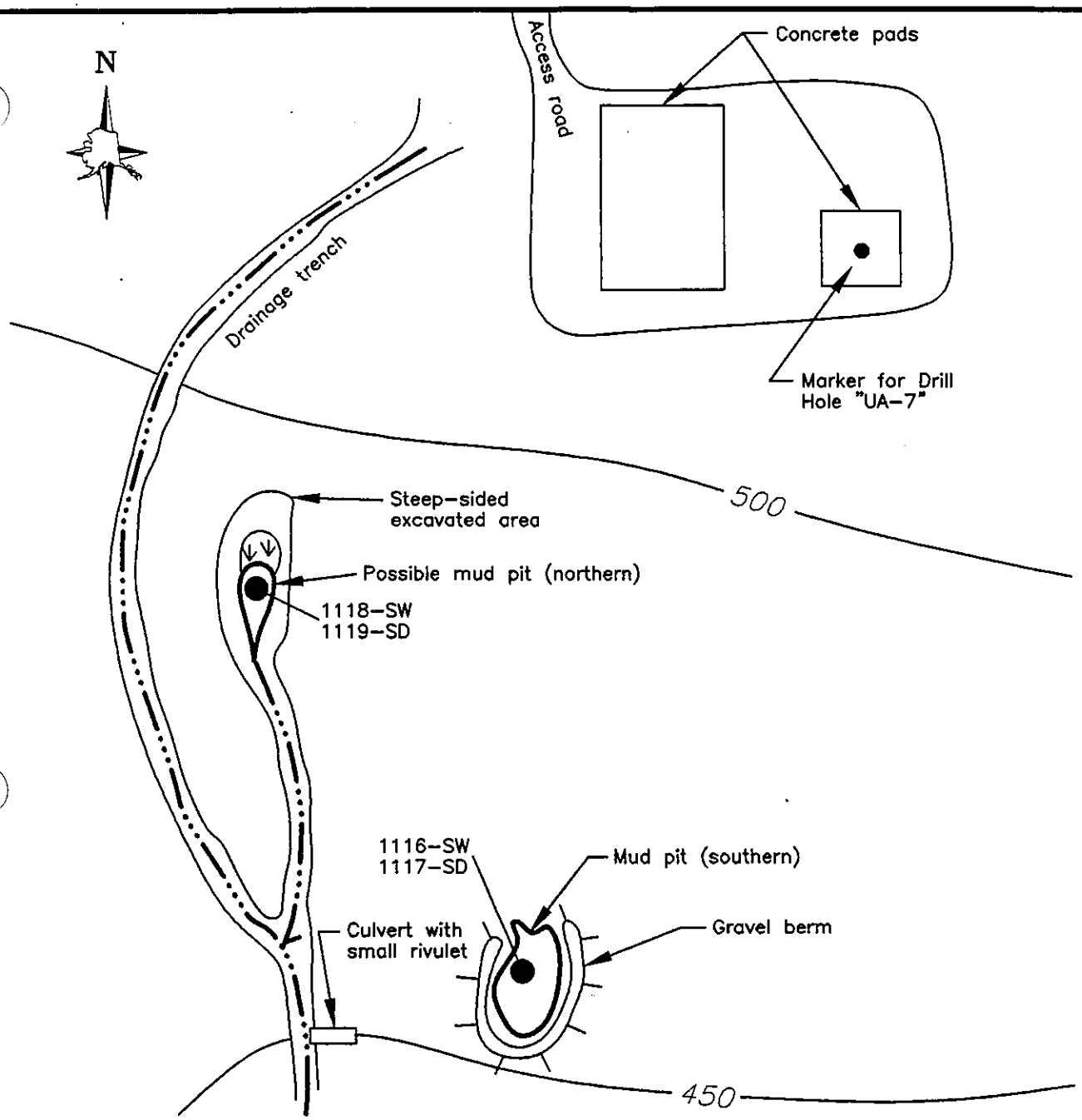
B analyte detected in method blank

U analyte concentration attributed to blank or laboratory contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

Bolded values indicate exceedance of background concentrations. See Appendix D of this report for a description of background concentration calculations.

Shaded cells indicate exceedance of Ecological Risk-Based Screening Concentrations presented in Table 2-10.



LEGEND

1118-SW ● Surface Water and Sediment Sampling Location and Number (All Sample Numbers Preceded by "98DOE-DRSE").

Stream

Marshy Area

APPROXIMATE SCALE (FEET)

0 100 200

Contour Interval= 50 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

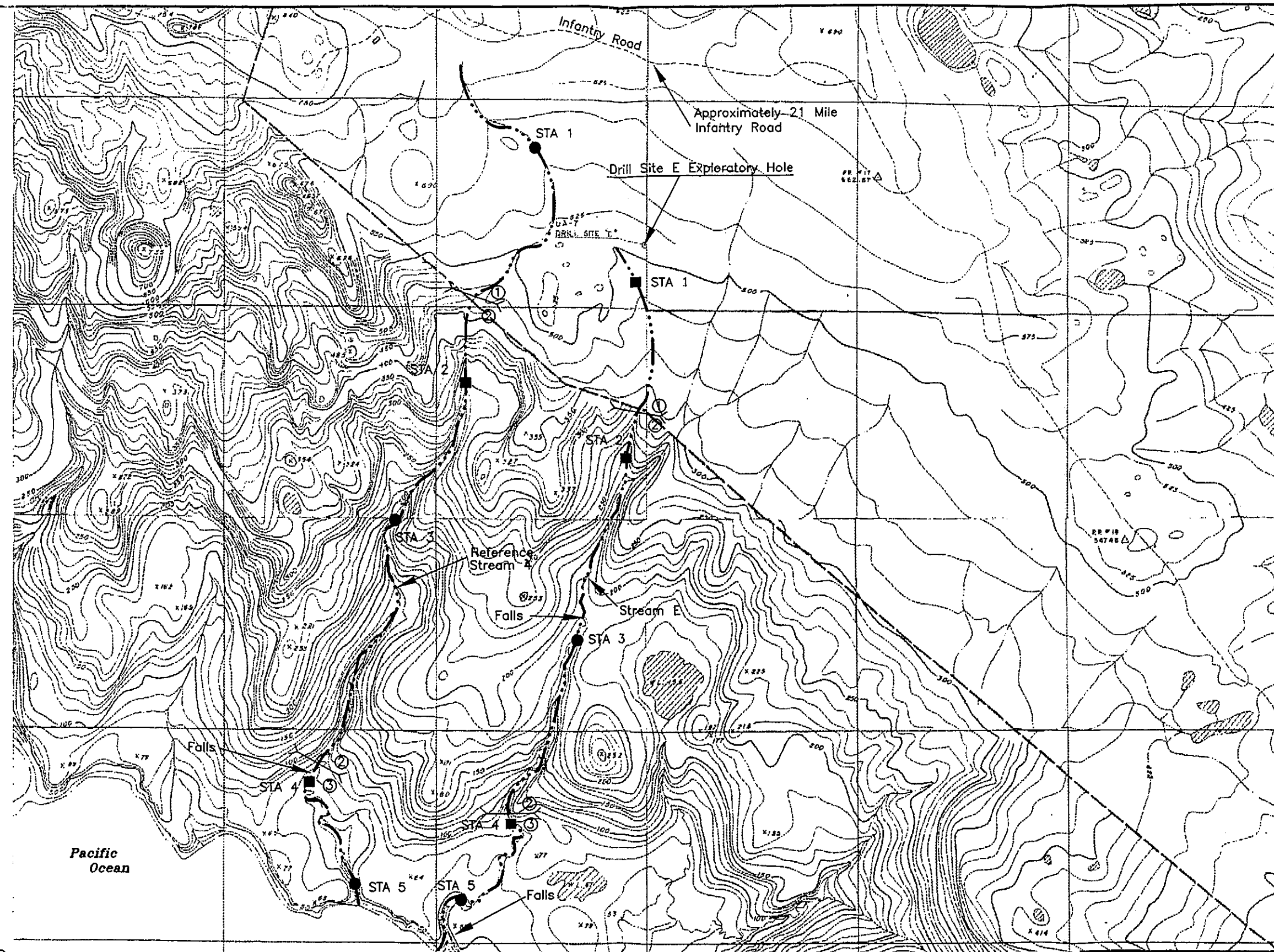
DRILL SITE E

September 1999
Revision Number: 0

X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4.8-1



LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Sections 4.8.4.2 and 4.9.4 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and Benthic Invertebrate Sampling. (See Sections 4.8.4.2 and 4.9.4 for Sample Numbers.)

② Reach Number

Reach Boundary

Investigated Stream Course

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

DRILL SITE E STREAM AND REFERENCE STREAM 4

September 1999
Revision Number: 0

X-0926

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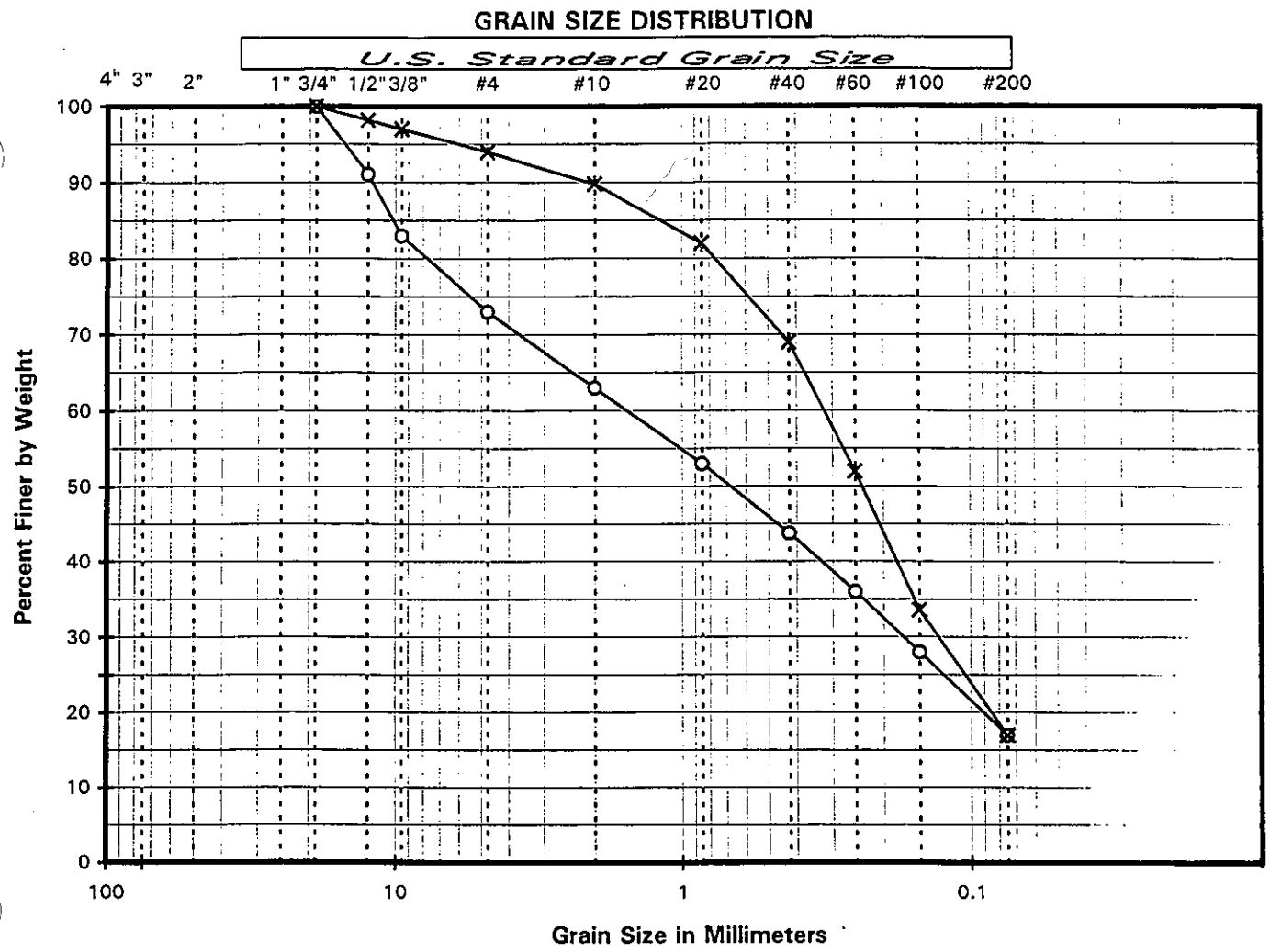
FIG. 4.8-2

FILE: DrillSiteE



Marker	Sample ID	Percent Passing by Dry Weight														
		U.S. Standard Sieve Size														
		4"	3"	2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.02mm
O	98DOE-DRSE-3037-SD					100	91	83	73	63	53	44	36	28	17	
X	98DOE-DRSE-3033-SD					100	98	97	94	90	82	69	52	34	17	
+																
-																

1998 Drill Site Investigation
Amchitka Island

GRAIN SIZE DISTRIBUTION CURVES
Stations 1 and 4, Stream E, Drill Site E

September 1999 X-0926

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Figure 4.8-3

Photo 4.8-1: Southern mud pit, Drill Site E, facing north. Pit dimensions are approximately 40 by 80 feet.

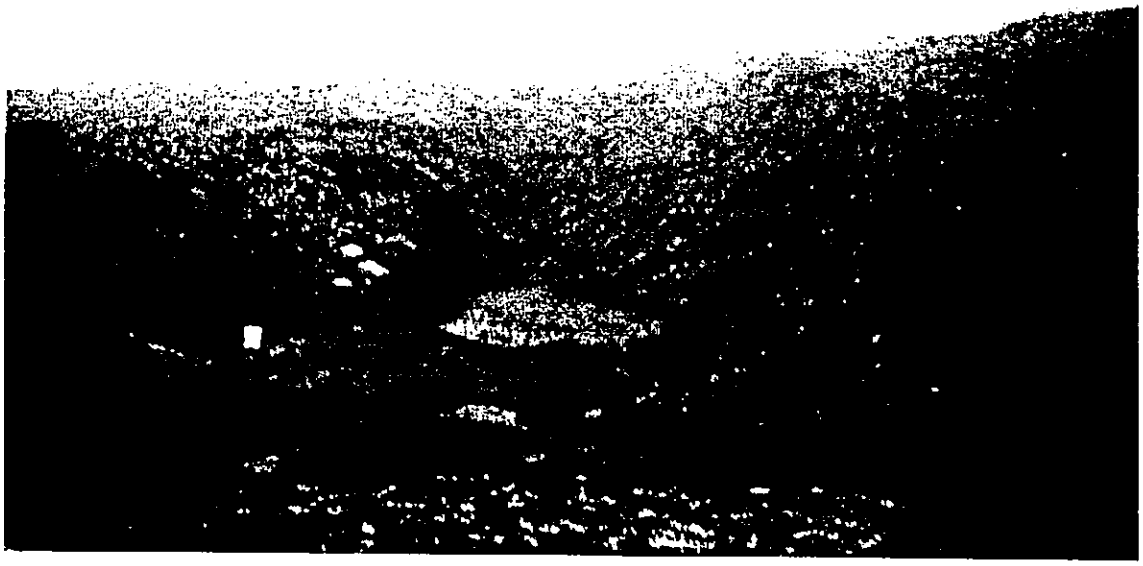


Photo 4.8-2: Northern mud pit, Drill Site E, facing south. This pit drains to the south, eventually entering Stream E.

Photo 4.8-3: Reach 2 of Stream E, facing downstream and south.

Photo 4.8-4: Reach 3 of Stream E, facing southwest. This reach has a flatter gradient than the two previous reaches.

4.9 REFERENCE STREAMS

Since the metals that are COPCs for the 1998 Drill Site Investigation are also naturally occurring, it was necessary to establish background concentrations from reference streams not impacted by anthropogenic contamination. Samples of water, sediment, benthic invertebrates, sediment for bioassays, and fish were collected from the reference streams following the same procedures used for site-related streams. In addition to metals, water and sediment samples were also analyzed for DRO to assess the possible contribution of naturally occurring organics to DRO concentrations reported in site-related streams. Fish tissue samples were also analyzed for PAHs and PCBs. Low levels of PAHs are pervasive across the planet through atmospheric transmission. PCBs are ubiquitous in marine settings and could possibly be spread to streams through migrating/decomposition of marine organisms.

The three nuclear test sites are situated at lower elevations (100 to 200 feet); whereas, the three other drill sites are at higher elevations (300 to 500 feet). Because of differences in stream and bedrock characteristics between these two areas, two lowland reference streams were selected (Reference Streams 1 and 2), as were two upland reference streams (Reference Streams 3 and 4). Observations and analytical results are described for each stream in the following sections.

4.9.1 Reference Stream 1

Reference Stream 1, one of two lowland reference streams included in the 1998 DOE Drill Site Investigation, is located about 1 mile northwest of the Milrow Site (Figure 4.1-2). This stream is approximately 4,500 feet long with an overall gradient of 2.8 percent. It begins at a small, unnamed lake (water level 144 feet), flows west, and then south to a beach on the Pacific Ocean. This stream was chosen as a reference stream because it appears to have few anthropogenic impacts. There are no roads nearby. The stream was accessed from the end of Rifle Range Road (2,000 feet to the south). There was some evidence of WWII activities along the stream, including lines of Rommel stakes (pickets for barbed-wire fence), tent and latrine placements (in Reach 3), and two empty 55-gallon drums (in Reach 3).

Field activities at Reference Stream 1 included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). One surface water and sediment sample was collected at each of five sampling stations along the length of the creek. At three of the sampling stations (Stations 1, 2, and 5) fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected. A second fish sample was collected at Station 5 as a background sample for PCB analysis.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.1-2.

Sample Numbers and Station Coordinates for Reference Stream 1

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 25' 23.5"	179° 09' 27.0"	120	4092-SW 4093-SD 4099-FS 4100-IN
2	51° 25' 19.2"	179° 09' 16.9"	100	4090-SW 4091-SD
3	51° 25' 15.6"	179° 09' 03.2"	80	4088-SW 4089-SD 4097-FS 4098-IN
4	51° 25' 10.8"	179° 08' 57.7"	70	4086-SW 4087-SD
5	51° 25' 03.6"	179° 08' 56.3"	40	4083-SW 4084-SD 4094-FS 4160-FS 4096-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.9.1.1 Stream Characteristics

Based on observations during the initial reconnaissance, Reference Stream 1 was divided into three stream reaches (Figure 4.1-2). Reach 1 begins near the outlet of a small pond, flows through a broad, gently sloping valley, and ends as the stream gradient increases. Reach 2 lies within a narrower valley (from 800 down to 400 feet wide) and includes a major tributary confluence. Reach 3 flows through a 200- to 300-foot-wide, steep-sided canyon with numerous small waterfalls and one 7-foot-high waterfall a short distance above the beach. The following table summarizes reach characteristics for Reference Stream 1.

Reach Characteristics for Reference Stream 1

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	2,000	1.7	Many bends	Peat
2	1,600	3.1	Few bends	Peat
3	900	4.4	Few bends	Gravel/Cobbles

Reach 1
In Reach 1, the stream channel is typically about 1 foot wide by 6 inches deep. In places, there are several braided channels of approximately equal size and minor tributaries entering. The stream banks are low and vertical to undercut with overhanging vegetation. In several places the stream flows beneath the ground surface. The channel is incised through peat, and the bottom generally consists of soft peat. In-stream vegetation is thick, consisting primarily of moss (*Fontinalus* sp.) and marsh marigold.

Station 1 was located about 700 feet upstream of the boundary between Reaches 1 and 2.

Reach 2
In Reach 2 both the average stream channel dimensions and the stream gradient increase. A major tributary that contributes about 50 percent of the overall stream flow enters from the north, about 100 feet upstream of Station 3. Above the confluence the channel averages 2 feet wide and 1 foot deep; below the confluence, the channel is 3 feet wide and 2 feet deep. The channel continues to be deeply incised through peat, forming vertical to undercut banks and occasionally subterranean tunnels. There are numerous 6-inch- to 1-foot-high waterfalls along the reach. Stations 2, 3, and 4 are located within Reach 2 (Figure 4.1-2). Photo 4.9-1 shows the downstream view near Station 2.

Reach 3
A steep-sided canyon, numerous falls, and an increased gradient characterize Reach 3. The stream banks are up to 5 feet high and generally vertical to undercut. The water depth ranges from 4 to 6 inches. The channel width averages 3 feet. The stream bottom typically consists of sand, gravel, and cobbles with deposits of silt and peat. The in-stream vegetation cover is about 40 percent and consists primarily of moss. A 7-foot-high waterfall is located about 200 feet upstream of the beach. Station 5 is located about halfway down Reach 3 (Photo 4.9-2).

4.9.1.2 Surface Water

Five surface water samples were collected from Reference Stream 1, one for each sampling station. Each sample was analyzed for DRO and metals. A summary of analytical results is presented in Table 4.9-1.

DRO was reported in all five surface water samples at concentrations ranging from 50.8 and 146 ug/L. These detections are interpreted as biogenic hydrocarbons quantified within the DRO range.

The following twelve metals were detected in the surface water samples from Reference Stream 1.

Aluminum	Calcium	Cobalt	Copper
Iron	Magnesium	Manganese	Potassium
Strontium	Titanium	Vanadium	Zinc

The concentrations of these metals are attributed to naturally-occurring background levels. As described in Appendix D, they were combined with the results for Reference Stream 2 and used to calculate statistically based background concentrations for these metals in lowland stream surface water.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented below. The average conductivity of Reference Stream 1 water is significantly lower than for any other project stream. This is probably related to the fact that metals concentrations in surface water samples from Reference Stream 1 were relatively low compared to other streams.

Surface Water Parameters for Reference Stream 1

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	6.4	9.9	11.2	87	Clear
2	6.1	9.5	9.5	91	Clear
3	6.3	9.4	11.5	82	Clear
4	6.1	9.4	10.0	86	Clear
5	6.0	9.4	9.7	91	Clear

4.9.1.3 Sediment

One sediment sample was collected at each of five stations on Reference Stream 1 The sediment samples were analyzed for DRO, TOC, AVS/SEM, and metals. A single sample was later analyzed for PCBs. Analytical results for sediment samples are summarized in Table 4.9-2 DRO was not detected in any of the sediment samples. A total of 21 metals was detected in the Reference Stream 1 sediment samples. These included the following:

Aluminum	Arsenic	Barium	Calcium	Cerium	Chromium
Cobalt	Copper	Iron	Lithium	Magnesium	Manganese
Molybdenum	Nickel	Potassium	Selenium	Strontium	Titanium
Uranium	Vanadium	Zinc			

As described in Appendix D, the metals results from this stream were combined with the results for Reference Stream 2 to calculate statistically-based background metals concentrations for lowland stream sediment.

The sediment sample from Station 5 was analyzed for PCBs in conjunction with samples from Reference Streams 3 and 4, to determine whether measurable concentrations of PCBs were present in reference stream sediment. No PCBs were detected, although the reporting limit was elevated (0.237 mg/kg) due to the relatively low 21 percent solids (high moisture content) typical for samples of peat-rich sediment in Amchitka streams.

AVS and SEM concentrations in the sediment samples from Reference Stream 1 are presented in the following table. Only at Station 1 where acid volatile sulfides were detected are they sufficient to limit the availability of the SEM metals to organisms.

AVS and SEM Concentrations for Reference Stream 1

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4093-SD	61.3	1.08	0.02
2	4091-SD	0	0.967	NA
3	4089-SD	0	3.59	NA
4	4087-SD	0	2.54	NA
5	4084-SD	0	1.81	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations. Organic content was also determined for three samples. No grain-size gradation analysis was performed due to insufficient mineral soil content. The results are presented in the following table.

Sediment Characteristics for Reference Stream 1

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4093-SD	91,600	55.7	Brown, silty PEAT
2	4091-SD	98,400	-	Brown PEAT
3	4089-SD	77,600	69.4	Brown, silty PEAT
4	4087-SD	76,400	-	Brown, silty PEAT
5	4084-SD	67,100	46.0	Brown, silty PEAT

4.9.1.4 Benthos

Benthic samples were collected from Stations 1, 3, and 5 in Reference Stream 1. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to

the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Reference Stream 1

Class	Order	Family	Common Name	Life Stage	Individuals per Station 1	3	5
Turbellaria	Tricladida	Planariidae	flatworm	adult		4	10
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult	4	164	102
Collembola	Collembola	Isotomidae	springtail	adult		4	
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph		4	
	Trichoptera	Limniphilidae	caddisfly	larva	56	56	42
	Diptera	Chironomidae	midge	larva	648	96	36
		Diamesinae	midge	larva			2
		Tipulidae	cranefly	larva		4	
				Total	**708**	**332**	**192**
				Family Biotic Index	5.85	6.57	6.53
				EPT Relative Abundance	7.9%	16.9%	21.9%
				Species Diversity	0.31	1.22	1.18

4.9.1.5 Sediment Toxicity Tests

Sediment samples collected from Stations 1, 3, and 5 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Sediment Toxicity for Reference Stream 1

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	90.00%	101.40%	0.280	55.50%	2.55	56.90%
3	47.50%	53.52%	0.588	116.70%	2.81	62.70%
5	83.75%	94.37%	0.281	55.80%	2.34	52.20%

4.9.1.6 Fish

Fish samples consisting of resident Dolly Varden were collected at Stations 1, 3, and 5. Samples from Stations 1 and 3 are shown in Photo 4.9-3. An additional fish sample was collected at

Station 5. The fish collected at each station were combined into one sample per station and submitted for whole body tissue analyses. Specific data such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of each of the fish samples.

Fish Sample Descriptions for Reference Stream 1

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	4099-FS	4 - 6.5	14	330	23.6	491
3	4097-FS	1.5 - 6.5	27	450	16.7	947
5	4094-FS	2 - 8.5	18	330	18.3	624
5 (extra)	4160-FS	2 - 6	25	225	9.0	755

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.9-3 and summarized below.

No PCBs were detected in fish samples from Reference Stream 1. Naphthalene, a PAH compound, was detected in one sample from Station 5. The concentration was estimated at 0.0255 mg/kg, which was below the detection limit for the rest of the PAHs analyses. No other PAHs were detected in the fish samples.

Nineteen metals were detected in the fish samples, as listed below.

Aluminum	Arsenic	Barium	Boron	Cadmium	
Calcium	Chromium	Cobalt	Copper	Iron	
Magnesium	Manganese	Potassium	Selenium	Strontium	Thorium
Titanium	Vanadium	Zinc			

The sample concentrations were compared to the project RBCs for fish consumption. None of the metals concentrations that exceeded background levels also exceeded the RBCs; however, there are no established RBCs for arsenic, calcium, magnesium, potassium, or thorium.

Inorganic arsenic was detected in each of the four fish samples from Reference Stream 1, at concentrations ranging from 0.00226 to 0.0104 mg/kg. These concentrations exceed the RBC of 0.0021 mg/kg for this compound.

4.9.2 Reference Stream 2

Reference Stream 2, the second of two lowland reference streams included in the 1998 DOE Drill Site Investigation, is located about 1 mile southeast of Cannikin Lake and White Alice

Creek (Figure 4.3-2). This stream is approximately 6,500 feet long, and is intersected by Infantry Road. The stream begins in a nearly flat, grass-sedge meadow and flows northeast to the Bering Sea. This stream was chosen as a reference stream because it was not associated with any drill site activities. However, there are anthropogenic effects to the stream resulting from the road crossing. There is evidence of siltation and deposition in an area up to 1,000 feet downstream of the road.

Field activities at Reference Stream 2 included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (resident Dolly Varden only). One surface water and sediment sample was collected at each of five sampling stations along the length of the creek. At three of the sampling stations (Stations 2, 3, and 5) fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.3-2.

Sample Numbers and Station Coordinates for Reference Stream 2

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 27' 38.3"	179° 07' 59.8"	129	4143-SW 4144-SD
2	51° 27' 41.3"	179° 08' 05.4"	115	4141-SW 4142-SD 4153-FS 4154-IN
3	51° 27' 49.5"	179° 08' 08.6"	106	4138-SW 4139-SD/4140-SD 4151-FS 4152-IN
4	51° 27' 55.2"	179° 08' 12.3"	95	4136-SW 4137-SD
5	51° 28' 06.0"	179° 08' 25.5"	40	4134-SW 4135-SD 4149-FS 4150-IN

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.9.2.1 Stream Characteristics

Based on observations during the initial reconnaissance, Reference Stream 2 was divided into three stream reaches. Reach 1 begins 3,500 feet upstream of Infantry Road and ends at the road. Reach 2 begins at the road and ends where the stream valley becomes steeper and narrower. An increased gradient and stream velocity characterize Reach 3, which ends at a sand and cobble beach. There were no significant fish barriers such as waterfalls observed along the stream. The following table summarizes reach characteristics for Reference Stream 2.

Reach Characteristics for Reference Stream 2

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	3,500	1.7	Many bends	Silty peat
2	1,500	1.5	Many bends	Silt
3	1,500	4.7	Few bends	Sand

Reach 1

The terrain along Reach 1 has very low relief. The stream channel is typically about 1 foot wide by 3 to 6 inches deep. The stream banks are low and vertical to undercut with overhanging vegetation. The bank vegetation consists primarily of grass with cow parsnip and wild celery. In numerous places the stream flows beneath the ground surface. The channel is incised through peat, and the bottom generally consists of silty peat. In-stream vegetation consists primarily of moss (*Fontinalus* sp.). One tributary enters Reference Stream 1 about 50 feet upstream of Station 2; this tributary contributes less than 15 percent to the overall stream discharge. Stations 1 and 2 were located about 900 and 200 feet, respectively, upstream of Infantry Road.

Reach 2

Reach 2 is located downstream of Infantry Road. Photo 4.9-4 shows the downstream view from Infantry Road. The stream appears to have been impacted by siltation from road-related construction activities and erosion. The natural drainage pattern may have been altered. Levees have formed along the stream for several hundred feet downstream of the road. The area between Stations 3 and 4 consists of a wetlands with disrupted drainage; there is no longer a main channel but rather multiple rivulets, and much of the flow is underground. The wetland covers an area roughly 800 by 200 feet. Where the channel is present it is often deeply incised, with stream banks that are up to 5 feet high and generally vertical to undercut. The incised nature of the stream is illustrated in Photo 4.9-5 taken at Station 3. The stream bottom consists mainly of silt.

Reach 3

The gradient increases from approximately 2 to 5 percent as Reach 3 approaches the sea. The stream channel here is about 3 feet wide by 1 foot deep. Banks are generally undercut with overhanging vegetation (grass). The stream bottom is firm and typically consists of sand, gravel,

and cobbles, especially in the lower portion of the reach. Station 5 is located in the lower portion of Reach 3, about 250 feet upstream of the beach.

4.9.2.2 Surface Water

Five surface water samples were collected from Reference Stream 2, one from each sampling station. Each sample was analyzed for DRO and metals. A summary of analytical results is presented in Table 4.9-1.

DRO was reported in all five surface water samples at concentrations ranging from 71.3 to 147 ug/L. However, 55.5 ug/L of DRO also was present in the laboratory method blank associated with this batch of samples. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. The reported concentrations of DRO are also comparable to the concentrations of DRO reported in water from the other lowland reference stream (Reference Stream 1) as explained in Section 4.9.1.2. Thus, the reported DRO values from Reference Stream 2 may represent laboratory contamination, biogenic hydrocarbons, or a combination of the two.

The following fourteen metals were detected in the surface water samples from Reference Stream 2.

Aluminum	Calcium	Chromium	Cobalt
Copper	Iron	Lithium	Magnesium
Manganese	Potassium	Strontium	Thallium
Titanium	Vanadium		

This is a similar list of metals to those found in Reference Stream 1 (Section 4.9.1.2), with the addition of chromium, lithium, and thallium and the absence of zinc. The concentrations of these 14 metals are attributed to naturally-occurring background levels. As described in Appendix D they were combined with the results from Reference Stream 1 to calculate statistically-based background concentrations for these metals in lowland stream surface water.

Metals concentrations in water from Stations 1 and 2 upstream of Infantry Road were compared with concentrations from the three stations downstream of the road, to determine if Infantry Road had a noticeable impact on water quality in Reference Stream 2. Increases in dissolved metals concentration that corresponded to higher metals concentrations in sediment downstream of the road were noted for aluminum, titanium, and vanadium. However, potassium and strontium concentrations in water increased downstream of the road, while their concentration in sediment decreased. In general, Infantry Road does not appear to have had a significant impact on water quality under the flow conditions present at the time the water samples were collected.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented below.

Surface Water Parameters for Reference Stream 2

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity
1	6.7	10.0	10.5	145	Clear
2	6.8	9.8	11.6	150	Clear
3	7.2	9.8	10.5	136	Clear
4	6.7	9.0	10.6	167	Clear
5	6.8	8.0	11.5	203	Clear

4.9.2.3 Sediment

One sediment sample was collected at each of five stations on Reference Stream 2; a duplicate sample was collected at Station 3. All sediment samples were analyzed for DRO, TOC, AVS/SEM, and metals. Analytical results for sediment samples are summarized in Table 4.9-2.

DRO was detected in four of the five stations at concentrations ranging from 9.47 to 15.3 ug/L. These detections are interpreted as biogenic hydrocarbons that are quantified within the DRO range.

The following 25 metals were detected in sediment samples from Reference Stream 2.

Aluminum	Arsenic	Barium	Boron	Cadmium
Calcium	Cerium	Chromium	Cobalt	Copper
Iron	Lithium	Magnesium	Manganese	Molybdenum
Nickel	Potassium	Selenium	Strontium	Thallium
Thorium	Titanium	Uranium	Vanadium	Zinc

This is the same list of metals found in Reference Stream 1 (Section 4.9.1.3), with the addition of boron, cadmium, thallium, and thorium. All 25 metals were detected at Station 5; upstream samples contained fewer metals. The concentrations of metals in Reference Stream 2 were attributed to naturally-occurring background levels. As described in Appendix D, they were combined with the results from Reference Stream 1 to calculate statistically-based background concentrations for these metals in lowland stream sediment.

Metals concentrations in sediment from Stations 1 and 2 upstream of Infantry Road were compared with concentrations from the three stations downstream of the road, to determine if Infantry Road had a noticeable impact on sediment quality in Reference Stream 2. Some concentrations increased between Stations 2 and 3, while others decreased. There does not

appear to be a significant impact to metals concentrations in sediment as a result of the road at the time of this study.

AVS and SEM concentrations in the sediment samples from Reference Stream 2 are presented in the following table. Results suggest there are insufficient acid volatile sulfides present at any of the stations in the reference stream to limit the availability of the SEM metals to organisms.

AVS and SEM Concentrations for Reference Stream 2

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	4144-SD	0	3.15	NA
2	4142-SD	0.132	1.89	14.32
3	4139-SD/4140-SD	0/0.369	3.07/3.1	NA/8.40
4	4137-SD	0	3.21	NA
5	4135-SD	0	3.91	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations. Organic content was also determined for three samples. The results are presented in the following table. No grain-size gradation analyses were performed due to insufficient mineral soil content.

Sediment Characteristics for Reference Stream 2

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	4144-SD	12,400	-	Silty PEAT
2	4142-SD	23,300	51.2	Brown SILT with organics
3	4139-SD	15,900	26.2	Brown, slightly sandy SILT with organics
4	4137-SD	19,200	-	Brown PEAT
5	4135-SD	13,800	12.1	Brown, medium to coarse SAND

4.9.2.4 Benthos

Benthic samples were collected on Reference Stream 2 at Stations 2, 3, and 5. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Reference Stream 2

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					2	3	5
Turbellaria	Tricladida	Planariidae	flatworm	adult			1
Peleycopoda	Spaeracea	Sphaeriidae	clam	juvenile	332	560	
Collembola	Collembola	Hypogasturidae	springtail	adult			3
		Isotomidae	springtail	adult		8	
Insecta	Ephemeroptera	Baetidae	mayfly	nymph			54
	Hemiptera	Veliidae	ripple bug	nymph		8	1
	Trichoptera	Limniphilidae	caddisfly	larva	20	24	22
	Diptera	Chironomidae	midge	larva	76	136	6
		Diamesinae	midge	larva			1
				Total	**428**	**736**	**88**
				Family Biotic Index	7.46	7.49	4.14
				EPT Relative Abundance	4.7%	3.3%	86.4%
				Species Diversity	0.65	0.73	1.1

4.9.2.5 Sediment Toxicity Tests

Sediment samples collected from Stations 2, 3, and 5 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation.

Measurements of toxicity include survival (percentage of initial seed organisms surviving to the end of the test), growth (average dry weight of surviving organisms), and biomass (total dry weight of surviving organisms). Since the toxicity tests were conducted in three batches, the data were control normalized in order to make appropriate comparisons. Normalization consisted of expressing the results as a percentage of the average laboratory control response for the laboratory control sample tested concurrently with the particular sample. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Sediment Toxicity in Reference Stream 2

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
2	87.50%	92.11%	0.299	57.30%	2.56	51.90%
3	75.00%	78.95%	0.301	57.70%	2.28	46.20%
5	76.25%	80.26%	0.360	69.00%	2.75	55.80%

4.9.2.6 Fish

Fish samples consisting of resident Dolly Varden were collected at Stations 2, 3, and 5. The fish collected at each station were combined into one sample for each station and submitted for whole body tissue analyses. Specific data, such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish samples.

Fish Sample Descriptions for Reference Stream 2

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
2	4153-FS	2 – 6.5	18	300	16.6	408
3	4151-FS	3.5 - 6	8	150	18.7	510
5	4149-FS	3 – 6.5	18	300	16.6	606

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.9-3 and summarized below.

No PAHs were detected in fish samples from Reference Stream 2. The PCB Aroclor 1254 was detected in one sample from Station 5 at an estimated concentration of 0.00823 mg/kg, which was below the detection limit for the rest of the PCB analyses. No other PCBs were detected in the fish samples.

Twenty-three metals were detected in at least one fish sample each.

Aluminum	Arsenic	Barium	Boron	Calcium	Cerium
Cesium	Chromium	Cobalt	Copper	Iron	Lithium
Magnesium	Manganese	Molybdenum	Potassium	Selenium	Strontium
Thallium	Thorium	Titanium	Vanadium	Zinc	

The list of metals detected in at least one sample each of Reference Stream 2 is similar to the list for Reference Stream 1 (Section 4.9.1.6), except cadmium was not detected, and cerium, cesium, lithium, molybdenum, and thallium were.

The sample concentrations were compared to the project RBCs for fish consumption. None of the sample concentrations exceeded the RBCs; however, there are no established values for arsenic, calcium, cerium, cesium, magnesium, potassium, or thorium.

Inorganic arsenic was detected in each of the three fish samples from Reference Stream 2 at concentrations ranging from 0.000832 to 0.0117 mg/kg. Two of three results exceeded the RBC of 0.0021 mg/kg for this compound.

4.9.3 Reference Stream 3

Reference Stream 3 was selected due to its similarity to upland streams at Drill Site D (Falls Creek) and Drill Site F (Limpet Creek), which were investigated as part of the 1998 Drill Site Investigation. This stream was chosen as a replacement for the originally selected Reference Stream 3 (Figure 4-4 of the 1998 *Management Plan*). That stream was abandoned after an initial reconnaissance revealed the potential for significant historical anthropogenic impact. Specifically, the pond at the headwaters of the original Reference Stream 3 was downgradient from the emplacement hole at Drill Site D. This location implied the possibility that Drill Site D drilling mud or other drilling-related fluids may have reached the pond (i.e. the headwaters of the stream) and thus impacted the stream. While there was no direct evidence that impacts to the pond or stream had occurred, a decision was made to abandon the original reference stream because of the potential for drilling-related impacts. Some WWII-era outlook buildings were noted on the bluff adjacent to the mouth of the new reference stream, but no other anthropogenic impacts were obvious, and the stream is not known to be related to any drilling activities.

The new Reference Stream 3 is located approximately 1 mile west of the Cannikin site (Figures 1-2 and 4.9-1). It is approximately 9,500 feet long and flows southwestward to the Pacific Ocean. The stream begins in a flat grass-sedge meadow, increases in gradient along its middle reaches, and flattens again before it enters the ocean.

Field activities at Reference Stream 3 included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (Dolly Varden only). One surface water and one sediment sample were collected at each of five sampling stations along the length of the creek. Fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected at Stations 1, 2, and 4.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.9-1.

Sample Numbers and Station Coordinates for Reference Stream 3

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 28.470'	179° 5.124'	265	3068-SW 3069-SD 3075-FS 3076-IN
2	51° 28.058'	179° 4.949'	185	3066-SW 3067-SD 3073-FS 3074-IN

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
3	51° 27.897'	179° 4.602'	110	3064-SW 3065-SD
4	51° 27.469'	179° 4.198'	45	3062-SW 3063-SD 3070-FS/3071-FS 3072-IN
5	51° 27.325'	179° 3.952'	15	3057-SW 3060-SD/3061-SD

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.9.3.1 Stream Characteristics

Based on observations during the initial reconnaissance, Reference Stream 3 was divided into three reaches (Figure 4.9-1). Reach 1 begins in a flat grass-sedge meadow surrounded by several small ponds. There were no distinct channels from any of the ponds, suggesting the stream headwaters were fed by subsurface flow except possibly during heavy rainfall events. The stream within Reach 1 meanders through a broad, gently-sloped valley and ends as the gradient increases at the beginning of Reach 2. Reach 2 lies within a narrower valley (400 to 800 feet wide) and ends just upstream of a major tributary confluence that contributes approximately 30 percent to the stream's volume. Portions of the stream within Reach 2 remain underground for distances of 20 to 50 feet. At the lower end of Reach 2, just upstream of the tributary, the valley widens again, and a significant decrease in gradient corresponds to the beginning of Reach 3. The wide valley within the upstream portion of Reach 3 narrows again after about 1,000 feet, and Reach 3 remains in a relatively steep-sided valley until it reaches the Pacific Ocean at a cobble and gravel beach. The following table summarizes reach characteristics for Reference Stream 3.

Reach Characteristics for Reference Stream 3

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	1,500 – 2,000	1.0	Few bends	Peat and silt
2	5,000	3 – 4	Many small bends	Gravel intermixed with and overlying silty peat
3	3,000	2 – 3	Many small bends	Cobbles and gravel mixed with sand and silty peat.

Reach 1

Reference Stream 3 begins in a 10- to 15-acre, relatively flat meadow at approximately Mile 12 on Infantry Road. The upstream portion of Reach 1 lies within a wet meadow, while the downstream portion of the reach is drier with the beginning of a shallow U-shaped valley. The edges of the wet meadow slope gently toward the stream channel. There are several ponds to the north and south of the meadow. These ponds are all at slightly higher elevations than the stream channel within Reach 1, and although there are no channels from most of these small ponds, it is likely they are the sources of Reference Stream 3, providing water to the channel through underground flow. At the farthest upstream portion of the reach there are several small braided channels of approximately equal size (less than 1 foot wide and 1 to 2 inches deep). These multiple channels come together within 300 feet of their origin and form a channel typically about 1 foot wide by 6 inches deep. This channel cuts through peat, and the bottom substrate is very soft peat. The are no banks within the meadow in Reach 1. Rather, the channel is beneath the surface and meanders within a wet boggy meadow that contains a large amount of standing water. Emergent sedges dominate the channel, all of the standing water, and the majority of the meadow. Station 1 was located along the channel in the middle portion of the wet sedge meadow.

One tributary flows from a small pond north of the stream channel into the stream. This tributary contributes approximately 10 to 15 percent to the flow of the main channel. In the vicinity of this confluence the channel widens and becomes incised approximately 2 to 3 feet into the meadow. In this same vicinity, likely as a result of the increased capacity and depth of the stream channel, the wet meadow ends, a broad U-shaped valley begins, and the stream banks become dominated with upland sedges and grasses. In a few areas the channel flows underground for short distances (20 to 50 feet). Reach 2 continues approximately 200 feet past the confluence to a distinct change in stream gradient.

Reach 2

Within the upstream portion of Reach 2 the average stream channel dimensions increase compared to Reach 1, a distinct valley is developed along the stream, and the stream gradient increases (Photo 4.9-6). In addition, the stream channel becomes incised 3 to 6 feet. The bottom substrate within Reach 2 is hard-packed, scoured peat with some cobble and gravel deposits, and has patchy areas of moss and filamentous algae. Station 2 is located about 1,800 feet downstream of the beginning of Reach 2 in the upper portion of the well-defined valley. Station 3 is in the mid-portion of Reach 2, approximately 2,000 feet downstream of Station 2 and 150 feet upstream of a tributary that enters from the north. This tributary contributes approximately 15 percent of the overall stream discharge. Reach 2 ends approximately 1,800 feet downstream of Station 3 and 200 feet upstream of a major tributary that enters the stream from the northwest. At this point the narrow valley opens into a wide plateau that marks the beginning of Reach 3.

Reach 3

Reach 3 begins at a decrease in gradient within a plateau that opens up from the Reach 2 valley, just upstream of a major tributary that flows into Reference Stream 3 from the northeast. This tributary contributes about 30 percent to the stream discharge. Approximately 1,000 feet below

the tributary a steep-sided valley forms along the stream. This valley continues to the stream's mouth at the Pacific Ocean. The stream substrate with Reach 3 includes cobbles and gravel, with some sand. Peat is also common. Patches of moss are attached to the stream bottom.

Within the plateau the channel continues to be deeply incised through peat, forming vertical to undercut banks and occasionally subterranean tunnels. Station 4 is located at the upstream end of the steep-sided valley approximately 1,500 feet downstream of the major tributary. Within this valley the stream channel widens and becomes slightly less incised and does not run underground. Station 5 is nearly 500 feet upstream of the mouth of the stream. Another tributary enters from the northwest between Station 5 and the mouth. This tributary contributes 15 to 20 percent to the stream's discharge. The stream enters the Pacific Ocean at a cobble and gravel beach.

4.9.3.2 Surface Water

Five surface water samples were collected from Reference Stream 3, one for each sampling station. Each sample was analyzed for DRO and metals. A summary of analytical results is presented in Table 4.9-4.

DRO was reported in three of five surface water samples at concentrations ranging from 62.7 to 84.8 ug/L. However, a concentration of 55.5 ug/L of DRO was present in the laboratory method blank associated with this batch of samples. In accordance with the EPA *National Functional Guidelines for Organic Data Review* (EPA, 1991), these samples have been qualified as nondetects at detection limits corresponding to the reported values, because they are less than five times the method blank concentration. The reported concentrations of DRO are also comparable to the concentrations of DRO reported in water from the other upland reference stream (Reference Stream 4, see Section 4.9.4.2). Thus, the reported DRO values from Reference Stream 3 may represent laboratory contamination, biogenic hydrocarbons, or a combination of the two.

Fifteen metals were detected in the surface water samples from Reference Stream 3, including:

Aluminum	Calcium	Chromium	Cobalt
Copper	Iron	Magnesium	Manganese
Nickel	Potassium	Strontium	Thallium
Titanium	Vanadium	Zinc	

The concentrations of these 15 metals were attributed to naturally-occurring background levels in the stream. As described in Appendix D, these concentrations were combined with the results for Reference Stream 4 to calculate statistically-based background concentrations for these metals in upland reference stream surface water.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Reference Stream 3

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	7.7	10.9	11.66	170	0
2	7.49	8.1	14.4	164	0
3	7.16	8.2	13.73	173	0
4	7.16	7.5	13.25	194	0
5	-	7.3	11.5	174	0

Note: - Turbidity not measured due to equipment malfunction

4.9.3.3 Sediment

One sediment sample was collected at each of five stations on Reference Stream 3. All sediment samples were analyzed for DRO, TOC, AVS/SEM, and metals. Sediment samples from Stations 4 and 5 were also analyzed for PCBs. Analytical results for sediment samples are summarized in Table 4.9-5.

No PCBs were detected in either of the two sediment samples. The detection limits were somewhat elevated due to relatively low percent solids (35 to 39 percent).

DRO was detected in one of the five samples (Station 1) at 206 mg/kg. This is interpreted as biogenic hydrocarbons quantified within the DRO range.

The following 25 metals were detected in the Reference Stream 3 sediment samples.

Aluminum	Arsenic	Barium	Boron
Calcium	Cerium	Chromium	Cobalt
Copper	Iron	Lithium	Magnesium
Manganese	Nickel	Potassium	Selenium
Strontium	Titanium	Vanadium	Zinc

The concentrations of these metals were attributed to naturally-occurring background. As described in Appendix D, they were combined with the results for Reference Stream 4 to calculate statistically-based background concentrations for these metals in upland reference stream sediment.

AVS and SEM concentrations in the sediment samples from Reference Stream 3 are presented in the following table. Results suggest that Stations 2 through 5 contain sufficient acid volatile sulfides to limit the bioavailability of the naturally-occurring SEM metals to organisms. The

SEM to AVS ration at Station 1 suggests the potential for naturally-occurring SEM metals to be bioavailable.

AVS and SEM Concentrations for Reference Stream 3

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	3069-SD	2.63	3.46	1.32
2	3067-SD	50.9	3.86	0.08
3	3065-SD	118	1.74	0.01
4	3063-SD	5.94	2.82	0.47
5	3060-SD/3061-SD	150/355	4.24/3.18	0.03/0.01

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations. Organic content determinations were performed on three samples to also allow for comparison of the substrate between stations where benthic invertebrates were sampled. No grain-size analyses were performed due to insufficient mineral soil content in the samples. The results of the total organic carbon and organic content analyses are presented in the following table.

Sediment Characteristics for Reference Stream 3

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	3069-SD	159,000	114.3	Dark brown peat
2	3067-SD	108,000	38.3	Dark brown peat
3	3065-SD	59,400	-	Dark brown silty peat
4	3063-SD	70,400	22.5	Dark brown silty peat
5	3060-SD/3061-SD	40,500/49,700	-	Dark brown peaty silt

4.9.3.4 Benthos

Benthic samples were collected from Reference Stream 3 at Stations 1, 2, and 4. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Reference Stream 3

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					1	2	4
Turbellaria	Tricladida	Planariidae	flatworm	adult		1	
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult	2	3	8
Peleycopoda	Spaeracea	Sphaeriidae	clam	juvenile	68		
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph		13	4
	Hemiptera	Veliidae	Ripple Bug	nymph		1	
	Trichoptera	Limniphilidae	caddisfly	larva	4	41	6
	Diptera	Chironomidae	midge	larva	90	36	46
Crustacea	Amphipoda	Talitridae (genus Hyalella sp.)	scud	adult	2		
				Total	**166**	**94**	**64**
				Family Biotic Index	6.82	4.89	5.94
				EPT Relative Abundance	2.4%	56.8%	15.6%
				Species Diversity	0.89	1.21	0.89

4.9.3.5 Sediment Toxicity Tests

Sediment samples collected from Stations 1, 2, and 4 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Sediment Toxicity Results, Reference Stream 3

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	62.50%	65.79%	0.324	62.1%	1.82	36.9%
2	57.50%	60.50%	0.318	60.9%	1.82	36.9%
4	91.25%	96.05%	0.320	61.3%	2.87	58.2%

4.9.3.6 Fish

Fish samples consisting of Dolly Varden were collected at Stations 1, 2, and 4. At Station 4 a large sample was collected and split (by weight) into one original and one field duplicate sample. Note that a 12-inch fish was collected at Station 1 that may have been a sea-run Dolly Varden.

The fish collected were combined into one sample for each station and submitted for whole-body tissue analyses. Specific data, such as the size of individual fish, are presented in the field fish-collection forms in Appendix J. The following table summarizes the size and weight of the fish samples.

Fish Sample Descriptions for Reference Stream 3

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
1	3075-FS	2.5 - 12	9	400	44.4	1240
2	3073-FS	2.5 - 6	35	320	9.1	633
4	3070-FS	2 - 6	19	310	16.3	802
4 (dupl.)	3071-FS	2 - 6	38	330	8.7	802

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. Analytical results are presented in Table 4.9-6 and summarized below.
No PAHs or PCBs were detected in fish samples from Reference Stream 3.

Nineteen metals were detected. The list of metals detected in at least one sample is as follows:

Aluminum	Arsenic	Barium	Boron	Calcium	Chromium
Copper	Iron	Magnesium	Manganese	Molybdenum	Potassium
Selenium	Strontium	Thallium	Thorium	Titanium	Vanadium
Zinc					

The results obtained for the sample and duplicate at Station 4 are remarkably similar. The metals concentrations were compared to the project RBCs for fish consumption. None of the sample concentrations exceeded the RBCs; however, there are no established values for arsenic, calcium, magnesium, potassium, or thorium.

Inorganic arsenic was detected in each of the four fish samples from Reference Stream 3 at concentrations ranging from 0.00147 to 0.0122 mg/kg. Two of four results exceeded the RBC of 0.0021 mg/kg for this compound.

4.9.4 Reference Stream 4

Reference Stream 4 is located west of Drill Site E (Figures 1-2 and 4.8-2). This stream is approximately 9,000 feet long, beginning about 500 feet south of Infantry Road and flowing southward to the Pacific Ocean. This stream was chosen as a reference stream because of its similarity to the Drill Site E stream investigated during this study, and because no anthropogenic impacts are known or were observed along the stream.

Field activities at Reference Stream 4 included a reconnaissance to document stream characteristics and select sample station locations, and sampling of surface water, sediment, benthic macroinvertebrates, and fish (Dolly Varden only). One surface water and sediment sample were collected at each of five sampling stations along the length of the creek. Fish, benthic macroinvertebrates, and sediment samples for bioassays were also collected at Stations 2, 3, and 4).

In all other upland streams, fish, benthic macroinvertebrate, and sediment bioassay samples were collected from each reach. However, at Reference Stream 4 these samples were not collected from Reach 1, because it was unlikely that fish could swim between Reach 2 to Reach 1 due to a steep gradient at the upstream end of Reach 2. In addition, the stream within Reach 1 appeared to be poor fish habitat because of its small size and underground flow.

The following table lists the sample numbers of each medium collected at each station, as well as site coordinates. Latitude and longitude of sampling stations were measured using a hand-held GPS receiver and are accurate to about ±100 feet. Station elevations were interpolated from contours in Figure 4.8-2.

Sample Numbers and Station Coordinates for Reference Stream 4

Station	North Latitude	East Longitude	Elevation (feet MLLW)	Sample Number
1	51° 33.704'	178° 57.268'	540	3050-SW 3050-SD
2	51° 33.322'	178° 57.053'	300	3049-SW 3049-SD 3055-FS 3056-IN
3	51° 33.101'	178° 56.905'	150	3048-SW 3048-SD 3053-FS 3054-IN
4	51° 32.786'	178° 56.772'	60	3047-SW 3047-SD 3051-FS 3052-IN
5	51° 32.644'	178° 56.775'	20	3044-SW/3045-SW 3044-SD

Notes: SW = surface water SD = sediment FS = fish IN = invertebrates

The following subsections present observations made during the reconnaissance and sampling activities and discuss analytical results for surface water, sediment, benthos, and fish samples.

4.9.4.1 Stream Characteristics

Based on observations during the initial reconnaissance, Reference Stream 4 was divided into three stream reaches (Figure 4.8-2). Reach 1 begins on a hill northwest of the Drill Site E emplacement hole and ends just before a major increase in gradient. After this short, (600 feet) steep descent, the gradient of Reach 2 decreases and the stream flows through a small plateau, then into a 100- to 150-foot-deep by 200- to 300-foot-wide valley. The stream remains within this valley throughout most of the length of Reach 2. There is a second small plateau on the eastern side of the stream about two-thirds of the distance down Reach 2. Reach 3 begins where the stream gradient decreases noticeably and the valley opens to a broad plateau before the stream reaches the ocean. The following table summarizes reach characteristics for Reference Stream 3.

Reach Characteristics for Reference Stream 4

Reach	Length (feet)	Overall Gradient (%)	Sinuosity	Substrate
1	2,500	2 – 3	Few bends	Dark brown silty peat
2	5,000	3 – 4	Many small bends	Cobbles and gravel with some sand and peat
3	1,500	1 – 2	Many bends	Cobbles and gravel with some sand

Reach 1

Reach 1 begins approximately 500 feet south of Infantry Road and 2,000 feet northwest of the Drill Site E emplacement hole. The headwaters of Reference Stream 4 are a series of small braided rivulets flowing down a short-grass and lichen covered hillside with a gradient of 2 to 3 percent. The braided channels are less than a foot wide and only 1 to 3 inches deep. Within the middle portion of Reach 1 the braided channels join to form a channel that is incised 3 to 6 feet and frequently flows underground (Photo 4.9-7). At this point the stream channel is typically about 2 feet wide and 2 to 10 inches deep. Within Reach 1 the stream banks vary from low and gently sloped to vertical and undercut. There is a lack of aquatic vegetation. Some moss (*Fontinalus* sp.) is present on the stream bottom. The bottom substrate is firm peat with some embedded cobbles and gravel. Station 1 was located approximately 700 feet upstream of the boundary between Reaches 1 and 2.

Reach 2

Reach 2 begins at a dramatic increase in gradient from approximately 3 to 6 percent. This steep area is about 600 feet long and then the gradient decreases to 3 to 4 percent for the remainder of Reach 2. At that point the stream enters a small plateau and is 3 to 6 feet wide and 0.5 to 2 feet deep. The bottom substrate is cobbles and gravel. In-stream vegetation includes large patches of moss that trap and hold a large amount of sand, silt, and peat. The banks are generally low (i.e. 1 to 3 feet) and vertical or undercut. About 300 feet downstream from the gradient decrease a

steep-sided valley forms along the stream (Photo 4.9-8), but the stream character remains the same as within the plateau. Within Reach 2 the stream never flows underground and the channel is clear.

A major tributary enters from the northwest about 2,000 feet downstream of the top of Reach 2 and contributes about 35 to 40 percent of the overall stream discharge. A 15- to 20-acre plateau forms on the eastern side of the stream about 1,000 feet downstream of the tributary. This plateau reverts back to steep-sided valley after approximately 400 feet, and the valley continues for the remainder of Reach 2. Station 2 is located 200 feet downstream of the steep section of Reach 2. Station 3 is approximately 500 feet downstream of the tributary confluence at the upstream edge of the second plateau. (Figure 4.8-2).

Reach 3

Reach 3 begins at a decrease in gradient to 1 to 2 percent and is characterized by a flat, open plateau leading to the stream's mouth at the Pacific Ocean. The character of the stream remains very similar to Reach 2 with a cobble and gravel substrate, clear channel, and vertical or undercut banks of 2 to 4 feet high. There is a slight increase in the amount of cobbles and a noticeable decrease in the amount of moss. The stream is about 3 to 6 feet wide and 2 to 6 feet deep. A few sandbars are present on the inner edge of stream meanders. There is a 3-foot waterfall about 150 feet downstream of the beginning of Reach 3. This waterfall is not likely to be a fish barrier at high water flows. As the stream reaches the ocean it cuts a small valley into the ocean-front bluff, but the overall stream character does not change. The mouth of the stream was piled with large driftwood logs and debris. This debris could be a barrier to sea-run fish passage. Cobbles, boulders, driftwood, and anthropogenic flotsam dominate the beach at the mouth of the stream.

4.9.4.2 Surface Water Quality

Five surface water samples were collected from Reference Stream 4, one at each sampling station. Each sample was analyzed for DRO and metals. A summary of analytical results is presented in Table 4.9-4.

DRO was reported in two of five surface water samples at concentrations ranging from 54.0 and 59.5 ug/L. These detections are interpreted as biogenic hydrocarbons that are quantified within the DRO range.

Ten metals were detected in at least one surface water sample:

Calcium	Cobalt	Magnesium	Manganese
Nickel	Potassium	Strontium	Thorium
Titanium	Zinc		

The concentrations of these ten metals are attributed to naturally-occurring background levels. As described in Appendix D, they were combined with the results for Reference Stream to calculate statistically-based background concentrations for these metals in upland reference stream surface water.

Surface water quality parameters measured at each station during the 1998 Drill Site Investigation are presented in the following table.

Surface Water Parameters for Reference Stream 4

Sampling Station	pH	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)
1	6.33	10.7	10.25	151	0
2	6.22	8.7	12.68	158	0
3	6.10	8.3	12.6	165	0
4	5.95	8.4	11.98	168	0
5	5.92	8.2	11.54	174	0

4.9.4.3 Sediment

One sediment sample was collected at each of five stations on Reference Stream 4. All sediment samples were analyzed for DRO, TOC, AVS/SEM, and metals. Sediment samples from Stations 3, 4, and 5 were also analyzed for PCBs. Analytical results for sediment samples are summarized in Table 4.9-5.

No PCBs were detected in the three analyzed sediment samples.

DRO was detected in four of the five sediment samples at concentrations ranging from 6.59 to 10.7 mg/kg. These are interpreted as biogenic hydrocarbons that are quantified within the DRO range.

The following 19 metals were detected in the sediment samples.

Aluminum	Arsenic	Barium	Calcium
Cerium	Chromium	Cobalt	Copper
Iron	Lithium	Magnesium	Manganese
Nickel	Potassium	Selenium	Strontium
Titanium	Vanadium	Zinc	

The concentrations of these 19 metals were attributed to naturally-occurring background levels. As described in Appendix D, they were combined with the results for Reference Stream 3 to calculate statistically-based background concentrations for these metals in upland reference stream sediment.

AVS and SEM concentrations in the sediment samples from Reference Stream 4 are presented in the following table. Analytical results suggest AVS are absent from the sediments at Reference Stream 4, indicating that naturally-occurring SEM present within the stream may be bioavailable. This complete absence of AVS in sediment is in contrast to many of the other upland streams. At Stations 2 through 5 the discrepancy is likely due to the location where the sediment samples were taken (mid-stream depositional areas) and their contents (unconsolidated peat or sand). These two factors lead to aeration of the sample via the flow of water between the sediment particles. Since AVS forms in anaerobic conditions, it would not be expected in sediment of this type.

AVS and SEM Concentrations for Reference Stream 4

Station	Sample Number	AVS (umole/g)	SEM (umole/g)	SEM:AVS Ratio
1	3050-SD	0	0.922	NA
2	3049-SD	0	1.71	NA
3	3048-SD	0	1.27	NA
4	3047-SD	0	0.646	NA
5	3044-SD/3045-SD	0	0.463	NA

TOC was determined for each of the sediment samples to allow normalization of organic chemical concentrations to carbon, and comparison between the substrate at the various stations for the benthic invertebrate analysis. Organic content was also determined for three samples to allow for comparison of the substrate between stations where benthic invertebrates were sampled. Grain-size analyses were performed on sediment samples from Stations 3 and 4, which contained sufficient mineral soil content so that the analyses were considered appropriate. The grain-size analyses also allow comparison of substrate between benthic invertebrate sampling stations. The results of the total organic carbon and organic content analyses are presented in the following table. The results of the grain-size analyses from Station 3 and 4 sediment samples are presented in Figure 4.9-3.

Sediment Characteristics for Reference Stream 4

Station	Sample Number	TOC (mg/kg dry weight)	Organic Content (% dry weight)	Soil Classification
1	3050-SD	21,900	-	Dark brown silty peat
2	3049-SD	38,000	11.4	Silt and sand with some peat
3	3048-SD	12,000	11.0	Dark brown peaty silt and sand
4	3047-SD	18,000	16.1	Dark brown peaty silt and sand
5	3044-SD/ 3045-SD	4,150	-	Dark brown peaty silt and sand

4.9.4.4 Benthos

Benthic samples were collected on Reference Stream 4 at Stations 2, 3, and 4. These samples were submitted to the Somerset, New Jersey, office of IT Corporation, where the invertebrates in each sample were identified and counted. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Benthic Invertebrates in Reference Stream 4

Class	Order	Family	Common Name	Life Stage	Individuals per Station		
					2	3	4
Oligochaeta	Tubificida	Tubificidae	tubifex worm	adult	76	92	134
Insecta	Ephemeroptera	Baetidae (genus Pseudocloeon sp.)	mayfly	nymph	6	1	4
	Trichoptera	Limniphilidae	caddisfly	larva	6		6
	Diptera	Empididae	dance fly	larva	6	1	
		Chironomidae	midge	larva	54		16
				Total	**148**	**94**	**160**
				Family Biotic Index	6.86	7.94	7.55
				EPT Relative Abundance	8.1%	1.1%	6.3%
				Species Diversity	1.1	0.12	0.59

4.9.3.5 Sediment Toxicity Tests

Sediment samples collected from Stations 2, 3, and 4 were used to perform 10-day freshwater sediment bioassay tests using larvae of the midge *Chironomus tentans*. The tests were performed by American Aquatic Testing in Allentown, Pennsylvania, under subcontract to IT Corporation. Results are presented in the following table. Refer to the *Triad Analysis of Drill Site and Test Site Stream Sediments* (Appendix F) for an evaluation of these data.

Sediment Toxicity Results, Reference Stream 4

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	Result (mg)	Normalized	Result (mg)	Normalized
1	87.50%	92.11%	0.377	72.2%	3.33	67.5%
2	91.25%	102.82%	0.315	62.5%	2.86	63.8%
4	76.25%	85.90%	0.396	78.6%	2.99	66.7%

4.9.3.6 Fish

Fish samples consisting of Dolly Varden were collected at Stations 2, 3, and 4. The fish collected at each station were combined into one sample for each station and submitted for whole-body tissue analyses. Specific data, such as the size of individual fish, are presented in the field fish collection forms in Appendix J. The following table summarizes the size and weight of the fish samples.

Fish Sample Descriptions for Reference Stream 4

Station	Sample Number	Length (inches)	Number of Fish	Total Sample Weight (grams)	Average Weight Per Fish (grams)	Electroshock Time (seconds)
2	3055-FS	2 – 5.5	41	310	7.6	1103
3	3053-FS	2.5 – 5	42	340	8.1	2423
4	3051-FS	2 - 11	18	390	21.7	1347

Fish tissue samples were analyzed for total metals, inorganic arsenic, PAHs, and PCBs. The sample from Station 3 was also tested for percent lipids. Analytical results are presented in Table 4.9-6 and summarized below.

No PAHs or PCBs were detected in fish samples from Reference Stream 4. There were 1.5 percent lipids in the fish sample from Station 3.

Nineteen metals were detected. The metals that were detected in at least one sample are as follows:

Aluminum	Arsenic	Barium	Boron	Calcium	Chromium
Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum
Potassium	Selenium	Strontium	Thallium	Titanium	Vanadium
Zinc					

The metals concentrations were compared to the project RBCs for fish consumption. None of the sample concentrations exceeded the RBCs; however, there are no established values for arsenic, calcium, magnesium, or potassium.

Inorganic arsenic was detected in each of the three fish samples from Reference Stream 4 at concentrations ranging from 0.000594 to 0.0015 mg/kg. These concentrations are below the RBC of 0.0021 mg/kg for this compound.

TABLE 4.9-1
SURFACE WATER ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration	98DOE-RS01-4092-SW	98DOE-RS01-4090-SW	98DOE-RS01-4088-SW	98DOE-RS01-4086-SW	98DOE-RS01-4083-SW	98DOE-RS02-4143-SW	98DOE-RS02-4141-SW	98DOE-RS02-4138-SW	98DOE-RS02-4136-SW	98DOE-RS02-4134-SW
			Reference Stream 1					Reference Stream 2				
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	-	94	80	90.6	50.8	146	141 U	142 U	147 U	71.3 U	136 U
Metals												
Aluminum	EPA 6020	269	119	138	165	161	175	ND(50)	ND(50)	57.3	74.3 J	87.5 J
Arsenic	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Cadmium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Calcium	EPA 6010B	4,320 [b]	1,110	1,250	1,240	1,390	1,440	3,700	3,700	3,320	3,570	4,320
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium	EPA 6020	2.25 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	2.25 J	1.78 J
Cobalt	EPA 6020	3.35	2.44	1.19	1.64	2.41	1.57	1.35	1.15	ND(1)	1.29	ND(1)
Copper	EPA 6020	10.8	5.29 J	1.16 J	2 J	2.39 J	1.52 J	ND(1)	1.69	ND(1)	1.42 J	1.11 J
Iron	EPA 6010B	993	667	552	563	877	592	612	515	502	618	315
Lithium	EPA 6020	1.17 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.17
Magnesium	EPA 6010B	4,690 [b]	1,620	1,630	1,510	1,540	1,560	3,830	3,720	3,430	3,960	4,690
Manganese	EPA 6020	267	28.4	19	12.3	13.2	8.3	69.2	13.1	5.77	86 J	5.34 J

TABLE 4.9-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Lowland Stream Background Concentration [a]	98DOE-RS01-4092-SW	98DOE-RS01-4090-SW	98DOE-RS01-4088-SW	98DOE-RS01-4086-SW	98DOE-RS01-4083-SW	98DOE-RS02-4143-SW	98DOE-RS02-4141-SW	98DOE-RS02-4138-SW	98DOE-RS02-4136-SW	98DOE-RS02-4134-SW
			Reference Stream 1					Reference Stream 2				
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Molybdenum	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Nickel	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Potassium	EPA 6010B	2,620	264	441	563	800	350	952	911	855	1,480	2,250
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	36.1	11.7	12.1	11.2	11.8	12.5	19.5	19.1	18.7	23.7	30.8
Thallium	EPA 6020	7.07 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	7.07 J	3.02 J
Thorium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Titanium	EPA 6020	6.13	3.11 J	3.27 J	3.7 J	4.33 J	4.34 J	1.58	1.31	1.48	2.34 J	2.91 J
Uranium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Vanadium	EPA 6020	4.43 [b]	ND(1)	ND(1)	1.68	1.09	1.13	ND(1)	ND(1)	ND(1)	1.85	4.43
Zinc	EPA 6020	50.3 [b]	50.3	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

TABLE 4.9-1 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in micrograms per liter)

J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U	analyte concentration attributed to blank contamination; result considered nondetect

TABLE 4.9-2
SEDIMENT ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS

Analyte	Analytical Method	Units	Lowland Stream Background Concentration	98DOE-RS01-4093-SD	98DOE-RS01-4091-SD	98DOE-RS01-4089-SD	98DOE-RS01-4087-SD	98DOE-RS01-4084-SD	98DOE-RS02-4144-SD	98DOE-RS02-4142-SD	98DOE-RS02-4139-SD	98DOE-RS02-4140-SD (Duplicate)	98DOE-RS02-4137-SD	98DOE-RS02-4135-SD
				Reference Stream 1					Reference Stream 2					
				Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	ND(22)	ND(22.9)	ND(25.6)	ND(27.8)	ND(18.9)	14.9	13.6	ND(10.1)	ND(10.9)	15.3	9.47
Polychlorinated Biphenyls	EPA 8082	mg/kg	-	-	-	-	-	ND	-	-	-	-	-	-
Metals														
Aluminum	EPA 6010B	mg/kg	45,400	24400	33100	18400	26700	28000	14200	17200	30200	33000	22100	35000
Arsenic	EPA 6020	mg/kg	100	7.57	21.1	15.5	6.63	11.4	5.73 J	2.48	3.42	40.3 J	9.19	20.3 J
Barium	EPA 6020	mg/kg	469	99.6	74.1	175	102	109	279	303	ND(633)	149	165	339
Boron	EPA 6010B	mg/kg	7.18 [b]	ND(13.7) UJ	ND(14.3) UJ	ND(16) UJ	ND(17.4) UJ	ND(11.8) UJ	ND(13) UJ	ND(6.4) UJ	ND(6.33) UJ	ND(6.83) UJ	7.18 J	5.42 J
Cadmium	EPA 6020	mg/kg	0.608 [b]	ND(2.74)	ND(2.86)	ND(3.21)	ND(3.47)	ND(2.37)	ND(1.3)	ND(1.28) UJ	ND(1.27) UJ	ND(1.37)	ND(1.39) UJ	0.608
Calcium	EPA 6010B	mg/kg	7,300	1480	1670	4580	2980	4980	5860	1950	2350	2830	2560	4090
Cerium	EPA 6020	mg/kg	14.2	9.89	12.6	8.12	9.2	10.9	5.91	6.05	7.72	8.65	8.17	8.72
Chromium	EPA 6020	mg/kg	11.8	8.51	8.45	5.66	7.73	8.4	4.8 J	3.77	3.4	7.57 J	4.31	6.27 J
Cobalt	EPA 6020	mg/kg	43.7	20.2	11	35.4	23.5	21.4	20.9 J	9.45 J	8.75 J	17.3 J	18.4 J	31.7 J
Copper	EPA 6020	mg/kg	71.1	36	38	24.5	40.7	51.5	21.5 J	25.4 J	46.3 J	59.3 J	39.8 J	40.9 J
Iron	EPA 6010B	mg/kg	155,000	53600	10400	81400	68600	48100	137000	37700	53400	61000	92800	56500
Lithium	EPA 6020	mg/kg	48.8	7.83	10.2	7.02	9.38	15.5	6.52	37.8	15.7	12.9	13.5	15.1
Magnesium	EPA 6010B	mg/kg	9,320	3510	2690	4280	6600	8220	4820	4010	5170	6150	4570	4990
Manganese	EPA 6020	mg/kg	20,700	6740	125	14400	12100	2260	41700	4640	5100	3300	9380	46300
Molybdenum	EPA 6020	mg/kg	5.5 [b]	ND(2.74)	ND(2.86)	5.5	ND(3.47)	ND(2.37)	4.1	ND(1.28)	ND(1.27)	ND(1.37)	ND(1.39)	5
Nickel	EPA 6020	mg/kg	13.6	4.98 J	5.12 J	7.65 J	7.36 J	8.04 J	4.36	3.15 J	4.25 J	9.17	4.7 J	11.6
Potassium	EPA 6010B	mg/kg	1,390	183 J	316 J	572 J	584 J	826 J	1180 J	441 J	635 J	808 J	507 J	759 J
Selenium	EPA 6020	mg/kg	5.44 [b]	3.74	5.44	3.37	ND(3.47)	ND(2.37)	ND(1.3)	ND(1.28) UJ	ND(1.27) UJ	ND(1.37)	ND(1.39) UJ	0.951
Strontium	EPA 6020	mg/kg	164	39.6	36.5	89	58.4	101	148 J	63.8	45.4	69.5 J	54.4	85.3 J
Thallium	EPA 6020	mg/kg	1 [b]	ND(2.74)	ND(2.86)	ND(3.21)	ND(3.47)	ND(2.37)	ND(1.3)	ND(1.28)	ND(1.27)	ND(1.37)	ND(1.39)	1
Thorium	EPA 6020	mg/kg	0.5 [b]	ND(2.74) UJ	ND(2.86) UJ	ND(3.21) UJ	ND(3.47) UJ	ND(2.37) UJ	ND(1.3)	ND(1.28)	ND(1.27)	ND(1.37)	ND(1.39)	0.5
Titanium	EPA 6020	mg/kg	3,010	585	733	210	653	968	976 J	1520	1930	1750 J	2130	1790 J
Uranium	EPA 6020	mg/kg	4.13 [b]	ND(2.74) UJ	4.13 J	ND(3.21) UJ	ND(3.47) UJ	ND(2.37) UJ	ND(1.3)	ND(1.28)	ND(1.27)	ND(1.37)	2.46	2.11
Vanadium	EPA 6020	mg/kg	734	194	239	245	204	239	124 J	99.7	77.6	163 J	184	479 J
Zinc	EPA 6020	mg/kg	434	45.5	47	167	86.9	112	94.7 J	55.3	70.5	81.4 J	116	292 J
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	91600	98400	77600	76400	67100	12400	23300	15900	16000	19200	13800
Acid Volatile Sulfide	Titration	umol/g	-	61.3	ND(0.0286)	ND(0.0321)	ND(0.0347)	ND(0.0237)	ND(0.013)	0.132	ND(0.0127)	0.369	ND(0.139)	ND(0.005)
Simultaneously Extracted Metals	Summation	umol/g	-	1.08	0.967	3.59	2.54	1.81	3.15	1.89	3.07	3.1	3.21	3.91

TABLE 4.9-2 (cont.)
SEDIMENT ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS

a	Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
b	This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.
ND(1)	Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
-	sample not analyzed for this parameter
mg/kg	milligrams per kilogram
umol/g	micromoles per gram
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

TABLE 4.9-3
FISH ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-RS01-4099-FS	98DOE-RS01-4097-FS	98DOE-RS01-4094-FS	98DOE-RS01-4160-FS	98DOE-RS02-4153-FS	98DOE-RS02-4151-FS	98DOE-RS02-4149-FS
				Reference Stream 1				Reference Stream 2		
				Station 1	Station 2	Station 5	Station 5	Station 2	Station3	Station 5
Polycyclic Aromatic Hydrocarbons										
Acenaphthene	SW8270 SIM	81.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Acenaphthylene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Anthracene	SW8270 SIM	405.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)anthracene	SW8270 SIM	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)pyrene	SW8270 SIM	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(b)fluoranthene	SW8270 SIM	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(ghi)perylene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(k)fluoranthene	SW8270 SIM	0.043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Chrysene	SW8270 SIM	0.43	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Dibenzo(a,h)anthracene	SW8270 SIM	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluoranthene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluorene	SW8270 SIM	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Naphthalene	SW8270 SIM	27.0	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	0.0255 J	ND(0.0335)	ND(0.0335)	ND(0.0335)
Phenanthrene	SW8270 SIM	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Pyrene	SW8270 SIM	40.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Polychlorinated Biphenyls										
Aroclor 1016	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.0384) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	ND(0.01) UJ

TABLE 4.9-3 (cont.)
FISH ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration	98DOE-RS01-4099-FS	98DOE-RS01-4097-FS	98DOE-RS01-4094-FS	98DOE-RS01-4160-FS	98DOE-RS02-4153-FS	98DOE-RS02-4151-FS	98DOE-RS02-4149-FS
				Reference Stream 1				Reference Stream 2		
				Station 1	Station 2	Station 5	Station 5	Station 2	Station3	Station 5
Aroclor 1242	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	ND(0.01) UJ
Aroclor 1248	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	0.00823 J
Aroclor 1260	SW8081	0.0016	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.0192) UJ	ND(0.01) UJ
Metals										
Aluminum	SW6020	1,351.9	475	17.6	35.5	89.8	20.8	112 J	17.5 J	33.5 J
Arsenic	SW6020	-	0.127	0.0293	0.037	0.0513	0.0718	0.0473 J	ND(0.0250) UJ	0.0795 J
Inorganic Arsenic	EPA Draft 1632	0.0021	0.0208	0.00584	0.00974	0.0104	0.00226	0.0117	0.000832	0.0053
Barium	SW6020	94.6	1.03	0.389	0.302	0.642	0.191	0.634	0.226	0.221
Beryllium	SW6020	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Boron	SW6020	121.7	28.6	13.4 UJ	7.27 UJ	10.9 UJ	11.6 UJ	12.3 UJ	21.7 UJ	7.43 UJ
Cadmium	SW6020	1.4	0.0373 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.0373	ND(0.0250)	ND(0.0250)	ND(0.0250)
Calcium	SW6020	NA	19,200	11900	8930	8930	710	4280	5050	6580
Cerium	SW6020	NA	0.0280 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.028	ND(0.0250)	ND(0.0250)
Cesium	SW6020	NA	0.0258 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.0258	ND(0.0250)
Chromium	SW6020	4.1	1.03	0.58	0.374	0.411	0.321	ND(0.0500) UJ	ND(0.0500) UJ	0.448 J
Cobalt	SW6020	81.1	0.0780 [b]	ND(0.0500)	0.055	0.0573	ND(0.0500)	0.078 J	ND(0.0500) UJ	ND(0.0500) UJ
Copper	SW6020	54.1	1.20 [b]	1.09 U	1.17 U	1.2 U	0.95 U	1.08	1.12	0.0794 U
Iron	SW6020	405.6	310	100	152	157	31	166 J	27.3 J	41.5 J
Lithium	SW6020	27.0	0.0993 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.0993	0.034	ND(0.0250)

TABLE 4.9-3 (cont.)
FISH ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in milligrams per kilogram)

Analyte	Analytical Method	EPA Region III Fish Consumption RBC	Lowland Stream Background Concentration[a]	98DOE-RS01-4099-FS	98DOE-RS01-4097-FS	98DOE-RS01-4094-FS	98DOE-RS01-4160-FS	98DOE-RS02-4153-FS	98DOE-RS02-4151-FS	98DOE-RS02-4149-FS
				Reference Stream 1				Reference Stream 2		
				Station 1	Station 2	Station 5	Station 5	Station 2	Station3	Station 5
Magnesium	SW6020	NA	408	340	303	358	313	303	275	295
Manganese	SW6020	189.3	160	22.9	23.8	7.59	4.65	21.7	7.28	3.4
Molybdenum	SW6020	6.8	0.173 [b]	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	0.173 J	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	27.0	ND	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)
Potassium	SW6020	NA	4,780 [b]	4130	4080	4780	370	3480	3300	3350
Selenium	SW6020	6.8	0.936	0.631	0.645	0.675	0.606	0.592	0.366	0.507
Strontium	SW6020	811.1	22.1	16.8	9.93	12.5	10	6.74 J	7.33 J	11 J
Thallium	SW6020	0.09	0.0283 [b]	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	0.0283 J	ND(0.0250) UJ	ND(0.0250) UJ
Thorium	SW6020	NA	3.43 [b]	3.43 J, B	ND(2.50) UJ, B	ND(2.50) UJ, B	ND(2.50) UJ, B	ND(2.50) UJ, B	2.68 J, B	ND(2.50) UJ, B
Titanium	SW6020	5,407.4	32.1	0.385	0.791	3.79	0.782	5.22 J	0.57 J	1.11 J
Uranium	SW6020	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	9.5	1.05	0.261	0.376	0.623	0.164	0.657	0.17	0.316
Zinc	SW6020	405.6	48.8	38.8	37.3	38.6	28.2	30.8	35.3	36.4

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

TABLE 4.9-3 (cont.)
FISH ANALYTICAL RESULTS FOR LOWLAND REFERENCE STREAMS
(concentrations in milligrams per kilogram)

B	analyte detected in method blank
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U	analyte concentration attributed to blank or laboratory contamination; result considered nondetect
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

TABLE 4.9-4
SURFACE WATER ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-RS03-3068-SW	98DOE-RS03-3066-SW	98DOE-RS03-3064-SW	98DOE-RS03-3062-SW	98DOE-RS03-3057-SW	98DOE-RS04-3050-SW	98DOE-RS04-3049-SW	98DOE-RS04-3048-SW	98DOE-RS04-3047-SW	98DOE-RS04-3044-SW	98DOE-RS04-3045-SW (Duplicate)
			Reference Stream 3					Reference Stream 4					
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5	Station 5
Diesel Range Hydrocarbons	AK 102	-	62.7	66.5	ND(50)	ND(50)	84.8 U	54	ND(50)	ND(50)	59.5	ND(50)	ND(50)
Metals													
Aluminum	EPA 6020	87.1 [b]	87.1 J	56.5 J	ND(50) UJ	ND(50) UJ	50.5 J	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Arsenic	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Barium	EPA 6020	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Boron	EPA 6010B	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)	ND(50)
Calcium	EPA 6010B	8,810 [b]	4,900	4,460	4,590	5,490	5,900	7,150	8,480	8,810	8,750	8,520	8,710
Cerium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chromium	EPA 6020	3.49 [b]	3.49 J	2.11 J	1.71 J	1.83 J	1.54 J	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Cobalt	EPA 6020	9.52	7.67	5.54	4.33	4.25	ND(1)	3.63	4.02	4	4.24	ND(1)	3.83
Copper	EPA 6020	13.4 [b]	1.22 J	1.59 J	13.4 J	1.09 J	1.48 J	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ
Iron	EPA 6010B	2,830 [b]	2,830	297	229	208	232	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)	ND(150)
Lithium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Magnesium	EPA 6010B	5,250	3,510	3,750	3,860	4,450	4,670	2,860	2,740	3,100	3,230	3,320	3,320
Manganese	EPA 6020	748	353 J	24.9 J	29.9 J	28.6 J	6.82 J	12.6	11.8	1.3	13.5	4.53	14.8
Nickel	EPA 6020	1.69 [b]	1.69	1.14	1.25	1.53	ND(1)	ND(1)	1.07	ND(1)	ND(1)	ND(1)	ND(1)

TABLE 4.9-4 (cont.)
SURFACE WATER ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS
(concentrations in micrograms per liter)

Analyte	Analytical Method	Upland Stream Background Concentration	98DOE-RS03-3068-SW	98DOE-RS03-3066-SW	98DOE-RS03-3064-SW	98DOE-RS03-3062-SW	98DOE-RS03-3057-SW	98DOE-RS04-3050-SW	98DOE-RS04-3049-SW	98DOE-RS04-3048-SW	98DOE-RS04-3047-SW	98DOE-RS04-3044-SW	98DOE-RS04-3045-SW (Duplicate)
			Reference Stream 3					Reference Stream 4					
			Station 1	Station 2	Station 3	Station 4	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5	Station 5
Potassium	EPA 6010B	1,190 [b]	1,190	771	802	890	742	812	790	899	778	906	785
Selenium	EPA 6020	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Strontium	EPA 6020	44.1 [b]	41	39.5	40.7	43.5	43.8	32.9	36.3	43	43.1	44.1	42.5
Thallium	EPA 6020	2.13 [b]	ND(1) UJ	ND(1) UJ	ND(1) UJ	2.13 J	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ
Thorium	EPA 6020	1.14 [b]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1) UJ	ND(1) UJ	1.14 J	ND(1) UJ	ND(1) UJ	ND(1) UJ
Titanium	EPA 6020	2.37 [b]	2.37 J	2.07 J	2.18 J	1.74 J	2.14 J	ND(1) UJ	1.04 J	ND(1) UJ	ND(1) UJ	ND(1) UJ	ND(1) UJ
Vanadium	EPA 6020	1.44 [b]	1.34	ND(1)	ND(1)	ND(1)	1.44	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Zinc	EPA 6020	12.8 [b]	11.9	ND(10)	12.8	ND(10)	ND(10)	11.5	12.5	ND(10)	ND(10)	ND(10)	ND(10)

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

J result considered estimated because less than the practical quantitation limit, or due to other quality control considerations

U analyte concentration attributed to blank contamination; result considered nondetect

UJ analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

TABLE 4.9-5
SEDIMENT ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

Analyte	Analytical Method	Units	Upland Stream Background Concentration[a]	98DOE-RS03-3069-SD	98DOE-RS03-3067-SD	98DOE-RS03-3065-SD	98DOE-RS03-3063-SD	98DOE-RS03-3060-SD	98DOE-RS03-3061-SD (Duplicate)	98DOE-RS043050-SD	98DOE-RS043049-SD	98DOE-RS043048-SD	98DOE-RS043047-SD	98DOE-RS043044-SD
				Reference Stream 3						Reference Stream 4				
				Station 1	Station 2	Station 3	Station 4	Station 5	Station 5	Station 1	Station 2	Station 3	Station 4	Station 5
Diesel Range Hydrocarbons	AK 102	mg/kg	-	206	ND(21)	ND(17)	ND(10.2)	ND(13.8)	ND(11.6)	10.1	ND(12.4)	9.95	10.7	6.59
Polychlorinated Biphenyls	EPA 8082	mg/kg	-	-	-	-	ND	-	ND	-	-	ND	ND	ND
Metals														
Aluminum	EPA 6010B	mg/kg	47,500	7400	29800	26700	32800	33100	30300	21700	28400	15600	17300	15700
Arsenic	EPA 6020	mg/kg	30.5	11.2	23.6	12.3	11.7	17.1	13.8	2.9	3.01	1.15	0.982	1.15
Barium	EPA 6020	mg/kg	468	91.1	232	96.9	145	104	146	41	44.3	38.5	43.2	40.7
Boron	EPA 6010B	mg/kg	6.42 [b]	ND(17.8) UJ	ND(13.1) UJ	ND(10.6) UJ	6.42 J	ND(8.65) UJ	ND(7.25) UJ	ND(5.62)	ND(7.73)	ND(2.5)	ND(2.5)	ND(2.5)
Calcium	EPA 6010B	mg/kg	7,720	4220	4650	4200	5090	6510	5980	2380	4450	4390	4180	5320
Cerium	EPA 6020	mg/kg	13	3.79	10.9	9.16	8.06	7.89	8.37	6.29	9.41	6.77	7.47	7.27
Chromium	EPA 6020	mg/kg	18.9	7.32	9.94	8.5	4.62	5.98	7.48	10.9	17.6	9.83	9.82	10.6
Cobalt	EPA 6020	mg/kg	37.3	8.83 J	27.6 J	18.5 J	10.2 J	12.2 J	16.5 J	12.5	17.7	10.4	8.84	8.77
Copper	EPA 6020	mg/kg	82.4	16 J	44.9 J	48.9 J	57.9 J	54 J	57.7 J	22.3	41	24.4	27.5	21.8
Iron	EPA 6010B	mg/kg	123,000	52700	104000	33400	70900	64100	67400	46900	54200	26000	16000 J	23900 J
Lithium	EPA 6020	mg/kg	21.7	ND(3.57)	8.29	10	12.2	15.2	14.2	6.2	15	11.6	10.1	7.98
Magnesium	EPA 6010B	mg/kg	17,000	1280	7410	8380	10800	12200	10900	5910	11200	5810	6120	5710
Manganese	EPA 6020	mg/kg	26,500	4910	13300	724	1420	761	1840	4450	2260	1500	786	755
Nickel	EPA 6020	mg/kg	23.8	5.16 J	17.9 J	8.14 J	6.39 J	6.65 J	8.84 J	9.5	14.8	8.75	8.05	8.14
Potassium	EPA 6010B	mg/kg	1,290	179 J	373 J	298 J	644 J	506 J	678 J	189	371	181	213	210
Selenium	EPA 6020	mg/kg	3.15 [b]	ND(3.57) UJ	3.15 J	2.83 J	ND(1.27) UJ	ND(1.73) UJ	ND(1.45) UJ	2.09	2.4	0.918	0.619	0.536
Strontium	EPA 6020	mg/kg	207	45.9	70.3	60.8	107	123	181	17.6	29.1	37.4	38.3	46.8
Thallium	EPA 6020	mg/kg	ND	ND(3.57)	ND(2.62)	ND(2.13)	ND(1.27)	ND(1.73)	ND(1.45)	ND(1.12)	ND(1.55)	ND(0.5)	ND(0.5)	ND(0.5)
Thorium	EPA 6020	mg/kg	ND	ND(3.57)	ND(2.62)	ND(2.13)	ND(1.27)	ND(1.73)	ND(1.45)	ND(1.12)	ND(1.55)	ND(0.5)	ND(0.5)	ND(0.5)
Titanium	EPA 6020	mg/kg	1,480	285	1070	982	778	942	965	499	537	313	432	464
Vanadium	EPA 6020	mg/kg	336	162	263	173	126	194	191	54.1	90.4	49	47.7	53.6
Zinc	EPA 6020	mg/kg	185	42.3	162	60.2	109	93.6	113	62.9	109	67.3	53.1	61.8
Total Organic Carbon	EPA 415.1 mod.	mg/kg	-	159000	108000	59400	70400	40500	49700	21900	38000	12000	18000	4150
Simultaneously Extracted Metals	Summation	umol/g	-	3.46	3.86	1.74	2.82	4.24	3.18	0.922	1.71	1.27	0.646	0.463
Acid Volatile Sulfide	Titration	umol/g	-	2.63	50.9	118	5.94	150	355	ND(0.0112)	ND(0.0155)	ND(0.005)	ND(0.005)	ND(0.005)

a Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.
b This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

TABLE 4.9-5
SEDIMENT ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

ND(1)	Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.
-	sample not analyzed for this parameter
mg/kg	milligrams per kilogram
umol/g	micromoles per gram
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations

TABLE 4.9-6
FISH ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration	98DOE-RS03-307-FS	98DOE-RS03-307-FS	98DOE-RS03-307-FS	98DOE-RS03-307-FS (Duplicate)	98DOE-RS04-305-FS	98DOE-RS04-305-FS	98DOE-RS04-305-FS
					Reference Stream 3				Reference Stream 4		
					Station 1	Station 3	Station 4	Station 4	Station 2	Station 3	Station 4
Polycyclic Aromatic Hydrocarbons											
Acenaphthene	SW8270 SIM	mg/kg	81.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Acenaphthylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Anthracene	SW8270 SIM	mg/kg	405.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)anthracene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(a)pyrene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(b)fluoranthene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(ghi)perylene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Benzo(k)fluoranthene	SW8270 SIM	mg/kg	0.043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Chrysene	SW8270 SIM	mg/kg	0.43	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Dibenzo(a,h)anthracene	SW8270 SIM	mg/kg	0.00043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluoranthene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Fluorene	SW8270 SIM	mg/kg	54.1	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Indeno(1,2,3-cd)pyrene	SW8270 SIM	mg/kg	0.0043	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Naphthalene	SW8270 SIM	mg/kg	27.0	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Phenanthrene	SW8270 SIM	mg/kg	NA	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Pyrene	SW8270 SIM	mg/kg	40.6	-	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)	ND(0.0335)
Polychlorinated Biphenyls											
Aroclor 1016	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1221	SW8081	mg/kg	-	-	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ	ND(0.02) UJ
Aroclor 1232	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1242	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ

TABLE 4.9-6 (cont.)
FISH ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

Analyte	Analytical Method	Units	EPA Region III Fish Consumption RBC	Upland Stream Background Concentration	98DOE-RS03-3075-FS	98DOE-RS03-3073-FS	98DOE-RS03-3070-FS	98DOE-RS03-3071-FS (Duplicate)	98DOE-RS04-3055-FS	98DOE-RS04-3053-FS	98DOE-RS04-3051-FS
					Reference Stream 3				Reference Stream 4		
					Station 1	Station 3	Station 4	Station 4	Station 2	Station 3	Station 4
Aroclor 1248	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1254	SW8081	mg/kg	-	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Aroclor 1260	SW8081	mg/kg	0.0016	-	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ	ND(0.01) UJ
Metals											
Aluminum	SW6020	mg/kg	1,351.9	38.8	6.93 J	11.1 J	12.1 J	18.7 J	28.3 J	17.1 J	13.1 J
Arsenic	SW6020	mg/kg	-	26.9	0.856 J	0.063 J	0.059 J	0.0798 J	0.049 J	ND(0.0250) UJ	1.12 J
Inorganic Arsenic	EPA Draft 1632	mg/kg	0.0021	0.456	0.0021	0.0122	0.00147	0.00257	0.00152	0.0015	0.000594
Barium	SW6020	mg/kg	94.6	0.567	0.0718	0.206	0.129	0.179	0.328	0.343	0.281
Beryllium	SW6020	mg/kg	2.7	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Boron	SW6020	mg/kg	121.7	24.1	10.9 UJ	16.4 UJ	9.43 UJ	14.7 UJ	7.65 UJ	11.2 UJ	16.3 UJ
Cadmium	SW6020	mg/kg	1.4	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Calcium	SW6020	mg/kg	NA	10,300	3700	5650	7130	5950	7250	6530	4450
Cerium	SW6020	mg/kg	NA	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Cesium	SW6020	mg/kg	NA	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Chromium	SW6020	mg/kg	4.1	0.684	0.287 J	0.397 J	0.297 J	0.358 J	0.266 J	0.405 J	0.538 J
Cobalt	SW6020	mg/kg	81.1	0.0510 [b]	ND(0.0500) UJ	ND(0.0500) UJ	ND(0.0500) UJ	ND(0.0500) UJ	ND(0.0500) UJ	0.051 J	ND(0.0500) UJ
Copper	SW6020	mg/kg	54.1	3.40	1.05	0.0696 U	0.753	0.744	0.635	0.738	2.43
Iron	SW6020	mg/kg	405.6	73.6	23.7 J	50.8 J	22.3 J	22.8 J	42 J	36.3 J	16 J
Lithium	SW6020	mg/kg	27.0	ND	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)	ND(0.0250)
Magnesium	SW6020	mg/kg	NA	349	268	270	313	275	305	268	293
Manganese	SW6020	mg/kg	189.3	161	2.67	32.2	6.58	6.48	3.08	3.44	1.09

TABLE 4.9-6 (cont.)
FISH ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

Analyte	Analytical Method	Units	EPA Region 11 Fish Consumption RBC	Upland Stream Background Concentration [a]	98DOE-RS03-307-FS	98DOE-RS03-307S-FS	98DOE-RS03-307O-FS	98DOE-RS03-307E-FS (Duplicate)	98DOE-RS04-305-FS	98DOE-RS04-303-FS	98DOE-RS04-305E-FS
					Reference Stream 3				Reference Stream 4		
					Station 1	Station 3	Station 4	Station 4	Station 2	Station 3	Station 4
Molybdenum	SW6020	mg/kg	6.8	0.150 [b]	0.15 J	ND(0.125) UJ	ND(0.125) UJ	ND(0.125) UJ	0.125 J	ND(0.125) UJ	ND(0.125) UJ
Nickel	SW6020	mg/kg	27.0	ND	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)	ND(0.125)
Potassium	SW6020	mg/kg	NA	4,310	3630	3530	3700	3650	3300	3230	3850
Selenium	SW6020	mg/kg	6.8	2.08	0.248	0.471	0.579	0.496	1.44	1.02	0.428
Strontium	SW6020	mg/kg	811.1	12.1 [b]	12.1 J	9.94 J	10.6 J	10.3 J	5.02 J	5.11 J	11.6 J
Thallium	SW6020	mg/kg	0.09	0.0755 [b]	0.0755 J	0.0258 J	ND(0.0250) UJ	ND(0.0250) UJ	0.0363 J	ND(0.0250) UJ	ND(0.0250) UJ
Thorium	SW6020	mg/kg	NA	4.67 [b]	ND(2.50) UJ, B	4.67 J, B	4.58 J, B	2.93 J, B	ND(2.50) UJ, B	ND(2.50) UJ, B	ND(2.50) UJ, B
Titanium	SW6020	mg/kg	5,407.4	0.834	0.212 J	0.336 J	0.474 J	0.492 J	0.536 J	0.374 J	0.537 J
Uranium	SW6020	mg/kg	4.1	ND	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)	ND(0.500)
Vanadium	SW6020	mg/kg	9.5	0.289	0.12	0.147	0.187	0.209	0.194	0.198	0.195
Zinc	SW6020	mg/kg	405.6	78.0	23.1	27.7	36	33	56.7	49.8	31.8
% Lipids	Lipids	% by Weight	-	-						1.5	

[a] Background concentrations, which are presented only for metals, are upper tolerance limits (UTL) unless otherwise noted. See Appendix D of this report for a description of background concentration calculations.

[b] This metal was not detected in a sufficient number of reference stream samples to allow calculation of a valid UTL. The concentration shown is the maximum detected concentration in the appropriate background samples.

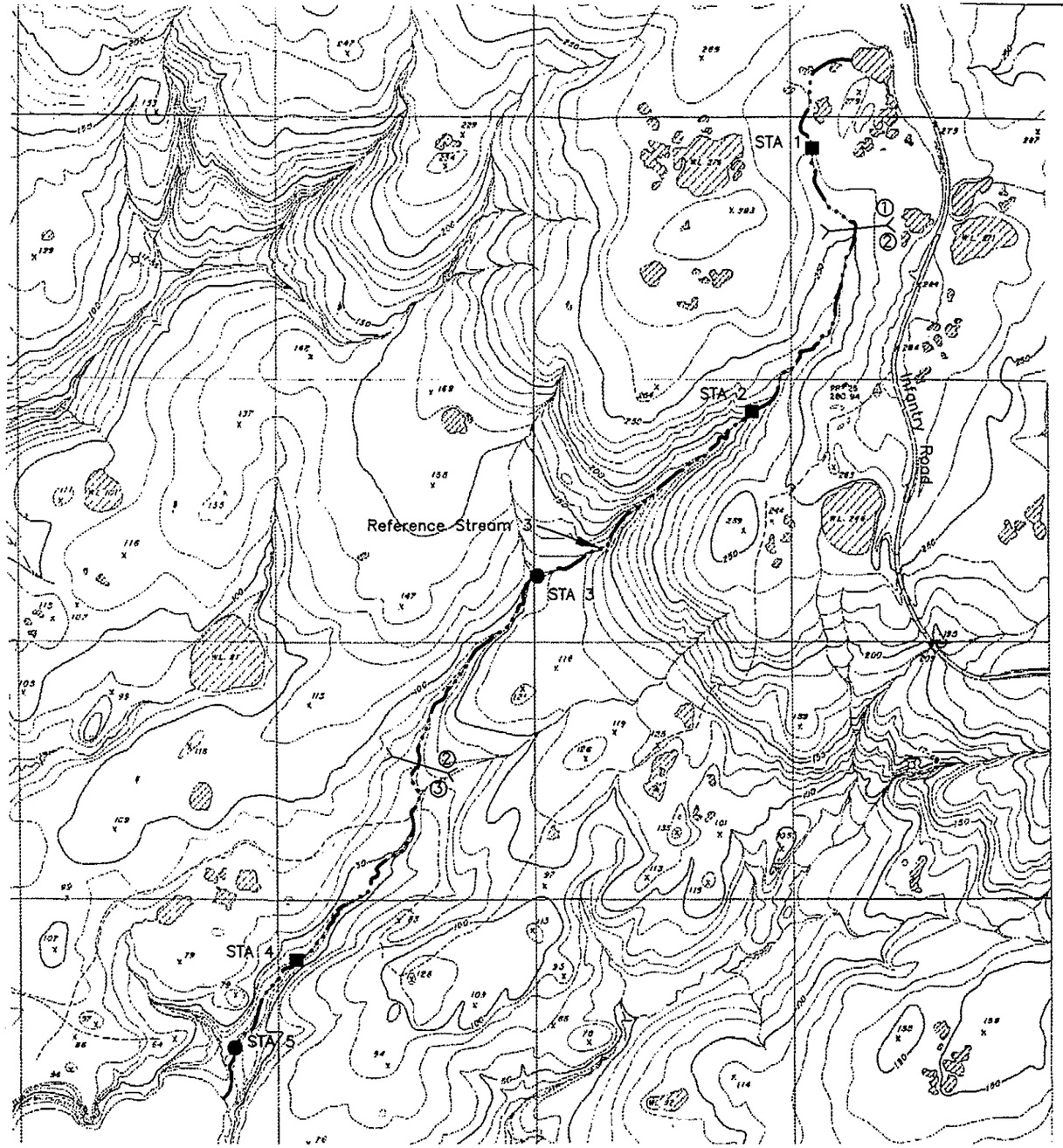
ND(1) Analyte not detected at a concentration above the reporting limit, which is shown in parentheses. Reporting limits for background samples varied, but are generally comparable to reporting limits for project samples; see Section 4.9.

\- sample not analyzed for this parameter

mg/kg milligrams per kilogram

TABLE 4.9-6 (cont.)
FISH ANALYTICAL RESULTS FOR UPLAND REFERENCE STREAMS

B	analyte detected in method blank
J	result considered estimated because less than the practical quantitation limit, or due to other quality control considerations
U	analyte concentration attributed to blank or laboratory contamination; result considered nondetect
UJ	analyte not detected at the listed concentration or analyte concentration attributed to blank contamination; result is considered estimated due to other quality control considerations



N

LEGEND

STA 3 ● Sampling Station for Surface Water and Sediment Sampling. (See Section 4.9.3 for Sample Numbers.)

STA 2 ■ Sampling Station for Surface Water, Sediment, Fish, and Benthic Invertebrate Sampling. (See Section 4.9.3 for Sample Numbers.)

② Reach Number

Reach Boundary

Investigated Stream Course

APPROXIMATE SCALE (FEET)

0 1000 2000

Contour Interval= 10 feet

Reference: Drawing based on **Amchitka Island Map Atlas** Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

REFERENCE STREAM 3

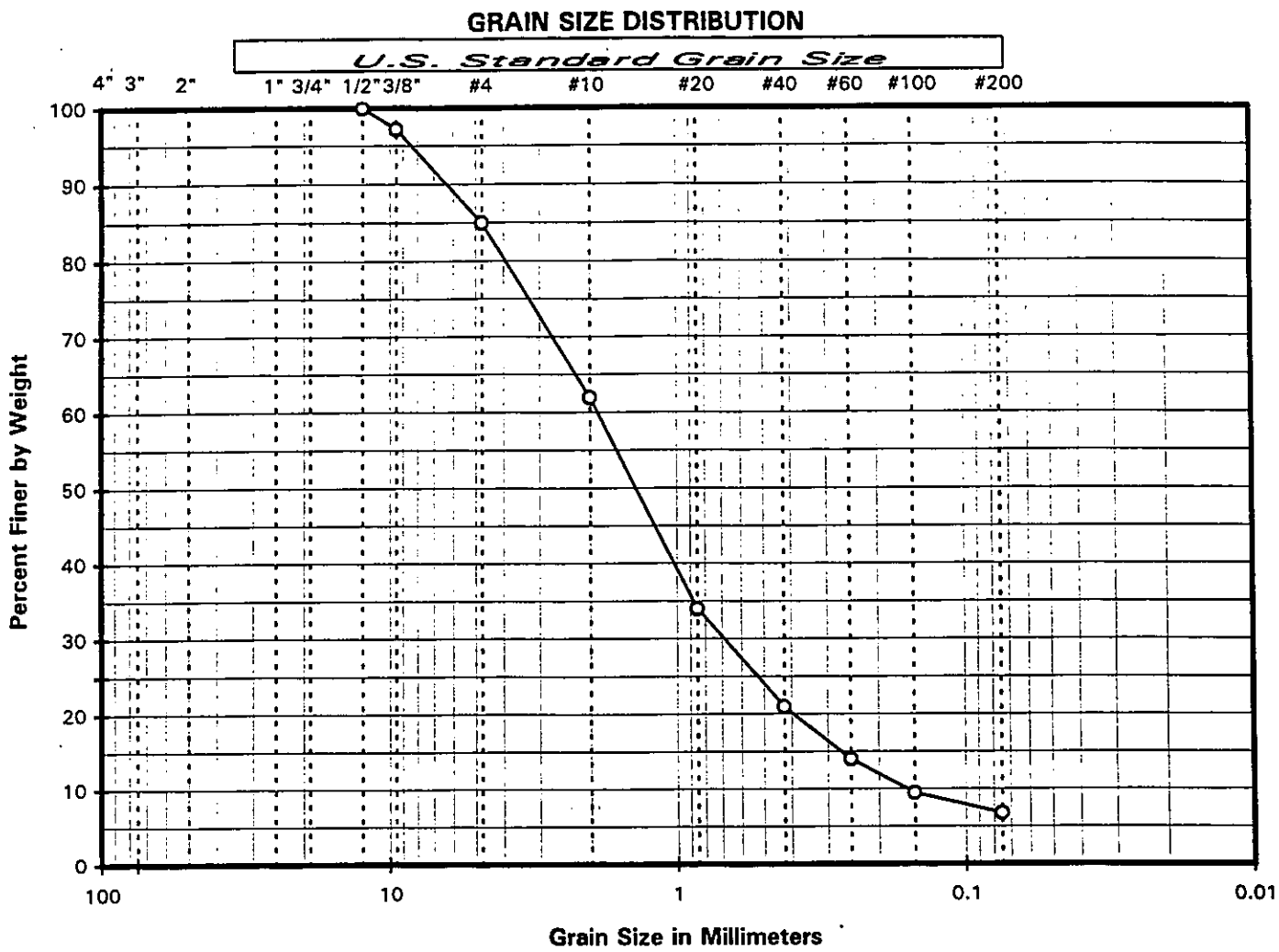
September 1999
Revision Number: 0

X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4.9-1

FILE: RefStrm3



Marker	Sample ID	Percent Passing by Dry Weight — U.S. Standard Sieve Size: 4"	3"	2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.02m	USC Soil Class
o	98DOE-RS02-4135-SD						100	97	85	62	34	21	14	9.5	6.8		SP-SM
x																	
+																	
-																	

1998 Drill Site Investigation
Amchitka Island

GRAIN SIZE DISTRIBUTION CURVES
Station 5, Reference Stream 2

September 1999 X-0926

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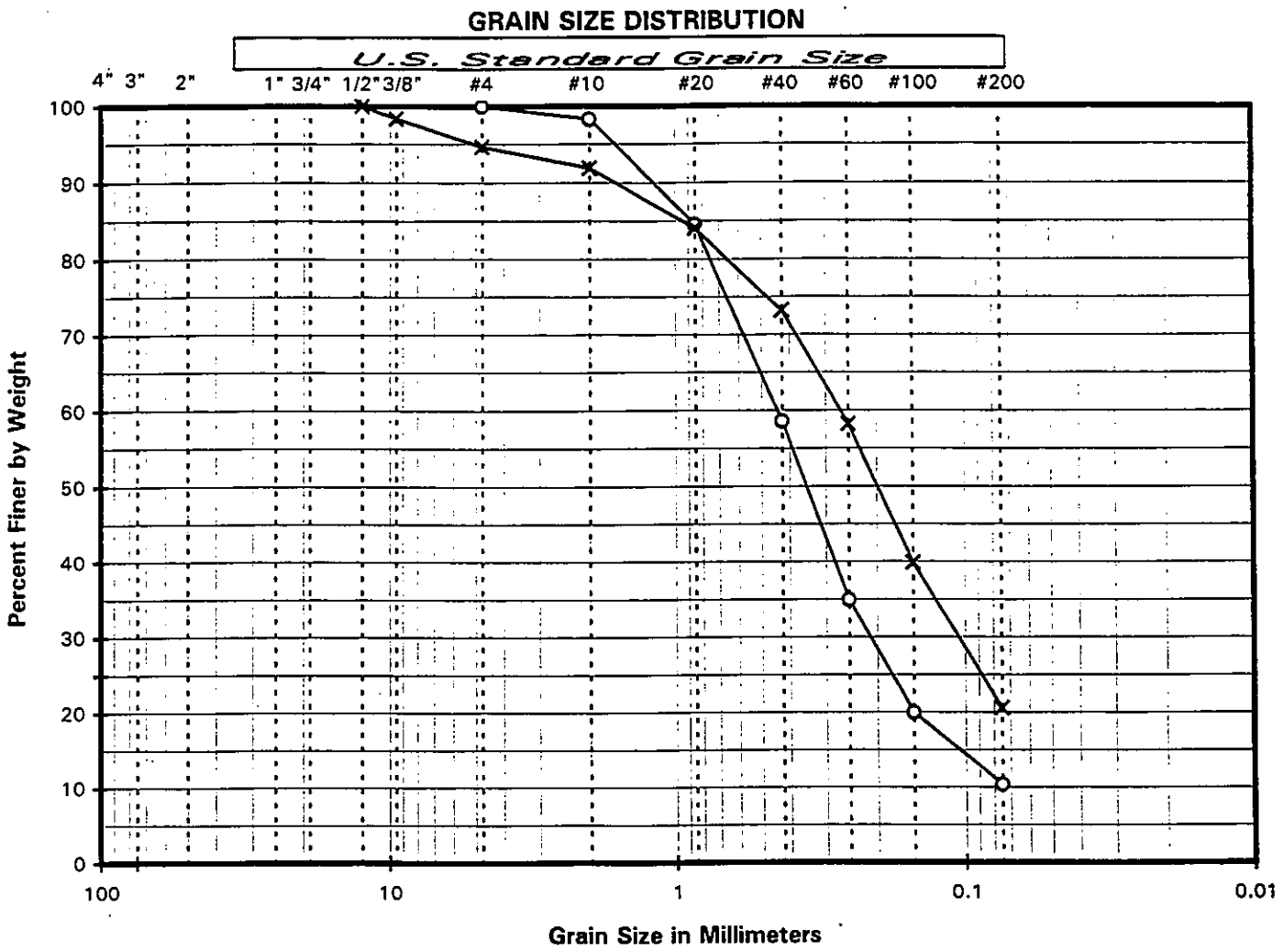
Figure 4.9-2



Marker	Sample ID	Percent Passing by Dry Weight — U.S. Standard Sieve Size: 4"	3"	2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.02m	USC Soil Class
o	98DOE-RS04-3048-SD								100	98	85	59	35	20	10		SP-SM
x	98DOE-RS04-3047-SD						100	98	95	92	84	73	58	40	21		SM
+																	

1998 Drill Site Investigation
Amchitka Island

GRAIN SIZE DISTRIBUTION CURVES
Stations 3 and 4, Reference Stream 4

September 1999 X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Figure 4.9-3

Photo 4.9-1: Reference Stream 1 near Station 2, facing downstream and south.

Photo 4.9-2: Station 5 of Reference Stream 1, facing west.

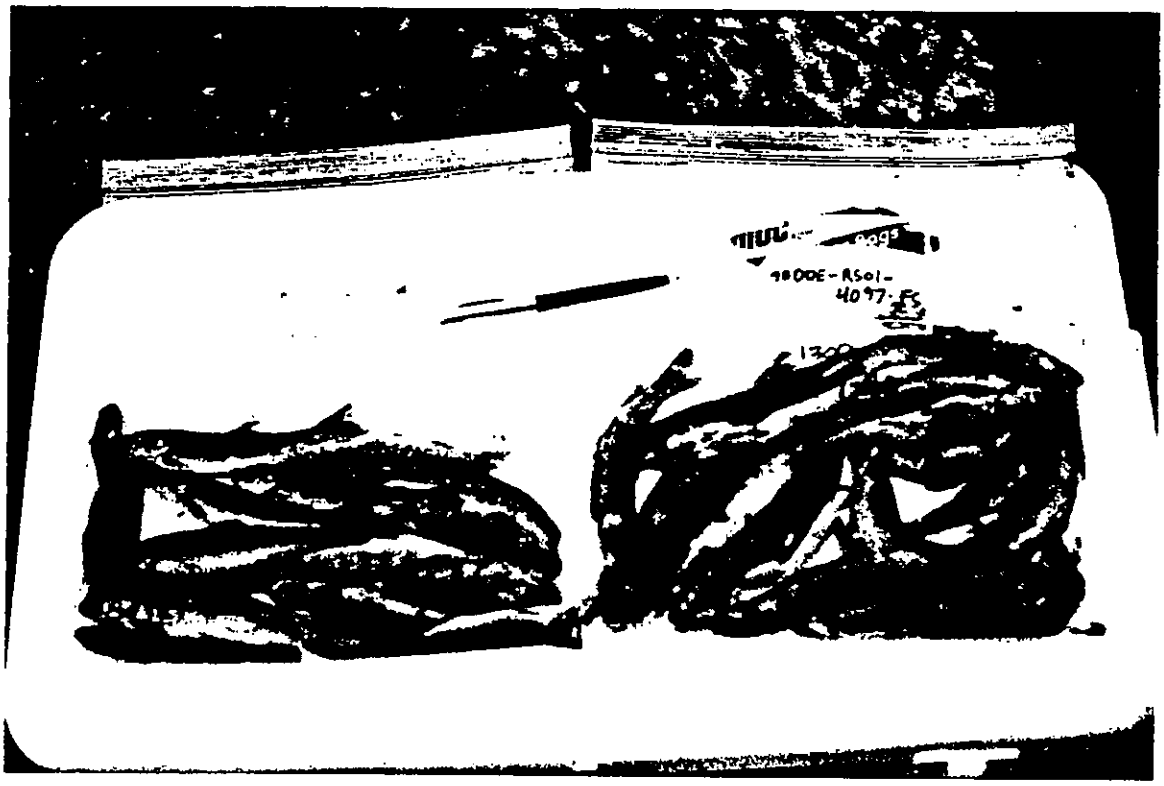


Photo 4.9-3: Fish samples collected from Reference Stream 1. The sample on the left was from Station 1 and the other sample from Station 2.

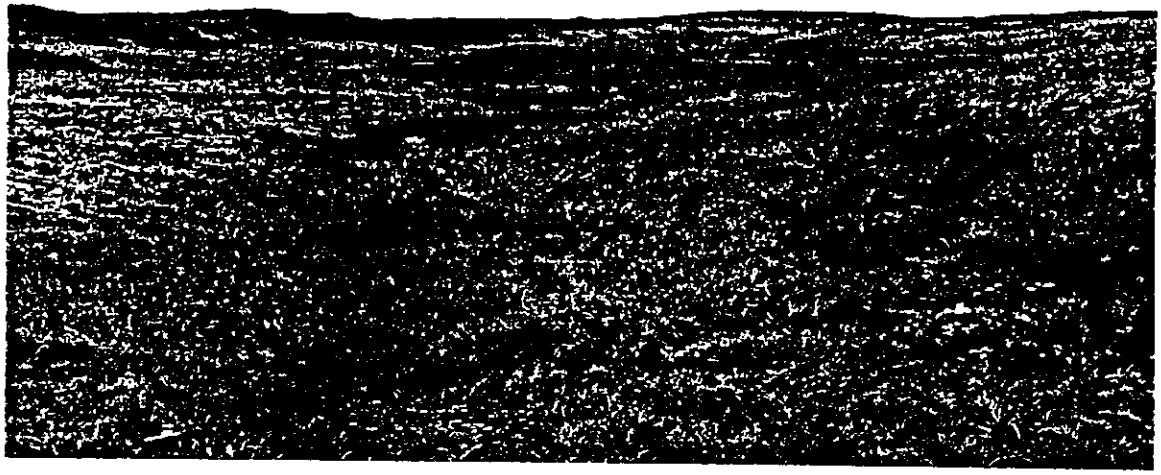


Photo 4.9-4: Reference Stream 2 as viewed from Infantry Road, looking downstream (north) towards Station 3.

Photo 4.9-5: Preparing to sample for invertebrates at Station 3 of Reference Stream 2. The stream channel is incised up to 5 feet below grade, and banks are vertical to undercut. (This individual is standing on the channel bottom.)

Photo 4.9-6: Reach 2 of Reference Stream 3, facing upstream and northeast.

Photo 4.9-7: Reach 1 of Reference Stream 4, facing downstream and south.

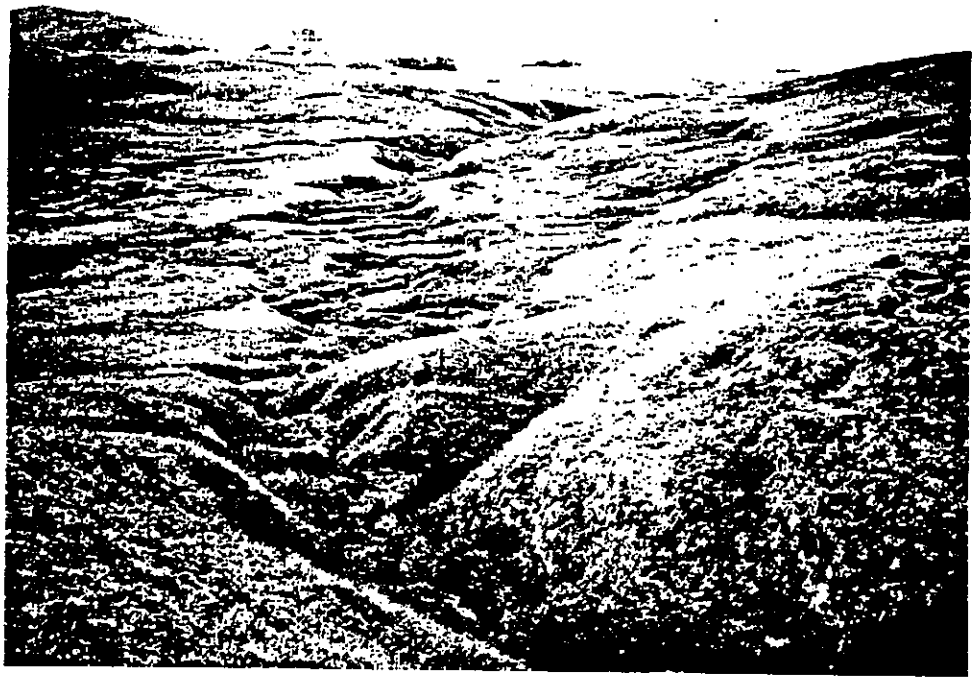


Photo 4.9-8: Reach 2 of Reference Stream 4, facing downstream and south.

4.10 AIRCRAFT GRAVEYARD

4.10.1 Site Description

The Aircraft Graveyard is a WWII-era scrap metal and debris dump located about 1,000 feet north of Kirilof Wharf (Figure 4.10-1). The site is designated in the USFWS *Summary of Site Contamination on Amchitka Island, Alaska* ("USFWS Database," dated October 1993) as site AMCH-BACA-011. The site is one of eleven shared or uncertain liability sites under a Memorandum of Agreement (MOA) between the USFWS, Navy, DOE, and DOD. The site is described in the USFWS Database as follows:

> "The Navy (1991) identified an Aircraft Graveyard north of fuel tanks at Constantine Harbor. The Service visited this site in June 1993. This site is approximately 2 acres in size and is bisected by an unused road. At least six lead-acid batteries were observed on the surface. Other metal observed was mostly aluminum."

During the 1998 Drill Site Investigation the site was observed to contain scrap aircraft parts scattered on the ground surface just north of the access road that bisects the site. The portion of the site south of the access road contained only a few pieces of debris visible at the ground surface.

The Aircraft Graveyard site has been the subject of several investigations that included sampling for chemical analysis. The site was sampled by the USFWS in 1985 and 1993, and by Foster Wheeler Environmental Corporation under contract to the USFWS in 1995. The results of these studies indicated the Aircraft Graveyard site contains measurable concentrations of PCBs. While analyses have been performed for other compounds during previous investigations, PCBs were indicated as the only remaining COPC at this site when the USFWS requested DOE include it in the scope of the 1998 investigation.

The most comprehensive investigation at the site was performed by Foster Wheeler in 1995. During this study samples were analyzed for PCBs in an on-island laboratory (using immunoassay test kits) and an off-site contract laboratory. The results of that study are summarized in the following table. The locations and results for 1995 samples that had detectable PCBs (based on off-site analysis) are shown in Figure 4.10-1. A more comprehensive discussion of the results of past studies at the Aircraft Graveyard is presented in the August 1998 *Management Plan*.

Summary of PCB Results From 1995 Foster Wheeler Sampling, Aircraft Graveyard

Sample Media	Number of Samples Analyzed		Number of Samples with Detected PCBs	PCB Concentration in Soil (mg/kg)	PCB Concentration in Water (ug/L)
Surface Soil	on site	9	1	0.52	-
	off site	0	0	-	-
Surface Water	on site	3	0	-	ND
	off site	1	0	-	ND
Sediment	on site	3	0	ND	-
	off site	1	1	0.46	-
Subsurface Soil	on site	3	0	ND	-
	off site	3	1	0.49	-
Groundwater	on site	3	3	-	62.4, 6.8, 2.92
	off site	3	2	-	19, 3.7

4.10.2 Characterization Activities

The USFWS has identified PCBs as a contaminant of particular concern on Amchitka due to its elevated presence in certain marine fauna. For this reason, and because of previous detections of PCBs, the Aircraft Graveyard site was targeted for a PCBs study during the 1998 Drill Site Investigation. Since the presence of PCBs at the site had already been documented, the approach taken in 1998 was to investigate surface water, sediment, and groundwater at locations downgradient of the Aircraft Graveyard to assess whether PCBs were migrating off site.

The initial site work consisted of a reconnaissance to observe site drainage patterns and select representative sampling locations. Two sampling locations were chosen along the stream draining the southern portion of the site. Monitoring wells were installed at each of the two locations, and groundwater samples were collected from the wells (no soil samples were collected from the borings used to install the wells). Soil descriptions and monitoring well completion logs are presented in Figure 4.10-2. Surface water and sediment samples were also collected from each of the two locations in the stream near the monitoring wells. A third sampling location was chosen within a roadside drainage ditch northeast of the site. Both surface water and sediment samples were collected at this location. Sampling locations are shown in Figure 4.10-1. Sample descriptions for the surface water and sediment samples are provided in the following table.

Sample Descriptions for Aircraft Graveyard

Sample No.	Sample Depth (feet)	Description
2003-SW		Surface Water
2004-SD	0 to 0.3	Brown, peaty Silt
2005-SW		Surface Water
2006-SD	0 to 0.3	Brown Peat
2007-SW		Surface Water
2008-SD	0.3 to 0.5	Brown, peaty Silt
2009-GW	0.5	Groundwater
2010-GW	0.5	Groundwater

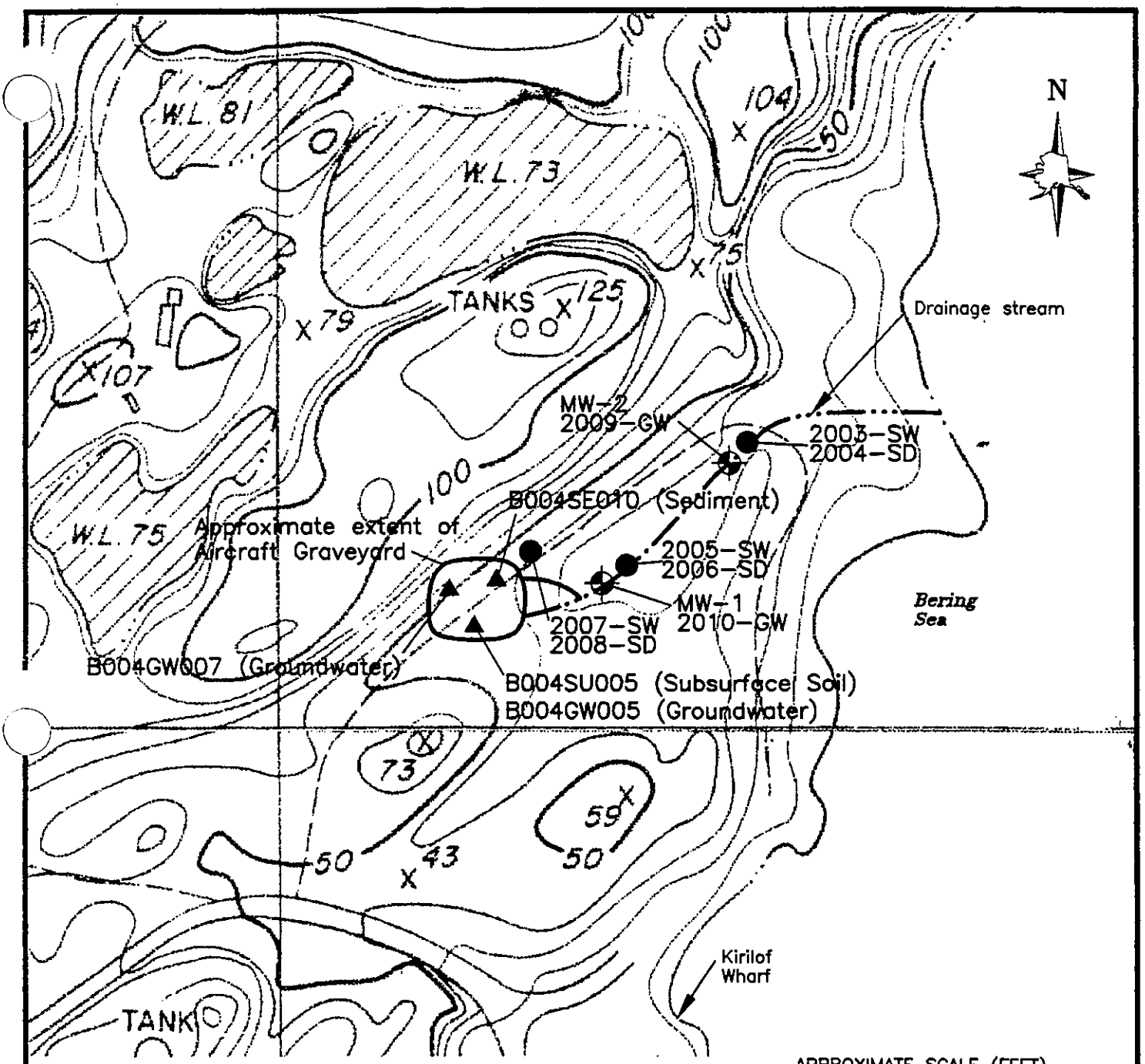
4.10.3 Analytical Results

The surface water, sediment, and groundwater samples were only analyzed for PCBs. No PCBs were detected in any of the samples. The reporting limits for the three sediment samples were elevated, ranging from 0.36 to 0.66 mg/kg, due to the low percent solids (high moisture content) of the peaty sediment. The reporting limits for two stream sediment samples are higher than the 0.46 and 0.52 mg/kg PCBs detected in the soil and sediment samples from the Foster Wheeler study. The reporting limits for the 1998 surface water and groundwater samples was 0.5 ug/L, which is well below the levels of PCBs reported in the Foster Wheeler water samples.

4.10.4 Conclusions

Based on the analytical results, PCBs do not appear to be migrating from the site in groundwater or surface water. The sediment data are less conclusive because of the elevated reporting limits. However, the 1998 sampling confirmed the absence of elevated levels of PCBs in the sediment. In addition, due to the peaty nature of the soil and the prevalent vegetative cover at the site and along the drainage, it appears that very little sediment is being transported from the site.

PCBs are relatively insoluble in water. This, plus the absence of detectable PCBs in the 1998 groundwater and surface water samples from the Aircraft Graveyard, suggest that the concentrations of PCBs reported in 1995 water samples (as great at 62 ug/L) may not be representative of the site. It is possible that inadvertent inclusion of a small amount of sediment in the 1995 water samples was responsible for the elevated PCB concentrations.



APPROXIMATE SCALE (FEET)

0 300 600

Contour Interval= 10 feet

LEGEND

MW-1
2010-GW
Monitoring Well Location and Number
(See Figure 4.10-2 for Well Logs)
(All Sample Numbers Preceded by "98DOE-ACGY").

2007-SW
Surface Water and Sediment Sampling Location
(All Sample Numbers Preceded by "98DOE-ACGY").

Samples Collected by Foster Wheeler in 1995

Reference: Drawing based on **Amchitka Island Map Atlas**
Holmes & Narver, 1968

Department of Energy
1998 Drill Site Investigation
Amchitka Island, Alaska

AIRCRAFT GRAVEYARD

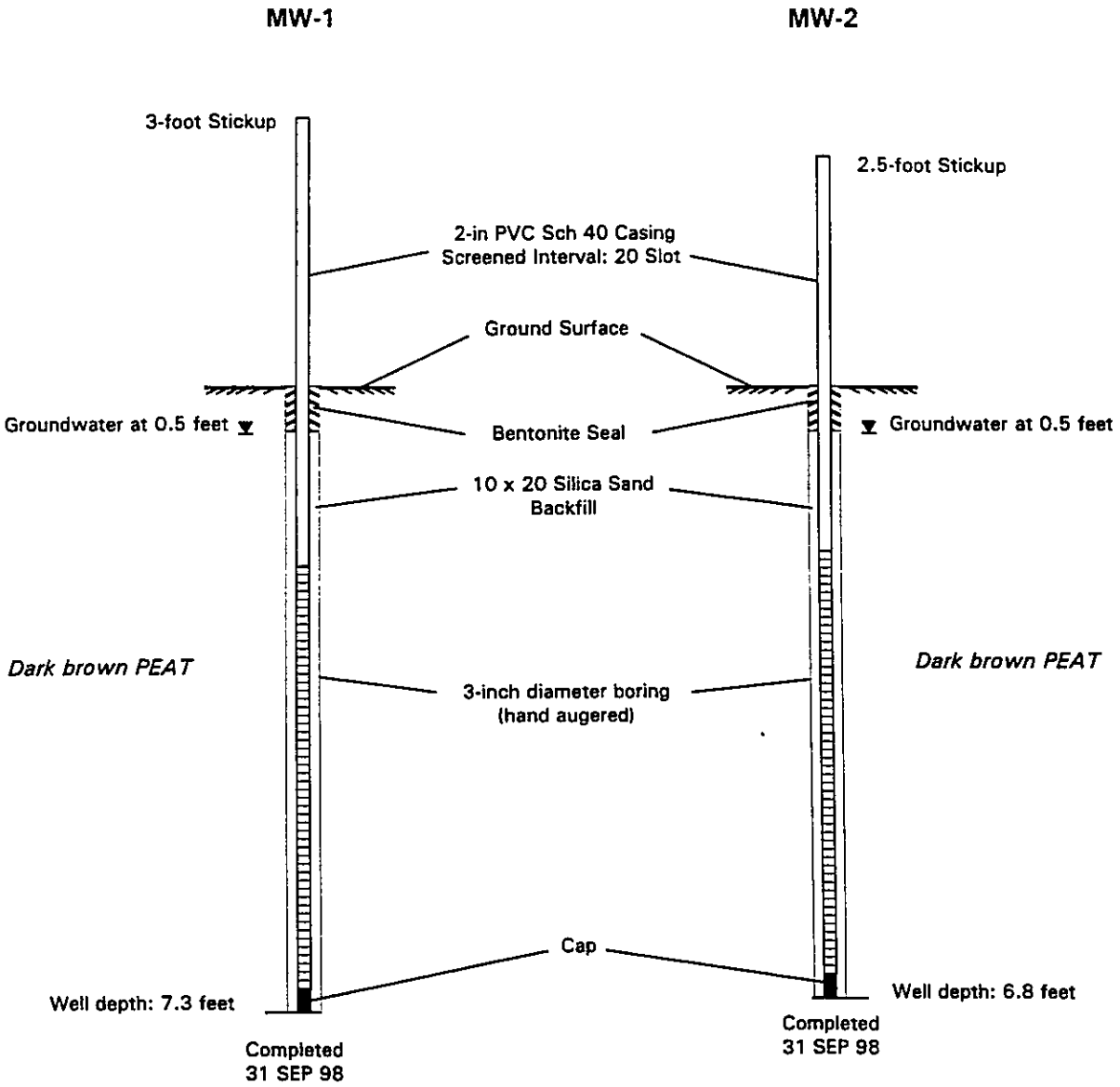
September 1999
Revision Number: 0

X-0926

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4.10-1

FILE:



Department of Energy
1998 Drill Site Investigations
Amichitka Island, Alaska

BORING AND MONITORING WELL LOGS AIRCRAFT GRAVEYARD

September 1999
Revision Number: 0

X-0926

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4.10-2

5.0 CONCLUSIONS

The primary objective of this investigation was to provide a comprehensive assessment of contamination resulting from drilling activities associated with nuclear testing conducted by the AEC and DOD during the late 1960s and early 1970s on Amchitka Island. The investigation was directed at evaluating contamination in remaining mud pits, residual contaminant levels in streams and lakes affected during the AEC and DOD operations, and impacts on invertebrates and fish in the affected streams and lakes. In addition, an investigation was conducted to determine whether PCBs are migrating from the Aircraft Graveyard, and fish were sampled and analyzed to provide a preliminary evaluation of radionuclide levels in fish from test site streams. The conclusions of the investigation, as they pertain to these specific objectives, are discussed in the following paragraphs.

5.1 Mud Pit Contamination

Mud pits were used to mix and store drilling mud for the exploratory drill holes and emplacement holes. Many of these mud pits were backfilled before the AEC left the island, and no visible evidence remains of their locations. All of the mud pits that were left open at the three test sites, the three exploratory drill hole sites, and other locations where drilling mud was reportedly stored were investigated during the 1998 field investigation. This investigation consisted of a reconnaissance to evaluate the size and stability of each pit, followed by sampling for chemical analysis of the mud and water contained within the pits. This investigation provides a basis for evaluating the potential adverse affects posed by the mud pits, both in their current configuration and in the unlikely event the mud and contained water were released to the streams that drain the sites.

The following table summarizes the mud-pit volumes and constituents detected at concentrations that exceed established environmental cleanup criteria and island background levels. Detailed summaries of chemical exceedances for mud-pit surface water and drilling mud are provided in Tables 5-1 and 5-2 for each of the sites.

Mud Pit Constituents

Site	Mud Volume (cubic yards)	Constituents of Concern in Mud	Water Volume (gallons)	Constituents of Concern in Water
Milrow Test Site	No open pits	--	None	--
Rifle Range Road Mud Pit	1,880	DRO, PAHs, Cr, Cu	Negligible	Not Tested
Long Shot Test Site	5,480 in 3 connected pits	DRO, VOCs, PAHs, Cr, Cu	338,500	Mn*
Cannikin Test Site	3,000	DRO, VOCs, PAHs, PCBs, Cr, Cu, Fe, Ni, Zn	364,000	Al*
Cannikin Drill Hole Site	490 in 2 separate pits	DRO, PAHs, Cr, Cu, Ni	63,000	None
Drill Site D	15,000 in 3 connected pits	DRO, PAHs, PCBs, Cd, Cr, Cu, Ni	5,590,000	Al*
Drill Site E	420 in 2 small pits	DRO, PAHs, Cr, Cu, Ni	23,300	None
Drill Site F	310	DRO, VOCs, PAHs, Cr	20,300	Al, Cu

* Maximum concentration detected exceeded ERBSC and background; whereas, the mean concentration was well below the ERBSC.

The drilling mud in each of the thirteen mud pits sampled contains elevated levels of diesel, associated PAHs, and chromium. With the exception of Drill Site F, the drilling mud in all of the pits also contains elevated levels of copper. Other metals detected sporadically at elevated levels include cadmium and nickel. Diesel-related volatiles were detected at elevated concentrations in mud samples from the Long Shot, Cannikin, and Drill Site F mud pits. PCBs were found at low levels in two of the drilling mud samples from the main Cannikin mud pit and one of the Drill Site D mud pits. Mud from most of the sites was not tested for PCBs. Since drilling mud reportedly was pumped from Drill Site D to other drill sites, it is possible that low levels of PCBs could be present in the mud in other mud pits.

The drilling mud in all of the mud pits is submerged below standing water, with the exception of the Rifle Range Road mud pit. The mud-pit water is contained within earthen berms, some of which were holding as little as 20,000 gallons and one with several million gallons of water at the time of the field investigation. In the case of the Long Shot and Drill Sites D and E, the mud pits have trenches or drains that allow high water to flow from the mud pits to nearby streams.

In contrast to the drilling mud, elevated concentrations of contaminants were only rarely detected in the mud-pit water. Low levels of DRO were detected in all of the water samples, but at concentrations generally consistent with biogenic levels in the reference streams and well below ADEC action levels. Only the small mud pit at Drill Site F had concentrations of any constituents consistently above ERBSCs and background levels (aluminum and copper). Isolated occurrences of other metals were also detected at levels above background, but in each case the concentrations were below ERBSCs.

The mud pits are not situated where they pose a significant risk of a release to streams that drain the sites, with one exception. At Drill Site D high earthen berms isolate a large quantity of drilling mud and impounded water from Falls Creek and an unnamed lake at its headwaters. The berms have performed adequately to date and appear to be stable, but it is possible that a large earthquake could reduce that stability and lead to failure.

5.2 Residual Impacts to Site Drainages

The evaluation of chemical impacts of past releases from the mud pits included investigation of streams known to have experienced releases during operations, as well as other water bodies in susceptible locations. This included four lakes (Cannikin Lake, Heart Lake, Drill Site D Lake, and Reed Pond) in the immediate vicinity of the drill and test sites.

The eight streams that drain the test and drill sites were sampled at five stations each to evaluate surface water and sediment chemistry, and at three stations each for macroinvertebrate and bioassay assessments. The sediment chemistry, benthic community, and bioassay results from each of these stations were evaluated using Triad Analysis. This approach provides a means of evaluating overall sediment quality and whether residual chemicals from mud pit releases have affected the benthic community in the streams. Four reference streams (not affected by site activities) were also sampled using the same techniques to provide background data for comparison. Fish samples for chemical analysis were also collected from the streams where sampling could be accomplished without endangering the resource.

Although several of the streams were greatly affected by releases of large quantities of drilling mud during the late 1960s or early 1970s, little physical or chemical evidence of these releases remains. Very few occurrences of drilling mud were found during the stream reconnaissance, and chemical analyses of stream water and sediment detected occasional minor traces of elevated contamination. Summaries of the exceedances in stream water and sediment are provided in Tables 5-3 and 5-4. Summaries of the exceedances in lake water and sediment are presented in Tables 5-5 and 5-6.

Only slight evidence remains of historic drilling-mud releases at the Milrow Test Site. Chemical analyses of Heart Lake sediment show elevated copper in sediment and no elevated metals in water. There is limited evidence of a chemical impact to Clevenger Creek, including elevated DRO in sediment and elevated aluminum and boron in water. The Triad Approach indicated the stream sediment quality was comparable to that in the reference streams. Analysis of two fish tissue samples from Clevenger Creek detected PCBs at estimated concentrations slightly above the EPA Region III RBC for human consumption. Similarly, total arsenic and inorganic arsenic were detected in fish tissue at levels above the RBCs and background levels.

Long Shot, Long Shot Pond, Reed Pond, and the streams that drain them (Bridge Creek and Cloudberry Creek) show no visible evidence of past drilling-mud releases and only slight chemical impacts. Reed Pond contained elevated barium in surface water and elevated copper in

sediment. The Triad Analysis ranks Bridge Creek and Cloudberry Creek stations as comparable to or better in overall sediment quality than reference streams. Rainbow Creek, which drains the Long Shot mud pits, does show evidence of a minor impact. The sediment samples from Stations 3 and 4 of Rainbow Creek contain elevated concentrations of diesel and chromium, which may be reflected in the toxicity and low diversity observed in the benthic macroinvertebrates at Station 3. Sediment quality may be a contributing factor to poor habitat along with low gradient, low discharge, poorly-defined drainage, and the excessive aquatic and bank vegetation observed in upper and middle Rainbow Creek. Only Station 3 of Rainbow Creek has an overall sediment quality ranking, as determined by the Triad Analysis, lower than the reference streams. A fish sample from Station 5 of Rainbow Creek contained Aroclor 1260 and inorganic arsenic, both at about 10 times the Region III RBCs for human consumption. The only other fish sample from the Long Shot streams that contained contaminants at levels above background and RBCs was from Station 5 of Bridge Creek, which contained slightly elevated levels of inorganic arsenic and iron.

Drilling mud released during nuclear testing activities at the Cannikin Test Site was encountered in sediment in the southwestern corner of Cannikin Lake. This mud contains elevated diesel, PAHs, and VOC concentrations as well as chromium, copper, nickel, and PCBs at levels above their respective RBCs and background levels. The lake water from this area contained elevated arsenic and boron. Chemical impacts to White Alice Creek, which drains both the lake and the test site, are considerably less pronounced. Chromium, copper, and nickel were elevated in stream sediment, whereas arsenic and boron were elevated in water, as was the case for Cannikin Lake. The Triad Analysis found the White Alice Creek station immediately downstream of the lake to have poor sediment quality relative to essentially all other lowland stream stations. This poor ranking reflected the elevated concentrations of metals as well as lower than reference ranks for the other two Triad components. In contrast, the other stations on White Alice Creek had an overall ranking within the range of the reference streams. Fish samples from each of the White Alice Creek stream stations and from Cannikin Lake contained Aroclor 1260 at estimated concentrations of about 10 to 20 times the RBC. The fish sample from farthest downstream also contained inorganic arsenic at a concentration above the RBC and background level in reference streams.

Minor residual affects from drilling mud releases at Drill Site D were noted in the chemical results from the lake directly below the mud pits and from the uppermost Falls Creek sampling station. Sediments in the lake contain slightly elevated DRO concentrations as well as elevated levels of chromium and copper. Stream sediment also had elevated chromium and copper. The Triad Analysis ranked Falls Creek as a whole within the range of the reference stations. Fish samples collected from Falls Creek exceed the RBCs for inorganic arsenic and PCBs. The arsenic concentrations were about one tenth of the concentration detected in upland reference streams and therefore cannot be attributed to site-related activities. It appears likely that drilling mud is the source of PCBs in fish, since the fish were resident and presumably could not have been exposed to PCBs in the ocean. PCBs were probably introduced to the stream environment during historic mud spill events.

Chemical results from Drill Site E stations indicate little evidence of residual impacts from historical drilling-mud releases. The only detections of chemicals in exceedance of ERBSCs and background levels were single occurrences of chromium and nickel in sediment from the upper two sampling locations. The Triad Analysis gave these stream stations high ranks relative to the reference streams. The fish tissue analyses from this stream detected no PAHs or PCBs, and no metals were detected in excess of both background and ERBSC values.

Stream water and sediment from Drill Site F (Limpet Creek) do not appear to be adversely impacted from past drilling-mud releases. No DRO, volatiles, or PAHs were detected, and the only metal that exceeded both background and ERBSCs in either water or sediment was zinc in one sediment sample. The Triad Analysis supported this finding, ranking all Limpet Creek stations above the reference streams in sediment quality. Aroclor 1260 was detected in two of three fish samples at concentrations about 10 times the RBC. The source of the PCBs is not known because drilling mud samples at Drill Site F were not tested for PCBs. However, it is likely that the PCBs detected in the fish are from the stream environment, since the sampled fish were resident and not likely exposed to the ocean environment. It is possible that drilling mud released historically into Limpet Creek contained PCBs that have persisted in the stream environment.

5.3 Radionuclide Sampling

Six fish samples from Cloudberry Creek, White Alice Creek, Cannikin Lake, and Pumphouse Lake were analyzed for americium-241, plutonium-238, plutonium-239/240 and cesium-137. The purpose of this sampling program was to provide site-specific data on radionuclide levels in resident fish that could be compared against world-wide fallout levels. The sample from Pumphouse Lake was collected to evaluate background levels of radioisotopes in fish that reside several miles away from the test sites.

Cesium-137 is the only radioisotope detected in the fish samples. It was detected in every sample, with the highest concentration of 0.739 piC/gm in a whole fish sample collected from the upper part of Cloudberry Creek. Levels detected in fish from White Alice Creek and Cannikin Lake (which are connected) ranged from 0.0999 to 0.223 piC/gm in fish guts, and 0.0967 to 0.154 piC/gm in gutted fish. The sample from Pumphouse Lake contained cesium-137 at 0.0613 piC/gm in gutted fish, but no radioisotopes were detected in the associated sample of fish innards. Given the reported error ranges for these analytical results, all of the samples from the Cannikin site contain low levels of cesium-137 within or below the range of cesium in the background sample; whereas, the sample from Cloudberry Creek is slightly elevated relative to background.

5.4 Aircraft Graveyard

The 1998 sampling results, obtained from a short distance downslope and downgradient from the Aircraft Graveyard, indicate that PCBs do not appear to be migrating from the site in groundwater or surface water. Similarly, no PCBs were detected in sediment samples, although the reporting limits were elevated due to the peaty nature of the streambed. The prevalent vegetative cover at the site and along the drainage, and the general lack of sediment in the stream, appears to result in low sediment transport from the site. Based on the findings from this investigation, the concentrations of PCBs reported in 1995 water samples (as great at 62 ug/L) do not appear to be representative of this site. This interpretation is supported by the relative insolubility of PCBs in water. A concentration of 62 ug/L, being relatively high, should be indicative of conditions that would be reflected in the 1998 sampling. It is possible that an inadvertent inclusion of a small amount of sediment in the 1995 water samples was responsible for the elevated PCB concentrations.

TABLE 5-1
SUMMARY OF SURFACE WATER ANAYTICAL RESULTS FOR MUD PITS
(concentrations in micrograms per liter)

Analyte	Cannikin								Long Shot			
	Mud Pit, 3 samples				Discretionary mud pits, 4 samples				6 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration [c]	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration [c]	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration [c]	Mean Concentration [c]
Diesel Range Organics			193	187			286	208			284	177
Metals												
Aluminum	0	1	121	57								
Arsenic [d]	1	0	1.57	0.86								
Calcium	3	-	4,790	4,720					6	-	11,600	10,420
Chromium [d]												
Cobalt					2	0	6.48	3.2	1	0	5.56	1.72
Copper												
Magnesium									6	-	6,700	6,023
Manganese									0	2	125	96.2
Molybdenum												
Nickel	2	0	7.49	4.51	2	0	1.25	0.87	3	0	5.91	1.87
Potassium												
Selenium												
Strontium	3	0	37.3	36.9					6	0	58.7	54.1
Thorium												
Titanium												
Vanadium												
Zinc												

TABLE 5-1 (cont.)
SUMMARY OF SURFACE WATER ANAYTICAL RESULTS FOR MUD PITS
(concentrations in micrograms per liter)

Analyte	Drill Site D				Drill Site E				Drill Site F			
	9 samples				7 samples				3 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]
Diesel Range Organics			125	64.3			132	125			129	99.6
Metals												
Aluminum	1	1	92	64.5					3	3	480	372
Arsenic [d]												
Calcium												
Chromium [d]	1	0	3.68	1.44								
Cobalt												
Copper									2	2	22.9	17.2
Magnesium					1	-	5,380	3,555				
Manganese												
Molybdenum	1	0	1.05	0.6					1	0	1.31	0.77
Nickel	1	0	2.1	1.41					2	0	3.01	2.04
Potassium					1	-	2,860	1,916	3	-	1,780	1,570
Selenium									1	0	1.53	0.84
Strontium					1	0	54.4	35.6				
Thorium	2	-	1.55	0.69								
Titanium	2	-	3	1.26					3	-	40.2	24.4
Vanadium									2	0	3.84	2.58
Zinc									2	0	77.8	48.3

[a] Background concentrations are presented in Table 2-8 of this report. See Appendix D of this report for a description of background concentration calculations.

[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-8 of this report.

[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.

[d] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

\- No background or ERBSC value is available for this compound or element.

TABLE 5-2
SUMMARY OF SEDIMENT ANALYTICAL RESULTS FOR MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Cannikin								Long Shot				Milrow				Drill Site D												Drill Site E						Drill Site F			
	Mud Pit 6 samples				Discretionary Mud Pits 4 samples				12 samples				Rifle Range Road Mud Pits 3 samples				South Mud Pit 5 samples				Northwest Mud Pit 10 samples				Northeast Mud Pit 9 samples				South Pit 1 sample			North Pit 1 sample			5 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Mean and Maximum Concentration	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Mean and Maximum Concentration	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]
Diesel Range Organics			14,000	5,734			7,940	3,563			58,800	15,007	-		2,620	1,221			1,800	498			2,420	830			711	374			10,600			214			12,800	5,461
Volatile Organic Compounds																																						
Acetone	-	2	0.833	0.306																																		
Ethylbenzene									-	2	3.19	1.98																							-	1	0.147	0.0607
Naphthalene	-	5	0.4	0.1392	-	2	7.7	2.54	-	12	137	70.6									-	4	0.682	0.22	-	5	0.912	0.403	-	1	2.99				-	3	1.13	0.3305
m,p-Xylene	-	1	0.114	0.0362					-	8	19.2	8.55																							-	4	0.343	0.1189
o-Xylene	-	1	0.0589	0.0253					-	10	11.2	4.98																							-	4	0.168	0.0532
Total xylenes									-	11	3.04	1.56																										
Polycyclic Aromatic Hydrocarbons																																						
Acenaphthene	-	2	0.944	0.3097	-	2	3.34	1.16	-	8	2.05	0.84	-	1	0.989	0.35					-	2	1.34	0.308					-	1	1.58				-	3	1.22	0.576
Acenaphthylene									-	3	0.802	0.274																	-	1	0.601							
Anthracene	-	2	0.687	0.207									-	2	0.823	0.335					-	6	0.312	0.101	-	6	0.1	0.039	-	1	0.751				-	3	0.6	0.3
Benzo(b) Fluoranthene																					-	1	0.054	0.0084														
Fluoranthene	-	5	0.238	0.111	-	1	0.311	0.091					-	1	0.177	0.076	-	1	0.0701	0.0196	-	1	0.243	0.0421					-	1	0.2				-	3	0.122	0.0661
Fluorene	-	6	3.35	1.29	-	4	13	4.26	-	12	7.03	2.52	-	2	2.09	0.733	-	4	0.386	0.1184	-	10	4.83	1.074	-	9	0.79	0.295	-	1	6.58	-	1	0.058	-	5	5.58	2.75
Naphthalene	-	3	0.224	0.0565	-	3	0.518	0.233	-	12	66.7	21.2									-	2	0.862	0.325	-	7	0.236	0.085	-	1	2.75				-	3	0.187	0.081
Phenanthrene	-	5	9.2	3.36	-	4	17.9	6.09	-	8	3.29	1.16	-	1	4.41	1.64	-	1	0.837	0.235	-	9	19.7	3.716	-	8	2.28	0.858	-	1	18.4				-	4	14.3	7.03
Pyrene	-	1	0.462	0.218	-	1	0.802	0.2558					-	2	0.525	0.32					-	1	0.437	0.0763					-	1	0.525							
Polychlorinated Biphenyls																																						
Aroclor 1248	-	2	0.215	0.156																																		
Aroclor 1260	-	2	0.308	0.201																	-	1	0.0669	0.0334	-	4	0.201	0.11										
Metals																																						
Arsenic	0	1	20.2	7.34					0	1	8.03	4.37	0	2	11.9	7.74					0	5	8.85	5.28	0	2	7.49	4.91	0	1	14.4				0	1	15.6	4.73
Barium																					1	-	614	254	1	-	690	320										
Beryllium																	1	-	1.99	1.37																		
Boron	3	-	81.7	39.3													2	-	37.5	17.6					4	-	12	5.67							5	-	38.2	35.3

TABLE 5-2 (cont.)
SUMMARY OF SEDIMENT ANALYTICAL RESULTS FOR MUD PITS
(concentrations in milligrams per kilogram)

Analyte	Cannikin Mud Pit 6 samples				Cannikin Discretionary Mud Pits 4 samples				Long Shot 12 samples				Milrow Rifle Range Road Mud Pits 3 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]
Cadmium					1	1	1.64	0.78								
Calcium	6	-	133,000	51,883	3	-	23,100	12,605	12	-	46,200	22,560	2	-	34,200	19,313
Cerium	6	-	48.4	29.3	2	-	35	20.3	7	-	31.9	20.5	2	-	23.5	18.1
Cesium	1	-	0.917	1.32	1	-	0.664	0.67	3	-	2.1	0.9	3	-	0.937	0.822
Chromium	6	5	1,010	392	3	2	158	79	6	5	117	45.9	3	2	664	439
Cobalt									2	-	100	29.53				
Copper	6	6	263	160	3	4	474	188	12	12	410	176	2	3	86	68.5
Iron	0	5	63,000	37,150	0	4	40,900	37,525	0	12	64,600	47,808	0	2	37,300	27,133
Magnesium	6	-	24,200	13,810	4	-	25,800	21,375	12	-	28,500	19,433	2	-	10,600	8,693
Manganese	0	6	864	699	0	4	1,690	1,330	0	10	4,040	1,402	0	2	792	605
Molybdenum																
Nickel	3	2	28.2	15.6	4	4	125	63.4	1	0	14.5	10.7*	1	0	14.4	9.2
Potassium					4	-	2,410	2,073	7	-	2,010	1,433	2	-	1,770	1,337
Strontium	6	-	346	253	3	-	332	200	8	-	1,120	407	2	-	363	228
Thallium													1	-	0.522	0.34
Thorium	6	-	16.8	7.70	4	-	10.5	4.82	12	-	7.83	3.3	3	-	4.45	3.36
Titanium									2	-	5,370	2,051				
Uranium	1	-	5.19	2.41												
Zinc	0	2	139	97												

Analyte	Drill Site D South Mud Pit 5 samples					Drill Site D Northwest Mud Pit 10 samples					Drill Site D Northeast Mud Pit 9 samples					Drill Site E South Pit 1 sample				Drill Site E North Pit 1 sample				Drill Site F 5 samples				
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]		Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]		Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]		Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Mean and Maximum Concentration		Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Mean and Maximum Concentration		Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	
Cadmium						3	3	1.03	0.4		1	1	0.888	0.66														
Calcium	3	-	12,800	9,296		10	-	26,400	18,541		9	-	33,000	25,044		1	-	20,800		1	-	8,710		2	-	21,000	9,660	
Cerium	5	-	59.3	45.1		7	-	39.4	24.3		9	-	49.9	30.5		1	-	16.8		1	-	30.3		5	-	19.5	16.3	
Cesium	1	-	2.17	1.41		7	-	1.51	0.78		1	-	0.546*	0.546*		1	-	0.723						1	-	0.632	0.41	
Chromium	5	5	206	153		10	10	1,090	398		9	9	912	566		1	1	123		1	1	37.7		5	5	296	119	
Cobalt																1	-	37.4										
Copper	1	5	92.2	65.7		8	10	239	136		6	9	180	113		1	1	106		1	1	128		0	5	50.8	47.2	
Iron	0	1	24,300	17,360		0	8	52,000	35,660		0	7	40,600	28,389		0	1	23,500		0	1	35,600		0	5	28,900	26,380	
Magnesium						1	-	20,800	10,880																			
Manganese	0	1	698	394		0	7	1,310	799		0	8	1,160	854		0	1	673		0	1	877						
Molybdenum	1	-	2.39	1.45		3	-	4.53	3.3																			
Nickel	0	2	18.8	15.6		1	2	25.9	11.34		1	3	29.9	15.9		1	1	26.7		1	1	48						
Potassium						7	-	4,340	2,582		8	-	3,150	2,142														
Strontium						6	-	364	230		8	-	412	292						1	0	208						
Thallium	1	-	2.31	1.44		1	-	1.16	0.34																			
Thorium	4	-	21.3	10.7		10	-	9.56	4.7		9	-	15.3	7.67		1	0	2.02		1	0	1.96		4	-	4.58	2.26	
Titanium						7	-	15,400	3181		2	-	2,680	1,187														
Uranium	5	-	6.72	4.79		10	-	4.34	1.97		9	-	5.51	2.87		1	0	1						3	-	1.81	0.92	
Zinc																				1	1	198						

[a] Background concentrations are presented in Table 2-9 of this report. See Appendix D of this report for a description of background concentration calculations.
[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-9 of this report.
[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.
* Mean concentration based only on detected concentrations due to reporting limits greater than twice the detected concentrations.
\- No background or ERBSC value is available for this compound or element.

TABLE 5-3
SUMMARY OF SURFACE WATER ANALYTICAL RESULTS FOR SITE STREAMS
(concentrations in micrograms per liter)

Analyte	Cannikin				Long Shot											
	White Alice Creek 5 samples				Bridge Creek 5 samples				Cloudberry Creek 5 samples				Rainbow Creek 5 samples			
	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]
Diesel Range Organics			95.3	78			77.2	52.2			54.6	36.7			121	66.5
Metals																
Aluminum	0	1	97.4	70.1												
Arsenic [d]	2	2	6.42	2.54												
Boron	2	2	424	177												
Calcium	4	-	5,500	4,716	2	-	7,250	4,662					5	-	8,220	7,034
Chromium [d]																
Cobalt																
Copper													1	1	17.7	4.6
Iron																
Lithium									1	0	1.21	0.64				
Magnesium					1	-	4,750	3,574					2	-	5,350	4,560
Molybdenum																
Nickel					4	0	1.32	1.02	3	0	1.27	0.86				
Potassium																
Selenium	1	0	1.1	0.6												
Strontium													4	0	58.3	44.6
Titanium																
Vanadium	2	0	4.94	2.55												
Zinc																

TABLE 5-3 (cont.)
SUMMARY OF SURFACE WATER ANALYTICAL RESULTS FOR SITE STREAMS
(concentrations in micrograms per liter)

Analyte	Milrow				Drill Site D				Drill Site E				Drill Site F			
	Clevenger Creek 5 samples				Falls Creek 5 samples				Unnamed Stream 5 samples				Limpet Creek 5 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]
Diesel Range Organics											104	68.5				ND
Metals																
Aluminum	2	3	625	296					2	2	105	73.9				
Arsenic [d]	3	0	1.85	1.16												
Boron	2	2	88.7	44.7												
Calcium	2	-	4,470	3,998												
Chromium [d]					1	1	12	2.8								
Cobalt	1	0	4.32	2.0												
Copper	1	2	11.8	6.63												
Iron	1	1	1,070	731												
Lithium					1	0	1.04	0.61								
Magnesium																
Molybdenum					1	0	1.01	0.6								
Nickel	2	0	1.97	1.02												
Potassium	1	-	2,730	2,322	5	-	2,270	2,038	4	-	1,610	1,333	4	-	1,640	1,322
Selenium																
Strontium																
Titanium	3	-	123	49.3					2	-	7.7	3.75				
Vanadium	1	0	4.44	2.97	5	0	2.37	1.88	2	0	2.25	1.27	1	0	2.02	1.27
Zinc					2	0	23.3	14.4	1	0	13.7	9.2	2	0	60.8	20.8

[a] Background concentrations are presented in Table 2-8 of this report. See Appendix D of this report for a description of background concentration calculations.
[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-8 of this report.
[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.
[d] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.
\- No background or ERBSC value is available for this compound or element.

TABLE 5-4
SUMMARY OF SEDIMENT ANALYTICAL RESULTS FOR SITE STREAMS
(concentrations in milligrams per kilogram)

Analyte	Cannikin: White Alice Creek 5 samples				Long Shot: Bridge Creek 5 samples				Long Shot: Cloudberry Creek 5 samples				Long Shot: Rainbow Creek 5 samples				Milrow: Clevenger Creek 5 samples				Drill Site D: Falls Creek 5 samples				Drill Site E: Unnamed Stream 5 samples				Drill Site F: Limpet Creek 5 samples			
	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]
Diesel Range Organics			116	54.4				ND				ND			2,110	683			542	155			176	39.97			22.1	7.5				ND
Polycyclic Aromatic Hydrocarbons																																
Benzo(b)fluoranthene																					-	1	0.0876	0.021								
Metals																																
Aluminum	3	-	68,300	44,856	1	-	63,900	33,080									1	-	90,600	33,320												
Arsenic	1	4	109	46.7	0	4	16.7	9.82	0	4	9.89	7.32	0	3	32.1	12.2	0	5	48.9	21.3	0	2	10	5.68								
Beryllium									1	-	2.9	1.9																				
Boron									1	-	159	38.7	1	-	18.2	14.9	3	-	198	164	5	-	163	80.6					3	-	89.3	30.4
Cadmium									1	1	3.17	1.95																				
Calcium	2	-	10,800	7,322	1	-	8,770	6,258	2	-	8,010	6,774					1	-	20,200	6,954												
Cerium	1	-	20.9	11.9													1	-	30.9	13.37	1	-	14.6	8.91	1	-	19.7	11.9				
Cesium									1	-	3.51	2.02					1	-	4.26	2.15												
Chromium	5	1	27.5	20.9									3	2	38.8	19.9	5	0	24.7	21.2	5	3	226	67.4	2	1	41.1	20.6				
Copper	3	5	168	90.5	0	5	68.4	51.3	1	5	71.7	60.5	0	4	61.4	41.9	1	5	247	88.5	1	5	93.1	47.2	0	5	68	36.6	0	5	57.6	27.7
Iron	0	4	96,800	60,340	0	5	98,600	57,920	0	4	79,900	49,440	1	3	192,000	56,274	0	5	108,000	78,120	0	3	85,500	39,632	0	5	31,000	24,200	0	3	64,800	30,200
Magnesium	3	-	36,600	17,662	2	-	12,300	8,480	4	-	16,800	11,250					1	-	37,500	12,720	1	-	17,300	5,068								
Manganese	0	4	10,300	4,812	0	4	6,320	1,833	0	4	5,160	1,904	0	3	14,700	3,699	0	5	9,020	3,009	0	4	2,310	1,513	0	3	1,260	656	0	1	1,250	416
Molybdenum					1	-	8.47	2.73													1	-	0.555*	0.555*	1	-	1.02	0.8	1	-	1.63	1.05
Nickel	3	3	24.9	16.2													1	1	18.9	8.93	0	2	21.9	16.1	1	2	32.5	15.8				
Potassium	1	-	3,880	1,351	2	-	4,050	1,604	1	-	2,630	1,363					1	-	3,560	1,293												
Selenium					1	-	8.86	3.24																	1	-	3.31	1.5	3	-	2.52	1.78
Strontium	2	-	547	266	1	-	178	131	1	-	221	115					1	-	609	187												
Thallium									1	-	4.08	2.14																				
Titanium																	1	-	5,760	1,748	1	-	1,590	775								
Uranium																					1	-	2.49	1.095								
Zinc	0	2	248	122	0	2	138	118					0	1	142	68.6	0	3	208	133	2	2	256	156					1	1	257	97.8

[a] Background concentrations are presented in Table 2-9 of this report. See Appendix D of this report for a description of background concentration calculations.
[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-9 of this report.
[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.
* Mean concentration based only on detected concentrations due to reporting limits greater than twice the detected concentrations.
\- No background or ERBSC value is available for this compound or element.

TABLE 5-5
SUMMARY OF SURFACE WATER ANALYTICAL RESULTS FOR SITE LAKES
(concentrations in micrograms per liter)

Analyte	Cannikin Lake 3 samples				Reed Pond (Long Shot) 2 samples				Heart Lake (Milrow) 3 samples				Drill Site D 3 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding ERBSCs [b]	Maximum Concentration	Mean Concentration [c]
Diesel Range Organics			72.2	63.4			137	125			56.8	56.8			119	83.1
Metals																
Aluminum	0	2	102	90.6					0	3	261	245	2	2	186	119
Arsenic [d]	3	3	7.53	7.2												
Barium					2	2	53	51.2								
Boron	3	3	468	445												
Calcium	3	-	5,500	5,370	1	-	7,330	5,375								
Chromium [d]													3	1	11.5	10.8
Cobalt	2	0	4.81	2.92												
Lithium													3	0	1.18	1.14
Nickel	1	0	1.2	0.7					3	0	1.81	1.57	2	0	1.92	1.8
Potassium													3	-	2,080	1,760
Titanium									3	-	8.21	8.03	3	-	8.83	4.71
Vanadium	3	0	5.31	5.22									2	0	1.65	1.54

[a] Background concentrations are presented in Table 2-8 of this report. See Appendix D of this report for a description of background concentration calculations.

[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-8 of this report.

[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.

[d] Analytical results were compared to the lowest Ecological Risk-Based Screening Concentration for this element; see Table 2-8.

\- No background or ERBSC value is available for this compound or element.

TABLE 5-6
SUMMARY OF SEDIMENT ANALYTICAL RESULTS FOR SITE LAKES
(concentrations in milligrams per kilogram)

Analyte	Cannikin Lake 3 samples				Reed Pond (Long Shot) 2 samples				Heart Lake (Milrow) 5 samples				Drill Site D Lake 5 samples			
	Number of Samples Exceeding Background	Number of Samples Exceeding ERBSCs	Maximum Concentration	Mean Concentration	Number of Samples Exceeding Background	Number of Samples Exceeding ERBSCs	Maximum Concentration	Mean Concentration	Number of Samples Exceeding Background	Number of Samples Exceeding ERBSCs	Maximum Concentration	Mean Concentration	Number of Samples Exceeding Background	Number of Samples Exceeding ERBSCs	Maximum Concentration	Mean Concentration
Gasoline Range Organics			25.9	16.8												
Diesel Range Organics			4,710	2,353			42.6	28.2				ND			146	113
Volatile Organic Compounds																
Acetone					-	2	1.02	0.7								
Ethylbenzene	-	1	0.186	0.169												
Naphthalene	-	1	5.53	1.95												
m,p-Xylene	-	1	0.836	0.493												
o-Xylene	-	1	0.498	0.273												
Polycyclic Aromatic Hydrocarbons																
Acenaphthene	-	2	1.89	0.771												
Anthracene	-	2	0.403	0.184												
Fluoranthene	-	1	0.227	0.097												
Fluorene	-	2	4.87	2.06									-	1	0.0432	0.017
Naphthalene	-	2	1.4	0.48												
Phenanthrene	-	2	12.1	5.49												
Pyrene	-	1	0.34	0.165												
Polychlorinated Biphenyls																
Aroclor 1248	-	1	0.185	0.09												
Aroclor 1260	-	2	0.107	0.091												
Metals																
Aluminum	2	-	55,900	44,200					2	-	77,500	47,020				
Arsenic	0	3	20.4	14.3	0	1	7.92	4.82								
Barium													2	-	515	366
Boron	2	-	15.6	11.2												
Cadmium	1	1	0.876	0.577												
Calcium	2	-	25,900	13,333	1	-	9,230	6,400	2	-	8,130	5,316	4	-	10,500	8,898
Cerium	2	-	21.1	14.2					1	-	16.3	11.09	4	-	61.4	36.2
Cesium	1	-	1.11	0.66	1	-	5.72	3.72								

TABLE 5-6 (cont.)
SUMMARY OF SEDIMENT ANALYTICAL RESULTS FOR SITE LAKES
(concentrations in milligrams per kilogram)

Analyte	Cannikin Lake 3 samples				Reed Pond (Long Shot) 2 samples				Heart Lake (Milrow) 5 samples				Drill Site D Lake 5 samples			
	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]	Number of Samples Exceeding Background[a]	Number of Samples Exceeding ERBSCs[b]	Maximum Concentration	Mean Concentration[c]
Chromium	3	2	257	175					2	-	21.7	14	4	4	695	420
Copper	2	3	203	142	0	2	47.5	37.5	4	5	192	96.3	2	5	98.3	72.4
Iron	0	3	55,900	48,733					0	3	66,400	28,592	0	5	32,700	27,220
Magnesium	3	-	23,300	19,167					2	-	29,400	11,274				
Manganese	0	2	956	746									0	4	783	550
Nickel	3	3	66.9	34.3												
Potassium									1	-	1,580	922	4	-	2,020	1,509
Strontium	1	-	251	144					1	-	196	101				
Thorium	2	-	2.81	1.94					1	-	0.855	1.66	5	-	16.8	7.76
Titanium													2	-	1,950	1,293
Uranium													4	-	6.22	3.2

[a] Background concentrations are presented in Table 2-9 of this report. See Appendix D of this report for a description of background concentration calculations.

[b] Ecological Risk-Based Screening Concentrations (ERBSCs) are presented in Table 2-9 of this report.

[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.

\- No background or ERBSC value is available for this compound or element.

TABLE 5-7
SUMMARY OF FISH ANALYTICAL RESULTS
(concentrations in milligrams per kilogram)

Analyte	Cannikin								Long Shot												Milrow				Drill Site D				Drill Site E				Drill Site F			
	White Alice Creek 4 samples				Cannikin Lake 2 samples				Bridge Creek 2 samples				Cloudberry Creek 3 samples				Rainbow Creek 2 samples				Clevenger Creek 3 samples				Falls Creek 2 samples				Unnamed Stream 3 samples				Limpet Creek 3 samples			
	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]	Number of Samples Exceeding Background [a]	Number of Samples Exceeding RBCs [b]	Maximum Concentration	Mean Concentration [c]
Polychlorinated Biphenyls																																				
Aroclor 1260	-	4	0.0394	0.0201	-	2	0.0248	0.0219									-	1	0.0161	0.0161	-	2	0.0094	0.0070	-	2	0.183	0.108					-	2	0.0204	0.012
Metals																																				
Arsenic	1	0	0.135	0.081	1	1	0.564	0.342	1	1	0.257	0.154									1	1	0.225	0.13									0	1	1.37	0.504
Inorganic Arsenic	1	4	0.0457	0.0179					1	2	0.154	0.082	0	1	0.0152	0.0059	1	2	0.0236	0.0144	2	3	0.055	0.032	-	2	0.00411	0.00395	0	1	0.00508	0.00265	0	1	0.00442	0.00268
Barium									1	0	1.62	0.941													2	0	0.722	0.647	3	0	1.08	0.81	3	0	0.83	0.736
Boron																																				
Cadmium					1	0	0.0535	0.0393																					1	0	0.0288	0.0179				
Calcium																													1	-	10,800	10,150				
Cerium									1	-	0.088	0.05	1	-	0.031	0.019																				
Cesium									1	-	0.0305	0.022									2	-	0.0285	0.0224					3	-	0.036	0.032				
Chromium [d]																									1	0	0.758	0.535								
Cobalt									1	0	0.257	0.141	1	0	0.111	0.054													3	0	0.15	0.113	1	0	0.0523	0.0341
Copper	1	0	1.31	0.962	2	0	1.86	1.54																												
Iron									1	1	10,900	5,479																					1	0	101	47.8
Lithium									1	0	0.17	0.098																								
Magnesium									1	-	473	373																								
Nickel					2	0	0.21	0.16	1	0	0.217	0.14	1	0	0.135	0.087					1	0	0.127	0.084	2	0	0.184	0.163	1	0	0.132	0.086				
Potassium																																	1	-	4,450	4,177
Strontium																													1	0	13.4	10.8	3	0	20.2	17.9
Thallium					1	0	0.05	0.038	1	0	0.0503	0.031																								
Thorium									1	0	4.06	2.66	1	-	4.17	2.22	1	-	5.4	3.3													1	-	4.98	2.49
Titanium																									2	0	1.07	0.964					1	0	1.25	0.745
Vanadium									1	0	2.6	1.5																					1	0	0.409	0.256

[a] Background concentrations are presented in Table 2-10 of this report. See Appendix D of this report for a description of background concentration calculations.
[b] EPA Region III Fish Consumption RBCs are presented in Table 2-10 of this report.
[c] Mean concentration calculations included nondetect results, which were assigned values of one-half their respective reporting limit.
[d] Analytical results were compared to the lowest EPA Region III Fish Consumption RBC for this element; see Table 2-10.
- No background or RBC value is available for this compound or element.

6.0 REFERENCES

Alaska Department of Environmental Conservation (ADEC). 1998. *Water Quality Standards.* 18 AAC 70. Juneau, AK.

_____. 1999a. *Oil and Hazardous Substances Pollution Control.* 18 AAC 75.

_____. 1999b. *Drinking Water.* 18 AAC 80.

American Society for Testing and Materials (ASTM). 1995. Method E 1706-95b. *Standard test methods for measuring the toxicity of sediment-associated contaminants with fresh water invertebrates.* West Conshohocken, PA.

Armstrong, R. H. 1977. Weather and climate In *The environment of Amchitka Island, Alaska.* Energy Research and Development Administration (ERDA) Report TID-26712: 53-58. M.L. Merritt and R.G. Fuller (Eds). Springfield, VA: National Technical Information Service.

Burkett, R. D. 1977. Limnology In *The environment of Amchitka Island, Alaska.* ERDA Report TID-26712: 269-286, M.L. Merritt and R.G. Fuller (Eds). Springfield, VA: National Technical Information Service.

Coats, R. R. 1947. Reconnaissance geology at some western Aleutian Islands. *Alaska volcano investigations, Progress of investigations in 1946.* Report No. 2, U. S. Geological Survey: 95-105.

Dudley Jr., W. W., W. C. Balance, and V. M. Glanzman. 1977. Hydrology In *The environment of Amchitka Island, Alaska.* ERDA Report TID-26712: 35-52, M.L. Merritt and R.G. Fuller (Eds). Springfield, VA: National Technical Information Service.

Foster Wheeler Environmental Corporation. 1996. *Site inspection report , Amchitka Island, Alaska.* Draft Final, 3 volumes. Prepared for U.S. Fish and Wildlife Service Pollution Control Office, Lakewood, Colorado.

Fuller, R.G., and J.B. Kirkwood. 1977. Ecological consequences of nuclear testing. In *The environment of Amchitka Island, Alaska.* ERDA Report TID-26712: 627-650, M.L. Merritt and R.G. Fuller (Eds). Springfield, VA: National Technical Information Service.

Gard Jr., L. M. 1977. Geologic history In *The environment of Amchitka Island, Alaska.* ERDA Report TID-26712: 13-34, M.L. Merritt and R.G. Fuller (Eds). Springfield, VA: National Technical Information Service.

Gard Jr., L. M. 1980. *The Pleistocene geology of Amchitka Island, Aleutian Islands, Alaska.* U. S. Geological Survey Bulletin 1478. 38p.

IT Corporation. 1999. *Triad analysis of drill site and test site stream sediments, Amchitka Island, Alaska.* Prepared for DOE Nevada Operations Office.

Jones, D. S., R. N. Hull, and G. W. Suter. 1996. *Toxicological benchmarks for screening contaminants of potential concern for effects on sediment associated biota.* Revision. Oak Ridge National Laboratory Report ES/ER/TM-95/R2. Oak Ridge, TN.

Koob, D.D. 1968. *Amchitka bioenvironmental program annual progress report, the freshwater ecology of Amchitka Island.* BMI-171-103. Battelle Memorial Institute. Columbus, OH.

Neuhold, J. M., and W. T. Helm. 1968. *Amchitka bioenvironmental program annual progress report, freshwater vertebrate and invertebrate ecology of Amchitka Island.* BMI-171-104. Battelle Memorial Institute. Columbus, OH.

Ontario Ministry of Environment and Energy. 1993. *Guidelines for the protection and management of aquatic sediment quality in Ontario.* Persaud, D., R. Jaagumagi, and A. Hayton.

Powers, H. A., R. R. Coats, and W. H. Nelson. 1960. *Geology and submarine physiography of Amchitka Island, Alaska.* U. S. Geological Survey Bulletin No. 1028: 521-554.

Shannon & Wilson. 1996. *Management plan, Amchitka Army Air Base phase I remedial investigation, Amchitka Island, Alaska*, includes the following: *Work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, baseline risk assessment work plan*, and *community relations plan.* Prepared for the U.S. Army Corps of Engineers.

_____. 1998a. *Site characterization report, Amchitka Army Air Base phase I remedial investigation, Amchitka Island, Alaska.* Prepared for the U.S. Army Corps of Engineers.

_____. 1998b. *Management plan, Amchitka Army Air Base phase II remedial investigation, Amchitka Island, Alaska.* Prepared for the U.S. Army Corps of Engineers.

_____. 1999a. *Final Report, Amchitka Army Air Base phase II remedial investigation, Amchitka Island, Alaska.* Prepared for the U.S. Army Corps of Engineers.

_____. 1999b. *Management plan, Department of Energy 1998 drill site investigation, Amchitka Island, Alaska.* Prepared for the Department of Energy through the U.S. Army Corps of Engineers.

U.S. Atomic Energy Commission. 1972. *Planning directive: demobilization, restoration, and monitoring, Amchitka Island test area*. Nevada Operations Office, NVO-107.

U.S. Environmental Protection Agency. 1985. *Ambient water quality criteria*. Washington D.C.

_____. 1986. *Quality criteria for water*. Report EPA/440/5-86/001. Washington D. C.

_____. 1993. *Office of water policy and technical guidance on interpretation and implementation of aquatic life metals criteria*, 40 CFR 131.36(b)(1).

_____. 1994. *National functional guidelines for organic data review*. USEPA Contract Laboratory Program, Office of Solid Waste and Emergency Response. Washington D.C.

_____. 1995a. Drinking water regulations and health advisories. Office of Water. Washington D.C.

_____. 1995b. *Water quality standards*. 40 CFR 131.

_____. 1995c. EPA Region IV, *Ecological screening values for sediments*.

_____. 1996a. *Recommended guidelines for measuring organic compounds in Puget Sound water, sediment, and tissue samples*. EPA Region 10, Puget Sound Water Quality Authority guidance document

_____. 1996b. *Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomous riparius*. Assessment and Remediation of Contaminated Sediments Project. EPA 905-R96-008, Great Lakes National Program Office.

_____. 1996c. *Water quality criteria documents for the protection of aquatic life in ambient water*, EPA-820-B-96-011.

_____. 1996d. *ECO update: ecotox thresholds*. Vol. 3, No. 2. Report EPA/540/F-95/038.

_____. 1998a. *Draft rapid bioassessment protocols for use in streams and rivers: periphyton, benthic, macroinvertebrates, and fish*. Office of Water, Washington D.C. EPA 841-D-97-002.

_____. 1998b. *Region III risk-based concentration table*. October 1, 1998.

_____. 1998c. *National recommended water quality criteria*. Federal Register. December 10, 1998 (63 FR 68354-68364).

_____. 1999. *EPA Region III risk-based concentrations for fish ingestion* (from the April 1999 RBC Table)

U.S. Fish and Wildlife Service (USFWS). 1993a. *Summary of site contamination on Amchitka Island, Alaska, May 1993.*

_____. 1993b. *Summary of site contamination on Amchitka Island, Alaska, October 1993.*

Valdez, R. A., W. T. Helm, and J. M. Neubold. 1977. Aquatic Ecology. In *The environment of Amchitka Island, Alaska.* Prepared for Division of Military Application, Energy Research and Development Administration. TID-26712. pp. 287-314.

Appendix A

Modifications to the August 1998 *Management Plan*

APPENDIX A

MODIFICATIONS TO THE AUGUST 1998 MANAGEMENT PLAN

This appendix documents significant modifications to the *DOE 1998 Drill Site Investigation Management Plan* (MP) in implementing project field work. The first section describes the discretionary sampling performed, the second section lists sites not sampled, and the third section discusses modifications to the technical approach outlined in the MP.

SECTION 1
DISCRETIONARY SAMPLING

Provisions were made in the scope of work for discretionary sampling in areas found or thought to be potentially-impacted based on reconnaissance efforts. The following section presents an annotated list of the locations where additional samples were collected.

PCB Testing

The original scope of work included PCB testing of only the water and sediment at the Aircraft Graveyard site only. During the course of the 1998 field work and in the months that followed, the scope of work was expanded to include PCB analysis of select mud-pit and stream sediment samples as well as most fish samples. The additional testing was performed on samples that had already been collected and were being stored at project laboratories.

Based on concerns of the on-site USFWS representative and subsequent discussions with the DOE manager and others, the decision was made to collect discretionary samples from the south end of Cannikin Lake. The concerns were the result of past reports (referenced in a USFWS database) of a possible landfill on the slopes above Cannikin Lake, which could have impacted the lake environment. Cannikin Lake sampling included PCB analysis of the three collected surface water and sediment samples. Test results showed two of three sediment samples contained PCBs (Aroclor 1248 and Aroclor 1260) at concentrations of 0.11 to 0.18 mg/kg. Surface water samples results reported no detection of PCBs.

In light of these results, it was decided that other Cannikin sediment samples, including all mud-pit and stream sample locations, should also be tested for PCBs. Two of twelve mud pit samples reported PCBs, while none of the White Alice Creek sediment samples had detected PCBs. The mud pits at Drill Site D were also tested for PCBs as were selected reference stream sediment samples. Based on concerns of PCB exposure in the aquatic environment of Cannikin Lake and the potential at other streams, as many fish samples as possible (35) were tested for PCBs. This included reference streams to provide a basis for comparison. All of the PCB analyses, besides Aircraft Graveyard, were added to the original scope of work.

The remainder of the discretionary sampling efforts are listed site by site.

Rifle Range Road Additional Mud Pit
As described in Section 4.1.4.3 of this report, four potential mud pit sites were investigated near the intersection of Infantry and Rifle Range Roads. Based on probing, one of these sites was determined to be a former mud pit and was sampled. Three discretionary mud/soil samples were collected from the mud pit.

Long Shot Site
Based on a reconnaissance of the Long Shot Site, the stream referred to as Rainbow Creek was added to the scope of work (Section 4.2.4.2.2.) A drainage ditch was found leading from the Long Shot Mud Pits, through a culvert under Infantry Road, and downstream to the road. This stream was investigated and sampled in the same manner as other project streams.

The reconnaissance of Long Shot also found that a trench leading to Reed Pond contained a small quantity of diesel-contaminated drilling mud. Based on these findings, Reed Pond was sampled, although there was no evidence of drilling mud, diesel odor, or sheen in near-shore sediments. Two discretionary samples (surface water and sediment) were collected to determine potential impacts to Reed Pond (Section 4.2.4.3.).

Cannikin Site
The original scope of work in the Cannikin investigation included the collection of sediment from five locations in the SGZ mud pit. This number of sampling locations was based on the classification of the mud pit as "large." The actual dimensions of the mud pit as measured in the field were smaller than anticipated, and the mud pit was reclassified as "small." Therefore, only three locations were sampled in the mud pit (see Section 3.3-1 of the 1998 *Management Plan* for the definitions of "large" and "small" mud pits).

Two additional mud pits were observed near an exploratory hole located south of Cannikin SGZ. Sampling of these mud pits was added to the scope of work, as discussed in detail in Section 4.3.4.1 of this report.

The original scope of work did not include sampling of Cannikin Lake for potential chemical impacts. During the 1998 investigation, the on-site USFWS expressed concern about a possible landfill reported southwest of the lake (which was never found during reconnaissance efforts). A sampling effort including three surface water and three sediment samples was added to the scope of work in order to investigate possible impacts (Section 4.3.1.).

Drill Site E
During a reconnaissance of Drill Site E two small mud pits were discovered. A sampling effort was added to the scope of work to characterize these mud pits. The added sampling effort consisted of one surface water and one sediment sample from each mud pit (Section 4.8.4.1.).

Drill Site F
The original scope of work proposed that the mud pit at Drill Site F be sampled in five locations, based on its classification as large (length greater than 200 feet). Based on reconnaissance, the mud pit was found to be small, and so the number of samples was reduced to three. At each sample location both a surface water and sediment sample were collected.

Pumphouse Lake
A fish sample was collected from Pumphouse Lake near base camp and analyzed for radionuclides as a background sample (Section 2.3.3.2.). The reference streams did not contain enough fish to provide the sample size of 2,000 grams necessary to achieve the desired reporting limits. Rather than depleting the resource, the background sample was collected from Pumphouse Lake, near base camp.

SECTION 2
SITES NOT SAMPLED

The following sites were investigated during the 1998 (in accordance with the MP) but not sampled, based on field findings. These modifications are discussed in more detail in the sections referenced for each site.

Long Shot Pond
As described in Section 4.2.4.3, a reconnaissance was conducted at Long Shot Pond. This included visual observation and sediment sampling from near shore and the middle of the pond. No drilling mud, diesel odor, or sheen was observed. Based on these findings, no samples were collected. Associated trenches were also observed, and no drilling mud was found.

Milepost 13 Lake
A reconnaissance of MP13 Lake found no evidence of drilling mud or related impacts, and as a result no samples were collected. As discussed in Section 4.4 of this report, subsequent research has indicated that the lake identified in the MP may not have been the lake reported to have contained drilling mud.

Milepost 14 Lake
MP14 Lake was probed but showed no evidence of drilling mud, sheen, or odor. The surrounding area also revealed no impacts from drilling mud. Therefore, the surface water and sediment samples planned for the site were not collected (Section 4.5.)

Drill Site F Lake
The western drainage, a large lake located west of Drill Site F and the upper section of its drainage stream, was observed, and the lake was probed using a hand auger. No drilling mud or impact from drilling mud was observed during the reconnaissance of the lake and stream. No samples were collected for laboratory analysis (Section 4.7.4.3).

Reference Stream 3
The originally proposed Reference Stream 3 was not sampled because of potential anthropogenic impacts. The pond at the stream's headwaters was downgradient from the emplacement hole at Drill Site D. This location implied the possibility that drilling mud could have reached the pond and stream. While there was no evidence of impacts found during the reconnaissance, a decision was made to abandon the proposed stream in favor of another stream away from drill sites (Section 4.5.2.)

SECTION 3
MODIFICATIONS TO TECHNICAL APPROACH

Stream Sediment and Surface Water Sampling (Section 5.3 of MP)
In referring to the preferred sequence of sampling activities, the MP stated that fish samples would be collected after water sampling and before sediment sampling in order to minimize disturbance of sediment in the stream. Instead, water and sediment samples from a given stream were collected at roughly the same time, and fish and benthic sampling occurred at least 24 hours later. The MP also indicated that fish samples would be collected a minimum of 12 hours following any disturbance of sediment; this was accomplished.

Stream Water Sampling (Section 5.3.1 of MP)
The MP indicated that stream water sampled for metals would be collected using a peristaltic pump with field filters. A hand vacuum pump was used instead of the peristaltic pump for all stream water samples. Other procedures, including using new tubing and filters at each station, were completed in accordance with the MP. This modification did not change the quality of samples in any way.

Horiba meters were used to measure water quality parameters. In many cases the turbidity meter did not work properly on these units. The values obtained were recorded and are presented in the report. If no number was obtained, the water was simply described as clear, slightly turbid, or turbid.

Stream Sediment Sampling (Section 5.3.2 of MP)
The most effective technique for sampling stream sediment in most cases turned out to be the gloved-hand method as opposed to using an Eckman dredge, coring device, or scoop.

During initial sampling efforts, drawbacks to the other proposed methods became apparent, including loss of sediment to the current and difficulty in maneuvering devices under cutbanks. With the gloved-hand method, a clean surgical glove was used at each station. The sampler was able to feel for pockets of suitable, fine-grain, organic-rich sediment, often located in hard-to-reach overhanging cutbanks. With this method there was less loss of sediment as it was brought to the surface than with a scoop, and without equipment to clean, the potential for cross-contamination was greatly reduced. This modification is considered to have improved the quality of sediment samples over other methods.

Because the PID did not appear to be an effective screening tool for determining which samples should be analyzed for volatiles, stream sediment samples were generally not screened. During initial sampling efforts, high PID readings (greater than 500 ppm) were obtained in highly-organic sediment that, based on lack of odor and setting, was unlikely to contain POL-based hydrocarbons. Whereas, most mud pit sediment samples, which were screened with a PID, reported low (less than 14 ppm) readings even where a strong diesel odor was evident. The conclusion was made that PID readings of stream sediment correlated primarily with percent organic content rather than presence of hydrocarbons. The fourth sample location from the mouth (usually Station 2) was generally sampled and tested for volatiles, by default, as specified

in the MP. This modification has no significant impact on the conclusions drawn at stream locations.

Benthic Invertebrate Sampling (Section 5.4 of MP)
It was implied in the MP that BMI could be individually placed in sample containers with forceps. Clevenger Creek and Reference Stream 1 were sampled for benthics in this way by hand-picking the organisms in the field and placing them into the preservative. This technique was judged to be too time-consuming. Subsequent benthic samples were collected by transferring the rinsed net contents, minus large rocks, into jars. Individual benthic organisms were counted and identified in the laboratory.

Appendix B

Sample Locations and Results from Previous DOE Investigations

1993

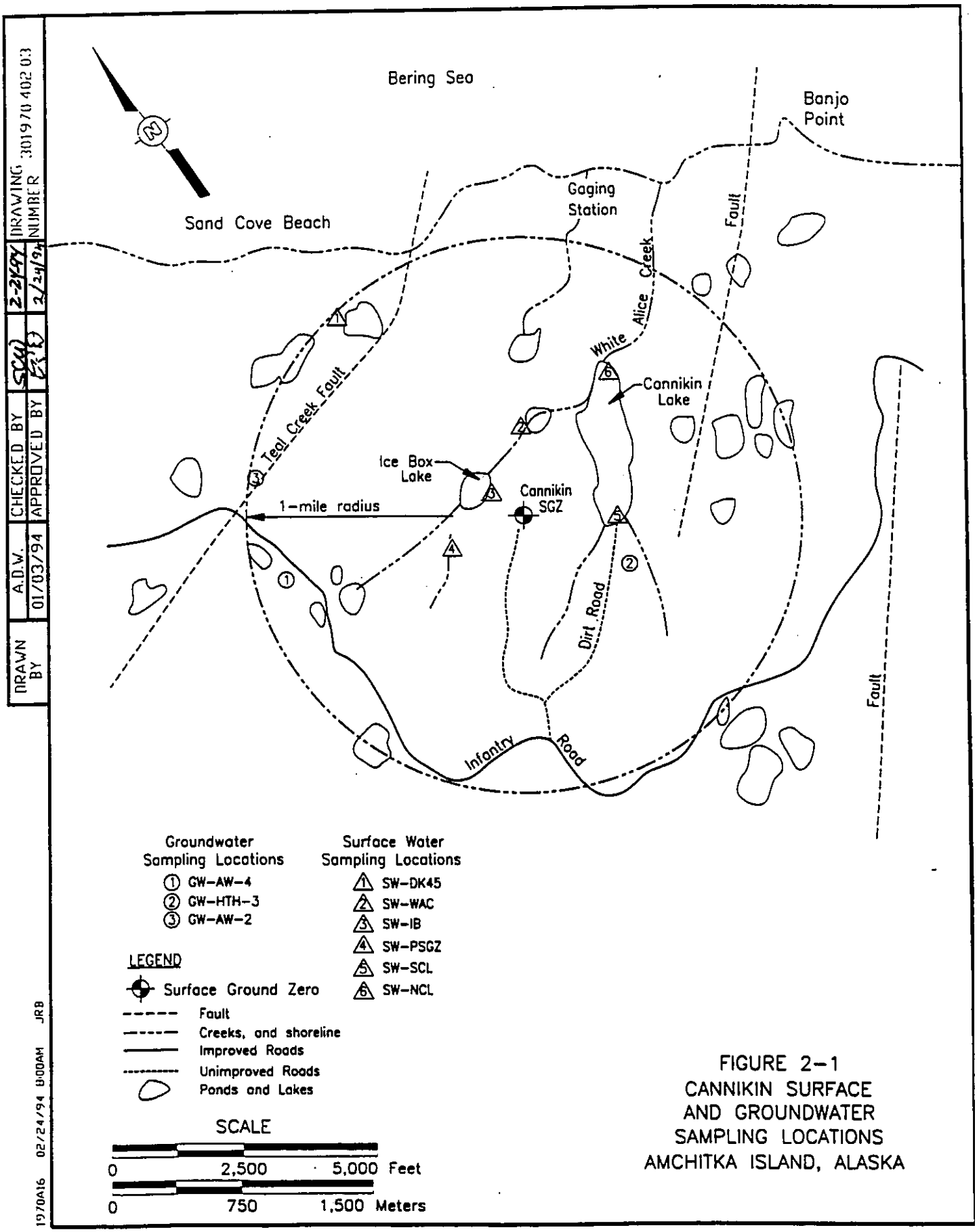


FIGURE 2-1
CANNIKIN SURFACE AND GROUNDWATER SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA

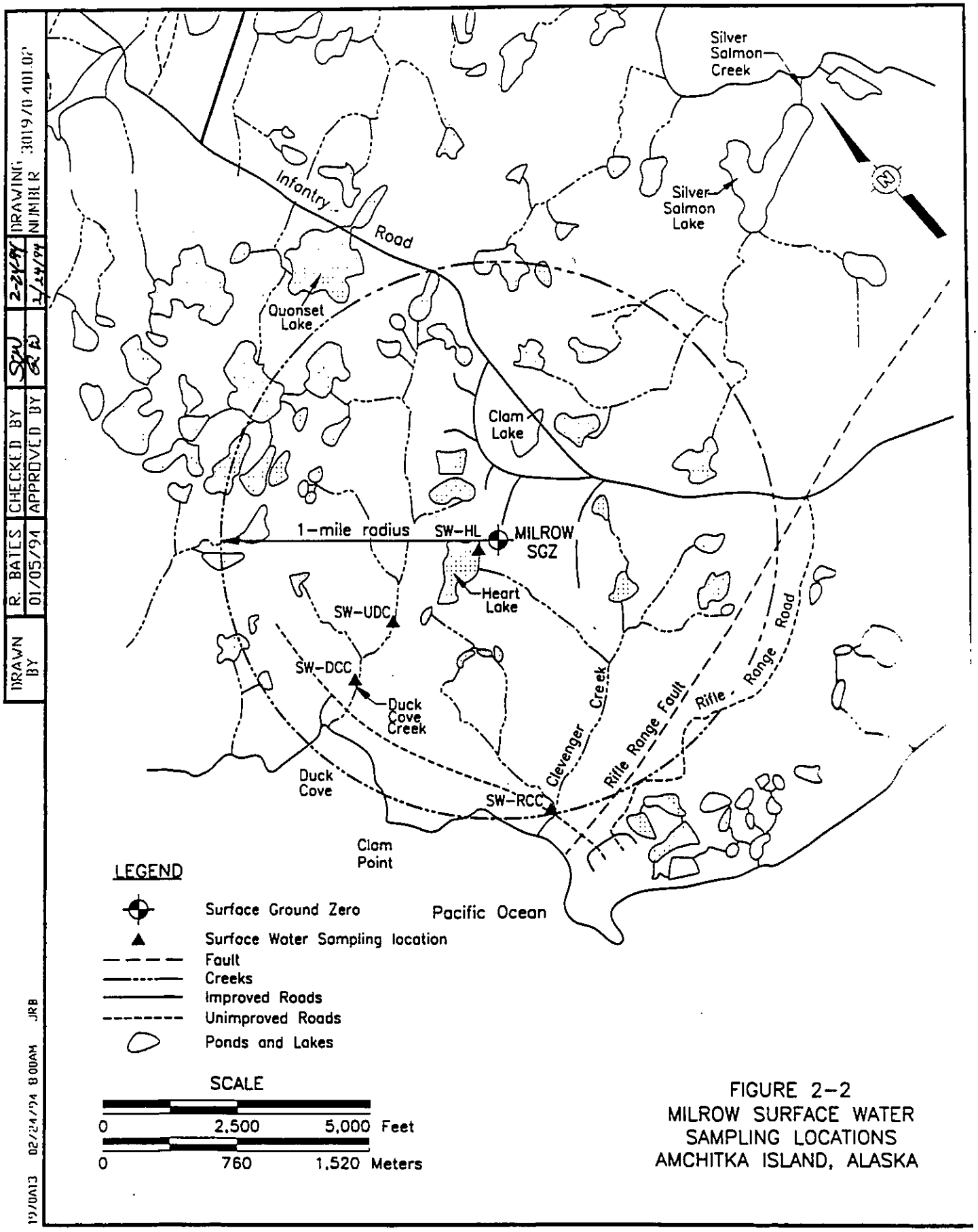


FIGURE 2-2
MILROW SURFACE WATER SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA

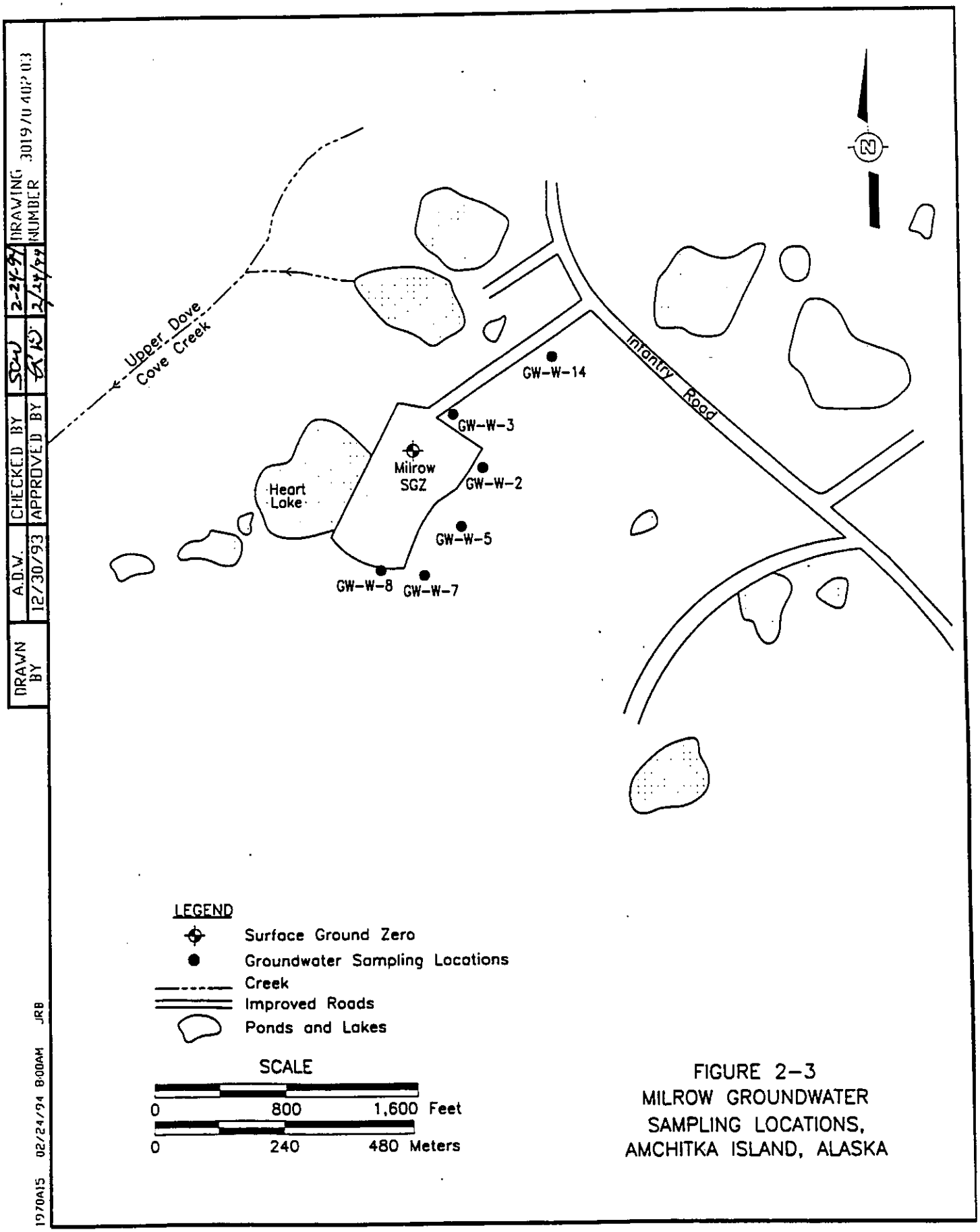
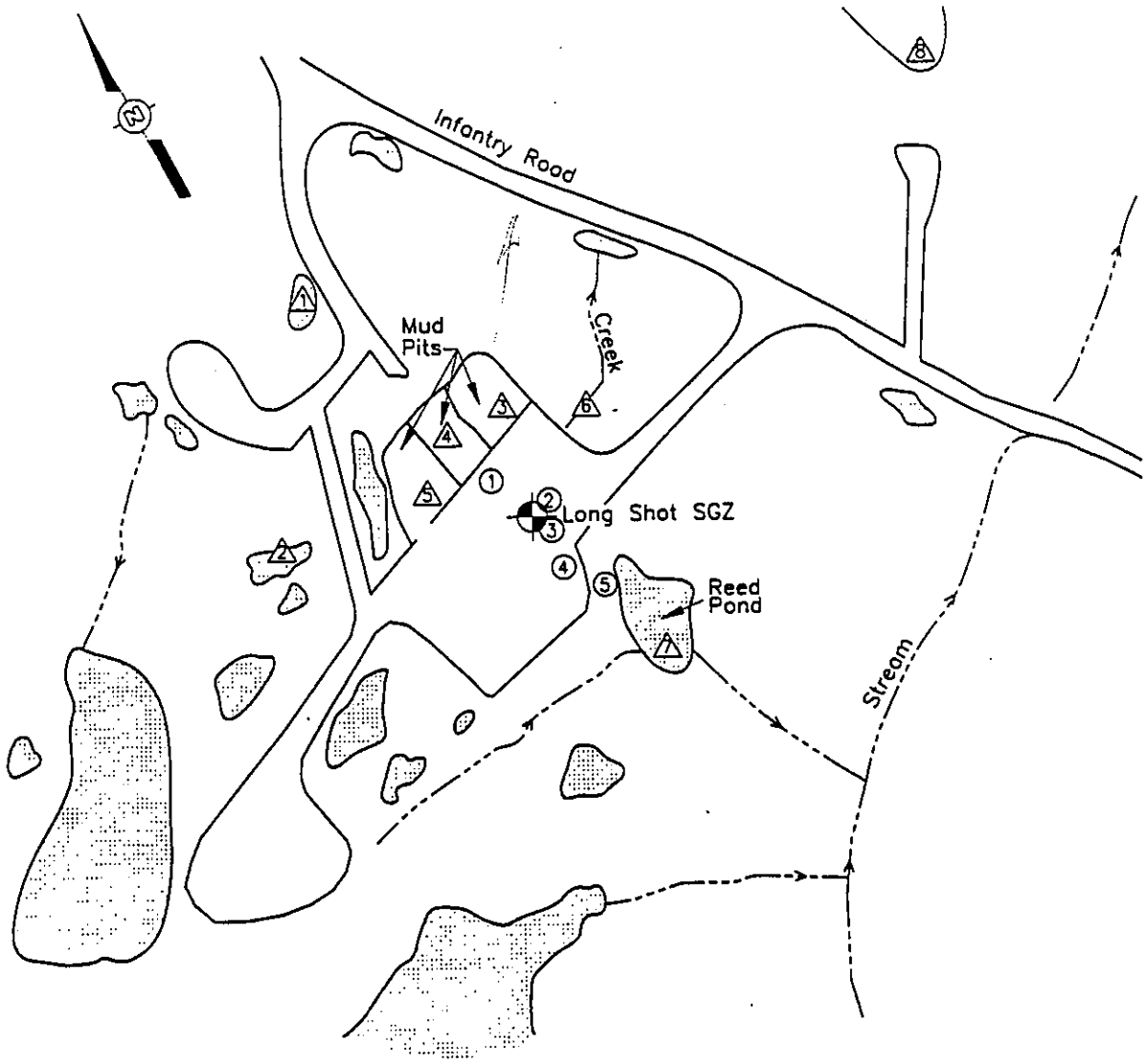


FIGURE 2-3
MILROW GROUNDWATER SAMPLING LOCATIONS, AMCHITKA ISLAND, ALASKA



Surface Water Sampling Locations

- 1 SW-LSPD-2
- 2 SW-LSPD-1
- 3 SW-LSMP-1
- 4 SW-LSMP-2
- 5 SW-LSMP-3
- 6 SW-SELS
- 7 SW-REED
- 8 SW-LSPD-3

Groundwater Sampling Locations

- 1 GW-WL-1
- 2 GW-LSGZ-1
- 3 GW-LSGZ-2
- 4 GW-WL-2
- 5 GW-EPAW-1

LEGEND

- Surface Ground Zero
- Creek
- Improved roads
- Ponds and Lakes

SCALE

0 400 800 Feet

0 120 240 Meters

FIGURE 2-4
LONG SHOT SURFACE AND GROUNDWATER SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA

DRAWN BY	A.D.W	CHECKED BY	SCW	2-24-94	DRAWING NUMBER	3019/0 4112 013
	12/30/93	APPROVED BY	RB	2/24/94		

1970A1B 02/24/94 10:00AM JRB

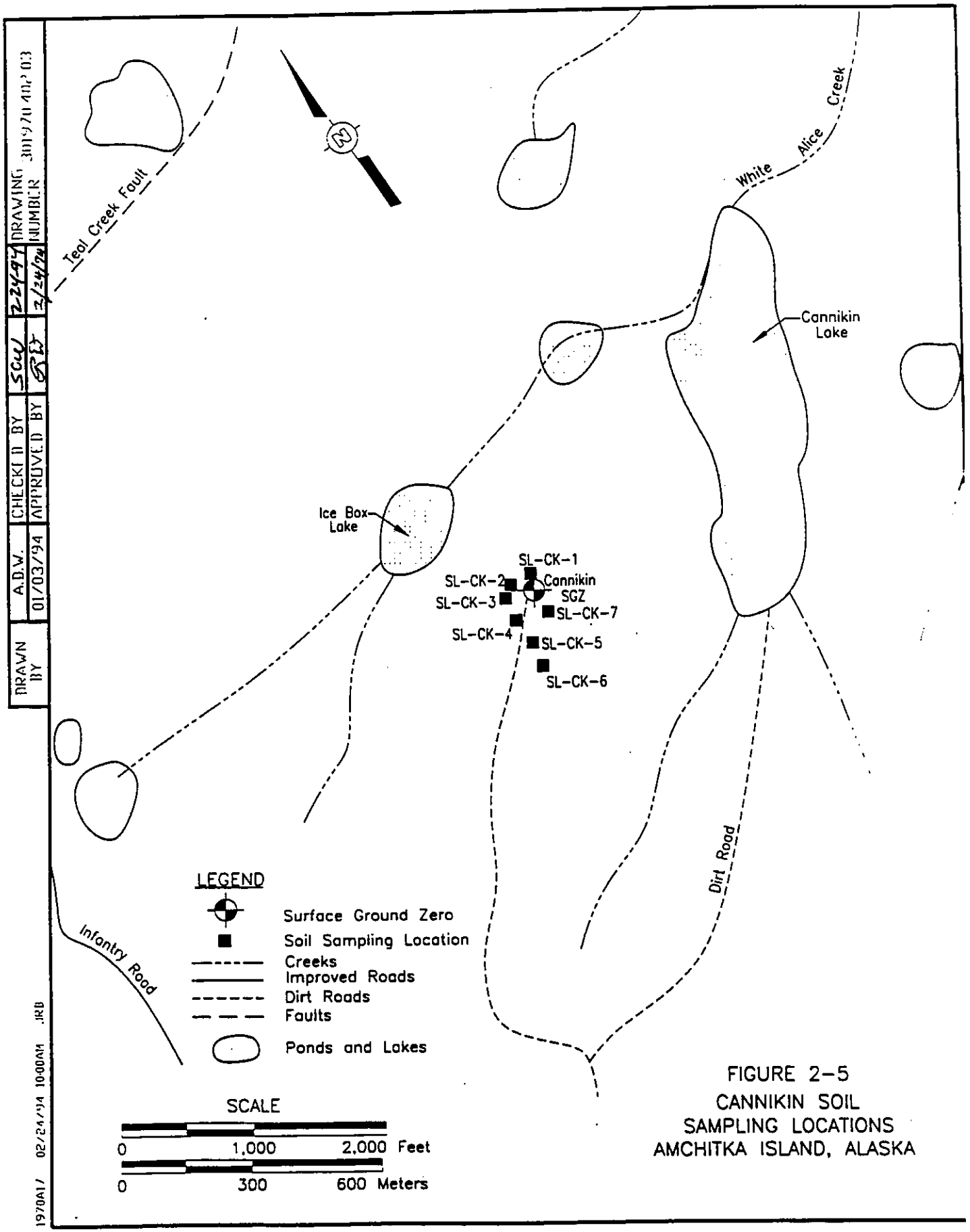


FIGURE 2-5
CANNIKIN SOIL
SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA

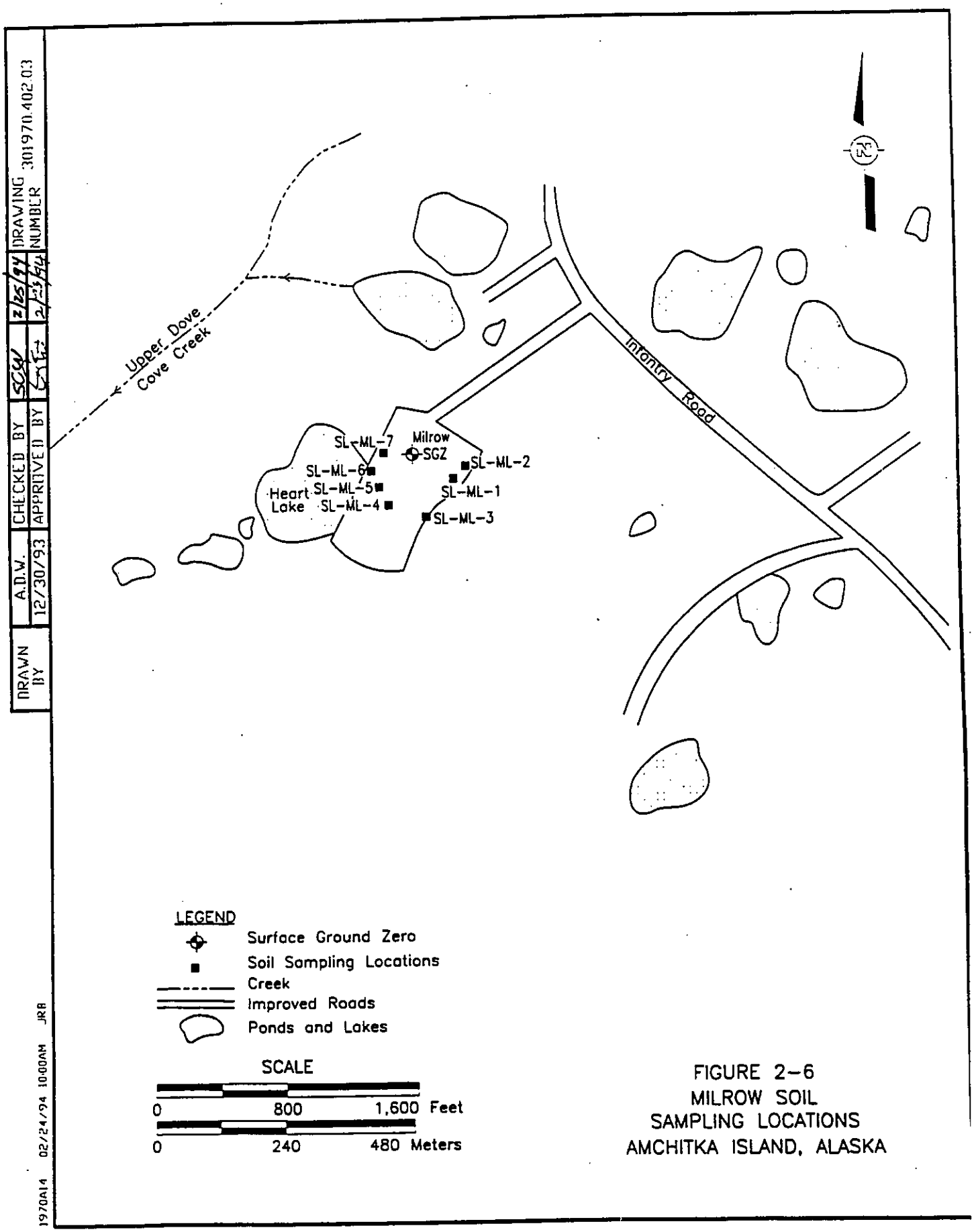
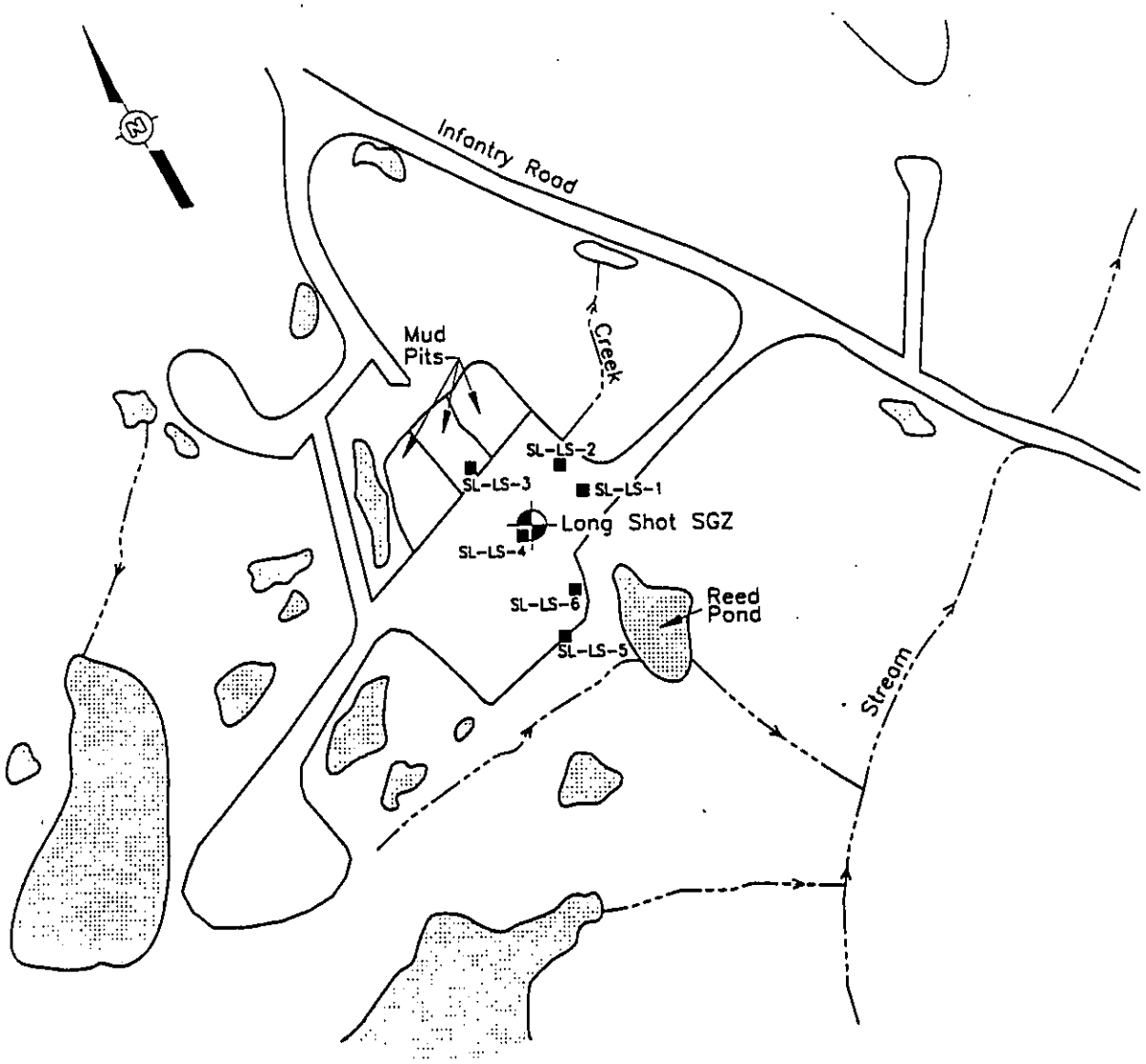


FIGURE 2-6
MILROW SOIL
SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA



LEGEND

- Surface Ground Zero
- Creek
- Improved roads
- Soil Sampling Locations
- Ponds and Lakes

SCALE

0 400 800 Feet

0 120 240 Meters

FIGURE 2-7
LONG SHOT SOIL
SAMPLING LOCATIONS
AMCHITKA ISLAND, ALASKA

DRAWN BY	A.D.W	CHECKED BY		DRAWING NUMBER
	12/30/93	APPROVED BY	2/24/94	

1970A19 02/24/94 2:00PM JRB

Amchitka Island Sampling Event

Inorganics in Surface Water

Cannikin

(all values in µg/L)

Analyte	SW-DK45		SW-WAC		SW-NCL		SW-SCL		SW-PSGZ		SW-IB	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	120		112		201		53.8	U	53.8	U	60.4	
Antimony	29.4	U	29.4	U	29.4	U	29.4	U	29.4	U	29.4	U
Arsenic	1	U	1	U	9.1		7.7		1	U	1	U
Barium	2		1.2	U	1.7		1.2	U	1.2	U	1.2	U
Beryllium	1	U	1	U	1	U	1	U	1	U	1	U
Cadmium	2.8	U	2.8	U	2.8	U	2.8	U	2.8	U	2.8	U
Calcium	3150		5190		7070		6710		5710		5060	
Chromium	3.7	U	3.7	U	3.7	U	3.7	U	3.7	U	3.7	U
Cobalt	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U
Copper	5.8		3.6	U	3.6	U	3.6	U	3.6	U	3.6	U
Iron	46.4		180		323		108		27.3		107	
Lead	6.3		1.8		5.3		12		1.4		1.5	
Magnesium	3480		3470		2880		2650		1750		3430	
Manganese	2		6		30.3		3.6		1.6	U	1.6	U
Mercury	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Nickel	13.2	U	13.2	U	13.2	U	13.2	U	13.2	U	13.2	U
Potassium	4390	U	4390	U	4390	U	4390	U	4390	U	4390	U
Selenium	1	U	1	U	1	U	1	U	1	U	1	U
Silver	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U
Sodium	21000		22400		118000		115000		17800		21700	
Thallium	1	U	1	U	1	U	1	U	1	U	1	U
Vanadium	7.9		7.1		10.5		8.5		6.5		8.5	
Zinc	15.7		16.5		16.3		31.7		9.4		6.8	

Q = Data qualifier

U = Analyte not detected above the specified value

Amchitka Island 1993 Sampling Event
Inorganics in Surface Water
Milrow
(all values in µg/L)

Analyte	SW-HL		SW-DCC		SW-RRC		SW-UDC	
	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	2600		114		439		165	
Antimony	29.4	U	29.4	U	29.4	U	29.4	U
Arsenic	1	U	1	U	1	U	1	U
Barium	3.1		1.5		1.2	U	1.3	
Beryllium	2.2		1	U	1	U	1	U
Cadmium	5.6		2.8	U	2.8	U	2.8	U
Calcium	4520		6010		4280		5450	
Chromium	3.7	U	3.7	U	179		3.7	U
Cobalt	4.5	U	4.5	U	4.5	U	4.5	U
Copper	4.8		4.4		155		5.4	
Iron	1200		192		530		234	
Lead	3.4		1	U	9.9		1	U
Magnesium	5570		5630		3980		5870	
Manganese	13.4		8.4		11.2		7.4	
Mercury	0.1	U	0.1	U	0.1	U	0.1	U
Nickel	13.2	U	13.2	U	13.2	U	13.2	U
Potassium	4390	U	4390	U	4390	U	4390	U
Selenium	1.4		1	U	1.4		1	U
Silver	9.6		3.4	U	3.4	U	13.2	U
Sodium	23400		33500		72800		30400	
Thallium	1	U	1	U	15.5		1	U
Vanadium	4.7	U	4.7	U	4.7	U	4.7	U
Zinc	36.7		23.2		2330		30.3	

Q = Data qualifier

Amchitka Island Sampling Event
Inorganics in Surface Water
Long Shot
(all values in µg/L)

Analyte	SW-SELS-1		SW-REED-1		SW-LSMP-1		SW-LSMP-2		SW-LSMP-3		SW-LSP-1	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	53.8	U	63.1		53.8	U	78.5		53.8	U	219	
Antimony	29.4	U	29.4	U	29.4	U	29.4	U	29.4	U	29.4	U
Arsenic	1	U	1	U	1	U	1	U	1	U	1	U
Barium	2.4		79.2		1.2	U	1.2	U	1.2	U	1.2	U
Beryllium	1	U	1	U	1	U	1	U	1	U	1	U
Cadmium	2.8	U	2.8	U	2.8	U	2.8	U	2.8	U	2.8	U
Calcium	18700		6100		13800		15100		16000		985	
Chromium	3.7	U	3.7	U	3.7	U	3.7	U	3.7	U	3.7	U
Cobalt	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U
Copper	3.6	U	3.6	U	3.6	U	8.7		3.6	U	3.6	U
Iron	3730		320		260		376		735		152	
Lead	1	U	1	U	1	U	1	U	3.6		1	U
Magnesium	9720		4160		9020		8960		9330		2730	
Manganese	1020		10.9		132		101		145		13.8	
Mercury	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Nickel	13.2	U	13.2	U	13.2	U	13.2	U	13.2	U	13.2	U
Potassium	4390	U	4390	U	4390	U	4390	U	4390	U	4390	U
Selenium	1	U	1	U	1	U	1	U	1	U	1	U
Silver	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U
Sodium	25600		18700		30400		30000		28800		22600	
Thallium	1	U	1	U	1	U	1	U	1	U	1	U
Vanadium	6.7		8.1		4.7	U	4.7	U	4.7	U	4.7	U
Zinc	19		29.1		19.7		7		16.5		20.2	

Q = Data qualifier
U = Analyte not detected above the specified value

Amchitka Island 1993 Sampling Event
Inorganics in Surface Water
Long Shot
(all values in µg/L)

Analyte	SW-LSPD-2		SW-LSPD-3	
	Value	Q	Value	Q
Aluminum	475		207	
Antimony	29.4	U	29.4	U
Arsenic	1	U	1	U
Barium	1.2	U	1.5	
Beryllium	1	U	1	U
Cadmium	2.8	U	2.8	U
Calcium	918		3470	
Chromium	3.7	U	3.7	U
Cobalt	4.5	U	4.5	U
Copper	3.6	U	3.6	U
Iron	684		423	
Lead	8.5		1	U
Magnesium	2000		4630	
Manganese	15.7		41.4	
Mercury	0.1	U	0.1	U
Nickel	13.2	U	13.2	U
Potassium	4390	U	4390	U
Selenium	1	U	1	U
Silver	3.4	U	3.4	U
Sodium	19200		24900	
Thallium	1	U	1	U
Vanadium	4.7	U	4.7	U
Zinc	26.5		17.8	

Q = Data qualifier

Amchitka Island Sampling Event
Inorganics in Groundwater
Cannikin
(all values in µg/L)

Analyte	GW-AW-2 Value	Q	GW-AW-4 Value	Q	GW-HTH-3 Value	Q
Aluminum	60.5		53.8	U	53.8	U
Antimony	29.4	U	29.4	U	29.4	U
Arsenic	1	U	1	U	1.2	
Barium	5.7		1.2	U	1.2	U
Beryllium	1	U	1	U	1	U
Cadmium	2.8	U	2.8	U	2.8	U
Calcium	6430		3230		2150	
Chromium	3.7	U	3.7	U	3.7	U
Cobalt	4.5	U	4.5	U	4.5	U
Copper	6.4		3.8		7.9	
Iron	123		30.3		396	
Lead	6.8		6.6		6.2	
Magnesium	3020		2200		438	
Manganese	6.9		1.6	U	50.3	
Mercury	0.1	U	0.1	U	0.31	
Nickel	13.2	U	13.2	U	13.2	U
Potassium	6220		4390	U	4390	U
Selenium	1	U	1	U	1	U
Silver	3.4	U	3.4	U	3.4	U
Sodium	25100		51200		78300	
Thallium	1	U	1	U	1	U
Vanadium	7.8		6.6		8.4	
Zinc	45.9		22.3		6.3	

Q = Data qualifier
U = Analyte not detected above the specified value

Amchitka Island 1993 Sampling Event
Inorganics in Groundwater
Long Shot
(all values in µg/L)

Analyte	GW-WL-1		GW-WL-2		GW-LSGZ-1		GW-LSGZ-2		GW-EPAW-1	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	53.8	U	65		53.8	U	59.5		53.8	
Antimony	29.4	U	29.4	U	31.1		29.4	U	29.4	U
Arsenic	1.1		1	U	1	U	1	U	1	U
Barium	1.3		1.5		3.3		6.6		2.3	
Beryllium	1	U	1	U	1	U	1	U	1	U
Cadmium	2.8	U	2.8	U	2.8	U	2.8	U	2.8	U
Calcium	16400		13100	U	5180		9600		19300	
Chromium	3.7	U	3.7	U	3.7	U	3.7	U	3.7	U
Cobalt	4.5	U	4.5	U	4.5	U	4.5	U	4.5	U
Copper	3.6	U	3.6	U	6.6		3.6	U	3.6	U
Iron	468		505		1030		51.6		46.3	
Lead	1	U	1	U	2.5		1	U	1	U
Magnesium	10200		9440		4080		6910		9490	
Manganese	864		702		47.8		54.5		82.4	
Mercury	0.1	U	0.1	U	0.15		0.1	U	0.1	U
Nickel	13.2	U	13.2	U	13.2	U	13.2	U	13.2	U
Potassium	4390	U	4390	U	5010		4850		4390	U
Selenium	1	U	1	U	1	U	1	U	1.7	
Silver	3.4	U	3.4	U	3.4	U	3.4	U	3.4	U
Sodium	34300		25100		70300		46000		27800	
Thallium	1	U	1	U	1	U	1	U	1	U
Vanadium	6.5		4.7	U	6.2		4.7	U	4.7	U
Zinc	25.8		8		28.5		5.1		6.3	

Q = Data qualifier

Amchitka Island Sampling Event

Inorganics in Soils

Cannikin

(all values in mg/kg)

Analyte	SL-CK-1		SL-CK-2		SL-CK-3		SL-CK-4		SL-CK-5		SL-CK-6		SL-CK-7	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	29000		33000		8900		20600		38000		37400		66300	
Antimony	9.2		10.6		11.7	U	7	U	16.8		12.6		15.7	
Arsenic	4.2		7.1		2.7		0.24	U	2.9		12.8		1.7	
Barium	138		57.9		97.7		32.9		126		120		152	
Beryllium	0.23	U	0.29	U	0.4	U	0.24	U	0.25	U	0.34	U	0.29	U
Cadmium	0.65	U	0.8	U	1.1	U	0.67	U	0.71	U	0.96	U	0.81	U
Calcium	10900		18600		59100		6820		11100		34400		4050	
Chromium	7.9		198		199		12.8		21.7		559		9.9	
Cobalt	27.8		25.5		4		12.8		27.7		23		36.7	
Copper	167		197		28.7		65.1		142		181		179	
Iron	48700		48600		8420		21500		49200		43200		65900	
Lead	96.1		54.7		29.6		7		10.6		97		4.8	
Magnesium	16300		17700		4230		5200		24700		13400		28800	
Manganese	1140		579		149		412		1080		807		1300	
Mercury	0.06	U	0.07	U	0.1	U	0.06	U	0.06	U	0.09	U	0.07	U
Nickel	19.8		55.2		5.2	U	19.5		30.9		20.4		32	
Potassium	2610		1270		1740	U	1050	U	1260		1500	U	1440	
Selenium	0.23	U	0.29	U	0.4	U	0.24	U	0.25	U	0.34	U	2.9	U
Silver	0.79	U	0.97	U	1.4	U	0.81	U	0.86	U	1.2	U	0.98	U
Sodium	1800		1450	U	512		1470		1820		9110		961	
Thallium	0.23	U	0.29	U	0.4	U	0.24	U	0.25	U	0.34	U	0.29	U
Vanadium	142		138		37.5		72.5		156		168		196	
Zinc	123		188		32.9		33.5		69.5		85.9		101	

Q = Data qualifier

U = Analyte not detected above the specified value

Amchitka Island 1993 Sampling Event
Inorganics in Soils
Milrow
(all values in mg/kg)

Analyte	SL-ML-1		SL-ML-2		SL-ML-3		SL-ML-4		SL-ML-5		SL-ML-6		SL-ML-7	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	43200		19800		68300		22000		8290		23800		21500	
Antimony	12.2		9.3		15.7		11.7		6.4	U	9.8		6.6	U
Arsenic	7.1		12.6		2.1		17.6		0.99		8.9		2.8	
Barium	100		144		141		133		67.5		4940		46	
Beryllium	0.26	U	0.28	U	0.3	U	0.28	U	0.22	U	0.33	U	0.22	U
Cadmium	0.73	U	0.77	U	0.83	U	0.78	U	0.61	U	0.91	U	0.63	U
Calcium	9350		26100		5190		51500		3190		52600		7600	
Chromium	10.5		886		27.7		389		3.5		410		5.6	
Cobalt	30.8		17.4		36.3		14.2		7.9		22.5		20.5	
Copper	195		98.1		173		81.8		47.3		125		146	
Iron	57600		35500		61500		29700		13900		40400		35100	
Lead	7.9		77.7		3.2		34.4		5.5		509		3.4	
Magnesium	20800		10300		26600		10200		4690		18600		11100	
Manganese	879		745		965		545		263		558		616	
Mercury	0.07	U	0.07	U	0.07	U	0.07	U	0.05	U	0.08	U	0.06	U
Nickel	18.5		12.6		21.7		12		6.9		22.2		14.1	
Potassium	1790		1680		2150		1810		1060		1870		1910	
Selenium	0.26	U	0.28	U	0.3	U	0.28	U	0.22	U	0.33	U	0.22	U
Silver	0.89	U	0.94	U	1	U	0.94	U	0.74	U	1.1	U	0.76	U
Sodium	2460		4140		1750		3590		1130		2080		1580	
Thallium	0.26	U	0.28	U	0.3	U	0.28	U	0.22	U	0.33	U	0.22	U
Vanadium	183		108		206		80		37.3		135		99.9	
Zinc	74.4		95.9		77.7		81.2		25.2		80.6		64.9	

Q = Data qualifier

Amchitka Island Sampling Event
Inorganics in Soils
Long Shot
(all values in mg/kg)

Analyte	SL-LS-1		SL-LS-2		SL-LS-3		SL-LS-4		SL-LS-5		SL-LS-6	
	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q	Value	Q
Aluminum	15300		31200		10600		18300		47000		43100	
Antimony	7.3	U	13.5		16.8		7.6	U	15.8		12.4	
Arsenic	2.8		6.1		3.2		2.3		3.8		2.1	
Barium	52.4		94.3		77		105		70.5		63	
Beryllium	0.25	U	0.28	U	0.54	U	0.26	U	0.3	U	0.25	U
Cadmium	0.7	U	0.78	U	1.5	U	0.73	U	0.85	U	0.7	U
Calcium	24600		14400		48700		27800		3770		3540	
Chromium	18.7		6.5		64.4		182		6.3		5.9	
Cobalt	9.9		26.7		7.8		21.8		25.5		28.9	
Copper	43.2		197		36.4		111		153		174	
Iron	20400		55900		19200		36600		40800		53300	
Lead	44.4		3.6		40		110		8		4.4	
Magnesium	5770		25600		9350		18800		12200		21900	
Manganese	305		1010		442		992		803		957	
Mercury	0.06	U	0.07	U	0.14	U	0.06	U	0.08	U	0.06	U
Nickel	10.6		15.7		7.5		27.2		17.7		17.7	
Potassium	1620		1220		2380	U	1230		1340	U	1690	
Selenium	0.25	U	0.28	U	0.54	U	0.26	U	0.3	U	0.25	U
Silver	0.85	U	0.94	U	1.8	U	0.88	U	1	U	0.85	U
Sodium	2140		13900		1170		1470		856	U	760	
Thallium	0.25	U	0.28	U	0.54	U	0.26	U	0.3	U	0.25	U
Vanadium	59.2		195		44.5		109		125		152	
Zinc	53.3		75.6		46.9		247		54.3		61.1	

Q = Data qualifier
U = Analyte not detected above the specified value

Amchitka Island 1993 Sampling Event
Preliminary Background Concentrations
Inorganics in Surface Soils
(all values in mg/kg)

Analyte	SS005	SS006	SS007	Mean	SD
Aluminum	14300	14500	13200	14000	700
Arsenic	2.6	2.3	2.4	2.4	0.2
Barium	30.7	29	25.2	28.3	2.8
Beryllium	0.35	ND	0.3	0.33	0.04
Calcium	8980	26700	10900	15527	9724
Chromium	7.1	6.1	6.6	6.6	0.5
Cobalt	8.7	8.6	8.1	8.5	0.3
Copper	54.7	52.6	48	51.8	3.4
Iron	21600	21900	21200	21567	351
Lead	4.5	2.8	4.4	3.9	1.0
Magnesium	6080	6340	5620	6013	365
Manganese	289	321	288	299	19
Nickel	8.9	6.5	5.3	6.9	1.8
Potassium	1300	1300	1180	1260	69
Sodium	2030	1880	1610	1840	213
Vanadium	72.9	75.4	74.2	74.2	1.3
Zinc	52	45.1	43.3	46.8	4.6

SD = Standard deviation

Amchitka Island Sampling Event
Preliminary Background Concentrations
Inorganics in Sediments
(all values in mg/kg)

Analyte	SE001	SE002	SE003	Mean	SD
Aluminum	18700	26100	21200	22000	3764
Arsenic	2	2.2	1.4	1.9	0.4
Barium	26.8	37	33.3	32.4	5.2
Calcium	9840	13500	9900	11080	2096
Chromium	7.8	9.2	8.2	8.4	0.7
Cobalt	10.7	11.9	10.7	11.1	0.7
Copper	51.4	59.2	51.5	54.0	4.5
Iron	29700	33700	31000	31467	2040
Lead	2.2	2.6	1.5	2.1	0.6
Magnesium	7770	8900	8340	8337	565
Manganese	387	439	397	408	28
Nickel	8.5	11.2	9.5	9.7	1.4
Potassium	1440	1900	1720	1687	232
Sodium	1830	2860	2230	2307	519
Vanadium	115	129	117	120.3	7.6
Zinc	55.3	63.5	60.2	59.7	4.1

SD = Standard deviation

Data are for the Southern Background Site presented in the USFWS Draft Final *Site Inspection Report, Amchitka Isand, Alaska*

Amchitka Island 1993 Sampling Event
Preliminary Background Concentrations
Inorganics in Subsurface Soils
(all values in mg/kg)

Analyte	SU001	SU002	SU003	Mean	SD
Aluminum	12000	13900	14400	13433	1266
Arsenic	1.5	1.4	1.2	1.4	0.2
Barium	24	27.3	30.8	27.4	3.4
Calcium	5400	6950	7020	6457	916
Chromium	9.9	11	9.7	10.2	0.7
Cobalt	6.5	9.2	8.4	8.0	1.4
Copper	35.3	44.5	39.9	39.9	4.6
Iron	14700	32600	21500	22933	9036
Lead	2.6	2.9	4.6	3.4	1.1
Magnesium	4040	4890	5110	4680	565
Manganese	148	264	202	205	58
Sodium	1480	1530	1450	1487	40
Vanadium	93.5	103	99.1	98.5	4.8
Zinc	36.6	43	42.2	40.6	3.5

SD = Standard deviation

Amchitka Island [illegible] Sampling Event
Semivolatile Organic Compounds in Surface Water
Milrow
(detected SVOCs only)
(all values in µg/L)

Analyte	SW-HL		
	Value	LQ	DV
Diethylphthalate	23		

LQ = Laboratory qualifier
DV = Data validation qualifier

Amchitka Island 1993 Sampling Event
Semivolatile Organic Compounds in Soils
Cannikin
(detected SVOCs only)
(all values in µg/kg)

Analyte	SL-CK-1			SL-CK-3			SL-CK-6RE			SL-CK-7		
	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV
2-Methylnaphthalene				100	J	J						
N-Nitrosodiphenylamine										110	J	J
Fluoranthene	72	J	J									
Pyrene							250	J	J			

Note: *2-methylnaphthalene was detected in the laboratory blank in the SL-CK-6RE run but not in the original run. It is likely that this compound is not present in SL-CK-3.*

LQ = Laboratory qualifier

Amchitka Island Sampling Event

Volatile Organic Compounds in Surface Water

Cannikin

(detected VOCs only)

(all values in µg/L)

Analyte	SW-WAC		
	Value	LQ	DV
Toluene	2	J	J

LQ = Laboratory qualifier

DV = Data validation qualifier

Amchitka Island 1993 Sampling Event
Volatile Organic Compounds in Surface Water
Milrow
(detected VOCs only)
(all values in µg/L)

Analyte	SW-HL		
	Value	LQ	DV
Benzene	2	J	J
Chlorobenzene	4	J	J
Toluene	4	J	J
Trichloroethene	2	J	J

LQ = Laboratory qualifier

Amchitka Island Sampling Event

Volatile Organic Compounds in Groundwater

Cannikin

(detected VOCs only)

(all values in µg/L)

Analyte	GW-AW-4		
	Value	LQ	DV
Benzene	2	J	J

LQ = Laboratory qualifier

DV = Data validation qualifier

Amchitka Island 1993 Sampling Event
Volatile Organic Compounds in Soils
Cannikin
(detected VOCs only)
(all values in µg/kg)

Analyte	SL-CK-6		
	Value	LQ	DV
Toluene	3	J	J
1,1,1-Trichloroethane	2	J	J

LQ = Laboratory qualifier

Amchitka Island 03 Sampling Event
Volatile Organic Compounds in Soils
Milrow
(detected VOCs only)
(all values in µg/kg)

Analyte	SL-ML-2			SL-ML-4			SL-ML-4RE		
	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV
Tetrachloroethene	3	J	J						
Toluene				42			14		
1,1,1-Trichloroethane							2	J	J
Trichloroethene							1	J	J

LQ = Laboratory qualifier
DV = Data validation qualifier

Amchitka Island 1993 Sampling Event
Volatile Organic Compounds in Soils
Longshot
(detected VOCs only)
(all values in µg/kg)

Analyte	SL-LS-1			SL-LS-2			SL-LS-3		
	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV
2-Butanone							96		
Chloromethane							60		
Ethylbenzene							11		
Tetrachloroethene	2	J	J						
Toluene				2	J	J	360		
Xylenes (total)							120		

LQ = Laboratory qualifier

Amchitka Island Sampling Event

Semivolatile Organic Compounds in Soils

Milrow

(detected SVOCs only)

(all values in µg/kg)

Analyte	SL-ML-2			SL-ML-2RE			SL-ML-4			SL-ML-4RE		
	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV	Value	LQ	DV
Pyrene	95	J	J	400	J	J	450	J	J	100	J	J

LQ = Laboratory qualifier

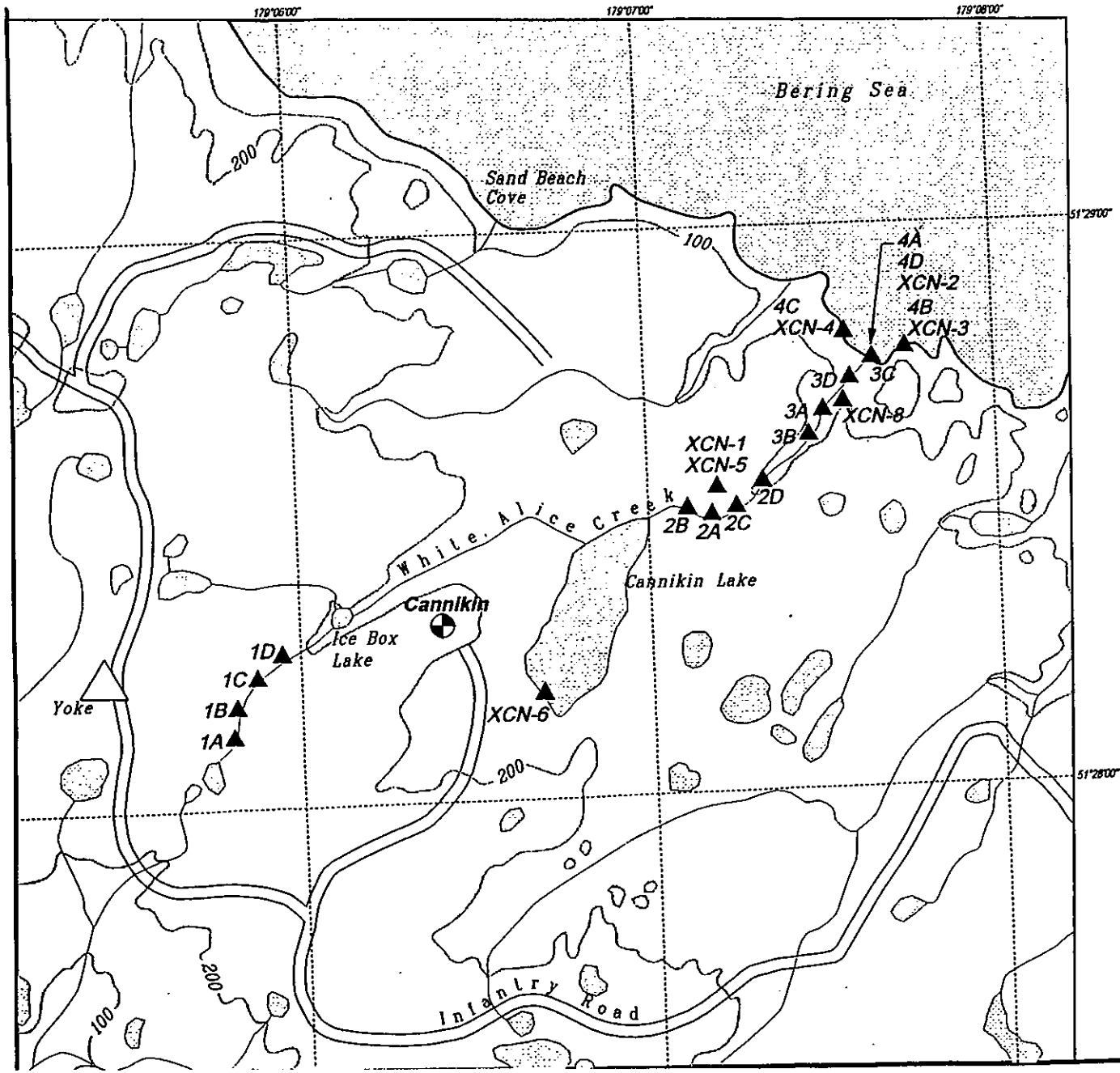
DV = Data validation qualifier

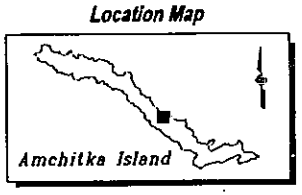
Amchitka Island 1993 Sampling Event
Semivolatile Organic Compounds in Soils
Longshot
(detected SVOCs only)
(all values in µg/kg)

Analyte	SL-LS-3		
	Value	LQ	DV
Phenanthrene	1400		

LQ = Laboratory qualifier

1997





Cannikin Area Schematic

1A ▲ Sample Location

Cannikin ⊕ Drill Sites

SCALE

0 250 500 Meters

PRELIMINARY

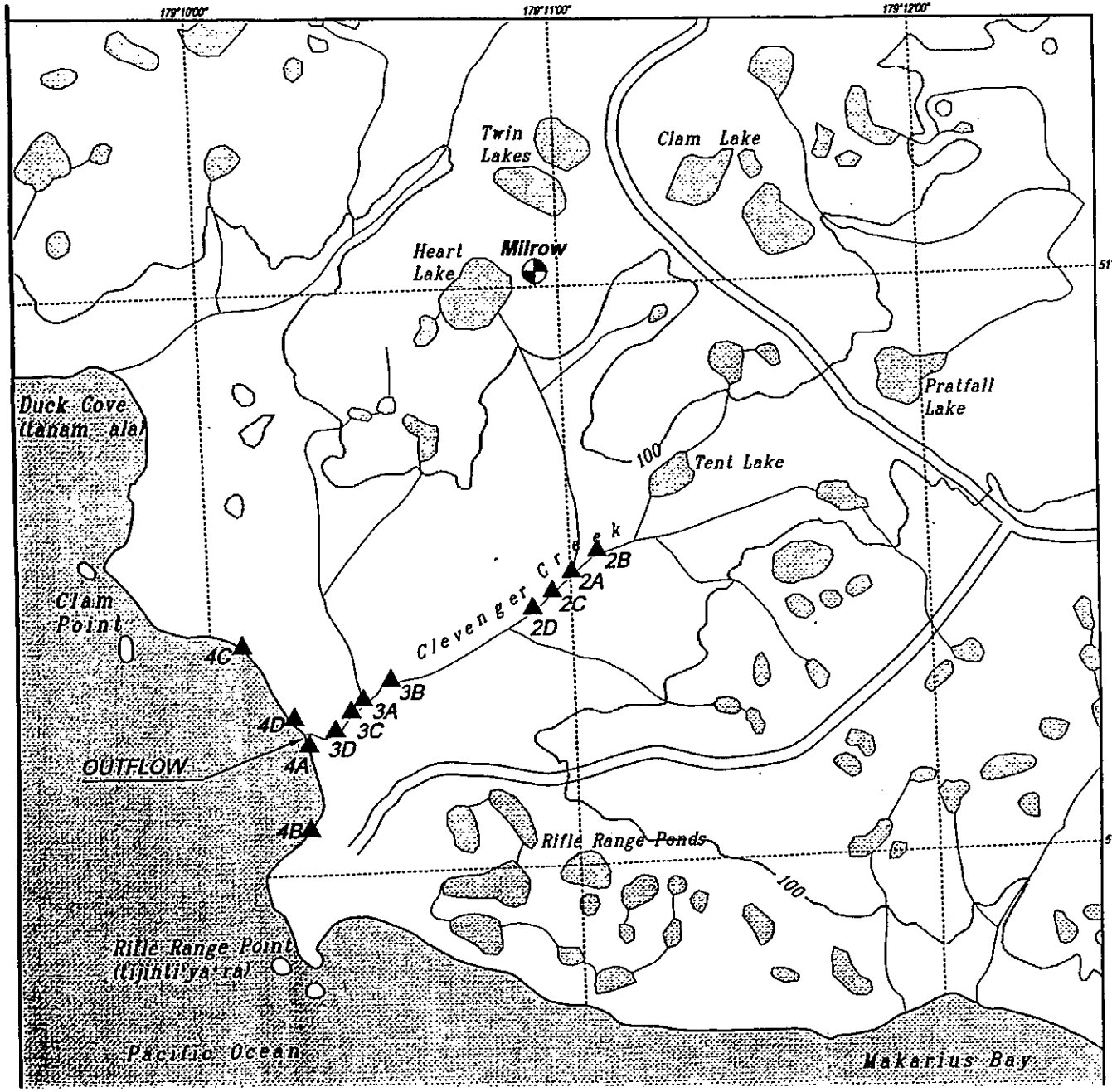
Notes

Grid coordinates shown in latitude/longitude

Source:

U.S. Geological Survey Map. 1975

Figure 2-1
Cannikin Sample Locations



Location Map

Milrow Area Schematic

1A ▲ Sample Location

Milrow ⊕ Drill Sites

SCALE

0 250 500 Meters

Notes

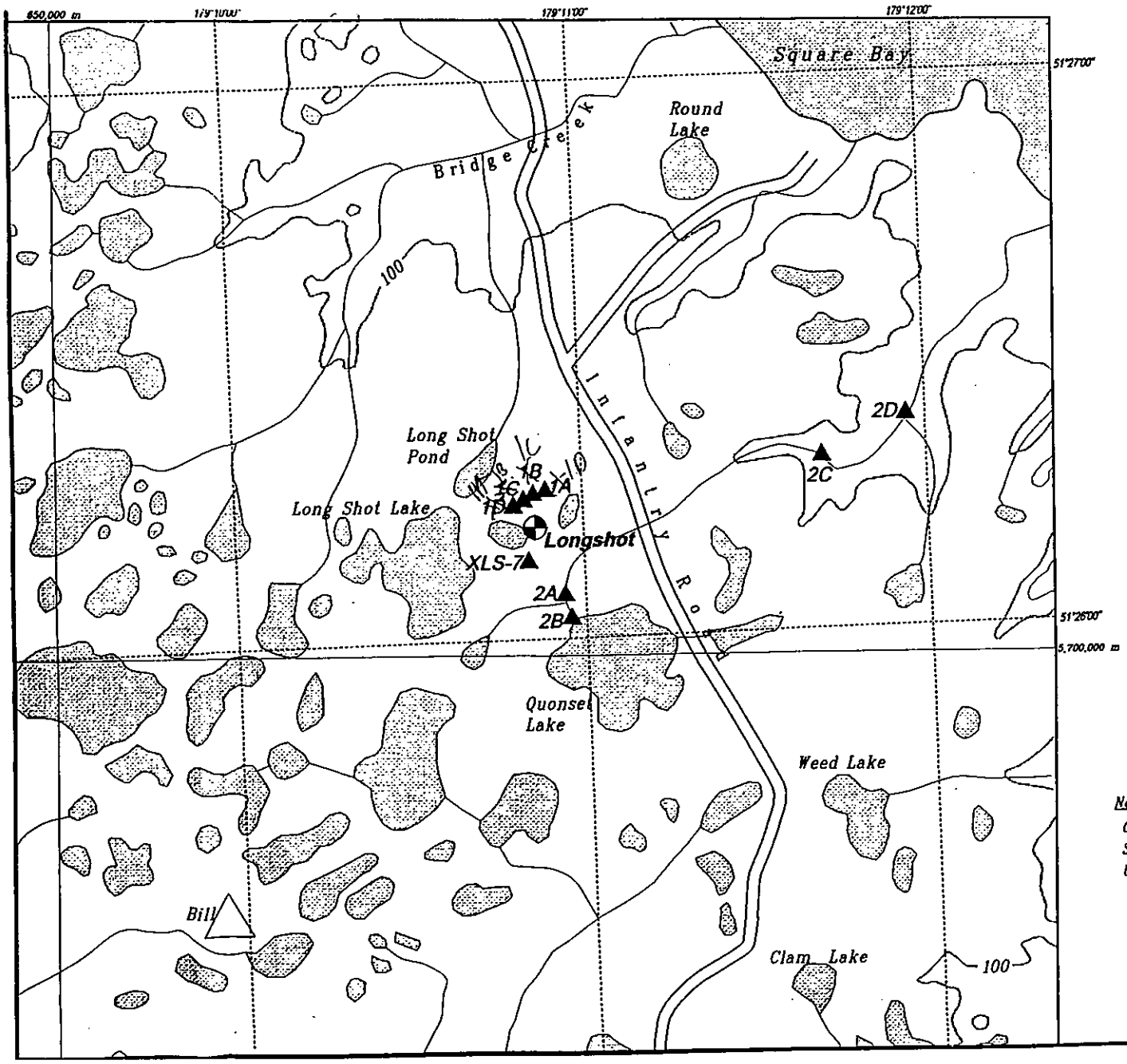
Grid coordinates shown in latitude/longitude.

Source:

U.S. Geological Survey Map. 1975

PRELIMINARY

Figure 2-2
Milrow Sample Locations



Longshot Area Schematic

1A ▲ Sample Location

Longshot ⊕ Drill Sites

SCALE

0 250 500 Meters

PRELIMINARY

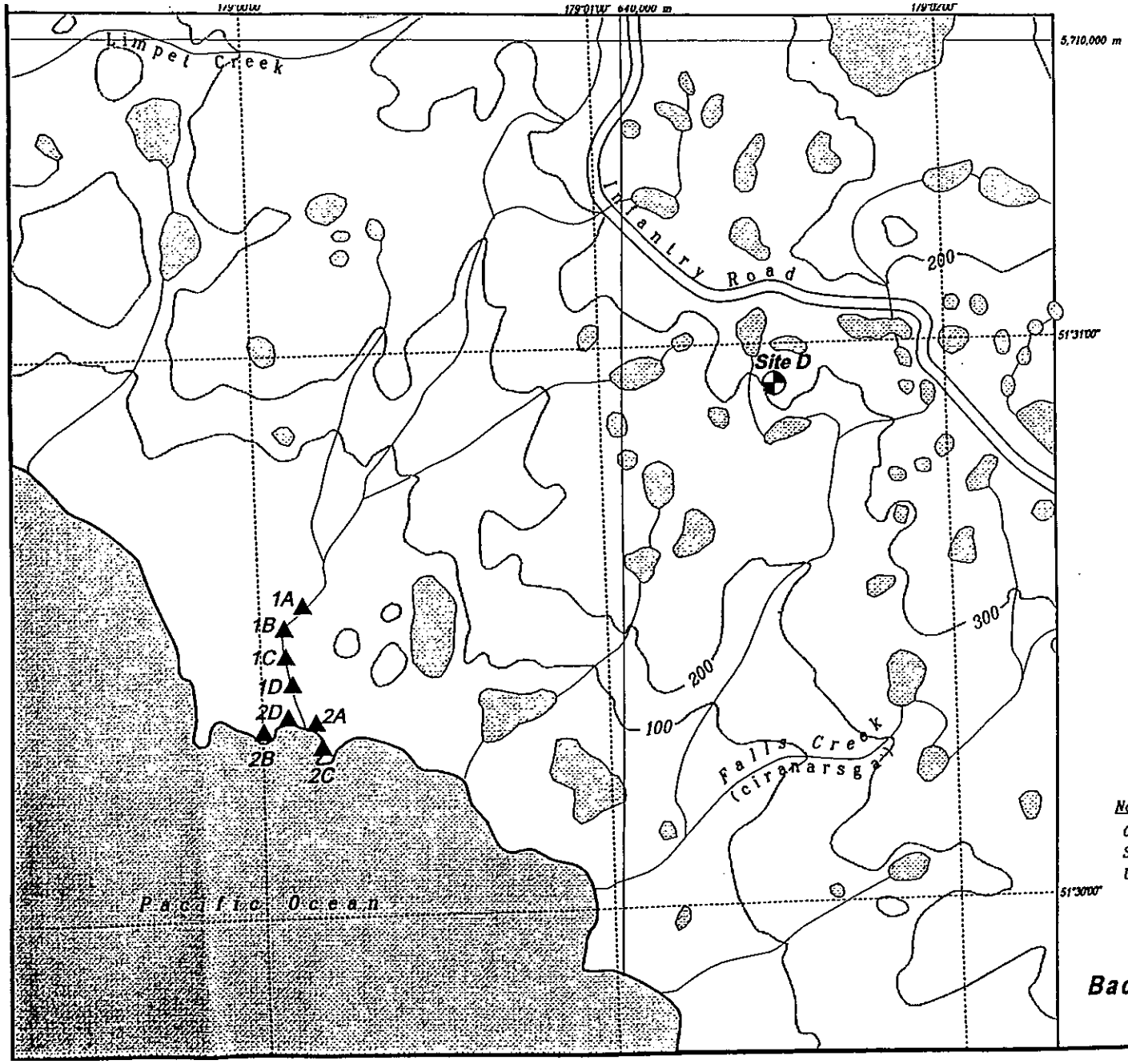
Notes

Grid coordinates shown in latitude/longitude and UTM, NAD 27

Source:

U.S. Geological Survey Map. 1975

Figure 2-3
Longshot Sample Locations



Location Map

Control Area Schematic

1A ▲ Sample Location

Site D ⊕ Drill Sites

SCALE

0 250 500 Meters

PRELIMINARY

Notes

Grid coordinates shown in latitude/longitude and UTM, NAD 27
Source:
U.S. Geological Survey Map. 1975

Figure 2-4
Background Stream Sample Locations

Anchorage Sediment Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	TOC Value	Q	Al Value	Q	Sb Value	Q	As Value	Q	Ba Value	Q
XCN-1	Brown silt to silty clay	79400	J	19700		1.1	UJ	32.6	J	87.8	J
XCN-5	Brown silt to silty clay	89100	J	17900		1.5	UJ	7.6	J	67.9	J
XCN-6[1]	Brown silty fine sand	20700	J	63900		0.34	UJ	18	J	89.9	J
CN-1A	Brown silt with fine sand	49900	J	44000		0.8	UJ	11.7	J	225	J
CN-1B	Brown silty fine to coarse sand	63400	J	43400		0.75	UJ	21.2	J	279	J
CN-1C	Brown silt	113000	J	26700		1.3	UJ	9.7	J	118	J
CN-1D											
CN-2A	Brown silty fine to coarse sand	23100	J	48900		0.44	UJ	96.6	J	227	J
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	6730	J	54400		0.31	UJ	47.7	J	150	J
CN-3D											
CN-4A	Brown fine to coarse sand	5080.	J	48500		0.32	UJ	47.6	J	137	J
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from Cannikin Lake

Amchitka Sediment Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Be Value	Q	Cd Value	Q	Ca Value	Q	Cr Value	Q	Co Value	Q
XCN-1	Brown silt to silty clay	0.54	U	0.54	U	4090	J	11.8	J	10.7	
XCN-5	Brown silt to silty clay	0.75	U	0.75	U	3530	J	4.6	J	10.1	
XCN-6[1]	Brown silty fine sand	0.17	U	0.17	U	4050	J	6.6	J	19.7	
CN-1A	Brown silt with fine sand	0.4	U	1.1		8270	J	20	J	36.8	
CN-1B	Brown silty fine to coarse sand	0.37	U	0.83		8880	J	11.6	J	37.1	
CN-1C	Brown silt	0.65	U	0.73		7910	J	14.4	J	14.6	
CN-1D											
CN-2A	Brown silty fine to coarse sand	0.22	U	0.22	U	10400	J	17.3	J	19.3	
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	0.16	U	0.16	U	10700	J	17.6	J	21	
CN-3D											
CN-4A	Brown fine to coarse sand	0.16	U	0.16	U	10500	J	15.8	J	20.3	
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value

Anchitka S[illegible] nt Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cu Value	Q	Fe Value	Q	Pb Value	Q	Mg Value	Q	Mn Value	Q
XCN-1	Brown silt to silty clay	40.4		23900	J	4.6		7990		1490	J
XCN-5	Brown silt to silty clay	41.5		16700	J	6.2		6100		263	J
XCN-6[1]	Brown silty fine sand	115		54600	J	4.9		26700		1080	J
CN-1A	Brown silt with fine sand	50.7		50700	J	6.9		10200		4570	J
CN-1B	Brown silty fine to coarse sand	66.7		107000	J	7.7		11400		27900	J
CN-1C	Brown silt	47.8		35900	J	9.4		6210		4040	J
CN-1D											
CN-2A	Brown silty fine to coarse sand	63.8		72500	J	4.8		19700		9020	J
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	108		70900	J	8.1		27900		5170	J
CN-3D											
CN-4A	Brown fine to coarse sand	90.4		69100	J	3.8		25700		5080	J
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from Cannikin Lake

Amchitka Sediment Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Ni Value	Q	K Value	Q	Se Value	Q	Ag Value	Q	Na Value	Q
XCN-1	Brown silt to silty clay	10	J	1310		1.6	UJ	0.54	U	5600	U
XCN-5	Brown silt to silty clay	6.1	J	2010		2.2	UJ	0.75	U	7030	U
XCN-6[1]	Brown silty fine sand	15.5	J	911		0.5	UJ	0.17	U	2730	U
CN-1A	Brown silt with fine sand	22.3	J	1070		1.2	UJ	0.4	U	5050	U
CN-1B	Brown silty fine to coarse sand	20.7	J	1030		1.1	UJ	0.37	U	4970	U
CN-1C	Brown silt	11.7	J	687		2	UJ	0.65	U	7040	U
CN-1D											
CN-2A	Brown silty fine to coarse sand	14.9	J	1510		0.66	UJ	0.22	U	5520	U
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	21.1	J	1610		0.47	UJ	0.18		4540	U
CN-3D											
CN-4A	Brown fine to coarse sand	20.2	J	1400		0.48	UJ	0.16	U	4390	U
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value

Amchitka S[illegible] nt Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Tl Value	Q	V Value	Q	Th Value	Q	Zn Value	Q	B Value	Q
XCN-1	Brown silt to silty clay	0.54	U	182	J	0.54	UJ	46.1	J	3.2	U
XCN-5	Brown silt to silty clay	0.75	U	228	J	0.75	UJ	42.9	J	4.5	U
XCN-6[1]	Brown silty fine sand	0.17	U	219	J	0.45	J	64.1	J	5.8	U
CN-1A	Brown silt with fine sand	0.78	J	397	J	0.74	J	152	J	2.4	U
CN-1B	Brown silty fine to coarse sand	0.93	J	395	J	0.37	UJ	173	J	2.2	U
CN-1C	Brown silt	0.65	U	272	J	0.65	UJ	91.5	J	3.9	U
CN-1D											
CN-2A	Brown silty fine to coarse sand	0.22	U	338	J	0.45	J	99	J	17	
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	0.16	U	245	J	0.47	J	89.2	J	5.3	U
CN-3D											
CN-4A	Brown fine to coarse sand	0.16	U	236	J	0.54	J	80.7	J	5.8	U
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from Cannikin Lake

Amchitka Sediment Samples
Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Li Value	Li Q	Mo Value	Mo Q	Sn Value	Sn Q	Sr Value	Sr Q	Ti Value	Ti Q
XCN-1	Brown silt to silty clay	6.9	U	1.2		7.6	UJ	60.1		704	
XCN-5	Brown silt to silty clay	5.6	U	0.85		9.6	UJ	75.8		654	
XCN-6[1]	Brown silty fine sand	35.7		0.29		3.7	UJ	34.3		1420	
CN-1A	Brown silt with fine sand	18.2		0.94		5.1	UJ	168		1130	
CN-1B	Brown silty fine to coarse sand	15.6		1.2		6	UJ	202		1020	
CN-1C	Brown silt	8.4	U	0.88		9.3	UJ	112		774	
CN-1D											
CN-2A	Brown silty fine to coarse sand	20.3		1.6		5.4	UJ	214		1490	
CN-2B	Brown with oxidized iron sandy silt										
CN-2C	Brown silt										
CN-2D											
CN-3A	Brown silt with sand										
CN-3B	Brown sandy silt to silty sand										
CN-3C	Brown fine to coarse sand	25.7		0.41		6.2	UJ	181		1350	
CN-3D											
CN-4A	Brown fine to coarse sand	22.2		0.39		4.1	UJ	164		1230	
CN-4B	Brown fine to coarse sand										
CN-4C	Brown silty fine sand										
CN-4D											

U = Analyte not detected above the specified value

Inorganics Analytical Results
Cannikin (White Alice Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cs Value	Q	U Value	Q	Ce Value	Q
XCN-1	Brown silt to silty clay	0.54	U	0.54	U	5.2	
XCN-5	Brown silt to silty clay	0.75	U	0.75	U	4.8	
XCN-6[1]	Brown silty fine sand	0.88		0.24		6.4	
CN-1A	Brown silt with fine sand	0.47		0.88		15.6	
CN-1B	Brown silty fine to coarse sand	0.41		0.55		10.7	
CN-1C	Brown silt	0.65	U	0.71		8.2	
CN-1D							
CN-2A	Brown silty fine to coarse sand	0.61		0.55		6.9	
CN-2B	Brown with oxidized iron sandy silt						
CN-2C	Brown silt						
CN-2D							
CN-3A	Brown silt with sand						
CN-3B	Brown sandy silt to silty sand						
CN-3C	Brown fine to coarse sand	0.6		0.39		6.9	
CN-3D							
CN-4A	Brown fine to coarse sand	0.43		0.36		6.9	
CN-4B	Brown fine to coarse sand						
CN-4C	Brown silty fine sand						
CN-4D							

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from Cannikin Lake

Amchitka S[illegible]nt Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	TOC Value	Q	Al Value	Q	Sb Value	Q	As Value	Q	Ba Value	Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	9420	J	38800		0.25	UJ	4.1	J	78.5	J
MR-4B	Brown fine to coarse sand	4390	J	37500		0.25	UJ	3.7	J	64.4	J
MR-4C	Brown fine to coarse sand	5310	J	33300		0.25	UJ	3.3	J	56.8	J
MR-4D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Be Value	Be Q	Cd Value	Cd Q	Ca Value	Ca Q	Cr Value	Cr Q	Co Value	Co Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	0.22		0.12	U	12800	J	3.7	J	11	
MR-4B	Brown fine to coarse sand	0.21		0.13	U	12800	J	3.5	J	9.5	
MR-4C	Brown fine to coarse sand	0.18		0.13	U	11400	J	3.2	J	9.4	
MR-4D											

U = Analyte not detected above the specified value

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cu Value	Q	Fe Value	Q	Pb Value	Q	Mg Value	Q	Mn Value	Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	64.7		35900	J	4.3		11500		1040	J
MR-4B	Brown fine to coarse sand	59.7		33000	J	3.1		10800		874	J
MR-4C	Brown fine to coarse sand	52.4		30200	J	2.6		9750		781	J
MR-4D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Ni Value	Ni Q	K Value	K Q	Se Value	Se Q	Ag Value	Ag Q	Na Value	Na Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	6.6	J	3120		0.37	UJ	0.12	U	17600	J
MR-4B	Brown fine to coarse sand	6.3	J	2970		0.38	UJ	0.13	U	17200	J
MR-4C	Brown fine to coarse sand	6.3	J	2690		0.38	UJ	0.13	U	15300	J
MR-4D											

U = Analyte not detected above the specified value

Amchitka S[illegible]nt Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Tl Value	Q	V Value	Q	Th Value	Q	Zn Value	Q	B Value	Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	0.12	U	131	J	0.58	J	64.6	J	2.4	U
MR-4B	Brown fine to coarse sand	0.13	U	122	J	0.58	J	64.7	J	6.6	U
MR-4C	Brown fine to coarse sand	0.13	U	129	J	0.5	J	57.6	J	4.6	U
MR-4D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Li Value	Q	Mo Value	Q	Sn Value	Q	Sr Value	Q	Ti Value	Q
MR-2A	Brown sandy silt										
MR-2B	Brown silt										
MR-2C	Brown silt										
MR-2D											
MR-3A	Brown silt with sand										
MR-3B	Brown silt with sand										
MR-3C	Brown with oxidized iron silt with sand										
MR-3D											
MR-4A	Brown fine to coarse sand	13.2		0.47		5.6	U	319		1780	
MR-4B	Brown fine to coarse sand	12.5		0.39		3.3	U	289		1660	
MR-4C	Brown fine to coarse sand	11		0.37		2.5	U	259		1580	
MR-4D											

U = Analyte not detected above the specified value

Amchitka S[illegible] ,it Samples
Inorganics Analytical Results
Milrow (Clevenger Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cs Value	Q	U Value	Q	Ce Value	Q
MR-2A	Brown sandy silt						
MR-2B	Brown silt						
MR-2C	Brown silt						
MR-2D							
MR-3A	Brown silt with sand						
MR-3B	Brown silt with sand						
MR-3C	Brown with oxidized iron silt with sand						
MR-3D							
MR-4A	Brown fine to coarse sand	2.8		0.41		13.6	
MR-4B	Brown fine to coarse sand	2.5		0.36		14.4	
MR-4C	Brown fine to coarse sand	2.3		0.32		12.4	
MR-4D							

U = Analyte not detected above the specified value
J = Estimated concentration

Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	TOC Value	Q	Al Value	Q	Sb Value	Q	As Value	Q	Ba Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	90300	J	35900		0.95	UJ	3.5	J	158	J
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits
[2] Sample is from a groundwater seep draining into the unnamed stream

Amchitka Sediment Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Be Value	Q	Cd Value	Q	Ca Value	Q	Cr Value	Q	Co Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	0.48	U	0.48	U	4430	J	2.5	J	21.7	
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cu Value	Q	Fe Value	Q	Pb Value	Q	Mg Value	Q	Mn Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	83.9		45400	J	9.8		10400		1030	J
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits
[2] Sample is from a groundwater seep draining into the unnamed stream

Amchitka Sediment Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Ni Value	Q	K Value	Q	Se Value	Q	Ag Value	Q	Na Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	7.3	J	1390		1.4	UJ	0.48	U	6130	U
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits

Anchitka S[illegible]nt Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Tl Value	Q	V Value	Q	Th Value	Q	Zn Value	Q	B Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	0.48	U	289	J	0.49	J	69	J	2.9	U
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits
[2] Sample is from a groundwater seep draining into the unnamed stream

Amchitka Sediment Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Li Value	Q	Mo Value	Q	Sn Value	Q	Sr Value	Q	Ti Value	Q
LS-1A[1]	Drilling Mud										
LS-1B[1]	Drilling Mud										
LS-1C[1]	Drilling Mud										
LS-1D[1]	Drilling Mud										
XLS-7[2]	Brown to black silty fine muck										
LS-2A	Brown silt										
LS-2B	Brown silt with sand										
LS-2C	Brown clayey silt	13.4		1.1		8.4	UJ	92.6		1560	
LS-2D											

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Long Shot (Unnamed Creek)
(all values in mg/kg dry weight)

Sample	Sediment Description	Cs Value	Q	U Value	Q	Ce Value	Q
LS-1A[1]	Drilling Mud						
LS-1B[1]	Drilling Mud						
LS-1C[1]	Drilling Mud						
LS-1D[1]	Drilling Mud						
XLS-7[2]	Brown to black silty fine muck						
LS-2A	Brown silt						
LS-2B	Brown silt with sand						
LS-2C	Brown clayey silt	0.48	U	0.57		8.1	
LS-2D							

U = Analyte not detected above the specified value
J = Estimated concentration
[1] Sample is from the Long Shot mud pits
[2] Sample is from a groundwater seep draining into the unnamed stream

Wet Weight

(all values in mg/kg)

Analyte	Mud Pits A and B Value	Qual.	Mud Pits C and D Value	Qual.	Mud Pits A and B[1] Value	Qual.	Mean	Std. Dev.	95% UCL of Mean
Aluminum	9680	J	15200	J	10200	J	11693	3048	15142
Arsenic	2.2	J	1.8	J	5.4	J	3.1	2.0	5.4
Barium	43.1		56.9		60.9		53.6	9.3	64.2
Calcium	4810		8410		5120		6113	1995	8371
Chromium	18.2	J	19.1	J	18.1	J	18.5	0.6	19.1
Cobalt	5.5	J	8.1	J	6.7	J	6.8	1.3	8.2
Copper	39.1	J	70.9	J	64.3	J	58.1	16.8	77.1
Iron	15400		21400		14700		17167	3683	21334
Lead	6.4	J	7.9	J	8.4	J	7.6	1.0	8.7
Magnesium	5130		8150		5280		6187	1702	8113
Manganese	275		487		289		350	119	484
Nickel	4.3	J	6	J	5	J	5.1	0.9	6.1
Potassium	712		1200		977		963	244	1239
Selenium	0.78	J	0.78	J	0.92	J	0.83	0.08	0.92
Sodium	1720	U	2850		1920	U	2163[2]	603[2]	2846[2]
Vanadium	56.8		40.5		53.4		50.2	8.6	60.0
Zinc	33.7	J	32.5	J	44.8	J	37.0	6.8	44.7
Thorium	0.94		1.2		0.96		1.03	0.14	1.20
Molybdenum	0.94	J	1.5	J	1.1	J	1.18	0.29	1.51
Strontium	106		133		86.1		108	24	135
Titanium	773		849		769		797	45	848
Cesium	0.32		0.47		0.41		0.40	0.08	0.49
Uranium	0.33	J	0.35	J	0.23	J	0.30	0.06	0.38
Cerium	6.6	J	10.4	J	9.8	J	8.9	2.0	11.2
TPH	5800	J	5700	J	3200	J	4900	1473	6567

[1]Duplicate sample

[2]Non-detected analyte was assumed to be present at the detection limit for the purpose of the statistical calculations

Amchitka Island Longshot Mud Pits
Metals Analytical Results (detected analytes only)
Dry Weight
(all values in mg/kg)

Analyte	Mud Pits A and B Value	Qual.	Mud Pits C and D Value	Qual.	Mud Pits A and B[1] Value	Qual.	Mean	Std. Dev.	95% UCL of Mean
Aluminum	36473	J	34506	J	32588	J	34522	1943	36721
Arsenic	8.3	J	4.1	J	17.3	J	9.9	6.7	17.5
Barium	162		129		195		162.0	32.7	199.0
Calcium	18124		19092		16358		17858	1386	19427
Chromium	68.6	J	43.4	J	57.8	J	56.6	12.7	70.9
Cobalt	20.7	J	18.4	J	21.4	J	20.2	1.6	22.0
Copper	147	J	161	J	205	J	171.2	30.4	205.6
Iron	58026		48581		46965		51191	5974	57951
Lead	24.1	J	17.9	J	26.8	J	23.0	4.6	28.1
Magnesium	19329		18502		16869		18233	1252	19650
Manganese	1036		1106		923		1022	92	1126
Nickel	16.2	J	13.6	J	16.0	J	15.3	1.4	16.9
Potassium	2683		2724		3121		2843	242	3117
Selenium	2.9	J	1.8	J	2.9	J	2.55	0.67	3.31
Sodium	6481	U	6470		6134	U	2163[2]	603[2]	2846[2]
Vanadium	214		91.9		171		158.9	61.9	228.9
Zinc	127	J	73.8	J	143	J	114.6	36.3	155.7
Thorium	3.5		2.7		3.1		3.11	0.41	3.58
Molybdenum	3.5	J	3.4	J	3.5	J	3.49	0.07	3.57
Strontium	399		302		275		325	65	399
Titanium	2913		1927		2457		2432	493	2990
Cesium	1.2		1.1		1.3		1.19	0.12	1.33
Uranium	1.2	J	0.79	J	0.73	J	0.92	0.28	1.24
Cerium	24.9	J	23.6	J	31.3	J	26.6	4.1	31.3
TPH	21854	J	12940	J	10224	J	15006	6084	21890

[1]Duplicate sample

[2]Non-detected analyte was assumed to be present at the detection limit for the purpose of the statistical calculations

Amchitka Island
Longshot Mud Pits
Metals Analytical Results

NOTE:
Based on the analytical results for the Longshot mud pit sediments, it appears that chrome lignosulfonate, a common drilling mud additive, was not used for the Longshot drilling. However, historical records indicate that at least 1400 tons of chrome lignosulfonate were shipped to the island for the Milrow drilling. If this additive was used for Milrow and subsequent drilling operations (Cannikin and Drill Sites D, E, and F), chromium concentrations in the drilling mud remaining from those operations are expected to be higher than the concentrations measured in the Longshot drilling mud.

The following table provides total and hexavalent chromium data for eleven samples collected from a mud pit at the Central Nevada Test Area (CNTA), where chrome lignosulfonate was used as a drilling mud additive. If chrome lignosulfonate was used on Amchitka for Milrow and post-Milrow drilling, chromium concentrations in the drilling mud should be no greater than those measured in the CNTA samples.

	Total Cr		Cr (VI)	
	Value	Q	Value	Q
	1160		22.7	U
	1960		28.1	
	1750		21.9	
	2030		41.6	
	2320		43.2	
	2070		56.5	
	1580		22.4	U
	1810		21.6	U
	2080		53	
	1480		32.6	
	2000		64.7	
Mean	1840		37.1	
Std. Dev.	329		15.6	
95% UCL of Mean	2035		46.4	

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	TOC Value	Q	Al Value	Q	Sb Value	Q	As Value	Q	Ba Value	Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	43200	J	32600		0.42	UJ	7.9	J	167	J
BKG-1C	Brown silty fine to coarse sand	41300	J	31900		0.43	UJ	7.4	J	176	J
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Be Value	Be Q	Cd Value	Cd Q	Ca Value	Ca Q	Cr Value	Cr Q	Co Value	Co Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	0.21	U	0.26		4950	J	10.5	J	16	
BKG-1C	Brown silty fine to coarse sand	0.21	U	0.46		6360	J	17.5	J	18.3	
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Cu Value	Q	Fe Value	Q	Pb Value	Q	Mg Value	Q	Mn Value	Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	45.7		27900	J	4.6		7580		285	J
BKG-1C	Brown silty fine to coarse sand	47.6		49500	J	4.5		11200		3340	J
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Ni Value	Q	K Value	Q	Se Value	Q	Ag Value	Q	Na Value	Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	20.9	J	658		0.63	UJ	0.21	U	2910	U
BKG-1C	Brown silty fine to coarse sand	52.9	J	854		0.64	UJ	0.21	U	2970	U
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value

Anichtka S[illegible]ent Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Tl Value	Q	V Value	Q	Th Value	Q	Zn Value	Q	B Value	Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	0.21	U	224	J	0.39	J	84.6	J	1.3	U
BKG-1C	Brown silty fine to coarse sand	0.21	U	170	J	0.42	J	89.9	J	1.3	U
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value
J = Estimated concentration

Amchitka Sediment Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Li Value	Q	Mo Value	Q	Sn Value	Q	Sr Value	Q	Ti Value	Q
BKG-1A	Dark Brown clayey silt										
BKG-1B	Brown sandy clayey silt	12.1		0.79		4	UJ	59.3		1400	
BKG-1C	Brown silty fine to coarse sand	13.9		0.75		18.8	UJ	74.7		1370	
BKG-1D											
BKG-2A	Brown silty fine sand										
BKG-2B	Brown silty fine to medium sand										
BKG-2C	Brown clayey silt with sand										
BKG-2D											

U = Analyte not detected above the specified value

Amchitka S[illegible]ent Samples
Inorganics Analytical Results
Reference Area Creek
(all values in mg/kg dry weight)

Sample	Sediment Description	Cs Value	Q	U Value	Q	Ce Value	Q
BKG-1A	Dark Brown clayey silt						
BKG-1B	Brown sandy clayey silt	0.21	U	0.61		7.8	
BKG-1C	Brown silty fine to coarse sand	0.3		0.47		6.9	
BKG-1D							
BKG-2A	Brown silty fine sand						
BKG-2B	Brown silty fine to medium sand						
BKG-2C	Brown clayey silt with sand						
BKG-2D							

U = Analyte not detected above the specified value
J = Estimated concentration

Appendix C

Data Quality Assessment Summary

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LIST OF ATTACHMENTS

Attachment No.

1 List of Sample Numbers and Associated Analyses

ACRONYMS AND ABBREVIATIONS

ADEC	Alaska Department of Environmental Conservation
AVS/SEM	acid volatile sulfides/simultaneously extracted metals
°C	degrees Celsius
COC	chain-of-custody
Corps	United States Army Corps of Engineers
DOE	United States Department of Energy
DQO	data quality objective
DRO	diesel range organics
FD	field duplicate sample
GRO	gasoline range organics
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MB	method blank
mg/kg	milligrams per kilogram
MS	matrix spike
MSD	matrix spike duplicate
NCA	North Creek Analytical
PCBs	polychlorinated biphenyls
PE	performance evaluation
QA	quality assurance
QA/QC	quality assurance/quality control
QAO	quality assurance objective
QAPP	Quality Assurance Project Plan
QC	quality control
RI	Remedial Investigation
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SIM	Selective Ion Monitoring
SOP	standard operating procedure
ug/L	micrograms per liter
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds

DATA QUALITY ASSESSMENT SUMMARY
1998 DEPARTMENT OF ENERGY DRILL SITE CHARACTERIZATION
AMCHITKA ISLAND, ALASKA

C1.0 INTRODUCTION

C1.1 PROJECT DESCRIPTION

Through the Alaska District, U.S. Army Corps of Engineers (Corps), the U.S. Department of Energy (DOE) in early 1998 contracted the planning of an investigation of possible chemical impacts at drill sites used during underground nuclear testing by its predecessor agencies on Amchitka Island. The fieldwork in support of this investigation was conducted during late summer 1998, and included the following:

- Sampling for chemical analysis of surface water and sediment (drilling mud) in former mud pits at each of the drill sites and test sites where they are still present, and in lakes that were used for mud storage.
- Sampling for chemical analysis of stream water and sediment in streams draining each of the drill sites and test sites, and in four reference streams.
- Sampling these streams to determine the abundance and diversity of benthic invertebrates and to collect sediment samples for bioassays.
- Collection of fish for chemical analysis from these streams.
- Collection of fish for radionuclide analysis from as many of the planned streams as contained a sufficient number of fish.
- Sampling surface water, sediment, and groundwater from the Aircraft Graveyard for polychlorinated biphenyls (PCBs) analysis.

This work was performed for the U.S. Army Corps of Engineers, Alaska District under Contract No. DACA85-94-D-0009, Delivery Order No. 0021, under funding provided by DOE.

C1.2 DESCRIPTION OF THE SAMPLING AND ANALYSIS AND QA/QC PROGRAMS

The Sampling and Analysis Plan (SAP) contained in the *Final Report, Amchitka Army Air Base, Phase I Remedial Investigation, Amchitka Island, Alaska, Management Plan*, issued on December 16, 1996, and the August 14, 1998, *Management Plan, Department of Energy 1998 Drill Site Investigation, Amchitka Island, Alaska,* included multimedia sampling and analyses. The data collected in the field and produced by the laboratory were used to assess the impacts

from former DOE drill sites. The December 1996 Quality Assurance Project Plan (QAPP) and its addendum (Section 6.0 of the August 1998 plan) included quality assurance/quality control (QA/QC) goals for generating data of known and acceptable quality. This appendix presents the assessment of the implementation of the SAP and QAPP and the resulting data qualifications.

C1.3 SAMPLING TECHNIQUES

Procedures for collecting surface water, sediment, benthic invertebrates, and fish samples are presented in the SAP portion of the December 1996 *Phase I RI Management Plan*, and Section 5.0 of the August 14, 1998, *Drill Site Investigation Management Plan.* The August 1998 DOE *Management Plan* referred to the December 1996 *Management Plan* for detailed information regarding specific sampling and sample handling procedures. All samples were preserved and submitted in laboratory-provided sample containers, certified pre-cleaned by their manufacturers, as defined in the above-referenced plans.

C1.4 FIELD QC GOALS

Field QC samples were used to assess the influence of sampling procedures, equipment, and handling on the reported results. They were also used to characterize matrix heterogeneity. Field QC samples consisted of field duplicate samples and trip blanks as defined below. The field QC data assessment procedures are discussed in Section C2.0. The field QC sample results are discussed in Section C3.0.

C1.4.1 Field Duplicate Samples

Field duplicates were collected in the form of collocated and split samples. The collocated sample was an additional sample collected at the same location as the original sample. Split samples were collected and homogenized before transferring aliquots into separate sets of sample containers. Field duplicate results were used to assess total precision and variability associated with the laboratory analysis and the sample collection process. Duplicate samples refer to a second sample collected simultaneously or sequentially using identical recovery techniques and treated identically during transportation and analysis.

Duplicates of volatile portions were collected as collocated, discrete samples, and were not homogenized. Duplicates of nonvolatile portions were collected as split samples, and were homogenized.

Duplicate samples were submitted blind to the project laboratory (North Creek Analytical, Bothell, Washington) for analysis. The frequency goal for the collection of field duplicates was a minimum of 10 percent of environmental samples. Section C3.0 presents the field sample and duplicate results.

C1.4.2 Equipment Blanks

Equipment rinsate blanks were collected when decontaminated sampling equipment was used, to determine the adequacy of the decontamination process. Two rinsate blanks were collected by pouring ASTM Type II water over a decontaminated equipment hand auger barrel. The frequency goal for collecting equipment blanks was 5 percent of samples collected with reusable sampling devices. The rinsate samples were analyzed for the same chemical constituents as the environmental samples, with the exception of the following:

- rinsate sample 98DOE-DRSD-1075-RB was not analyzed for polychlorinated biphenyls (PCBs) by Method SW8082 or volatile organic compounds (VOCs) by Method SW5030/SW8260B

- rinsate sample 98DOE-LONG-1136-RB was not analyzed for VOCs by Method SW5030/SW8260B, as well as 21 metals by Methods SW6010B, SW6020, and SW7470A.

The equipment blank results are discussed in Section C3.0.

C1.4.3 Trip Blanks

A trip blank is a sample of organic-free water placed in a sample container in an uncontaminated laboratory area prior to fieldwork, and then handled in the same manner as the field samples. Trip blanks were prepared only for aqueous volatile organic compound (VOC) samples. Trip blank results were used to identify contamination from sample containers, or from cross contamination of samples during transportation and/or storage procedures. The goal of trip blank submittal was one trip blank to accompany each cooler containing samples for VOC analysis.

Aqueous sodium bisulfate trip blanks (low level) and methanol trip blanks (high level) accompanied soil and sediment samples for analysis by Methods SW5035/SW8260B and SW5030/SW8260B, respectively.

C1.5 SAMPLE STORAGE AND SHIPMENT PROCEDURES

Samples were collected in the field and delivered to the on-site laboratory (located in a separate "Weatherport" tent) at the end of each day for storage and shipment. Samples were stored in refrigerators at $4°C \pm 2°C$.

Samples were prepared for shipment by the project chemist. Sample containers were individually wrapped in resealable plastic bags and shipped in sample coolers with ice substitute, "bubble wrap" packing material, and a temperature blank. A completed chain-of-custody (COC) form and a blank cooler receipt form were enclosed in a plastic bag and taped to the lid of the cooler. The cooler drain was taped shut, custody seals applied, and the cooler securely taped and labeled in accordance with federal and state regulations.

Samples were generally packed and shipped from Amchitka to Adak by Security Aviation charter aircraft the day before the scheduled twice-weekly Reeve Airlines flight from Adak to Anchorage. On Adak, an agent of Clearwater Environmental took custody of the coolers and stored them in a cool, secure location. The coolers were then shipped as priority freight on Reeve to Anchorage, arriving about 30 hours after they had been packed. In Anchorage, the samples were retrieved by a representative of North Creek Analytical (NCA), who checked cooler temperatures, re-iced the samples, completed COC and cooler receipt documentation, and shipped them on a night flight to the Seattle-Tacoma Airport via Alaska Airlines Gold Streak service. There they were picked up by a NCA courier and transported to their Bothell laboratory, arriving about 48 hours after they originally left Amchitka. The exception to this procedure was on weekends, with no Reeve flights, when samples were flown directly from Amchitka to Anchorage on Security Aviation charter aircraft.

The project chemistry laboratory was the Bothell, Washington, facility of North Creek Analytical (NCA). There was no independent quality assurance (QA) laboratory; no triplicate QA samples were analyzed for either chemistry or radionuclides. All soil and water samples were analyzed in Bothell with the exception of the SW5030/SW8260B and SW5035/SW8260B field-extracted volatiles analyses on sediment samples, since only the Portland facility was set up to perform these analyses. Similarly, all chemical analyses of fish tissue were performed in the Portland facility, except as noted below. Samples analyzed by NCA's Portland facility were sent to Portland, Oregon via Alaska Airlines or Federal Express.

Analysis of inorganic arsenic in fish tissue was performed at the Battelle Marine Sciences Laboratory in Sequim, Washington. Radionuclide analyses on fish tissue were performed at the Charleston, South Carolina facility of General Engineering Laboratories (formerly known as Environmental Physics, Inc.). Identification of invertebrates in the stream sediment samples was performed in the Somerset, New Jersey office of IT Corporation, under subcontract to DOE. American Aquatics Testing, Inc. in Allentown, Pennsylvania, under subcontract to IT

Corporation performed bioassay tests using the stream sediment samples. Organic content and grain size analyses on stream sediment samples were performed in Shannon & Wilson's Fairbanks, Alaska soil laboratory.

North Creek Analytical analyzed samples from both the 1998 Department of Energy Drill Site Investigation and the Corps Phase II Remedial Investigation (RI). Therefore samples from the two projects were often shipped in the same cooler with a common trip blank, although separate chain-of-custody forms were completed for each project (see Appendix H). The laboratory also analyzed samples from both projects in the same sample delivery group, and laboratory QC samples were common to the two projects.

C1.6 NUMBER OF SAMPLES SUBMITTED

Attachment 1 presents the list of samples submitted for this project, along with the laboratory sample identification, the sample matrix, and the analyses performed. Table C1-1 presents the number of environmental samples, trip blanks, and field duplicates, as well as the percentage of field duplicates. All samples were analyzed for the requested analyses.

C1.7 SIGNIFICANT PROBLEMS ENCOUNTERED

For soil sample 98DOE-MILR-4017-SD, dry weight could not be calculated due to insufficient sample volume. Results were reported on a wet weight basis for this sample. Similarly, sample weight could not be determined for sample 98DOE-LONG-4051-SD, therefore an average weight of other sediment samples was used by the laboratory; all results for this sample are considered estimates. SW5030/SW8260B results for 67 sediment samples and SW5035/SW8260B results for 30 sediment samples had elevated reporting limits due to low dry weight (less than 50 percent solids). The results for several compounds in six SW5030/SW8260B samples were adjusted due to percent solids (qualified as estimated "J"), and results for an additional three samples were qualified as estimated "J" due to the use of sample field weights in the calculations.

Two fish samples had elevated reporting limits for SW8081 due to limited sample quantity.

TABLE C1-1
SUMMARY OF ENVIRONMENTAL AND QC SAMPLE ANALYSES
DOE 1998 SITE CHARACTERIZATION REPORT

Sample Type	AK101	AK102	SW8260B	SW8270C	SW8081 or SW8082	Metals	Inorganic Arsenic	Total Organic Carbon	AVS/SEM	Fish Lipids
Soil Samples										
Environmental samples	3	131	68	111	41	131	-	60	60	-
Field duplicates (FD)	-	8	4	6	3	8	-	4	4	-
%FD	0%	6%	6%	5%	7%	6%	-	7%	7%	-
Project laboratory trip blanks	-	-	5	-	-	-	-	-	-	-
Water Samples										
Environmental samples	-	100	78	81	8	99	-	-	-	-
Field duplicates (FD)	-	5	4	4	-	5	-	-	-	-
%FD	-	5%	5%	5%	0%	5%	-	-	-	-
Project laboratory trip blanks	-	-	8	-	-	-	-	-	-	-
Fish Samples										
Environmental samples	-	-	-	35	35	36	35	-	-	5
Field duplicates (FD)	-	-	-	3	3	3	2	-	-	1
%FD	-	-	-	9%	9%	8%	6%	-	-	20%

AVS acid volatile sulfides
SEM simultaneously extracted metals

C2.0 QA/QC ACTIVITIES

C2.1 FIELD AUDITS

Field audits were performed by the RI Task Manager to assure that proper procedures were being followed and field documentation was complete. Field audits included the observation of sampling and sample packing procedures, and the review of logbooks and forms. Deviations from the documented SAP procedures were corrected immediately in the field. Additional work was performed when review of the logbooks indicated further investigation was necessary to meet the requirements of the SAP.

C2.2 DATA ASSESSMENT PROCEDURES

Laboratory data generated for this project was assessed to determine whether the project-specified quality assurance objectives (QAOs) were met, quantitatively evaluate data quality, identify potential limitations on data use; and determine whether site-specific data quality objectives (DQOs) were met. The data assessment calculations and applications used for the Amchitka Island data are based on the United States Environmental Protection Agency (USEPA) *Guidelines for Assessing and Reporting Data Quality for Environmental Measurements* (January 1983), and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic and Organic Data Review* (February 1994).

Several procedures were used to control the sampling and analytical processes to produce data of sufficient quality for project needs. These included thorough project planning, the use of standard field, analytical, and QC procedures, and auditing performed during field activities. If a problem occurred in spite of these controls, this data assessment report identifies the problem, determines which data were affected, and states how use of that data may be limited.

The routine QC procedures conducted in the laboratory are established in the published methods, the QAPP, and the analytical standard operating procedures (SOPs) prepared by each laboratory. The laboratory was responsible for following the procedures and operating the analytical systems within statistical control limits. These procedures included proper instrument maintenance, calibration and calibration checks, and laboratory QC sample analyses at the required frequencies (i.e., method blanks [MBs], laboratory control samples/laboratory control sample duplicates [LCSs/LCSDs], etc.). Associated QC sample analytical results were reported with the sample results so the project staff could evaluate the analytical process performance in conjunction with field QC data, and make determinations about data quality and suitability for intended data uses.

A project data review was conducted on an analytical and field batch basis, by utilizing the project laboratory case narratives and assessing QC samples and associated field sample results. Project data assessment procedures included:

- Initial review of analytical and field data for complete and accurate documentation, chain-of-custody forms, and required frequency of field and laboratory QC samples.
- Calculation of completeness by method and matrix or by analyte, if designated.
- Review of field QC sample results to identify contamination and assure DQOs were met.
- Evaluation of analytical blank results to identify systematic contamination.
- Comparison of spike and duplicate results with project objectives for precision and accuracy.
- Statistical calculations for overall method accuracy and precision using the appropriate QC sample results.
- Assigning data qualifier flags to the data as necessary to reflect limitations identified.

The statistical calculations for the data assessment process, and ways in which the calculations apply to environmental sample results, are presented in Table C2-1.

The data qualification scheme for field and analytical QC samples is described in the QAPP and its addendum. The data qualifier flags shown in Table C2-2 are based on the USEPA National Functional Guidelines. Table C2-3 shows the relationships between various types of QC and field samples that may be similarly influenced by QC problems. The data qualification scheme provided the basis for determining whether sample results should be qualified, but the reviewers' judgment was also critical in determining whether data quality and usability had been systematically influenced and whether additional data points required qualification. The following descriptions provide rationale for the data qualification scheme.

C2.2.1 Blank Data Assessment

Blank results indicate whether reported analytes (such as methylene chloride) may be attributed to laboratory sources (reagents, glassware, and instrumentation), or to field sources or conditions (equipment, shipping, handling, and ambient conditions), rather than the sampled soil or water. Laboratory blanks include method or system blanks analyzed with each preparation and

analytical batch. Equipment and trip blanks are field blanks collected at specified frequencies or under selected conditions to monitor contamination from non-laboratory sources.

The most common laboratory contaminants, methylene chloride, phthalates, acetone, toluene, and 2-butanone, are ubiquitous; controlling them to within acceptable low levels is part of standard laboratory procedures. When these or other analytes were reported in field samples or field blanks and in the associated method blank at concentrations attributable to blank contamination (within five or ten times the blank concentrations, depending on the analyte), the field sample results were qualified "U" to indicate the result should be considered not detected. Common contaminants in field samples that are not reported in the associated method blank may be qualified if they are systematic.

Field blank results were assessed individually. Field blanks are related to the field samples as shown in Table C2-3. The probable contamination source was identified, and associated sample results were qualified as necessary based on the relative concentrations between the blank and field sample (in accordance with the National Functional Guidelines). The results of the blank assessment are presented in Section C3.0.

C2.2.2 Accuracy

Accuracy is associated with correctness and is a comparison between a measured value and a known or expected value. Accuracy is assessed by comparing LCS, matrix spike (MS), surrogate spike, and performance evaluation (PE) sample recoveries with the project objectives presented in the QAPP and its addendum. Section C3.1 presents the results of the LCS, MS, and surrogate spike data assessment.

C2.2.3 Laboratory Control Samples

Laboratory control samples are spikes of target analytes in reagent-grade water or clean (Ottawa) sand that are taken through sample preparation and analysis to assess statistical control of the method. If a LCS recovery is outside the established limits, samples from the same preparation and/or analytical batch may exhibit similar analyte recoveries, and are qualified in accordance with the National Functional Guidelines. Nondetect sample results associated with low LCS recoveries indicate a potential false negative; elevated LCS recoveries indicate the potential for falsely elevated results. The system must be assessed to determine the reason for the out-of-control occurrence, and corrective action may be indicated, up to and including resampling and reanalysis of affected samples.

C2.2.4 Matrix Spikes/Matrix Spike Duplicates (MS/MSD)

A matrix spike is a solution of target analytes at known concentrations that is spiked into a field sample before sample preparation and analysis. The results of the duplicate MS are compared to the original MS to provide an estimate of bias present due to potential matrix interferences. Matrix spike results were assessed by comparison with the MS recovery ranges presented in the QAPP and its addendum. When MS recoveries were outside this range, corresponding sample results were qualified as appropriate. The results of the MS/MSD data assessment are presented in Section C3.0.

C2.2.5 Surrogate Spikes

Surrogate spikes are a group of compounds that are not otherwise found in nature but behave similarly to the target analytes that have been selected for each method. Reported for organic analyses, surrogate spike results are used to assess target analyte recovery for each sample and measure system performance and matrix interference. Surrogate spike recoveries were compared to the recovery limits presented in the QAPP and its addendum. Surrogates represent different types or classes of analytes measured by a method, and the results are used to qualify similar analytes (e.g., acid extractables, phenolic compounds, etc.). Field sample results that had surrogate recoveries outside the limits were qualified as estimates and were rejected if recoveries were very low.

C2.2.6 Precision

Precision is a measure of variability between duplicate analyses, and is calculated for field and laboratory duplicates. Precision is evaluated by comparing the relative percent difference (RPD) of LCSs/LCSDs, MSs/MSDs, and field duplicate samples with the RPD objectives stated in the QAPP and its addendum.

If the RPD for the LCS/LCSD did not meet the objective, all samples in the same analytical or preparation batch were qualified. Because the MS/MSD and field duplicate RPD objectives are based on the same criteria, any MS/MSD or field split results which did not meet the objective may indicate increased or excessive analytical or matrix variability and were qualified, in accordance with the National Functional Guidelines.

TABLE C2-1
STATISTICAL CALCULATIONS

Statistic	Symbol	Formula	Definition	Uses
Relative Percent Difference	RPD	$\left[\frac{(X_1 - X_2)}{\left(\frac{(X_1 + X_2)}{2}\right)}\right] x\,100$	Measure of variability that adjusts for the magnitude of observations	Used when there are only two observations; mathematically related to CV
Percent Recovery	R	$\left(\frac{X_{meas}}{X_{true}}\right) x\,100$	Recovery of spiked compound in pure matrix	Recovery of LCS, surrogate spikes
Percent Recovery	R	$\frac{\text{value of spiked sample} - \text{value of unspiked sample}}{\text{value of added spike}} x\,100$	Recovery of spiked compound in sample matrix	MS recovery

X = Observation (concentration)

TABLE C2-2
DATA QUALIFIER FLAGS

Qualifier Flag	Definition
J	Analyte concentration considered an estimated value because one or more QC specifications were not met Analyte identification verified, but quantitation is below detection limit or above calibration range for the analysis
R	Rejected results; identification and/or quantitation could not be verified because critical QC specifications were not met
U	Analyte was not detected Analyte concentrations attributed to blank contamination; result considered nondetect
N	Analyte identification presumptive; no second column analysis performed, or GC/MS tentative identification

TABLE C2-3
QUALITY CONTROL AND FIELD SAMPLE RELATIONSHIPS

QC Samples	Tracking Parameters	Associated Field Samples
Method Blank	Analytical batch, preparation date	Samples prepared and analyzed in the same analytical or preparation batch
LCS/LCSD	Analytical batch, preparation date	Samples prepared and analyzed in the same analytical or preparation batch
MS/MSD	Analytical batch, preparation date, matrix	Samples prepared and analyzed in the same analytical or preparation batch; similar matrix conditions (same soil type, site, well, boring, etc.)
Surrogate Spikes	Sample ID, location, preparation date	Samples collected from a similar matrix; same preparation batch
Trip Blanks	Cooler ID, sample date	VOC samples shipped in the same cooler, containers from the same lot
Equipment Blanks	Equipment ID, sample dates	Samples collected with the same equipment before and after blank was collected, similar sampling conditions
Field Duplicates	Sample ID, location, sampling team, matrix	Samples collected from similar conditions/matrix using similar procedures
Laboratory Duplicates	Sample ID, analytical batch, preparation batch, matrix	Samples in the same analytical or preparation batch, similar matrix conditions

ID identification number
LCS/LCSD laboratory control sample/laboratory control sample duplicate
MS/MSD matrix spike/matrix spike duplicate
VOC volatile organic compound

C3.0 METHOD PERFORMANCE SUMMARIES/ASSESSMENTS

This section presents the laboratory and field method performance summaries and assessments. The data were assessed using the procedures described in Section C2.0

Table C3-1 lists the laboratory analytical methods used to analyze samples submitted for this project. Methods performed for this project were identical with those presented in the QAPP with the exception of total organic carbon (analyzed by Method E415.1 rather than E410.1). In addition, three soil samples were analyzed for gasoline range organics by Method AK 101 and 37 fish tissue samples were analyzed for inorganic arsenic by draft USEPA Method 1632. These analyses were added during the project and were not included in the QAPP.

Sample quantitation limits were generally met for most methods, with exceptions occurring due to dilutions for high levels of analytes, matrix interference, and percent solids less than 50 percent (which occurred frequently due to the highly organic nature of most soils on Amchitka). No field analyses were performed for this project with the exception of pH, conductivity, turbidity, dissolved oxygen, and temperature measurements for water samples, which were performed as defined in the QAPP; and Level I headspace screening of soils for total volatiles with a photoionization detector.

C3.1 DATA ASSESSMENT SUMMARY

Project data were reviewed for complete and accurate documentation and achievement of required QC sample frequency. The data assessment included a review of representativeness, comparability, and completeness. A summary of the findings is presented below.

C3.1.1 Sample Receipt

Samples that were not properly labeled and logged in were identified by comparison of field sample documentation, chain-of-custody records, and laboratory sample log-in documentation, and corrected by the laboratory. The most common error affected the portion of the sample number specifying the media sampled. The nature of the sample numbering system incorporates redundancy, so it was possible to determine with certainty from the field notes the correct sample number. Quality was not affected by these occurrences.

Sample COC forms were complete. In each of these cases custody of the samples is documented by the cooler receipt forms, which show custody seals were present and intact on the coolers upon receipt.

Four samples were received broken by the NCA Bothell facility. These samples included one 1-liter amber bottle each for samples 98DOE-DRSF-1023-SW, 98DOE-ACGY-2007-SW, 98DOE-LONG-3010-SW, and 98DOE-LONG-4119-SW. Multiple sample containers were submitted to the laboratory for each of these samples; therefore, the laboratory was able to perform the requested analyses.

Temperatures were not recorded in Anchorage for coolers NCA Bothell-59, NCA Bothell-75, and NCA Bothell-76; however the highest cooler temperature recorded for the other 71 coolers upon arrival in Anchorage was 6.9 degrees Celsius (°C). Since the three coolers for which temperatures were not measured were in transit for a similar amount of time as the other 71 coolers, the lack of temperature measurements does not adversely affect the data.

Temperatures above 8°C were measured for several coolers upon receipt at the NCA Portland facility (after they had been shipped there from NCA's Bothell facility). The coolers, samples contained in the coolers, requested analyses, and cooler temperatures are listed below:

- B809041, Cooler NCA Portland-01, 8.6°C in Bothell and 10.2°C in Portland
  98DOE-MILR-1004-SD — All samples analyzed by SW5030/SW8260B and SW5035/SW8260B
  98DOE-MILR-1005-SD
  98DOE-MILR-1006-SD
  98DOE-MILR-1007-SD
  98DOE-MILR-1008-SD
  98DOE-TB02-0000-TB

- B809153, Cooler NCA Portland-03, 20.4°C
  98DOE-LONG-4035-SD — All samples analyzed by SW5030/SW8260B and SW5035/SW8260B
  98DOE-DRSF-3012-SD
  98DOE-LONG-4051-SD
  98DOE-DRSD-1047-SD
  98DOE-DRSD-1045-SD
  98DOE-DRSD-1044-SD
  98DOE-DRSD-1046-SD
  98DOE-DRSD-1048-SD

- B809256, Cooler NCA Portland-05, 18.2°C
  98DOE-DRSD-1051-SD — All samples analyzed by SW5030/SW8260B
  98DOE-DRSD-1053-SD
  98DOE-DRSD-1052-SD
  98DOE-DRSD-1049-SD
  98DOE-DRSD-1050-SD
  TB-101

- B809421, Cooler NCA Portland-08, 11.2°C
  98DOE-CANN-1105-SD All samples analyzed by SW5030/SW8260B
  98DOE-CANN-1111-SD
  98DOE-CANN-1114-SD
  98DOE-CANN-1109-SD
  98DOE-CANN-1115-SD
  98DOE-CANN-1110-SD
  98DOE-DRSD-1099-SD
  98DOE-CANN-1104-SD
  98DOE-DRSD-1097-SD
  98DOE-DRSD-1096-SD
  98DOE-DRSD-1091-SD
  98DOE-DRSD-1092-SD
  98DOE-DRSD-1093-SD
  98DOE-DRSD-1095-SD
  98DOE-CANN-1103-SD
  98DOE-DRSD-1094-SD
  98DOE-DRSD-1098-SD
  98DOE-LONG-4120-SD

- B809457, Cooler NCA Portland-10, 14.8°C
  98DOE-LONG-1140-SD All samples analyzed by SW5030/SW8260B and
  98DOE-LONG-1139-SD SW5035/SW8260B

- B809458, Cooler NCA Portland-09, 11.5°C
  98DOE-DRSE-1117-SD All samples analyzed by SW5030/SW8260B
  98DOE-LONG-1127-SD
  98DOE-LONG-1129-SD
  98DOE-LONG-1125-SD
  98DOE-LONG-1124-SD
  98DOE-LONG-1128-SD
  98DOE-LONG-1131-SD
  98DOE-LONG-1134-SD
  98DOE-LONG-1126-SD
  98DOE-LONG-1130-SD
  98DOE-LONG-1132-SD
  98DOE-LONG-1135-SD
  98DOE-LONG-1133-SD
  98DOE-LONG-1123-SD
  98DOE-DRSE-1119-SD
  High/low level trip blank

According to the project laboratory, all samples were iced with ice substitute the morning they were shipped from Bothell via Alaska and Horizon Airlines GoldStreak Service. The samples were received and temperatures recorded by NCA Portland personnel on the same business day that the samples were shipped, typically about 8 hours after leaving the Bothell facility. The ice substitute bags were stiff and cold when the coolers were opened. Water temperature blanks were not enclosed in the coolers.

NCA normally measures soil temperatures using a Raytek PM Plus infrared temperature gun; however, the NCA Portland employee recording the temperatures thought that all temperatures were measured with a glass thermometer, which she had experience using for water temperature blanks. The temperatures for the coolers listed above were measured by NCA Portland personnel by placing a glass thermometer inside the cooler upon receipt. The thermometer was not placed against or in samples, but recorded the air temperature in the cooler, which is not reflective of sample or gel-ice temperatures. The measured temperature was recorded on log-in documents when the thermometer was withdrawn from the cooler. The length of time the thermometer was in the cooler was not recorded; however, it was typically only for several minutes prior to logging in the samples. On one instance, the NCA Portland employee placed the thermometer in a cooler when picking the samples up at the GoldStreak office, and left the thermometer in the cooler for about 20 minutes while returning to the laboratory. In this case the temperature was allowed to equilibrate for a longer period, resulting in a measured temperature of 7.8°C.

The temperature measurement technique clearly provided results that are biased high. Since the ice substitute was cold and samples were only in transit from the Bothell facility for 6 to 8 hours, the sample temperatures were likely well below those recorded. This is confirmed by the temperature of cooler NCA Portland-06, which was logged in at the NCA Portland facility by a different NCA employee using the Raytek PM Plus infrared temperature gun. In this case, a temperature of 1°C was recorded for samples that were in transit a similar period of time as those listed above.

Although it is unlikely that data quality was affected, the results for the samples listed above have been qualified as follows to reflect the elevated cooler temperatures.

- Results for samples analyzed by Method SW5035/SW8260B have been qualified as estimated "J" or "UJ" due to potential low bias. It should, however, be noted that although sample temperatures were potentially above 8°C, samples submitted for this analysis were preserved in the field using an aqueous sodium bisulfate solution to inhibit biological growth and the associated degradation of volatile compounds.

- Samples analyzed by Method SW5030/SW8260B were extracted/preserved in the field with methanol. Methanol is also used to field extract/preserve samples for Method AK101, Gasoline Range Organics, to minimize the loss of volatiles during transit to the laboratory. With the methanol preservation, refrigeration of AK101 samples at 4°C is not required, although samples must be kept below 25°C. Since

the SW5030/SW8260B samples were similarly preserved and the cooler temperatures were not above 25°C, the results for this method were not qualified.

Samples were properly preserved and analyzed within the specified holding times with the following exceptions:

- Sample 98DOE-MILR-1003-SW for AK102 analysis was re-extracted outside of holding time. The original extract was lost during the last phase of extraction. The result was qualified as estimated "J".

- PCB analyses were performed from 3 to 4 months beyond holding time for the following samples. Since PCBs are persistent in the environment and the sediment samples were stored at 4°C (a temperature cooler than field conditions on Amchitka), the sample results were qualified as estimated "J" or "UJ".

  98DOE-CANN-1019-SD
  98DOE-CANN-1016-SD
  98DOE-CANN-1017-SD
  98DOE-CANN-1018-SD
  98DOE-CANN-1020-SD
  98DOE-CANN-1021-SD
  98DOE-CANN-1022-SD
  98DOE-DRSD-1045-SD
  98DOE-DRSD-1047-SD
  98DOE-DRSD-1044-SD
  98DOE-DRSD-1046-SD
  98DOE-DRSD-1048-SD
  98DOE-RS01-4084-SD
  98DOE-DRSD-1050-SD
  98DOE-DRSD-1071-SD
  98DOE-DRSD-1070-SD
  98DOE-DRSD-1074-SD
  98DOE-DRSD-1073-SD
  98DOE-CANN-4110-SD
  98DOE-CANN-4102-SD
  98DOE-CANN-4108-SD
  98DOE-CANN-4104-SD
  98DOE-CANN-4106-SD
  98DOE-RS04-3044-SD
  98DOE-RS04-3047-SD
  98DOE-RS04-3048-SD
  98DOE-DRSD-1093-SD
  98DOE-DRSD-1099-SD

98DOE-DRSD-1097-SD
98DOE-DRSD-1092-SD
98DOE-DRSD-1091-SD
98DOE-RS03-3061-SD
98DOE-RS03-3063-SD
98DOE-CANN-1114-SD
98DOE-CANN-1115-SD

- PCB analyses for all fish samples were performed from 4 to 7½ months beyond holding time. Since PCBs are persistent in the environment and the fish tissue samples were frozen, the sample results were qualified as estimated "J" or "UJ".

C3.1.2 Method Blanks

Method blanks (MB) were free of common laboratory contaminants with the exception of methylene chloride in eight SW8260B method blanks. Detections of methylene chloride at less than 10 times the MB concentration were qualified as nondetect, "U". There were no methylene chloride detections in samples associated with the method blanks that were greater than 10 times the blank concentration.

The laboratory also identified methylene chloride as a suspected contaminant for the following SW8260B samples:

98DOE-MILR-1001-SW
98DOE-MILR-1002-SW
98DOE-LONG-1009-SW
98DOE-LONG-1010-SW
98DOE-LONG-1011-SW
98DOE-LONG-1012-SW
98DOE-MILR-1000-TB
98DOE-CANN-1013-SW
98DOE-CANN-1014-SW
98DOE-CANN-1015-SW
98DOE-MILR-1006-SD
98DOE-MILR-1007-SD

The laboratory indicated that toluene in sample 98DOE-CANN-1108-SW was suspected laboratory contamination.

Three AK102 laboratory method blanks contained similar concentrations of diesel range organics (DRO) as reported in the samples. In accordance with the USEPA *National Functional Guidelines for Organic Data Review* (USEPA, 1994) these samples could be qualified as

nondetects at detection limits corresponding to the reported values because they are less than five times the method blank concentration. However, this approach might be questionable when used on samples from a mud pit known to contain diesel. Accordingly, stream samples associated with these method blanks were qualified as nondetect, "U", and samples from mud pits were qualified "B" to indicate the presence of DRO in the method blank.

The laboratory identified carbon disulfide as being a suspected contaminant originating from the sample containers (which were not certified clean for carbon disulfide) used for the following SW5035/SW8260B samples. The carbon disulfide results for these samples were qualified as nondetect, "U".

98DOE-TB02-0000-TB
98DOE-CANN-1019-SD
98DOE-DRSF-1026-SD
98DOE-DRSF-1027-SD
98DOE-CANN-1017-SD
98DOE-MILR-4016-SD
98DOE-MILR-4017-SD
98DOE-DRSF-3012-SD
98DOE-LONG-4051-SD
98DOE-TB-100
98DOE-DRSD-1087-SD
98DOE-DRSD-1086-SD
98DOE-DRSD-1090-SD
98DOE-DRSD-1089-SD

In addition, copper, magnesium, potassium, and titanium were each detected in one method blank, and although the sample concentrations were sufficiently higher than the blank concentration (according to the USEPA *National Functional Guidelines for Organic Data Review*) the laboratory indicated that the sample results may be biased high. These associated results were therefore qualified as estimated "J".

Method blanks for fish tissue sample contained boron, copper, and molybdenum. Detections of these compounds at less than five times the method blank concentrations were qualified as nondetect, "U". The laboratory also indicated possible instrument contamination by thorium, which was previously used as an internal standard. All thorium sample results have been qualified "B" to indicate possible laboratory contamination.

C3.1.3 Laboratory Control Sample Results

LCS results were reviewed for all analytical batches. Data were qualified according to National Functional Guidelines. In general, LCS results that were below the project-specified control limit were qualified as estimated or rejected because of the potential low bias. LCS results that were above the project-specified control limit were qualified as estimated because of the potential high bias.

The project laboratory erroneously failed to perform LCS analyses for the SW8260B water samples (encompassing ten sample delivery groups). However, they note that the method requires the analysis of LCS samples "to verify that the laboratory can perform the analysis in a clean matrix when the results of the matrix spike analysis indicate a potential problem due to the matrix itself." The laboratory points out that all the spike recoveries for the MS and MSD analyses for these sample delivery groups were within acceptance criteria.

The LCS results indicated that the systems were generally in control. LCS recoveries for naphthalene by Method SW8270C SIM were low for one analytical batch and the sample results were rejected "R". In addition, the LCS recovery for iron in SW6010B analytical batch 1080150 was above the upper control limit; positive iron results for samples in the analytical batch were qualified as estimated "J".

Fish tissue LCS recoveries were high for boron for two analytical batches and for thorium for one analytical batch. Positive results for these compounds were qualified as estimated "J" in the appropriate analytical batches.

C3.1.4 Matrix Spikes

In general, the MS/MSD results indicated good precision and accuracy, with the exception of metals in sediment and fish tissue. Boron results were qualified as estimated for 72 sediment samples due to low MS recovery; 2 results were rejected. Sediment results for a variety of other metals were also qualified as estimated due to low MS or MSD recovery: beryllium and cerium for 14 samples; chromium and manganese for 12; cobalt and nickel for 34; molybdenum for 46; potassium for 27; selenium for 39; thorium for 8; and zinc for 11. High MS recovery or MS recovery not being reported resulted in estimated values for 17 sediment samples for potassium, copper, and vanadium.

Fish tissue MS and MSD recoveries outside criteria were typically high or not reported. The result for pyrene for one fish tissue sample was qualified as estimated. Positive boron and thorium results were qualified as estimated for 37 and 10 samples, respectively. Aluminum, iron, strontium, and titanium results were qualified as estimated for 17 samples.

C3.1.5 Surrogate Spikes

Surrogate spikes were generally in control with the exception of some out-of-criteria recoveries for Methods AK101 and SW8260B. Data were qualified according to National Functional Guidelines. In general, the results for samples with surrogate recovery results below the project-specified control limit were qualified as estimated or rejected due to the potential low bias. Results above the project-specified control limit were qualified as estimated due to the potential high bias. Results were qualified as estimated for six sediment samples for Method SW5035/SW8260B and detected compounds were qualified as estimated for another eight samples. Detected compounds were qualified as estimated for four Method SW8260B surface water or trip blank samples due to high surrogate recovery. Results were also qualified as estimated for three AK101 sediment samples and two Method SW8081 fish tissue samples.

C3.1.6 Laboratory Duplicates

RPDs for laboratory duplicate samples were outside criteria for a variety of metals in sediment and fish tissue, including aluminum, arsenic, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, lithium, manganese, molybdenum, nickel, potassium, selenium, strontium, thallium, thorium, titanium, uranium, vanadium, and zinc. Results for these metals (791 individual metals sample results) were qualified as estimated "J" or "UJ".

Metals qualified as estimated for fish tissue due to RPDs outside criteria for laboratory duplicate samples included 17 arsenic, chromium, cobalt, iron, and thallium results, and 37 molybdenum results.

C3.1.7 Internal Standards

Recovery of internal standards was not included in this data evaluation. However, the laboratory indicated internal standard recoveries as potentially affecting data in several instances. Positive Method SW5035/SW8260B results were qualified as estimated for 19 samples due to a laboratory indication that results may be biased high. Results for four of these samples were also considered estimated because they were beyond the calibration range of the analysis.

C3.1.8 Other Quality Control Issues

Calibration data were not included in this data evaluation. However, results for one Method SW5035/SW8260B and one Method SW5030/SW8260B sample were qualified as estimated since the laboratory indicated it was run just outside the 12-hour BFB tune time limit. In addition, results for vinyl chloride for two SW5030/SW8260B samples were qualified as estimated due to continuing calibration checks outside the method criteria.

C3.2 FIELD QC SAMPLE DATA ASSESSMENT SUMMARY

C3.2.1 Trip Blanks

Eight aqueous trip blanks were submitted for VOC analyses. Methylene chloride was detected in the aqueous SW8260B trip blanks. The detected concentrations were 2.58 to 9.48 micrograms per liter (ug/L). These detections had no direct impact on the data since they were consistent with detections in the method blanks and were present in the field samples at less than 10 times the concentration detected in the method blanks. Therefore, all methylene chloride detections in project water samples were attributed to laboratory contamination and the field sample results were qualified "U".

Three methanol trip blanks were submitted along with soil and sediment environmental samples for SW5030/SW8260B (high-level) analyses in order to identify potential contaminants in the methanol used to preserve the samples and to determine if cross contamination occurred during sample storage, handling, or transportation. Three aqueous sodium bisulfate trip blanks were analyzed by Method SW5035/SW8260B (low-level volatiles). No contaminants were detected in the methanol trip blanks; carbon disulfide was detected in all of the aqueous sodium bisulfate trip blanks at concentrations ranging from 0.00719 to 0.0142 milligrams per kilogram (mg/kg). These detections had no direct impact on the data because they were consistent with detections in the method blanks and were present in the field samples at less than 10 times the concentration detected in the method blanks. Therefore, all carbon disulfide detections in project water samples were attributed to laboratory contamination and the field sample results were qualified "U".

C3.2.2 Field Blanks

Two rinsate blanks were collected by pouring ASTM Type II water over a decontaminated equipment hand auger barrel.

Rinsate blank 98DOE-DRSD-1075-RB contained 173 ug/L of DRO, 289 ug/L potassium, 2.59 ug/L nickel, and 1.8 ug/L vanadium. The next sample collected with the decontaminated hand auger was 98DOE-RRMP-1076-SL, which contained significantly higher concentrations of the analytes detected in the rinsate blank (2,620 mg/kg DRO, 1770 mg/kg potassium, 5.67 mg/kg nickel, and 95.1 mg/kg vanadium).

Rinsate blank 98DOE-LONG-1136-RB contained 63.7 ug/L DRO, 5.6 ug/L nickel, and 14.1 ug/L zinc. No subsequent samples were collected with the decontaminated hand auger.

C3.2.3 Field Duplicates and Replicates

The project-specified frequency for the collection of field duplicates and replicates was one per 10 environmental samples. Only 5 to 7 percent duplicates were analyzed for soil methods, with the exception of AK101 for which no duplicate samples were analyzed (there were only 3 AK101 samples). For water samples, 5 percent duplicates were analyzed for AK102, SW8260B, SW8270C SIM, and metals; no duplicates were analyzed for PCBs. Eight percent duplicates were analyzed for SW8270C SIM, SW8082 and metals in fish tissue, and 5 percent duplicates were analyzed for inorganic arsenic. These deviations are not considered to have significantly affected the ability to evaluate data quality. Numbers of samples, and calculated percentages of duplication, are shown in Table C1-1. The field duplicate results and calculated RPD values for original sample/duplicate pairs are presented in Tables C3-2 and C3-3 for soil and water, respectively.

RPD values for soil samples were within the project-specified control limit of 50 percent with the exceptions of:

- Diesel range organics in 98DOE-DRSD-1051/1052-SD had a RPD of 77.8 percent.
- RPDs for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, n-butylbenzene, and xylenes 98DOE-LONG-1123/1224-SD ranged from 50 to 76 percent.
- The RPD for fluorene for 98DOE-CANN-1020/1021-SD was 52.4 percent, and the RPD for naphthalene for 98DOE-CANN-1109/1110-SD was 139 percent. RPDs for eight SW8270C SIM compounds for 98DOE-DRSD-1051/1052-SD ranged from 84 to 140 percent. RPDs for four SW8270C SIM compounds for 98DOE-LONG-1123/1124-SD ranged from 60 to 67 percent.
- The RPDs for all detected compounds for 98DOE-MILR-4008/4009-SD exceeded the control limit and ranged from 67 percent for zinc by SEM to 98 percent for barium.
- RPDs for boron and copper for 98DOE-CANN-1020/1021-SD were 55 percent.
- RPDs for arsenic, chromium, cobalt, nickel, and vanadium in 98DOE-RS02-4139/4140-SD ranged from 66 to 169 percent.
- Manganese had a RPD for 98DOE-RS03-3060/3061-SD of 83 percent; acid volatile sulfides had a RPD of 81 percent.

RPD values for water samples were within the project-specified control limit of 30 percent with the following exceptions:

- Diesel range organics had RPDs of 39 and 47 percent for 98DOE-CANN-1106/1107-SW and 98DOE-DRSD-1080/1081-SW, respectively.

- Cobalt had RPDs of 131 and 122 percent for 98DOE-CANN-1106/1107-SW and 98DOE-LONG-1011/1012-SW, respectively.

- RPDs for manganese in 98DOE-CANN-1106/1107-SW, 98DOE-DRSE-3034/3035-SW, and 98DOE-RS04-3044/3045-SW were 77, 84, and 106 percent, respectively.

- Potassium had RPDs of 48 and 40 percent in 98DOE-CANN-1106/1107-SW and 98DOE-LONG-1011/1012-SW, respectively.

- RPDs for aluminum, copper, and titanium ranged from 48 to 152 percent in 98DOE-DRSE-3034/3035-SW.

- Nickel had a RPD of 114 percent in 98DOE-LONG-1011/1012-SW.

The peat and highly organic soils found on Amchitka were difficult to homogenize when duplicate split samples were being prepared in the field. In addition, duplicate soil and sediment samples for volatile and gasoline range organics (GRO) analyses were collocated samples rather than split, homogenized samples. Given the low percent solids of the peat soils, a relatively minor change in the solids content could impact the RPD between collocated samples. These factors (in addition to spatial variability in contaminant concentrations) may explain some of the cases of RPDs that exceeded the project QAOs.

C3.3 LABORATORY RE-ANALYSES

The project laboratory reanalyzed the following samples:

- 28 sediment samples for aluminum

- 1 sample for PCBs by SW8082

- 9 surface water samples for beryllium

- 22 sediment and 10 surface water samples for boron

- 35 sediment and 10 surface water samples for calcium

- 19 surface water samples for chromium

- 1 surface water sample for diesel range organics

- 55 sediment and 19 surface water samples for iron
- 32 sediment samples for lithium
- 5 sediment and 10 surface water samples for magnesium
- 15 sediment and 9 surface water samples for molybdenum
- 11 sediment and 10 surface water samples for potassium
- 9 surface water samples for thallium
- 9 surface water samples for thorium
- 19 surface water samples for vanadium
- 1 fish tissue sample for PCBs
- 1 fish tissue sample for polycyclic aromatic hydrocarbons

The laboratory reported only the results for reanalyses.

TABLE C3-1
ANALYTICAL METHODS FOR WATER AND SOIL SAMPLES, 1998 DOE DRILL SITE INVESTIGATION

Method	Parameter/Analytes	Reference
AK101	Gasoline Range Organics	Alaska Department of Environmental Conservation Underground Storage Tanks Procedures Manual
AK102	Diesel Range Organics	Alaska Department of Environmental Conservation Underground Storage Tanks Procedures Manual
SW8021B	Aromatic and Halogenated Volatiles	USEPA Test Methods for Evaluating Solid Waste, SW846, Revision 2, December 1996
SW8082	Polychlorinated Biphenyls	USEPA Test Methods for Evaluating Solid Waste, SW846, December 1996
SW8260B	Volatile Organic Compounds	USEPA Test Methods for Evaluating Solid Waste, SW846, December 1996
5035/8260B	Low-level Extraction/Volatile Organic Compounds	USEPA Test Methods for Evaluating Solid Waste, SW846, December 1996
5030/8260B	High-level Extraction/Volatile Organic Compounds	USEPA Test Methods for Evaluating Solid Waste, SW846, December 1996
SW8270C SIM	Polycyclic Aromatic Hydrocarbons (Selective Ion Monitoring)	USEPA Test Methods for Evaluating Solid Waste, SW846, Revision 3, December 1996
SW6010B	Metals	USEPA Test Methods for Evaluating Solid Waste, SW846, Revision 2, December 1996
SW6020	Metals	USEPA Test Methods for Evaluating Solid Waste, SW846, September, 1994
E415.1 modified	Total Organic Carbon	USEPA Methods for the Chemical Analysis of Water and Wastes, EPA-600/4-79-020, USEPA , EMSL, 1979
D91AVS/SEM	Acid Volatile Sulfides-Simultaneously Extracted Metals	Draft Analytical Method for Determination of Acid Volatile Sulfides in Sediment, USEPA 1991

SIM Selective Ion Monitoring
USEPA United States Environmental Protection Agency
AVS/SEM method: Metals are analyzed by SW6020.

TABLE C3-2
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
98DOE-CANN-1020-SD					
Diesel Range Organics	AK 102	mg/kg	3330	4430	28.4
Naphthalene	SW5035/SW8260B	mg/kg	ND(0.0524)	0.0582	-
Acenaphthene	SW8270C	mg/kg	0.0953	0.154	47.1
Fluoranthene		mg/kg	0.0635	0.101	45.6
Fluorene		mg/kg	0.372	0.636	52.4
Naphthalene		mg/kg	0.0191	ND(0.02)	-
Phenanthrene		mg/kg	1.59	2.42	41.4
Pyrene		mg/kg	0.146	0.239	48.3
Aluminum	SW6010B	mg/kg	20000	21500	7.2
Arsenic	SW6020	mg/kg	16.9	20.2	17.8
Barium	SW6020	mg/kg	148	166	11.5
Boron	SW6010B	mg/kg	46.7	81.7	54.5
Calcium	SW6010B	mg/kg	102000	133000	26.4
Cerium	SW6020	mg/kg	21.4	27.7	25.7
Chromium	SW6020	mg/kg	326	483	38.8
Cobalt	SW6020	mg/kg	10.5	11.6	10.0
Copper	SW6020	mg/kg	149	263	55.3
Iron	SW6010B	mg/kg	29300	24700	17.0
Lithium	SW6020	mg/kg	8.22	10	19.5
Magnesium	SW6010B	mg/kg	9520	10500	9.8
Manganese	SW6020	mg/kg	507	499	1.6
Nickel	SW6020	mg/kg	25.5	28.2	10.1
Potassium	SW6010B	mg/kg	667	667	0.0
Strontium	SW6020	mg/kg	181	170	6.3
Thorium	SW6020	mg/kg	5.8	7.62	27.1
Titanium	SW6020	mg/kg	905	1160	24.7
Uranium	SW6020	mg/kg	2.46	3.48	34.3
Vanadium	SW6020	mg/kg	69.4	64.6	7.2
Zinc	SW6020	mg/kg	125	139	10.6
98DOE-CANN-1109-SD					
Diesel Range Organics	AK 102	mg/kg	2940	1770	49.7
Acenaphthene	SW8270C	mg/kg	0.277	0.201	31.8
Fluoranthene		mg/kg	ND(0.0489)	0.0257	-
Fluorene		mg/kg	0.81	0.599	30.0
Naphthalene		mg/kg	0.119	0.0214	139.0
Phenanthrene		mg/kg	1.4	1.04	29.5
Pyrene		mg/kg	0.0593	0.0471	22.9
Aluminum	SW6010B	mg/kg	33200	31800	4.3
Arsenic	SW6020	mg/kg	2.81	2.67	5.1

TABLE C3-2 (cont.)
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
Barium	SW6020	mg/kg	335	305	9.4
Cadmium	SW6020	mg/kg	ND(1.48)	1.64	-
Calcium	SW6010B	mg/kg	23100	17200	29.3
Cerium	SW6020	mg/kg	22.2	23.1	4.0
Chromium	SW6020	mg/kg	140	158	12.1
Cobalt	SW6020	mg/kg	10.9	10.7	1.9
Copper	SW6020	mg/kg	113	124	9.3
Iron	SW6010B	mg/kg	38200	35300	7.9
Lithium	SW6020	mg/kg	8.26	8.32	0.7
Magnesium	SW6010B	mg/kg	22300	16900	27.6
Manganese	SW6020	mg/kg	1270	1300	2.3
Nickel	SW6020	mg/kg	45.5	51.2	11.8
Potassium	SW6010B	mg/kg	2410	2020	17.6
Strontium	SW6020	mg/kg	308	332	7.5
Thorium	SW6020	mg/kg	6.12	6.84	11.1
Titanium	SW6020	mg/kg	546	815	39.5
Uranium	SW6020	mg/kg	2.4	2.5	4.1
Vanadium	SW6020	mg/kg	72.1	85.1	16.5
Zinc	SW6020	mg/kg	57.9	57.1	1.4
98DOE-DRSD-1051-SD					
Diesel Range Organics	AK 102	mg/kg	475	1080	77.8
Naphthalene	SW5030/SW8260B	mg/kg	0.533	0.682	24.5
Acenaphthene	SW8270C	mg/kg	1.34	0.413	105.8
Anthracene		mg/kg	ND(0.0033)	0.312	-
Benzo (a) anthracene		mg/kg	0.018	ND(0.00862)	-
Benzo (b) fluoranthene		mg/kg	0.054	0.0174	102.5
Benzo (ghi) perylene		mg/kg	0.00771	ND(0.00862)	-
Benzo (k) fluoranthene		mg/kg	0.00642	ND(0.00862)	-
Chrysene		mg/kg	0.027	0.00871	102.4
Fluoranthene		mg/kg	0.243	0.0975	85.5
Fluorene		mg/kg	4.83	1.54	103.3
Indeno (1,2,3-cd) pyrene		mg/kg	0.0218	ND(0.00862)	-
Naphthalene		mg/kg	0.862	0.152	140.0
Phenanthrene		mg/kg	19.7	6.3	103.1
Pyrene		mg/kg	0.437	0.178	84.2
Aluminum	SW6010B	mg/kg	25800	22200	15.0
Arsenic	SW6020	mg/kg	6.71	6.41	4.6
Barium	SW6020	mg/kg	298	279	6.6
Calcium	SW6010B	mg/kg	26400	24500	7.5
Cerium	SW6020	mg/kg	27.7	32.9	17.2
Cesium	SW6020	mg/kg	0.731	ND(1.31)	-

TABLE C3-2 (cont.)
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
Chromium	SW6020	mg/kg	1040	1020	1.9
Cobalt	SW6020	mg/kg	10.6	10.6	0.0
Copper	SW6020	mg/kg	142	130	8.8
Iron	SW6010B	mg/kg	39100	31600	21.2
Lithium	SW6020	mg/kg	9.58	8.35	13.7
Magnesium	SW6010B	mg/kg	11800	10500	11.7
Manganese	SW6020	mg/kg	852	842	1.2
Molybdenum	SW6020	mg/kg	0.676	ND(1.31)	-
Nickel	SW6020	mg/kg	8.17	9.23	12.2
Potassium	SW6010B	mg/kg	3000	2680	11.3
Selenium	SW6020	mg/kg	0.706	ND(1.31)	-
Strontium	SW6020	mg/kg	198	189	4.7
Thorium	SW6020	mg/kg	5.3	7.74	37.4
Titanium	SW6020	mg/kg	1870	1670	11.3
Uranium	SW6020	mg/kg	2.17	2.99	31.8
Vanadium	SW6020	mg/kg	86.3	82.2	4.9
Zinc	SW6020	mg/kg	68.6	69.4	1.2
98DOE-LONG-1123-SD					
Diesel Range Organics	AK 102	mg/kg	11600	15200	26.9
1,2,4-Trimethylbenzene	SW5030/SW8260B	mg/kg	105	198	61.4
1,3,5-Trimethylbenzene		mg/kg	19.8	39.1	65.5
Naphthalene		mg/kg	84.9	137	47.0
n-Butylbenzene		mg/kg	9.23	20.6	76.2
p-Isopropyltoluene		mg/kg	ND(7.17)	14.6	-
Xylenes (total)		mg/kg	1.67	2.79	50.2
Acenaphthene	SW8270C	mg/kg	1.6	0.802	66.4
Acenaphthylene		mg/kg	0.509	ND(0.286)	-
Fluorene		mg/kg	3.76	1.87	67.1
Naphthalene		mg/kg	31.2	16.9	59.5
Phenanthrene		mg/kg	2.03	1.07	61.9
Aluminum	SW6010B	mg/kg	23900	21600	10.1
Arsenic	SW6020	mg/kg	5.82	5.25	10.3
Barium	SW6020	mg/kg	167	146	13.4
Calcium	SW6010B	mg/kg	46200	40400	13.4
Cerium	SW6020	mg/kg	31.3	28.2	10.4
Chromium	SW6020	mg/kg	98.6	89.4	9.8
Cobalt	SW6020	mg/kg	13.2	11.7	12.0
Copper	SW6020	mg/kg	123	108	13.0
Iron	SW6010B	mg/kg	52200	48000	8.4
Lithium	SW6020	mg/kg	14.5	12.8	12.5
Magnesium	SW6010B	mg/kg	21800	19100	13.2

TABLE C3-2 (cont.)
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
Manganese	SW6020	mg/kg	1130	1030	9.3
Nickel	SW6020	mg/kg	7.88	7.12	10.1
Potassium	SW6010B	mg/kg	1660	1470	12.1
Strontium	SW6020	mg/kg	431	404	6.5
Thorium	SW6020	mg/kg	6.51	6.04	7.5
Titanium	SW6020	mg/kg	1220	1120	8.5
Vanadium	SW6020	mg/kg	108	92.8	15.1
Zinc	SW6020	mg/kg	79.4	72.9	8.5
98DOE-LONG-4053-SD					
Aluminum	SW6010B	mg/kg	17100	18000	5.1
Arsenic	SW6020	mg/kg	ND(6.31)	6.45	-
Barium	SW6020	mg/kg	79.5	68.5	14.9
Calcium	SW6010B	mg/kg	8010	7840	2.1
Cerium	SW6020	mg/kg	6.83	7.7	12.0
Chromium	SW6020	mg/kg	ND(6.31)	6.45	-
Cobalt	SW6020	mg/kg	8.33	8.82	5.7
Copper	SW6020	mg/kg	59.3	52.6	12.0
Iron	SW6010B	mg/kg	49600	48200	2.9
Lithium	SW6020	mg/kg	10.2	12	16.2
Magnesium	SW6010B	mg/kg	7490	7620	1.7
Manganese	SW6020	mg/kg	711	566	22.7
Nickel	SW6020	mg/kg	6.86	7.61	10.4
Potassium	SW6010B	mg/kg	1080	1220	12.2
Strontium	SW6020	mg/kg	59.6	50.8	15.9
Titanium	SW6020	mg/kg	702	639	9.4
Vanadium	SW6020	mg/kg	135	121	10.9
Zinc	SW6020	mg/kg	70.2	71.5	1.8
Copper	SW6020 SEM	mg/kg	40.2	38.2	5.1
Nickel	SW6020 SEM	mg/kg	ND(6.31)	18.5	-
Zinc	SW6020 SEM	mg/kg	66.8	70	4.7
Simultaneously Extracted Metals	Summation	umol/g	1.63	1.96	18.4
Acid Volatile Sulfide	Titration	umol/g	1550	1200	25.5
Total Organic Carbon	E415.1 mod.	mg/kg	157000	220000	33.4
98DOE-MILR-4008-SD					
Diesel Range Organics	AK 102	mg/kg	29.6	ND(8.5)	-
Aluminum	SW6010B	mg/kg	90600	34900	88.8
Arsenic	SW6020	mg/kg	14.6	6.05	82.8
Barium	SW6020	mg/kg	355	121	98.3
Boron	SW6010B	mg/kg	193	76.8	86.1
Calcium	SW6010B	mg/kg	20200	8180	84.7

TABLE C3-2 (cont.)
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
Cerium	SW6020	mg/kg	30.9	13.5	78.4
Cesium	SW6020	mg/kg	4.26	1.8	81.2
Chromium	SW6020	mg/kg	24.7	9.8	86.4
Cobalt	SW6020	mg/kg	38.3	14.5	90.2
Copper	SW6020	mg/kg	247	94.2	89.6
Iron	SW6010B	mg/kg	93100	36000	88.5
Lithium	SW6020	mg/kg	41.7	16.9	84.6
Magnesium	SW6010B	mg/kg	37500	15500	83.0
Manganese	SW6020	mg/kg	793	297	91.0
Nickel	SW6020	mg/kg	18.9	7.35	88.0
Potassium	SW6010B	mg/kg	3560	1480	82.5
Strontium	SW6020	mg/kg	609	262	79.7
Titanium	SW6020	mg/kg	5760	2410	82.0
Vanadium	SW6020	mg/kg	420	154	92.7
Zinc	SW6020	mg/kg	208	90.5	78.7
Copper	SW6020 SEM	mg/kg	16	7.63	70.8
Zinc	SW6020 SEM	mg/kg	93.8	46.5	67.4
Simultaneously Extracted Metals	Summation	umol/g	1.67	0.823	68.0
Acid Volatile Sulfide	Titration	umol/g	112	ND(0.0106)	-
Total Organic Carbon	E415.1 mod.	mg/kg	92000	44900	68.8
98DOE-RS02-4139-SD					
Aluminum	SW6010B	mg/kg	30200	33000	8.9
Arsenic	SW6020	mg/kg	3.42	40.3	168.7
Barium	SW6020	mg/kg	ND(633)	149	-
Calcium	SW6010B	mg/kg	2350	2830	18.5
Cerium	SW6020	mg/kg	7.72	8.65	11.4
Chromium	SW6020	mg/kg	3.4	7.57	76.0
Cobalt	SW6020	mg/kg	8.75	17.3	65.6
Copper	SW6020	mg/kg	46.3	59.3	24.6
Iron	SW6010B	mg/kg	53400	61000	13.3
Lithium	SW6020	mg/kg	15.7	12.9	19.6
Magnesium	SW6010B	mg/kg	5170	6150	17.3
Manganese	SW6020	mg/kg	5100	3300	42.9
Nickel	SW6020	mg/kg	4.25	9.17	73.3
Potassium	SW6010B	mg/kg	635	808	24.0
Strontium	SW6020	mg/kg	45.4	69.5	41.9
Titanium	SW6020	mg/kg	1930	1750	9.8
Vanadium	SW6020	mg/kg	77.6	163	71.0
Zinc	SW6020	mg/kg	70.5	81.4	14.4
Copper	SW6020 SEM	mg/kg	66.1	67.3	1.8
Nickel	SW6020 SEM	mg/kg	9.21	8.51	7.9

TABLE C3-2 (cont.)
FIELD DUPLICATE PAIR RESULTS, SOIL SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Units	Original Sample Result	Field Duplicate Result	Original/ Duplicate RPD
Zinc	SW6020 SEM	mg/kg	125	127	1.6
Simultaneously Extracted Metals	Summation	umol/g	3.07	3.1	1.0
Acid Volatile Sulfide	Titration	umol/g	ND(0.0127)	0.369	-
Total Organic Carbon	E415.1 mod.	mg/kg	15900	16000	0.6
98DOE-RS03-3060-SD					
Aluminum	SW6010B	mg/kg	33100	30300	8.8
Arsenic	SW6020	mg/kg	17.1	13.8	21.4
Barium	SW6020	mg/kg	104	146	33.6
Calcium	SW6010B	mg/kg	6510	5980	8.5
Cerium	SW6020	mg/kg	7.89	8.37	5.9
Chromium	SW6020	mg/kg	5.98	7.48	22.3
Cobalt	SW6020	mg/kg	12.2	16.5	30.0
Copper	SW6020	mg/kg	54	57.7	6.6
Iron	SW6010B	mg/kg	64100	67400	5.0
Lithium	SW6020	mg/kg	15.2	14.2	6.8
Magnesium	SW6010B	mg/kg	12200	10900	11.3
Manganese	SW6020	mg/kg	761	1840	83.0
Nickel	SW6020	mg/kg	6.65	8.84	28.3
Potassium	SW6010B	mg/kg	506	678	29.1
Strontium	SW6020	mg/kg	123	181	38.2
Titanium	SW6020	mg/kg	942	965	2.4
Vanadium	SW6020	mg/kg	194	191	1.6
Zinc	SW6020	mg/kg	93.6	113	18.8
Copper	SW6020 SEM	mg/kg	73.1	52.2	33.4
Nickel	SW6020 SEM	mg/kg	13.3	11.7	12.8
Zinc	SW6020 SEM	mg/kg	191	143	28.7
Simultaneously Extracted Metals	Summation	umol/g	4.24	3.18	28.6
Acid Volatile Sulfide	Titration	umol/g	150	355	81.2
Total Organic Carbon	E415.1 mod.	mg/kg	40500	49700	20.4

- sample not analyzed or RPD value not calculated
ND(1) not detected, with the reporting limits shown in parentheses
RPD relative percent difference
mg/kg milligrams per kilogram
ug/g micrograms per gram
umol/g micromoles per gram
shaded RPD greater than project-specified control limit of 50%.

TABLE C3-3
FIELD DUPLICATE PAIR RESULTS, WATER SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Original Sample Result (ug/L)	Field Duplicate Result (ug/L)	Original/ Duplicate RPD
98DOE-CANN-1106-SW				
Diesel Range Hydrocarbons	AK 102	286	192	39.3
Aluminum	SW6020	59.2	58.2	1.7
Calcium	SW6010B	2810	2800	0.4
Cobalt	SW6020	1.12	5.38	131.1
Copper	SW6020	2.76	2.8	1.4
Magnesium	SW6010B	1320	1330	0.8
Manganese	SW6020	9.1	20.4	76.6
Nickel	SW6020	ND(1)	1.25	-
Potassium	SW6010B	338	549	47.6
Strontium	SW6020	15.8	15.3	3.2
98DOE-DRSD-1080-SW				
Diesel Range Hydrocarbons	AK 102	77.7	125	46.7
Aluminum	SW6020	83.3	75.3	10.1
Calcium	SW6010B	3060	3030	1.0
Chromium	SW6020	3.68	2.8	27.2
Copper	SW6020	1.64	1.31	22.4
Magnesium	SW6010B	1790	1750	2.3
Manganese	SW6020	3.41	3.17	7.3
Molybdenum	SW6020	ND(1)	1.05	-
Potassium	SW6010B	753	989	27.1
Strontium	SW6020	21.7	21	3.3
Thallium	SW6020	ND(1)	1.62	-
Thorium	SW6020	ND(1)	1.15	-
Titanium	SW6020	1.02	ND(1)	-
98DOE-DRSE-3034-SW				
Diesel Range Hydrocarbons	AK 102	ND(50)	54.3	-
Aluminum	SW6020	85.8	52.4	48.3
Calcium	SW6010B	3780	3570	5.7
Cobalt	SW6020	4.63	ND(1)	-
Copper	SW6020	2.85	1.1	88.6
Iron	SW6010B	150	ND(150)	-
Magnesium	SW6010B	2830	2780	1.8
Manganese	SW6020	19.9	8.09	84.4
Nickel	SW6020	1.65	ND(1)	-
Potassium	SW6010B	1220	1330	8.6
Strontium	SW6020	29.3	28.5	2.8
Titanium	SW6020	7.7	1.05	152.0
Vanadium	SW6020	ND(1)	1.31	-

TABLE C3-3 (cont.)
FIELD DUPLICATE PAIR RESULTS, WATER SAMPLE DETECTIONS AND CALCULATED RPD VALUES

Analyte	Analytical Method	Original Sample Result (ug/L)	Field Duplicate Result (ug/L)	Original/ Duplicate RPD
Zinc	SW6020	11.6	ND(10)	-
98DOE-LONG-1011-SW				
Diesel Range Hydrocarbons	AK 102	284	278	2.1
Calcium	SW6010B	9300	9440	1.5
Cobalt	SW6020	1.35	5.56	121.9
Iron	SW6010B	540	597	10.0
Magnesium	SW6010B	5280	5420	2.6
Manganese	SW6020	112	125	11.0
Nickel	SW6020	1.61	5.91	114.4
Potassium	SW6010B	958	1430	39.5
Strontium	SW6020	50.5	51.8	2.5
Thallium	SW6020	ND(1)	1.09	-
Titanium	SW6020	1.65	1.6	3.1
Vanadium	SW6020	ND(1)	1.82	-
98DOE-RS04-3044-SW				
Calcium	SW6010B	8520	8710	2.2
Cobalt	SW6020	ND(1)	3.83	-
Magnesium	SW6010B	3320	3320	0.0
Manganese	SW6020	4.53	14.8	106.3
Potassium	SW6010B	906	785	14.3
Strontium	SW6020	44.1	42.5	3.7

- sample not analyzed or RPD value not calculated
ND(1) not detected, with the reporting limits shown in parentheses
RPD relative percent difference
ug/L micrograms per liter
shaded RPD greater than project-specified control limit of 30%.

C4.0 SUMMARY

Samples were collected and analyzed as specified in the *Final Report, Amchitka Army Air Base, Phase I Remedial Investigation, Amchitka Island, Alaska, Management Plan*, issued on December 16, 1996, and the August 14, 1998, *Management Plan, Department of Energy 1998 Drill Site Investigation, Amchitka Island, Alaska*. Data quality were assessed by comparing field and laboratory QC sample results with the QAOs for representativeness, comparability, and completeness. The data quality assessment indicated most sample results were acceptable for use without qualification. However, some individual sample results and analytical batch results were qualified as estimated values or rejected because one or more QC specifications were not met.

Samples were received by the laboratory in a chilled state, intact, and with their COC forms, with the exceptions noted in Section C3.0. Samples were analyzed within the required hold times with the exceptions discussed in Section C3.0.

Project sample locations were selected to include each of the potentially affected media at sites of concern. These media included surface and subsurface soils, groundwater, surface water, and stream sediment. Samples were collected using accepted standard field procedures, as described in project sampling plans, and were analyzed in accordance with standard USEPA and Alaska Department of Environmental Conservation (ADEC) methods. The use of standard sampling procedures between locations, and standard analytical procedures by the project laboratory ensures the representativeness of the data and the comparability of one set of sample analytical data to another.

Laboratory QC results were generally in compliance, with the exceptions discussed in Section C3.0. Field QC samples indicated no external contamination of the samples.

Completeness calculations were conducted for each analytical method for the project laboratory samples. Data that were qualified as estimated values ("J" and "UJ"), or data qualified "U" because the compound was detected in a method blank, are considered usable; rejected data were qualified "R" and are not usable. Completeness for each of the analytical methods was 100 percent, with the exception of the following. Completeness for SW6010B in soil was just below 100 percent, due to the rejection of results for 2 of 834 samples due to low matrix spike recoveries. Completeness for SW8270C SIM in soil was 99 percent, due to the rejection of naphthalene results for 22 samples for low LCS recoveries.

C5.0 REFERENCES

Alaska Department of Environmental Conservation, 1995. *Underground Storage Tanks Procedures Manual*, Juneau, Alaska.

Shannon & Wilson, Inc. 1996. *Amchitka Army Air Base Phase I Remedial Investigation, Amchitka Island, Alaska, Management Plan.* Prepared for the Department of the Army, Alaska District Corps of Engineers. December.

_____, 1998. *Management Plan, Department of Energy 1998 Drill Site Investigation, Amchitka Island, Alaska.* Prepared for the Department of the Army, Alaska District Corps of Engineers. June.

U.S. Environmental Protection Agency, 1983a. *Guidelines for assessing and reporting data quality for environmental measurements*: Report EPA-Z/590, Washington, D.C.

_____, 1993b. *Methods for chemical analysis of water and wastes*, 3rd ed.: Report EPA-600/4-83/020, Washington, D.C.

_____, 1994a. *Contract laboratory program national functional guidelines for inorganic and organic data review*, Washington, D.C.

_____, 1994b, *Test methods for evaluating solid waste, physical/chemical methods*, 3rd ed. with update 2: Report EPA SW846.

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
Aircraft Graveyard																									
98DOE-ACGY-2003-SW	B809108-03	Water															1								
98DOE-ACGY-2004-SD	B809115-12	Soil							1																
98DOE-ACGY-2005-SW	B809108-02	Water															1								
98DOE-ACGY-2006-SD	B809115-14	Soil							1																
98DOE-ACGY-2007-SW	B809108-01	Water															1								
98DOE-ACGY-2008-SD	B809115-13	Soil							1																
98DOE-ACGY-2009-GW	B809111-16	Water															1								
98DOE-ACGY-2010-GW	B809111-14	Water															1								
Cannikin Site																									
98DOE-CANN-1013-SW	B809034-09	Water													1										
98DOE-CANN-1013-SW	B809036-01	Water												1		1									
98DOE-CANN-1013-SW	B809037-06	Water																1	1						
98DOE-CANN-1014-SW	B809034-10	Water													1										
98DOE-CANN-1014-SW	B809036-02	Water												1		1									
98DOE-CANN-1014-SW	B809037-07	Water																1	1						
98DOE-CANN-1015-SW	B809034-11	Water													1										
98DOE-CANN-1015-SW	B809036-03	Water												1		1									
98DOE-CANN-1015-SW	B809037-08	Water																1	1						
98DOE-CANN-1016-SD	B809105-03	Soil					1																		
98DOE-CANN-1016-SD	B809113-02	Soil			1			1	1	1	1														
98DOE-CANN-1016-SD	B809113-02RE1	Soil								1															
98DOE-CANN-1016-SD	B809113-02RE3	Soil								1															
98DOE-CANN-1017-SD	B809105-09	Soil					1																		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1017-SD	B809113-03	Soil			1			1	1	1	1														
98DOE-CANN-1017-SD	B809113-03RE1	Soil								1															
98DOE-CANN-1017-SD	B809113-03RE3	Soil								1															
98DOE-CANN-1018-SD	B809105-11	Soil					1																		
98DOE-CANN-1018-SD	B809113-04	Soil			1			1	1	1	1														
98DOE-CANN-1018-SD	B809113-04RE1	Soil								1															
98DOE-CANN-1018-SD	B809113-04RE3	Soil								1															
98DOE-CANN-1019-SD	B809105-01	Soil				1	1																		
98DOE-CANN-1019-SD	B809113-01	Soil			1			1	1	1	1														
98DOE-CANN-1019-SD	B809113-01RE1	Soil								1															
98DOE-CANN-1019-SD	B809113-01RE3	Soil								1															
98DOE-CANN-1020-SD	B809105-08	Soil	Orig				1																		
98DOE-CANN-1020-SD	B809113-05	Soil	Orig		1			1	1	1	1														
98DOE-CANN-1020-SD	B809113-05RE1	Soil	Orig							1															
98DOE-CANN-1020-SD	B809113-05RE3	Soil	Orig							1															
98DOE-CANN-1021-SD	B809105-06	Soil	FD				1																		
98DOE-CANN-1021-SD	B809113-06	Soil	FD		1			1	1	1	1														
98DOE-CANN-1021-SD	B809113-06RE1	Soil	FD							1															
98DOE-CANN-1021-SD	B809113-06RE3	Soil	FD							1															
98DOE-CANN-1022-SD	B809105-07	Soil					1																		
98DOE-CANN-1022-SD	B809113-07	Soil			1			1	1	1	1														
98DOE-CANN-1022-SD	B809113-07RE1	Soil								1															
98DOE-CANN-1022-SD	B809113-07RE3	Soil								1															
98DOE-CANN-1100-SW	B809376-01	Water												1		1	1								
98DOE-CANN-1100-SW	B809384-05	Water																	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1100-SW	B809384-05RE1	Water																1							
98DOE-CANN-1100-SW	B809388-02	Water													1										
98DOE-CANN-1101-SW	B809368-02	Water												1		1	1								
98DOE-CANN-1101-SW	B809384-03	Water																	1						
98DOE-CANN-1101-SW	B809384-03RE1	Water																1							
98DOE-CANN-1101-SW	B809388-01	Water													1										
98DOE-CANN-1102-SW	B809368-01	Water												1		1	1								
98DOE-CANN-1102-SW	B809384-04	Water																	1						
98DOE-CANN-1102-SW	B809384-04RE1	Water																1							
98DOE-CANN-1102-SW	B809388-03	Water													1										
98DOE-CANN-1103-SD	B809388-10	Soil			1			1	1	1	1														
98DOE-CANN-1103-SD	B809421-15	Soil				1																			
98DOE-CANN-1103-SD	B809479-02	Soil		1																					
98DOE-CANN-1104-SD	B809388-09	Soil			1			1	1	1	1														
98DOE-CANN-1104-SD	B809421-08	Soil				1																			
98DOE-CANN-1104-SD	B809479-01	Soil		1																					
98DOE-CANN-1105-SD	B809377-01	Soil			1			1	1	1	1														
98DOE-CANN-1105-SD	B809421-01	Soil				1																			
98DOE-CANN-1105-SD	B809479-03	Soil		1																					
98DOE-CANN-1106-SW	B809385-09	Water	Orig												1			1	1						
98DOE-CANN-1106-SW	B809387-02	Water	Orig											1		1									
98DOE-CANN-1107-SW	B809385-07	Water	FD												1			1	1						
98DOE-CANN-1107-SW	B809387-03	Water	FD													1									
98DOE-CANN-1107-SW	B809389-03	Water	FD											1											
98DOE-CANN-1108-SW	B809385-08	Water													1			1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1108-SW	B809387-01	Water												1		1									
98DOE-CANN-1109-SD	B809377-02	Soil	Orig		1			1	1	1	1														
98DOE-CANN-1109-SD	B809421-04	Soil	Orig			1																			
98DOE-CANN-1110-SD	B809377-03	Soil	FD		1			1	1	1	1														
98DOE-CANN-1110-SD	B809421-06	Soil	FD			1																			
98DOE-CANN-1111-SD	B809377-04	Soil			1			1	1	1	1														
98DOE-CANN-1111-SD	B809421-02	Soil				1																			
98DOE-CANN-1112-SW	B809385-12	Water													1			1	1						
98DOE-CANN-1112-SW	B809389-02	Water												1		1									
98DOE-CANN-1113-SW	B809385-11	Water													1			1	1						
98DOE-CANN-1113-SW	B809389-01	Water												1		1									
98DOE-CANN-1114-SD	B809421-03	Soil				1																			
98DOE-CANN-1114-SD	B809475-09	Soil			1			1	1	1	1														
98DOE-CANN-1115-SD	B809421-05	Soil				1																			
98DOE-CANN-1115-SD	B809475-10	Soil			1			1	1	1	1														
98DOE-CANN-4101-SW	B809299-03	Water														1									
98DOE-CANN-4101-SW	B809302-02	Water												1											
98DOE-CANN-4101-SW	B809303-19	Water																1	1						
98DOE-CANN-4101-SW	B809303-19RE1	Water																1	1						
98DOE-CANN-4101-SW	B809309-27	Water													1										
98DOE-CANN-4102-SD	B809305-07	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4102-SD	B809305-07RE1	Soil									1														
98DOE-CANN-4102-SD	B809305-07RE2	Soil								1															
98DOE-CANN-4103-SW	B809297-01	Water												1		1									
98DOE-CANN-4103-SW	B809309-12	Water													1			1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-4103-SW	B809309-12RE1	Water																	1						
98DOE-CANN-4104-SD	B809305-09	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4104-SD	B809305-09RE1	Soil									1														
98DOE-CANN-4104-SD	B809305-09RE2	Soil								1															
98DOE-CANN-4105-SW	B809296-03	Water												1											
98DOE-CANN-4105-SW	B809297-03	Water														1									
98DOE-CANN-4105-SW	B809303-17	Water																1	1						
98DOE-CANN-4105-SW	B809303-17RE1	Water																1	1						
98DOE-CANN-4105-SW	B809309-25	Water													1										
98DOE-CANN-4106-SD	B809305-10	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4106-SD	B809305-10RE1	Soil									1														
98DOE-CANN-4106-SD	B809305-10RE2	Soil								1															
98DOE-CANN-4107-SW	B809296-02	Water												1		1									
98DOE-CANN-4107-SW	B809309-05	Water													1			1	1						
98DOE-CANN-4107-SW	B809309-05RE1	Water																1	1						
98DOE-CANN-4108-SD	B809305-08	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4108-SD	B809305-08RE1	Soil									1														
98DOE-CANN-4108-SD	B809305-08RE2	Soil								1															
98DOE-CANN-4108-SD	B809310-16	Soil					1																		
98DOE-CANN-4109-SW	B809299-01	Water												1		1									
98DOE-CANN-4109-SW	B809303-18	Water																1	1						
98DOE-CANN-4109-SW	B809303-18RE1	Water																1	1						
98DOE-CANN-4109-SW	B809309-24	Water													1										
98DOE-CANN-4110-SD	B809305-06	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4110-SD	B809305-06RE1	Soil									1														

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-4110-SD	B809305-06RE2	Soil								1															
98DOE-CANN-4125-FS	1341-32	Fish																						1	
98DOE-CANN-4125-FS	P904267-32	Fish																		1	1		1		1
98DOE-CANN-4127-FS	1341-31	Fish																						1	
98DOE-CANN-4127-FS	P904267-31	Fish																		1	1		1		
98DOE-CANN-4130-FS	1341-30	Fish																						1	
98DOE-CANN-4130-FS	P904267-30	Fish																		1	1		1		
98DOE-CANN-4132-FS	1341-29	Fish																						1	
98DOE-CANN-4132-FS	P904267-29	Fish	Orig																	1	1		1		
98DOE-CANN-4132-FS	P904267-29RE1	Fish	Orig																		1				
98DOE-CANN-4146-FS	B809495-07	Fish	Orig																	1	1	1	1		1
98DOE-CANN-4147-FS	B809495-08	Fish	FD																	1	1	1	1		1
98DOE-CANN-4148-FS	1341-28	Fish	FD																					1	
98DOE-CANN-4148-FS	P904267-28	Fish	FD																	1	1		1		
Drill Site D																									
98DOE-DRSD-1037-SW	B809150-02	Water												1		1									
98DOE-DRSD-1037-SW	B809161-01	Water													1			1	1						
98DOE-DRSD-1038-SW	B809149-03	Water												1		1									
98DOE-DRSD-1038-SW	B809161-02	Water													1			1	1						
98DOE-DRSD-1039-SW	B809149-02	Water												1		1									
98DOE-DRSD-1039-SW	B809161-03	Water													1			1	1						
98DOE-DRSD-1040-SW	B809152-03	Water												1		1									
98DOE-DRSD-1040-SW	B809161-04	Water													1			1	1						
98DOE-DRSD-1041-SW	B809152-02	Water												1		1									
98DOE-DRSD-1041-SW	B809161-05	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1042-SW	B809150-03	Water														1									
98DOE-DRSD-1042-SW	B809152-01	Water												1											
98DOE-DRSD-1042-SW	B809161-06	Water													1			1	1						
98DOE-DRSD-1044-SD	B809153-06	Soil				1	1																		
98DOE-DRSD-1044-SD	B809162-03	Soil			1			1	1	1	1														
98DOE-DRSD-1044-SD	B809162-03RE1	Soil								1															
98DOE-DRSD-1045-SD	B809153-05	Soil				1	1																		
98DOE-DRSD-1045-SD	B809162-01	Soil			1			1	1	1	1														
98DOE-DRSD-1045-SD	B809162-01RE1	Soil								1															
98DOE-DRSD-1046-SD	B809153-07	Soil				1	1																		
98DOE-DRSD-1046-SD	B809162-04	Soil			1			1	1	1	1														
98DOE-DRSD-1046-SD	B809162-04RE1	Soil								1															
98DOE-DRSD-1047-SD	B809153-04	Soil				1	1																		
98DOE-DRSD-1047-SD	B809162-02	Soil			1			1	1	1	1														
98DOE-DRSD-1047-SD	B809162-02RE1	Soil								1															
98DOE-DRSD-1048-SD	B809153-08	Soil				1	1																		
98DOE-DRSD-1048-SD	B809162-05	Soil			1			1	1	1	1														
98DOE-DRSD-1048-SD	B809162-05RE1	Soil								1															
98DOE-DRSD-1049-SD	B809256-04	Soil				1																			
98DOE-DRSD-1049-SD	B809258-01	Soil			1			1		1	1														
98DOE-DRSD-1050-SD	B809256-05	Soil				1																			
98DOE-DRSD-1050-SD	B809258-02	Soil			1			1	1	1	1														
98DOE-DRSD-1051-SD	B809256-01	Soil	Orig			1																			
98DOE-DRSD-1051-SD	B809258-03	Soil	Orig		1			1		1	1														
98DOE-DRSD-1052-SD	B809256-03	Soil	FD			1																			

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1052-SD	B809258-05	Soil	FD		1			1		1	1														
98DOE-DRSD-1053-SD	B809256-02	Soil				1																			
98DOE-DRSD-1053-SD	B809258-04	Soil			1			1		1	1														
98DOE-DRSD-1069-SD	B809303-09	Soil			1			1		1	1														
98DOE-DRSD-1069-SD	B809310-04	Soil				1																			
98DOE-DRSD-1070-SD	B809303-06	Soil			1			1	1	1	1														
98DOE-DRSD-1070-SD	B809310-03	Soil				1																			
98DOE-DRSD-1071-SD	B809303-05	Soil			1			1	1	1	1														
98DOE-DRSD-1071-SD	B809310-02	Soil				1																			
98DOE-DRSD-1072-SD	B809303-10	Soil			1			1		1	1														
98DOE-DRSD-1072-SD	B809310-06	Soil				1																			
98DOE-DRSD-1073-SD	B809303-08	Soil			1			1	1	1	1														
98DOE-DRSD-1073-SD	B809310-09	Soil				1																			
98DOE-DRSD-1074-SD	B809303-07	Soil			1			1	1	1	1														
98DOE-DRSD-1074-SD	B809310-08	Soil				1																			
98DOE-DRSD-1075-RB	B809298-03	Water												1											
98DOE-DRSD-1075-RB	B809301-03	Water														1									
98DOE-DRSD-1075-RB	B809303-02	Water																1	1						
98DOE-DRSD-1079-SW	B809296-01	Water												1		1									
98DOE-DRSD-1079-SW	B809309-19	Water													1			1	1						
98DOE-DRSD-1079-SW	B809309-19RE1	Water																	1						
98DOE-DRSD-1080-SW	B809300-02	Water	Orig											1		1									
98DOE-DRSD-1080-SW	B809309-06	Water	Orig												1			1	1						
98DOE-DRSD-1080-SW	B809309-06RE1	Water	Orig															1	1						
98DOE-DRSD-1081-SW	B809300-01	Water	FD											1		1									

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1081-SW	B809309-11	Water	FD												1			1	1						
98DOE-DRSD-1081-SW	B809309-11RE1	Water	FD																1						
98DOE-DRSD-1082-SW	B809297-02	Water												1											
98DOE-DRSD-1082-SW	B809300-03	Water														1									
98DOE-DRSD-1082-SW	B809309-04	Water													1			1	1						
98DOE-DRSD-1082-SW	B809309-04RE1	Water																1	1						
98DOE-DRSD-1083-SW	B809302-03	Water												1		1									
98DOE-DRSD-1083-SW	B809309-01	Water													1			1	1						
98DOE-DRSD-1083-SW	B809309-01RE1	Water																1	1						
98DOE-DRSD-1084-SW	B809304-01	Water												1		1									
98DOE-DRSD-1084-SW	B809309-03	Water													1			1	1						
98DOE-DRSD-1084-SW	B809309-03RE1	Water																1	1						
98DOE-DRSD-1085-SW	B809302-01	Water												1											
98DOE-DRSD-1085-SW	B809304-02	Water														1									
98DOE-DRSD-1085-SW	B809309-18	Water													1			1	1						
98DOE-DRSD-1085-SW	B809309-18RE1	Water																	1						
98DOE-DRSD-1086-SD	B809305-03	Soil			1			1		1	1														
98DOE-DRSD-1086-SD	B809305-03RE1	Soil									1														
98DOE-DRSD-1086-SD	B809305-03RE2	Soil								1															
98DOE-DRSD-1086-SD	B809310-12	Soil					1																		
98DOE-DRSD-1087-SD	B809305-05	Soil			1			1		1	1														
98DOE-DRSD-1087-SD	B809305-05RE1	Soil									1														
98DOE-DRSD-1087-SD	B809305-05RE2	Soil								1															
98DOE-DRSD-1087-SD	B809310-11	Soil					1																		
98DOE-DRSD-1088-SD	B809305-02	Soil			1			1		1	1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1088-SD	B809305-02RE1	Soil									1														
98DOE-DRSD-1088-SD	B809305-02RE2	Soil								1															
98DOE-DRSD-1088-SD	B809310-15	Soil					1																		
98DOE-DRSD-1089-SD	B809305-04	Soil			1			1		1	1														
98DOE-DRSD-1089-SD	B809305-04RE1	Soil									1														
98DOE-DRSD-1089-SD	B809305-04RE2	Soil								1															
98DOE-DRSD-1089-SD	B809310-14	Soil					1																		
98DOE-DRSD-1090-SD	B809305-01	Soil			1			1		1	1														
98DOE-DRSD-1090-SD	B809305-01RE1	Soil									1														
98DOE-DRSD-1090-SD	B809305-01RE2	Soil								1															
98DOE-DRSD-1090-SD	B809310-13	Soil					1																		
98DOE-DRSD-1091-SD	B809375-13	Soil			1			1		1	1														
98DOE-DRSD-1091-SD	B809375-13RE1	Soil							1	1															
98DOE-DRSD-1091-SD	B809375-13RE2	Soil									1														
98DOE-DRSD-1091-SD	B809421-11	Soil				1																			
98DOE-DRSD-1092-SD	B809375-12	Soil			1			1	1	1	1														
98DOE-DRSD-1092-SD	B809375-12RE2	Soil								1	1														
98DOE-DRSD-1092-SD	B809421-12	Soil				1																			
98DOE-DRSD-1093-SD	B809375-06	Soil			1			1	1	1	1														
98DOE-DRSD-1093-SD	B809375-06RE1	Soil								1															
98DOE-DRSD-1093-SD	B809375-06RE2	Soil									1														
98DOE-DRSD-1093-SD	B809421-13	Soil				1																			
98DOE-DRSD-1094-SD	B809375-09	Soil			1			1		1	1														
98DOE-DRSD-1094-SD	B809375-09RE1	Soil								1															
98DOE-DRSD-1094-SD	B809375-09RE2	Soil									1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1094-SD	B809421-16	Soil				1																			
98DOE-DRSD-1095-SD	B809375-07	Soil			1			1		1	1														
98DOE-DRSD-1095-SD	B809375-07RE1	Soil								1															
98DOE-DRSD-1095-SD	B809375-07RE2	Soil									1														
98DOE-DRSD-1095-SD	B809421-14	Soil				1																			
98DOE-DRSD-1096-SD	B809375-08	Soil			1			1		1	1														
98DOE-DRSD-1096-SD	B809375-08RE1	Soil								1															
98DOE-DRSD-1096-SD	B809375-08RE2	Soil									1														
98DOE-DRSD-1096-SD	B809421-10	Soil				1																			
98DOE-DRSD-1097-SD	B809375-11	Soil			1			1	1	1	1														
98DOE-DRSD-1097-SD	B809375-11RE1	Soil								1															
98DOE-DRSD-1097-SD	B809375-11RE2	Soil									1														
98DOE-DRSD-1097-SD	B809421-09	Soil				1																			
98DOE-DRSD-1098-SD	B809375-14	Soil			1			1		1	1														
98DOE-DRSD-1098-SD	B809375-14RE1	Soil								1															
98DOE-DRSD-1098-SD	B809375-14RE2	Soil									1														
98DOE-DRSD-1098-SD	B809421-17	Soil				1																			
98DOE-DRSD-1099-SD	B809375-10	Soil			1			1	1	1	1														
98DOE-DRSD-1099-SD	B809375-10RE1	Soil								1															
98DOE-DRSD-1099-SD	B809375-10RE2	Soil									1														
98DOE-DRSD-1099-SD	B809421-07	Soil				1																			
98DOE-DRSD-3001-SD	B809105-13	Soil				1																			
98DOE-DRSD-3001-SD	B809115-08	Soil			1			1		1	1	1	1												
98DOE-DRSD-3001-SW	B809110-01	Water												1		1									
98DOE-DRSD-3001-SW	B809111-04	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-3002-SD	B809105-16	Soil				1																			
98DOE-DRSD-3002-SD	B809115-07	Soil			1			1		1	1	1	1												
98DOE-DRSD-3002-SW	B809110-03	Water												1		1									
98DOE-DRSD-3002-SW	B809111-01	Water													1			1	1						
98DOE-DRSD-3003-SD	B809105-14	Soil				1																			
98DOE-DRSD-3003-SD	B809115-09	Soil			1			1		1	1	1	1												
98DOE-DRSD-3003-SW	B809109-03	Water												1		1									
98DOE-DRSD-3003-SW	B809111-02	Water													1			1	1						
98DOE-DRSD-3004-SD	B809105-15	Soil				1																			
98DOE-DRSD-3004-SD	B809115-10	Soil			1			1		1	1	1	1												
98DOE-DRSD-3004-SW	B809110-02	Water												1		1									
98DOE-DRSD-3004-SW	B809111-05	Water													1			1	1						
98DOE-DRSD-3005-SD	B809115-11	Soil			1			1		1	1	1	1												
98DOE-DRSD-3005-SW	B809109-02	Water												1		1									
98DOE-DRSD-3005-SW	B809111-03	Water													1			1	1						
98DOE-DRSD-3006-F1	1341-10	Fish																						1	
98DOE-DRSD-3006-F1	P904267-10	Fish																		1	1		1		
98DOE-DRSD-3007-F1	1341-9	Fish																						1	
98DOE-DRSD-3007-F1	P904267-09	Fish																			1		1		
98DOE-DRSD-3007-F1	P904267-09RE1	Fish																		1					
Drill Site E																									
98DOE-DRSE-1116-SW	B809465-02	Water													1										
98DOE-DRSE-1116-SW	B809467-02	Water												1		1									
98DOE-DRSE-1116-SW	B809470-05	Water																1	1						
98DOE-DRSE-1117-SD	B809458-01	Soil				1																			

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSE-1117-SD	B809475-08	Soil			1			1		1	1														
98DOE-DRSE-1118-SW	B809465-01	Water													1										
98DOE-DRSE-1118-SW	B809467-01	Water												1		1									
98DOE-DRSE-1118-SW	B809470-04	Water																1	1						
98DOE-DRSE-1119-SD	B809458-15	Soil				1																			
98DOE-DRSE-1119-SD	B809475-11	Soil			1			1		1	1														
98DOE-DRSE-3032-SD	B809265-03	Soil			1			1		1	1	1	1												
98DOE-DRSE-3032-SW	B809262-01	Water														1		1	1						
98DOE-DRSE-3032-SW	B809265-01	Water												1	1										
98DOE-DRSE-3033-SD	B809265-04	Soil			1			1		1	1	1	1												
98DOE-DRSE-3033-SW	B809262-02	Water																1	1						
98DOE-DRSE-3033-SW	B809265-02	Water												1	1	1									
98DOE-DRSE-3034-SW	B809298-02	Water	Orig											1		1									
98DOE-DRSE-3034-SW	B809303-04	Water	Orig															1	1						
98DOE-DRSE-3034-SW	B809309-22	Water	Orig												1										
98DOE-DRSE-3035-SD	B809303-15	Soil			1			1		1	1	1	1												
98DOE-DRSE-3035-SW	B809298-01	Water	FD											1											
98DOE-DRSE-3035-SW	B809299-02	Water	FD													1									
98DOE-DRSE-3035-SW	B809303-03	Water	FD															1	1						
98DOE-DRSE-3035-SW	B809309-23	Water	FD												1										
98DOE-DRSE-3036-SD	B809303-14	Soil			1			1		1	1	1	1												
98DOE-DRSE-3036-SD	B809310-01	Soil				1	1																		
98DOE-DRSE-3036-SW	B809301-02	Water												1		1									
98DOE-DRSE-3036-SW	B809309-02	Water													1			1	1						
98DOE-DRSE-3036-SW	B809309-02RE1	Water																1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSE-3037-SD	B809303-16	Soil			1			1		1	1	1	1												
98DOE-DRSE-3037-SW	B809301-01	Water												1		1									
98DOE-DRSE-3037-SW	B809303-01	Water																1	1						
98DOE-DRSE-3037-SW	B809309-26	Water													1										
98DOE-DRSE-3039-F1	1341-13	Fish																						1	
98DOE-DRSE-3039-F1	P904267-13	Fish																		1	1		1		
98DOE-DRSE-3040-F1	1341-12	Fish																						1	
98DOE-DRSE-3040-F1	P904267-12	Fish																		1	1		1		
98DOE-DRSE-3042-F1	1341-11	Fish																						1	
98DOE-DRSE-3042-F1	P904267-11	Fish																		1	1		1		
Drill Site F																									
98DOE-DRSF-1023-SW	B809108-04	Water												1		1									
98DOE-DRSF-1023-SW	B809111-09	Water													1			1	1						
98DOE-DRSF-1024-SW	B809109-01	Water												1		1									
98DOE-DRSF-1024-SW	B809111-08	Water													1			1	1						
98DOE-DRSF-1025-SW	B809107-03	Water												1		1									
98DOE-DRSF-1025-SW	B809111-10	Water													1			1	1						
98DOE-DRSF-1026-SD	B809105-02	Soil					1																		
98DOE-DRSF-1026-SD	B809113-08	Soil			1			1		1	1														
98DOE-DRSF-1026-SD	B809113-08RE1	Soil								1															
98DOE-DRSF-1026-SD	B809113-08RE3	Soil								1															
98DOE-DRSF-1027-SD	B809105-04	Soil				1	1																		
98DOE-DRSF-1027-SD	B809113-09	Soil			1			1		1	1														
98DOE-DRSF-1027-SD	B809113-09RE1	Soil								1															
98DOE-DRSF-1027-SD	B809113-09RE3	Soil								1															

Appendix D

Calculations of Naturally Occurring Background Concentrations

Calculation of Naturally Occurring Background Concentrations

D 1.0 Introduction

In support of the 1998 Drill Site Investigation on Amchitka, samples were collected from streams unlikely to have been impacted by known previous human activity. Data from chemical analysis of these background samples are evaluated in this appendix in order to establish naturally-occurring levels of inorganics with which data from project samples can be compared. Such comparisons are necessary to determine whether inorganic concentrations detected in project samples are present in the environment due to human activity or solely as a result of natural processes.

D 2.0 Background Data

Shannon and Wilson, Inc. collected background samples from four reference streams (RS01 – RS04) on Amchitka during the 1998 Drill Site Investigation. Five sediment samples were collected from each stream, and field duplicate sediment samples were collected from RS01 and RS03. Five water samples were also collected from each stream, and a field duplicate water sample was collected from RS04. Fish samples were also collected from each reference stream and analyzed. A total of 14 fish tissue samples were analyzed from the reference streams.

The four reference streams are located in different elevations on Amchitka. Streams RS01 and RS02 drain areas of lower elevation. Streams draining the lowland area of Amchitka have low gradients and velocities. Few gravel or rocky areas are present, and the stream substrate is predominately soft organic muck. Streams RS03 and RS04 drain areas of higher elevation. Streams draining the upland area of Amchitka are typically better developed than lowland streams and have steeper gradients. Many of the streams in the upland area have a bedrock substrate along much of their length. Because the differences between the upland and lowland streams are likely to cause differences in stream chemistry, inorganic results for sediment were compared between upland and lowland streams to determine whether statistically significant differences were present. Similarly, inorganic results for water were compared between upland and lowland streams, and inorganic results for fish tissue samples were compared between upland and lowland streams.

D 2.1 Comparing Upland and Lowland Reference Streams

The upland and lowland stream distributions were compared using the statistical test appropriate for the type of distributions being compared. The Shapiro-Wilk test was used to determine whether distributions were normal, lognormal or nonparametric. T-tests were used to compare normal and lognormal distributions, and Wilcoxon rank sum tests were used for nonparametric distributions. Results of these comparisons were statistically significant (p-value < 0.05) for some of the inorganic chemicals compared in each medium. Because distributions of upland and lowland reference streams were

statistically different for some inorganic chemicals in each medium, background concentrations were analyzed separately for upland and lowland reference streams for each medium.

D 3.0 Calculation of Background Metals Concentrations for Comparison with Project Sample Concentrations

Inorganic concentrations in background samples were used to calculate upper tolerance limits (UTLs) for water, sediment, and fish tissue in both upland and lowland streams. The UTL is defined as the 95% upper confidence limit on the 95th percentile of the distribution of background concentrations. If the distribution of background concentrations was normally distributed, the UTL was calculated using the following formula:

$$UTL = x + ks$$

Where:

x = mean of the background data.
k = one-sided tolerance factor for a specified percentile and sample size
s = standard deviation of the background data

If the distribution of background concentrations was lognormally distributed, the UTL was calculated using the following formula (USEPA, 1989):

$$UTL' = \exp(x' + ks')$$

Where:

exp = constant (base of the natural log)
x' = mean of the log transformed data
k = one-sided tolerance factor for a specified percentile and sample size
s' = standard deviation of the log transformed data

If the distribution of background samples for a metal was nonparametric, the maximum concentration was used as the background concentration because for nonparametric distributions of relatively few samples, the UTL is approximated by the maximum value (USEPA, 1992).

Summary statistics, including UTLs, are shown for sediment, water and fish tissue for upland and lowland reference streams in Tables D-1 through D-6.

For some inorganic chemicals, the fraction of samples with results reported as non-detect exceeded 30%. In these cases, no comparison was made between the upland and lowland streams, and a UTL was not calculated. Instead, the maximum concentration detected in the appropriate group of background samples was used as the background concentration. When 30% or less of the samples were reported as non-detect, the non-detect results were

included in comparisons or calculations, and the value assigned to a non-detect result was equal to one-half the detection limit.

Field duplicates were included in the comparisons and calculations as additional samples.

Two extreme values were excluded from the calculation of the background UTL for manganese in lowland stream sediment. These outlying values were the maximum concentrations of manganese detected in reference or site-related streams, and were excluded from the analysis based on professional judgement.

D 4.0 References

United States Environmental Protection Agency (USEPA), 1989. Statistical analysis of ground-water monitoring data at Resource Conservation and Recovery Act (RCRA) facilities, interim final guidance. Office of Solid Waste. Waste Management Division. PB89151047. Washington. April.

USEPA, 1992. Statistical analysis of ground-water monitoring data at Resource Conservation and Recovery Act (RCRA) facilities, addendum to interim final guidance. Office of Solid Waste. Waste Management Division. Washington. July.

Table D-1
Summary Statistics for Metals in Sediment from Lowland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (mg/kg)	Maximum Detected Conc. (mg/kg)	Sample Mean [a] (mg/kg)	Sample Standard Deviation [b]	K-Statistic [c]	Upper Tolerance Limit [d] (mg/kg)
Aluminum	11	11	14,200	35,000	25,663	7,025	2.815	45,400
Arsenic	11	11	2.48	40.3	9.68 [e]	2.29 [f]	2.815	100 [g]
Barium	10	11	74.1	339	191.90	98.60	2.815	469
Beryllium	0	11	-	-	-	-	-	NC [h]
Boron	2	11	5.42	7.18	-	-	-	NC [i]
Cadmium	1	11	0.608	0.608	-	-	-	NC [i]
Calcium	11	11	1,480	5,860	3,212	1,453	2.815	7,300
Cerium	11	11	5.91	12.6	8.72	1.95	2.815	14.2
Cesium	0	11	-	-	-	-	-	NC [h]
Chromium	11	11	3.4	8.51	6.26	1.97	2.815	11.8
Cobalt	11	11	8.75	35.4	19.82	8.47	2.815	43.7
Copper	11	11	21.5	59.3	38.54	11.57	2.815	71.1
Iron	11	11	10,400	137,000	63,682	32,534	2.815	155,000
Lithium	11	11	6.52	37.8	12.11 [e]	1.64 [f]	2.815	48.8 [g]
Magnesium	11	11	2,690	8,220	5,001	1,535	2.815	9,320
Manganese	9[j]	9[j]	125	14,400	6,449	4.70	3.031	20,700
Molybdenum	3	11	4.1	5.5	-	-	-	NC [i]
Nickel	11	11	3.15	11.6	6.40	2.57	2.815	13.6
Potassium	11	11	183	1,180	619.18	272.50	2.815	1,390
Selenium	4	11	0.951	5.44	-	-	-	NC [i]
Strontium	11	11	36.5	148	71.90	32.66	2.815	164
Thallium	1	11	1	1	-	-	-	NC [i]
Thorium	1	11	0.5	0.5	-	-	-	NC [i]
Titanium	11	11	210	2,130	1,204	643	2.815	3,010
Uranium	3	11	2.11	4.13	-	-	-	NC [i]
Vanadium	11	11	77.6	479	182.91 [e]	1.64 [f]	2.815	734 [g]
Zinc	11	11	45.5	292	90.92 [e]	1.74 [f]	2.815	434 [g]

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=11 (except for manganese, where n=9)
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - Value shown is the geometric mean.
f - Value shown is the geometric standard deviation.
g - UTL is based on a lognormal distribution.
h - UTL was not calculated because the chemical was not detected in background samples.
i - UTL was not calculated due to insufficient number of detections in background samples.
j - Two extreme results were excluded from this analysis.
conc. - concentration
mg/kg - milligrams per kilogram
NC - Not calculated

Table D-2
Summary Statistics for Metals in Sediment from Upland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (mg/kg)	Maximum Detected Conc. (mg/kg)	Sample Mean[a] (mg/kg)	Sample Standard Deviation[b]	K-Statistic[c]	Upper Tolerance Limit[d] (mg/kg)
Aluminum	11	11	7,400	33,100	23,527	8,503	2.815	47500
Arsenic	11	11	0.982	23.6	8.99	7.65	2.815	30.5
Barium	11	11	38.5	232	76.86 [e]	1.90 [f]	2.815	468 [g]
Beryllium	0	11	-	-	-	-	-	NC [h]
Boron	1	11	6.42	6.42	-	-	-	NC [i]
Cadmium	0	11	-	-	-	-	-	NC [h]
Calcium	11	11	2,380	6,510	4,670	1,083	2.815	7720
Cerium	11	11	3.79	10.9	7.76	1.85	2.815	13
Cesium	0	11	-	-	-	-	-	NC [h]
Chromium	11	11	4.62	17.6	9.33	3.39	2.815	18.9
Cobalt	11	11	8.77	27.6	12.94 [e]	1.46 [f]	2.815	37.3 [g]
Copper	11	11	16	57.9	37.85	15.82	2.815	82.4
Iron	11	11	16,000	104,000	50,864	25,631	2.815	123,000
Lithium	10	11	6.2	15.2	10.23	4.07	2.815	21.7
Magnesium	11	11	1,280	12,200	7,793	3,275	2.815	17,000
Manganese	11	11	724	13300	1,845 [e]	2.58 [f]	2.815	26,500 [g]
Molybdenum	0	11	-	-	-	-	-	NC [h]
Nickel	11	11	5.16	17.9	8.74 [e]	1.43 [f]	2.815	23.8 [g]
Potassium	11	11	179	678	309.51 [e]	1.66 [f]	2.815	1,290 [g]
Selenium	7	11	0.536	3.15	-	-	-	NC [i]
Strontium	11	11	17.6	181	68.84	49.17	2.815	207
Thallium	0	11	-	-	-	-	-	NC [h]
Thorium	0	11	-	-	-	-	-	NC [h]
Titanium	11	11	285	1,070	660.64	291.67	2.815	1480
Uranium	0	11	-	-	-	-	-	NC [h]
Vanadium	11	11	47.7	263	127.62	74.05	2.815	336
Zinc	11	11	42.3	162	84.93	35.69	2.815	185

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=11.
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - Value shown is the geometric mean.
f - Value shown is the geometric standard deviation.
g - UTL is based on a lognormal distribution.
h - UTL was not calculated because the chemical was not detected in background samples.
i - UTL was not calculated due to insufficient number of detections in background samples.
conc. - concentration
mg/kg - milligrams per kilogram
NC - Not calculated

Table D-3
Summary Statistics for Metals in Surface Water from Lowland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (ug/L)	Maximum Detected Conc. (ug/L)	Sample Mean [a] (ug/L)	Sample Standard Deviation [b]	K-Statistic [c]	Upper Tolerance Limit [d] (ug/L)
Aluminum	8	10	57.3	175	102.71	56.96	2.911	269
Arsenic	0	10	-	-	-	-	-	NC [e]
Barium	0	10	-	-	-	-	-	NC [e]
Beryllium	0	10	-	-	-	-	-	NC [e]
Boron	0	10	-	-	-	-	-	NC [e]
Cadmium	0	10	-	-	-	-	-	NC [e]
Calcium	10	10	1,110	4,320	2,500	1,310	-	4,320 [f]
Cerium	0	10	-	-	-	-	-	NC [e]
Cesium	0	10	-	-	-	-	-	NC [e]
Chromium	2	10	1.78	2.25	-	-	-	NC [g]
Cobalt	8	10	1.15	2.44	1.4	0.661	2.911	3.35
Copper	8	10	1.11	5.29	1.4 [h]	2.02 [i]	2.911	10.8 [j]
Iron	10	10	315	877	581	141	2.911	993
Lithium	1	10	1.17	1.17	-	-	-	NC [g]
Magnesium	10	10	1,510	4,690	2,749	1,280	-	4,690 [f]
Manganese	10	10	5.34	86	16.76 [h]	2.59 [i]	2.911	267 [j]
Molybdenum	0	10	-	-	-	-	-	NC [e]
Nickel	0	10	-	-	-	-	-	NC [e]
Potassium	10	10	264	2,250	886.6	596.6	2.911	2,620
Selenium	0	10	-	-	-	-	-	NC [e]
Strontium	10	10	11.2	30.8	17.11	6.51	2.911	36.1
Thallium	2	10	3.02	7.07	-	-	-	NC [g]
Thorium	0	10	-	-	-	-	-	NC [e]
Titanium	10	10	1.31	4.34	2.837	1.13	2.911	6.13
Uranium	0	10	-	-	-	-	-	NC [e]
Vanadium	5	10	1.09	4.43	-	-	-	NC [g]
Zinc	1	10	50.3	50.3	-	-	-	NC [g]

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=10.
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - UTL was not calculated because the chemical was not detected in background samples.
f - The maximum detected concentration was used as the UTL for nonparametric distributions.
g - UTL was not calculated due to insufficient number of detections in background samples.
h - Value shown is the geometric mean.
i - Value shown is the geometric standard deviation.
j - UTL is based on a lognormal distribution.
conc. - concentration
ug/L -micrograms per liter
NC - Not calculated

Table D-4
Summary Statistics for Metals in Surface Water from Upland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (ug/L)	Maximum Detected Conc. (ug/L)	Sample Mean [a] (ug/L)	Sample Standard Deviation [b]	K-Statistic [c]	Upper Tolerance Limit [d] (ug/L)
Aluminum	3	11	50.5	87.1	-	-	-	NC [e]
Arsenic	0	11	-	-	-	-	-	NC [f]
Barium	0	11	-	-	-	-	-	NC [f]
Beryllium	0	11	-	-	-	-	-	NC [f]
Boron	0	11	-	-	-	-	-	NC [f]
Cadmium	0	11	-	-	-	-	-	NC [f]
Calcium	11	11	4,460	8,810	6,887	1,838	-	8,810 [g]
Cerium	0	11	-	-	-	-	-	NC [f]
Cesium	0	11	-	-	-	-	-	NC [f]
Chromium	5	11	1.54	3.49	-	-	-	NC [e]
Cobalt	9	11	3.63	7.67	3.86	2.01	2.815	9.52
Copper	5	11	1.09	13.4	-	-	-	NC [e]
Iron	5	11	208	2,830	-	-	-	NC [e]
Lithium	0	11	-	-	-	-	-	NC [f]
Magnesium	11	11	2,740	4,670	3,528	611.5	2.815	5,250
Manganese	11	11	1.3	353	15.05 [h]	4.01 [i]	2.815	748 [j]
Molybdenum	0	11	-	-	-	-	-	NC [f]
Nickel	5	11	1.07	1.69	-	-	-	NC [e]
Potassium	11	11	742	1,190	851	125	-	1,190 [g]
Selenium	0	11	-	-	-	-	-	NC [f]
Strontium	11	11	32.9	44.1	40.9	3.53	-	44.1 [g]
Thallium	1	11	2.13	2.13	-	-	-	NC [e]
Thorium	1	11	1.14	1.14	-	-	-	NC [e]
Titanium	6	11	1.04	2.37	-	-	-	NC [e]
Uranium	0	11	-	-	-	-	-	NC [f]
Vanadium	2	11	1.34	1.44	-	-	-	NC [e]
Zinc	4	11	11.5	12.8	-	-	-	NC [e]

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=11.
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - UTL was not calculated due to insufficient number of detections in background samples.
f - UTL was not calculated because the chemical was not detected in background samples.
g - The maximum detected concentration was used as the UTL for nonparametric distributions.
h - Value shown is the geometric mean.
i - Value shown is the geometric standard deviation.
j - UTL is based on a lognormal distribution.
conc. - concentration
ug/L -micrograms per liter
NC - Not calculated

Table D-5
Summary Statistics for Metals in Fish Tissue for Lowland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (mg/kg)	Maximum Detected Conc. (mg/kg)	Sample Mean [a] (mg/kg)	Sample Standard Deviation [b]	K-Statistic [c]	Upper Tolerance Limit [d] (mg/kg)
Aluminum	7	7	17.5	112	35.9 [e]	2.14 [f]	3.401	475 [g]
Arsenic (total)	6	7	0.0293	0.0795	0.0469	0.0234	3.401	0.127
Arsenic (inorganic)	7	7	0.0008	0.0117	0.00658	0.00418	3.401	0.0208
Barium	7	7	0.191	0.642	0.372	0.193	3.401	1.03
Beryllium	0	7	-	-	-	-	-	- [h]
Boron	7	7	7.27	21.7	12.1	4.84	3.401	28.6
Cadmium	1	7	0.037	0.037	-	-	3.401	NC [i]
Calcium	7	7	710	11,900	6,630	3,680	3.401	19,200
Cerium	1	7	0.028	0.028	-	-	-	NC [i]
Cesium	1	7	0.026	0.026	-	-	-	NC [i]
Chromium	5	7	0.321	0.58	0.312	0.212	3.401	1.03
Cobalt	3	7	0.055	0.078	-	-	-	NC [i]
Copper	7	7	0.0794	1.2	0.956	0.395	-	1.2 [j]
Iron	7	7	27.3	166	96.4	62.8	3.401	310
Lithium	2	7	0.034	0.0993	-	-	-	NC [i]
Magnesium	7	7	275	358	312	28	3.401	408
Manganese	7	7	3.4	23.8	10.1 [e]	2.25 [f]	3.401	160 [g]
›lybdenum	1	7	0.173	0.173	-	-	-	NC [i]
.ckel	0	7	-	-	-	-	-	NC [h]
Potassium	7	7	370	4,780	3,360	1,420	-	4,780 [j]
Selenium	7	7	0.366	0.675	0.575	0.106	3.401	0.94
Strontium	7	7	6.74	16.8	10.6	3.38	3.401	22.1
Thallium	1	7	0.028	0.028	-	-	-	NC [i]
Thorium	2	7	2.68	3.43	-	-	-	NC [i]
Titanium	7	7	0.385	5.22	1.17 [e]	2.65 [f]	3.401	32.1 [g]
Uranium	0	7	-	-	-	-	-	NC [h]
Vanadium	7	7	0.164	0.657	0.367	0.201	3.401	1.05
Zinc	7	7	28.2	38.8	35.1	4.05	3.401	48.8

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=7.
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - Value shown is the geometric mean.
f - Value shown is the geometric standard deviation.
g - UTL is based on a lognormal distribution.
h - UTL was not calculated because the chemical was not detected in background samples.
i - UTL was not calculated due to insufficient number of detections in background samples.
 'he maximum detected concentration was used as the UTL for nonparametric distributions.
 .ic. - concentration
mg/kg - milligrams per kilogram
NC - Not calculated

Table D-6
Summary Statistics for Metals in Fish Tissue for Upland Background Streams

Analyte	Number of Detections	Number of Samples	Minimum Detected Conc. (mg/kg)	Maximum Detected Conc. (mg/kg)	Sample Mean[a] (mg/kg)	Sample Standard Deviation[b]	K-Statistic[c]	Upper Tolerance Limit[d] (mg/kg)
Aluminum	7	7	6.93	28.3	15.3	6.91	3.401	38.8
Arsenic (total)	6	7	0.049	1.12	0.109 [e]	5.05 [f]	3.401	26.9 [g]
Arsenic (inorganic)	7	7	0.0006	0.0122	0.00201 [e]	2.504 [f]	3.401	0.0456 [g]
Barium	7	7	0.0718	0.343	0.22	0.102	3.401	0.567
Beryllium	0	7	-	-	-	-	-	NC [h]
Boron	7	7	7.65	16.4	12.4	3.45	3.401	24.1
Cadmium	0	7	-	-	-	-	-	NC [h]
Calcium	7	7	3,700	7,250	5,810	1,330	3.401	10,300
Cerium	0	7	-	-	-	-	-	NC [h]
Cesium	7	7	-	-	-	-	-	NC [h]
Chromium	7	7	0.266	0.538	0.364	0.094	3.401	0.68
Cobalt	1	7	0.051	0.051	-	-	-	NC [i]
Copper	7	7	0.0696	2.43	0.917	0.73	3.401	3.4
Iron	7	7	16	50.8	30.6	12.7	3.401	73.6
Lithium	0	7	-	-	-	-	-	NC [h]
Magnesium	7	7	268	313	285	19	3.401	349
Manganese	7	7	1.09	32.2	4.57 [e]	2.86 [f]	3.401	164 [g]
'ybdenum	2	7	0.125	0.15	-	-	-	NC [i]
..kel	0	7	-	-	-	-	-	NC [h]
Potassium	7	7	3,230	3,850	3,560	221	3.401	4,310
Selenium	7	7	0.248	1.44	0.669	0.414	3.401	2.08
Strontium	7	7	5.02	12.1	9.24	2.95	-	12.1 [j]
Thallium	3	7	0.0258	0.0755	-	-	-	NC [i]
Thorium	3	7	2.93	4.67	-	-	-	NC [i]
Titanium	7	7	0.212	0.537	0.423	0.121	3.401	0.83
Uranium	0	7	-	-	-	-	-	NC [h]
Vanadium	7	7	0.12	0.209	0.179	0.032	3.401	0.289
Zinc	7	7	23.1	56.7	36.9	12.1	3.401	78

Notes:
a - Mean values are from normal distributions unless otherwise noted.
b - Standard deviations are from normal distributions unless otherwise noted.
c - K-statistics were based on the 95% confidence limit on the 95th percentile and n=7.
d - Upper tolerance limits (UTLs) are for normal distributions unless otherwise noted.
e - Value shown is the geometric mean.
f - Value shown is the geometric standard deviation.
g - UTL is based on a lognormal distribution.
h - UTL was not calculated because the chemical was not detected in background samples.
i - UTL was not calculated due to insufficient number of detections in background samples.
he maximum detected concentration was used as the UTL for nonparametric distributions.
..c. - concentration
..ng/kg - milligrams per kilogram
NC - Not calculated

Appendix E

Electronic Laboratory Data Files
(included only in some copies of this report)

NOTES FOR APPENDICES E and G

Appendix E to the *Amchitka Army Air Base Phase II RI Site Characterization Report* consists of an electronic ("disk") file in Microsoft Excel 97 presenting the laboratory results for all samples analyzed by the project laboratories. Appendix E is a hard copy printout of the same data presented in the electronic file. **Users of the electronic file are cautioned that executing a "print" command will result in printing a large number of sheets of paper.** The following information is presented for every sample and analysis:

- Project sample number ("Sample Number")
- Laboratory sample number ("Lab Sample ID")
- Reported result
- Qualifier flags assigned based on data review by Shannon & Wilson, Inc.
- Laboratory reporting limit (this is the reporting limit that was achieved, taking into account dilutions and interferences, not the method detection limit)

The primary purpose of these appendices is to provide the laboratory reporting limits for all analytes for every sample. The tables presented in Section 4.0 of the *1998 Drill Site Characterization Report* contain all analytes that were detected in the samples.

Separate tables are presented for each analytical method (or group of methods), and for "soil", "water", and "fish" matrices. Each table within this appendix is page-numbered separately according to the following list. In both the electronic and hard copy versions, sample numbers are presented as rows, and analytes are presented as columns. Page numbers increase with increasing sample number, with continuation sheets for additional analytes. For tables that contain several pages of analytes, the first analyte (ordered alphabetically, with numbers appearing first) on each group of pages is also indicated below.

Samples have been sorted by the second four-character group in the project sample number, which generally distinguishes the site at which the sample was collected (the reader is referred to the discussion of the sample numbering scheme presented in Section 2.2.5 of the *1998 Drill Site Characterization Report*).

All of the data for a given analysis or group of analyses are contained in a single file. Soil, water, and fish results are contained in different "sheets" within the file. Sheet names are listed in the table of contents below.

Table	Page Numbering	Sheet in Electronic File
Petroleum Hydrocarbons in Sediment	A-1 through A-4	hydrocarbons sediment
Petroleum Hydrocarbons in Surface Water	B-1 through B-3	hydrocarbons water

Volatile Organic Compounds in Sediment	C-1 through C-66	VOCs sediment
1,1,1,2-Tetrachloroethane	C-1	
1,1-Dichloropropene	C-7	
1,2-Dibromoethane	C-13	
1,3-Dichloropropane	C-19	
4-Chlorotoluene	C-25	
Bromodichloromethane	C-31	
Chloroethane	C-37	
Dibromomethane	C-43	
Methylene Chloride	C-49	
sec-Butylbenzene	C-55	
trans-1,3-Dichloropropene	C-61	
Volatile Organic Compounds in Surface Water	D-1 through D-24	VOCs water
1,1,1,2-Tetrachloroethane	D-1	
1,2,3-Trichloropropane	D-4	
1,3,5-Trimethylbenzene	D-7	
4-Chlorotoluene	D-10	
Bromomethane	D-13	
cis-1,3-Dichloropropene	D-16	
Methylene Chloride	D-19	
tert-Butylbenzene	D-22	
Polycyclic Aromatic Hydrocarbons in Sediment	E-1 through E-10	PAHs sediment
Acenaphthene	E-1	
Chrysene	E-6	
Polycyclic Aromatic Hydrocarbons in Surface Water	F-1 through F-6	PAHs water
Acenaphthene	F-1	
Chrysene	F-4	
Polycyclic Aromatic Hydrocarbons in Fish	G-1 through G-4	PAHs fish
Acenaphthene	G-1	
Chrysene	G-3	
Polychlorinated Biphenyls in Sediment	H-1 through H-2	PCBs sediment
Polychlorinated Biphenyls in Surface Water	I-1	PCBs water
Polychlorinated Biphenyls in Fish	J-1 through J-2	PCBs fish
Metals in Sediment	K-1 through K-30	metals sediment
Aluminum	K-1	
Chromium	K-11	
Potassium	K-21	

Metals in Water	L-1 through L-15	metals water
Aluminum	L-1	
Chromium	L-6	
Potassium	L-11	
Metals in Fish	M-1 through M-9	metals fish
Aluminum	M-1	
Chromium	M-4	
Nickel	M-7	
Total Organic Carbon in Sediment	N-1 through N-2	TOC sediment
Acid Volatile Sulfide and Simultaneously Extracted Metals in Sediment	O-1 through O-3	AVS-SEM sed
Fish Lipids	P-1	lipids fish
Radionuclides in Fish	not numbered	not in electronic file

(Radionuclide results were not included in Shannon & Wilson's QC data review.)

Laboratory sample numbers with a suffix containing the letter "R" indicate that the sample was reanalyzed.

Results are presented as a number if the analyte was detected, or as "ND" followed by the reporting limit (in parentheses). Results are followed by a letter flag, if applicable. For instance, in the example:

ND(100) U

The "ND" indicates that the analyte was not detected.

The "(100)" indicates that the laboratory reporting limit was 100 (units are presented in the heading of each table).

The result was flagged "U" (not detected) by Shannon & Wilson (see Appendix C for a description of the flagging conventions), and

In the example:

20.6 J

The "20.6" is the laboratory-reported value (units are presented in the heading of each table), and

The result was flagged "J" (estimated) by Shannon & Wilson (see Appendix C for a description of the flagging conventions).

A blank cell:

indicates that the sample was not analyzed for that parameter or analyte.

Data Qualifier Flags Used in this Appendix:

B	analyte present in analytical method blank
J	estimated concentration
R	rejected value
U	analyte undetected
UJ	undetected, estimated concentration

List of Trip Blanks

Trip blanks appear in the tables of laboratory data in this appendix. The following list should be referred to for identification of trip blanks.

Matrix	Lab Sample ID	Sample Number	Analytical Method
water	98DOE-MILR-1000-TB	B809034-08	EPA 8260B
water	98DOE-TB07-0000-SW	B809161-16	EPA 8260B
water	Trip Blank	B809111-15	EPA 8260B
water	TRIP BLANK	B809309-28	EPA 8260B
water	Trip Blank	B809385-10	EPA 8260B
water	Trip Blank	B809465-06	EPA 8260B
water	Trip Blank-100	B809265-05	EPA 8260B
water	Trip Blank-28	B809165-10	EPA 8260B
soil	98DOE-TB02-0000-TB	B809041-06	EPA 8260B/5030
soil	High/low level trip blank	B809458-16	EPA 8260B/5030
soil	TB-101	B809256-06	EPA 8260B/5030
soil	98DOE-TB-100	B809153-09	EPA 8260B/5035
soil	98DOE-TB02-0000-TB	B809041-06	EPA 8260B/5035
soil	Trip Blank	B809105-19	EPA 8260B/5035

Appendix F

Triad Analysis Report

Prepared by IT Corporation

Triad Analysis of Drill Site and Test Site Stream Sediments

Amchitka Island, Alaska

September 1999

TRIAD ANALYSIS OF DRILL SITE AND TEST SITE STREAM SEDIMENTS

AMCHITKA ISLAND, ALASKA

Prepared for
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Las Vegas, Nevada

Prepared by
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September 1999

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List of Acronyms and Abbreviations

DRO	Diesel-range organics
PAH	Polyclyclic aromatic hydrocarbons
EPT	Ephermeroptera-Plecoptera-Trichoptera
RTR	Ratio-to-Reference
COPCs	Contaminant(s) of Potential Concern
TOC	Total organic carbon
ppm	Part(s) per million
QSAR	Quantitative structure-activity relationship(s)
LC_{50}	Concentration lethal to 50 percent of the test organisms
ASTM	American Society for Testing and Materials
°C	Degree(s) Celsius
mg	Milligram(s)
hr	Hour(s)
EPA	Environmental Protection Agency
ml	Milliliter(s)
mg/L	Milligram(s) per liter
mm	Millimeter(s)
mmol/kg	Millimole(s) per kilogram
FBI	Family Biotic Index
mg/kg	Milligram(s) per kilogram
AVS	Acid Volatile Sulfide(s)
SEM	Simultaneously extracted metals
%OC	Percent organic carbon
PCA	Principal Component Analysis

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-4103-SW	B809309-12RE1	Water																	1						
98DOE-CANN-4104-SD	B809305-09	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4104-SD	B809305-09RE1	Soil									1														
98DOE-CANN-4104-SD	B809305-09RE2	Soil								1															
98DOE-CANN-4105-SW	B809296-03	Water												1											
98DOE-CANN-4105-SW	B809297-03	Water														1									
98DOE-CANN-4105-SW	B809303-17	Water																1	1						
98DOE-CANN-4105-SW	B809303-17RE1	Water																1	1						
98DOE-CANN-4105-SW	B809309-25	Water													1										
98DOE-CANN-4106-SD	B809305-10	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4106-SD	B809305-10RE1	Soil									1														
98DOE-CANN-4106-SD	B809305-10RE2	Soil								1															
98DOE-CANN-4107-SW	B809296-02	Water												1		1									
98DOE-CANN-4107-SW	B809309-05	Water													1			1	1						
98DOE-CANN-4107-SW	B809309-05RE1	Water																1	1						
98DOE-CANN-4108-SD	B809305-08	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4108-SD	B809305-08RE1	Soil									1														
98DOE-CANN-4108-SD	B809305-08RE2	Soil								1															
98DOE-CANN-4108-SD	B809310-16	Soil					1																		
98DOE-CANN-4109-SW	B809299-01	Water												1		1									
98DOE-CANN-4109-SW	B809303-18	Water																1	1						
98DOE-CANN-4109-SW	B809303-18RE1	Water																1	1						
98DOE-CANN-4109-SW	B809309-24	Water													1										
98DOE-CANN-4110-SD	B809305-06	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4110-SD	B809305-06RE1	Soil									1														

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-4110-SD	B809305-06RE2	Soil								1															
98DOE-CANN-4125-FS	1341-32	Fish																						1	
98DOE-CANN-4125-FS	P904267-32	Fish																		1	1		1		1
98DOE-CANN-4127-FS	1341-31	Fish																						1	
98DOE-CANN-4127-FS	P904267-31	Fish																		1	1		1		
98DOE-CANN-4130-FS	1341-30	Fish																						1	
98DOE-CANN-4130-FS	P904267-30	Fish																		1	1		1		
98DOE-CANN-4132-FS	1341-29	Fish																						1	
98DOE-CANN-4132-FS	P904267-29	Fish	Orig																	1	1		1		
98DOE-CANN-4132-FS	P904267-29RE1	Fish	Orig																		1				
98DOE-CANN-4146-FS	B809495-07	Fish	Orig																	1	1	1	1		1
98DOE-CANN-4147-FS	B809495-08	Fish	FD																	1	1	1	1		1
98DOE-CANN-4148-FS	1341-28	Fish	FD																					1	
98DOE-CANN-4148-FS	P904267-28	Fish	FD																	1	1		1		
Drill Site D																									
98DOE-DRSD-1037-SW	B809150-02	Water												1		1									
98DOE-DRSD-1037-SW	B809161-01	Water													1			1	1						
98DOE-DRSD-1038-SW	B809149-03	Water												1		1									
98DOE-DRSD-1038-SW	B809161-02	Water													1			1	1						
98DOE-DRSD-1039-SW	B809149-02	Water												1		1									
98DOE-DRSD-1039-SW	B809161-03	Water													1			1	1						
98DOE-DRSD-1040-SW	B809152-03	Water												1		1									
98DOE-DRSD-1040-SW	B809161-04	Water													1			1	1						
98DOE-DRSD-1041-SW	B809152-02	Water												1		1									
98DOE-DRSD-1041-SW	B809161-05	Water													1			1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1042-SW	B809150-03	Water														1									
98DOE-DRSD-1042-SW	B809152-01	Water												1											
98DOE-DRSD-1042-SW	B809161-06	Water													1			1	1						
98DOE-DRSD-1044-SD	B809153-06	Soil				1	1																		
98DOE-DRSD-1044-SD	B809162-03	Soil			1			1	1	1	1														
98DOE-DRSD-1044-SD	B809162-03RE1	Soil								1															
98DOE-DRSD-1045-SD	B809153-05	Soil				1	1																		
98DOE-DRSD-1045-SD	B809162-01	Soil			1			1	1	1	1														
98DOE-DRSD-1045-SD	B809162-01RE1	Soil								1															
98DOE-DRSD-1046-SD	B809153-07	Soil				1	1																		
98DOE-DRSD-1046-SD	B809162-04	Soil			1			1	1	1	1														
98DOE-DRSD-1046-SD	B809162-04RE1	Soil								1															
98DOE-DRSD-1047-SD	B809153-04	Soil				1	1																		
98DOE-DRSD-1047-SD	B809162-02	Soil			1			1	1	1	1														
98DOE-DRSD-1047-SD	B809162-02RE1	Soil								1															
98DOE-DRSD-1048-SD	B809153-08	Soil				1	1																		
98DOE-DRSD-1048-SD	B809162-05	Soil			1			1	1	1	1														
98DOE-DRSD-1048-SD	B809162-05RE1	Soil								1															
98DOE-DRSD-1049-SD	B809256-04	Soil				1																			
98DOE-DRSD-1049-SD	B809258-01	Soil			1			1		1	1														
98DOE-DRSD-1050-SD	B809256-05	Soil				1																			
98DOE-DRSD-1050-SD	B809258-02	Soil			1			1	1	1	1														
98DOE-DRSD-1051-SD	B809256-01	Soil	Orig			1																			
98DOE-DRSD-1051-SD	B809258-03	Soil	Orig		1			1		1	1														
98DOE-DRSD-1052-SD	B809256-03	Soil	FD			1																			

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1052-SD	B809258-05	Soil	FD		1			1		1	1														
98DOE-DRSD-1053-SD	B809256-02	Soil				1																			
98DOE-DRSD-1053-SD	B809258-04	Soil			1			1		1	1														
98DOE-DRSD-1069-SD	B809303-09	Soil			1			1		1	1														
98DOE-DRSD-1069-SD	B809310-04	Soil				1																			
98DOE-DRSD-1070-SD	B809303-06	Soil			1			1	1	1	1														
98DOE-DRSD-1070-SD	B809310-03	Soil				1																			
98DOE-DRSD-1071-SD	B809303-05	Soil			1			1	1	1	1														
98DOE-DRSD-1071-SD	B809310-02	Soil				1																			
98DOE-DRSD-1072-SD	B809303-10	Soil			1			1		1	1														
98DOE-DRSD-1072-SD	B809310-06	Soil				1																			
98DOE-DRSD-1073-SD	B809303-08	Soil			1			1	1	1	1														
98DOE-DRSD-1073-SD	B809310-09	Soil				1																			
98DOE-DRSD-1074-SD	B809303-07	Soil			1			1	1	1	1														
98DOE-DRSD-1074-SD	B809310-08	Soil				1																			
98DOE-DRSD-1075-RB	B809298-03	Water												1											
98DOE-DRSD-1075-RB	B809301-03	Water														1									
98DOE-DRSD-1075-RB	B809303-02	Water																1	1						
98DOE-DRSD-1079-SW	B809296-01	Water												1		1									
98DOE-DRSD-1079-SW	B809309-19	Water													1			1	1						
98DOE-DRSD-1079-SW	B809309-19RE1	Water																	1						
98DOE-DRSD-1080-SW	B809300-02	Water	Orig											1		1									
98DOE-DRSD-1080-SW	B809309-06	Water	Orig												1			1	1						
98DOE-DRSD-1080-SW	B809309-06RE1	Water	Orig															1	1						
98DOE-DRSD-1081-SW	B809300-01	Water	FD											1		1									

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1081-SW	B809309-11	Water	FD												1			1	1						
98DOE-DRSD-1081-SW	B809309-11RE1	Water	FD																1						
98DOE-DRSD-1082-SW	B809297-02	Water												1											
98DOE-DRSD-1082-SW	B809300-03	Water														1									
98DOE-DRSD-1082-SW	B809309-04	Water													1			1	1						
98DOE-DRSD-1082-SW	B809309-04RE1	Water																1	1						
98DOE-DRSD-1083-SW	B809302-03	Water												1		1									
98DOE-DRSD-1083-SW	B809309-01	Water													1			1	1						
98DOE-DRSD-1083-SW	B809309-01RE1	Water																1	1						
98DOE-DRSD-1084-SW	B809304-01	Water												1		1									
98DOE-DRSD-1084-SW	B809309-03	Water													1			1	1						
98DOE-DRSD-1084-SW	B809309-03RE1	Water																1	1						
98DOE-DRSD-1085-SW	B809302-01	Water												1											
98DOE-DRSD-1085-SW	B809304-02	Water														1									
98DOE-DRSD-1085-SW	B809309-18	Water													1			1	1						
98DOE-DRSD-1085-SW	B809309-18RE1	Water																	1						
98DOE-DRSD-1086-SD	B809305-03	Soil			1			1		1	1														
98DOE-DRSD-1086-SD	B809305-03RE1	Soil									1														
98DOE-DRSD-1086-SD	B809305-03RE2	Soil								1															
98DOE-DRSD-1086-SD	B809310-12	Soil					1																		
98DOE-DRSD-1087-SD	B809305-05	Soil			1			1		1	1														
98DOE-DRSD-1087-SD	B809305-05RE1	Soil									1														
98DOE-DRSD-1087-SD	B809305-05RE2	Soil								1															
98DOE-DRSD-1087-SD	B809310-11	Soil					1																		
98DOE-DRSD-1088-SD	B809305-02	Soil			1			1		1	1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1088-SD	B809305-02RE1	Soil									1														
98DOE-DRSD-1088-SD	B809305-02RE2	Soil								1															
98DOE-DRSD-1088-SD	B809310-15	Soil					1																		
98DOE-DRSD-1089-SD	B809305-04	Soil			1			1		1	1														
98DOE-DRSD-1089-SD	B809305-04RE1	Soil									1														
98DOE-DRSD-1089-SD	B809305-04RE2	Soil								1															
98DOE-DRSD-1089-SD	B809310-14	Soil					1																		
98DOE-DRSD-1090-SD	B809305-01	Soil			1			1		1	1														
98DOE-DRSD-1090-SD	B809305-01RE1	Soil									1														
98DOE-DRSD-1090-SD	B809305-01RE2	Soil								1															
98DOE-DRSD-1090-SD	B809310-13	Soil					1																		
98DOE-DRSD-1091-SD	B809375-13	Soil			1			1		1	1														
98DOE-DRSD-1091-SD	B809375-13RE1	Soil							1	1															
98DOE-DRSD-1091-SD	B809375-13RE2	Soil									1														
98DOE-DRSD-1091-SD	B809421-11	Soil				1																			
98DOE-DRSD-1092-SD	B809375-12	Soil			1			1	1	1	1														
98DOE-DRSD-1092-SD	B809375-12RE2	Soil								1	1														
98DOE-DRSD-1092-SD	B809421-12	Soil				1																			
98DOE-DRSD-1093-SD	B809375-06	Soil			1			1	1	1	1														
98DOE-DRSD-1093-SD	B809375-06RE1	Soil								1															
98DOE-DRSD-1093-SD	B809375-06RE2	Soil									1														
98DOE-DRSD-1093-SD	B809421-13	Soil				1																			
98DOE-DRSD-1094-SD	B809375-09	Soil			1			1		1	1														
98DOE-DRSD-1094-SD	B809375-09RE1	Soil								1															
98DOE-DRSD-1094-SD	B809375-09RE2	Soil									1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-1094-SD	B809421-16	Soil				1																			
98DOE-DRSD-1095-SD	B809375-07	Soil			1			1		1	1														
98DOE-DRSD-1095-SD	B809375-07RE1	Soil								1															
98DOE-DRSD-1095-SD	B809375-07RE2	Soil									1														
98DOE-DRSD-1095-SD	B809421-14	Soil				1																			
98DOE-DRSD-1096-SD	B809375-08	Soil			1			1		1	1														
98DOE-DRSD-1096-SD	B809375-08RE1	Soil								1															
98DOE-DRSD-1096-SD	B809375-08RE2	Soil									1														
98DOE-DRSD-1096-SD	B809421-10	Soil				1																			
98DOE-DRSD-1097-SD	B809375-11	Soil			1			1	1	1	1														
98DOE-DRSD-1097-SD	B809375-11RE1	Soil								1															
98DOE-DRSD-1097-SD	B809375-11RE2	Soil									1														
98DOE-DRSD-1097-SD	B809421-09	Soil				1																			
98DOE-DRSD-1098-SD	B809375-14	Soil			1			1		1	1														
98DOE-DRSD-1098-SD	B809375-14RE1	Soil								1															
98DOE-DRSD-1098-SD	B809375-14RE2	Soil									1														
98DOE-DRSD-1098-SD	B809421-17	Soil				1																			
98DOE-DRSD-1099-SD	B809375-10	Soil			1			1	1	1	1														
98DOE-DRSD-1099-SD	B809375-10RE1	Soil								1															
98DOE-DRSD-1099-SD	B809375-10RE2	Soil									1														
98DOE-DRSD-1099-SD	B809421-07	Soil				1																			
98DOE-DRSD-3001-SD	B809105-13	Soil				1																			
98DOE-DRSD-3001-SD	B809115-08	Soil			1			1		1	1	1	1												
98DOE-DRSD-3001-SW	B809110-01	Water												1		1									
98DOE-DRSD-3001-SW	B809111-04	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSD-3002-SD	B809105-16	Soil				1																			
98DOE-DRSD-3002-SD	B809115-07	Soil			1			1		1	1	1	1												
98DOE-DRSD-3002-SW	B809110-03	Water												1		1									
98DOE-DRSD-3002-SW	B809111-01	Water													1			1	1						
98DOE-DRSD-3003-SD	B809105-14	Soil				1																			
98DOE-DRSD-3003-SD	B809115-09	Soil			1			1		1	1	1	1												
98DOE-DRSD-3003-SW	B809109-03	Water												1		1									
98DOE-DRSD-3003-SW	B809111-02	Water													1			1	1						
98DOE-DRSD-3004-SD	B809105-15	Soil				1																			
98DOE-DRSD-3004-SD	B809115-10	Soil			1			1		1	1	1	1												
98DOE-DRSD-3004-SW	B809110-02	Water												1		1									
98DOE-DRSD-3004-SW	B809111-05	Water													1			1	1						
98DOE-DRSD-3005-SD	B809115-11	Soil			1			1		1	1	1	1												
98DOE-DRSD-3005-SW	B809109-02	Water												1		1									
98DOE-DRSD-3005-SW	B809111-03	Water													1			1	1						
98DOE-DRSD-3006-F1	1341-10	Fish																						1	
98DOE-DRSD-3006-F1	P904267-10	Fish																		1	1		1		
98DOE-DRSD-3007-F1	1341-9	Fish																						1	
98DOE-DRSD-3007-F1	P904267-09	Fish																			1		1		
98DOE-DRSD-3007-F1	P904267-09RE1	Fish																		1					
Drill Site E																									
98DOE-DRSE-1116-SW	B809465-02	Water													1										
98DOE-DRSE-1116-SW	B809467-02	Water												1		1									
98DOE-DRSE-1116-SW	B809470-05	Water																1	1						
98DOE-DRSE-1117-SD	B809458-01	Soil				1																			

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSE-1117-SD	B809475-08	Soil			1			1		1	1														
98DOE-DRSE-1118-SW	B809465-01	Water													1										
98DOE-DRSE-1118-SW	B809467-01	Water												1		1									
98DOE-DRSE-1118-SW	B809470-04	Water																1	1						
98DOE-DRSE-1119-SD	B809458-15	Soil				1																			
98DOE-DRSE-1119-SD	B809475-11	Soil			1			1		1	1														
98DOE-DRSE-3032-SD	B809265-03	Soil			1			1		1	1	1	1												
98DOE-DRSE-3032-SW	B809262-01	Water														1		1	1						
98DOE-DRSE-3032-SW	B809265-01	Water												1	1										
98DOE-DRSE-3033-SD	B809265-04	Soil			1			1		1	1	1	1												
98DOE-DRSE-3033-SW	B809262-02	Water																1	1						
98DOE-DRSE-3033-SW	B809265-02	Water												1	1	1									
98DOE-DRSE-3034-SW	B809298-02	Water	Orig											1		1									
98DOE-DRSE-3034-SW	B809303-04	Water	Orig															1	1						
98DOE-DRSE-3034-SW	B809309-22	Water	Orig												1										
98DOE-DRSE-3035-SD	B809303-15	Soil			1			1		1	1	1	1												
98DOE-DRSE-3035-SW	B809298-01	Water	FD											1											
98DOE-DRSE-3035-SW	B809299-02	Water	FD													1									
98DOE-DRSE-3035-SW	B809303-03	Water	FD															1	1						
98DOE-DRSE-3035-SW	B809309-23	Water	FD												1										
98DOE-DRSE-3036-SD	B809303-14	Soil			1			1		1	1	1	1												
98DOE-DRSE-3036-SD	B809310-01	Soil				1	1																		
98DOE-DRSE-3036-SW	B809301-02	Water												1		1									
98DOE-DRSE-3036-SW	B809309-02	Water													1			1	1						
98DOE-DRSE-3036-SW	B809309-02RE1	Water																1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSE-3037-SD	B809303-16	Soil			1			1		1	1	1	1												
98DOE-DRSE-3037-SW	B809301-01	Water												1		1									
98DOE-DRSE-3037-SW	B809303-01	Water																1	1						
98DOE-DRSE-3037-SW	B809309-26	Water													1										
98DOE-DRSE-3039-F1	1341-13	Fish																						1	
98DOE-DRSE-3039-F1	P904267-13	Fish																		1	1		1		
98DOE-DRSE-3040-F1	1341-12	Fish																						1	
98DOE-DRSE-3040-F1	P904267-12	Fish																		1	1		1		
98DOE-DRSE-3042-F1	1341-11	Fish																						1	
98DOE-DRSE-3042-F1	P904267-11	Fish																		1	1		1		
Drill Site F																									
98DOE-DRSF-1023-SW	B809108-04	Water												1		1									
98DOE-DRSF-1023-SW	B809111-09	Water													1			1	1						
98DOE-DRSF-1024-SW	B809109-01	Water												1		1									
98DOE-DRSF-1024-SW	B809111-08	Water													1			1	1						
98DOE-DRSF-1025-SW	B809107-03	Water												1		1									
98DOE-DRSF-1025-SW	B809111-10	Water													1			1	1						
98DOE-DRSF-1026-SD	B809105-02	Soil					1																		
98DOE-DRSF-1026-SD	B809113-08	Soil			1			1		1	1														
98DOE-DRSF-1026-SD	B809113-08RE1	Soil								1															
98DOE-DRSF-1026-SD	B809113-08RE3	Soil								1															
98DOE-DRSF-1027-SD	B809105-04	Soil				1	1																		
98DOE-DRSF-1027-SD	B809113-09	Soil			1			1		1	1														
98DOE-DRSF-1027-SD	B809113-09RE1	Soil								1															
98DOE-DRSF-1027-SD	B809113-09RE3	Soil								1															

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSF-1028-SD	B809105-10	Soil					1																		
98DOE-DRSF-1028-SD	B809113-10	Soil			1			1		1	1														
98DOE-DRSF-1028-SD	B809113-10RE1	Soil								1															
98DOE-DRSF-1028-SD	B809113-10RE3	Soil								1															
98DOE-DRSF-1029-SD	B809105-12	Soil				1	1																		
98DOE-DRSF-1029-SD	B809113-11	Soil			1			1		1	1														
98DOE-DRSF-1029-SD	B809113-11RE1	Soil								1															
98DOE-DRSF-1029-SD	B809113-11RE3	Soil								1															
98DOE-DRSF-1030-SD	B809105-05	Soil				1	1																		
98DOE-DRSF-1030-SD	B809113-12	Soil			1			1		1	1														
98DOE-DRSF-1030-SD	B809113-12RE1	Soil								1															
98DOE-DRSF-1030-SD	B809113-12RE3	Soil								1															
98DOE-DRSF-3009-SD	B809158-06	Soil			1			1		1	1	1	1												
98DOE-DRSF-3009-SD	B809158-06RE1	Soil								1															
98DOE-DRSF-3009-SD	B809158-06RE2	Soil								1															
98DOE-DRSF-3009-SW	B809155-01	Water												1		1									
98DOE-DRSF-3009-SW	B809165-02	Water													1			1	1						
98DOE-DRSF-3010-SD	B809162-06	Soil			1			1		1	1	1	1												
98DOE-DRSF-3010-SD	B809162-06RE1	Soil								1															
98DOE-DRSF-3010-SW	B809148-03	Water												1		1									
98DOE-DRSF-3010-SW	B809165-01	Water													1			1	1						
98DOE-DRSF-3011-SD	B809162-08	Soil			1			1		1	1	1	1												
98DOE-DRSF-3011-SD	B809162-08RE1	Soil								1															
98DOE-DRSF-3011-SW	B809147-02	Water												1		1									
98DOE-DRSF-3011-SW	B809161-07	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSF-3012-SD	B809153-02	Soil				1	1																		
98DOE-DRSF-3012-SD	B809162-07	Soil			1			1		1	1	1	1												
98DOE-DRSF-3012-SD	B809162-07RE1	Soil								1															
98DOE-DRSF-3012-SW	B809150-01	Water												1		1									
98DOE-DRSF-3012-SW	B809161-10	Water													1			1	1						
98DOE-DRSF-3013-SD	B809162-11	Soil			1			1		1	1	1	1												
98DOE-DRSF-3013-SD	B809162-11RE1	Soil								1															
98DOE-DRSF-3013-SW	B809147-03	Water												1		1									
98DOE-DRSF-3013-SW	B809165-03	Water													1			1	1						
98DOE-DRSF-3014-F1	1341-16	Fish																						1	
98DOE-DRSF-3014-F1	P904267-16	Fish																		1	1		1		
98DOE-DRSF-3015-F1	1341-15	Fish																						1	
98DOE-DRSF-3015-F1	P904267-15	Fish																		1	1		1		1
98DOE-DRSF-3016-F1	1341-14	Fish																						1	
98DOE-DRSF-3016-F1	P904267-14	Fish																		1	1		1		
Long Shot Site																									
98DOE-LONG-1009-SW	B809034-04	Water												1	1										
98DOE-LONG-1009-SW	B809039-04	Water														1									
98DOE-LONG-1009-SW	B809040-06	Water																1	1						
98DOE-LONG-1010-SW	B809034-05	Water													1										
98DOE-LONG-1010-SW	B809035-01	Water												1											
98DOE-LONG-1010-SW	B809040-01	Water														1		1	1						
98DOE-LONG-1011-SW	B809034-06	Water	Orig												1										
98DOE-LONG-1011-SW	B809035-02	Water	Orig											1											
98DOE-LONG-1011-SW	B809039-05	Water	Orig													1									

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-1011-SW	B809040-07	Water	Orig															1	1						
98DOE-LONG-1012-SW	B809034-07	Water	FD												1										
98DOE-LONG-1012-SW	B809035-03	Water	FD											1											
98DOE-LONG-1012-SW	B809040-02	Water	FD													1		1	1						
98DOE-LONG-1120-SW	B809465-03	Water													1										
98DOE-LONG-1120-SW	B809468-02	Water												1		1									
98DOE-LONG-1120-SW	B809470-03	Water																1	1						
98DOE-LONG-1121-SW	B809465-04	Water													1										
98DOE-LONG-1121-SW	B809470-02	Water												1		1		1	1						
98DOE-LONG-1122-SW	B809465-05	Water													1										
98DOE-LONG-1122-SW	B809468-01	Water														1									
98DOE-LONG-1122-SW	B809470-01	Water												1		1		1	1						
98DOE-LONG-1123-SD	B809458-14	Soil	Orig			1																			
98DOE-LONG-1123-SD	B809475-02	Soil	Orig		1			1		1	1														
98DOE-LONG-1124-SD	B809458-05	Soil	FD			1																			
98DOE-LONG-1124-SD	B809475-03	Soil	FD		1			1		1	1														
98DOE-LONG-1125-SD	B809458-04	Soil				1																			
98DOE-LONG-1125-SD	B809475-04	Soil			1			1		1	1														
98DOE-LONG-1126-SD	B809458-09	Soil				1																			
98DOE-LONG-1126-SD	B809475-07	Soil			1			1		1	1														
98DOE-LONG-1127-SD	B809458-02	Soil				1																			
98DOE-LONG-1127-SD	B809475-05	Soil			1			1		1	1														
98DOE-LONG-1128-SD	B809458-06	Soil				1																			
98DOE-LONG-1128-SD	B809475-06	Soil			1			1		1	1														
98DOE-LONG-1129-SD	B809458-03	Soil				1																			

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-1129-SD	B809475-01	Soil			1			1		1	1														
98DOE-LONG-1130-SD	B809458-10	Soil				1																			
98DOE-LONG-1130-SD	B809485-06	Soil			1			1		1	1														
98DOE-LONG-1131-SD	B809458-07	Soil				1																			
98DOE-LONG-1131-SD	B809485-02	Soil			1			1		1	1														
98DOE-LONG-1132-SD	B809458-11	Soil				1																			
98DOE-LONG-1132-SD	B809485-04	Soil			1			1		1	1														
98DOE-LONG-1133-SD	B809458-13	Soil				1																			
98DOE-LONG-1133-SD	B809485-01	Soil			1			1		1	1														
98DOE-LONG-1134-SD	B809458-08	Soil				1																			
98DOE-LONG-1134-SD	B809485-03	Soil			1			1		1	1														
98DOE-LONG-1135-SD	B809458-12	Soil				1																			
98DOE-LONG-1135-SD	B809485-05	Soil			1			1		1	1														
98DOE-LONG-1136-RB	B809468-03	Water												1		1									
98DOE-LONG-1137-SW	B809462-01	Water													1			1	1						
98DOE-LONG-1137-SW	B809466-01	Water												1		1									
98DOE-LONG-1138-SW	B809462-02	Water													1			1	1						
98DOE-LONG-1138-SW	B809466-02	Water												1		1									
98DOE-LONG-1139-SD	B809457-02	Soil				1	1																		
98DOE-LONG-1139-SD	B809479-05	Soil			1			1		1	1														
98DOE-LONG-1140-SD	B809457-01	Soil				1	1																		
98DOE-LONG-1140-SD	B809479-04	Soil			1			1		1	1														
98DOE-LONG-4034-SW	B809151-01	Water												1		1									
98DOE-LONG-4034-SW	B809161-14	Water													1			1	1						
98DOE-LONG-4035-SD	B809153-01	Soil				1	1																		

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4035-SD	B809158-01	Soil			1			1		1	1	1	1												
98DOE-LONG-4035-SD	B809158-01RE1	Soil								1															
98DOE-LONG-4035-SD	B809158-01RE2	Soil								1															
98DOE-LONG-4036-SW	B809147-01	Water														1									
98DOE-LONG-4036-SW	B809151-02	Water												1											
98DOE-LONG-4036-SW	B809161-15	Water													1			1	1						
98DOE-LONG-4037-SD	B809158-02	Soil			1			1		1	1	1	1												
98DOE-LONG-4037-SD	B809158-02RE1	Soil								1															
98DOE-LONG-4037-SD	B809158-02RE2	Soil								1															
98DOE-LONG-4038-SW	B809148-02	Water												1		1									
98DOE-LONG-4038-SW	B809161-13	Water													1			1	1						
98DOE-LONG-4039-SD	B809158-05	Soil			1			1		1	1	1	1												
98DOE-LONG-4039-SD	B809158-05RE1	Soil								1															
98DOE-LONG-4039-SD	B809158-05RE2	Soil								1															
98DOE-LONG-4040-SW	B809148-01	Water												1											
98DOE-LONG-4040-SW	B809149-01	Water														1									
98DOE-LONG-4040-SW	B809161-12	Water													1			1	1						
98DOE-LONG-4041-SD	B809158-04	Soil			1			1		1	1	1	1												
98DOE-LONG-4041-SD	B809158-04RE1	Soil								1															
98DOE-LONG-4041-SD	B809158-04RE2	Soil								1															
98DOE-LONG-4042-SW	B809151-03	Water												1		1									
98DOE-LONG-4042-SW	B809161-11	Water													1			1	1						
98DOE-LONG-4043-SD	B809158-03	Soil			1			1		1	1	1	1												
98DOE-LONG-4043-SD	B809158-03RE1	Soil								1															
98DOE-LONG-4043-SD	B809158-03RE2	Soil								1															

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4044-SW	B809156-01	Water												1		1									
98DOE-LONG-4044-SW	B809165-04	Water													1			1	1						
98DOE-LONG-4045-SD	B809162-09	Soil			1			1		1	1	1	1												
98DOE-LONG-4045-SD	B809162-09RE1	Soil								1															
98DOE-LONG-4046-SW	B809159-01	Water												1		1									
98DOE-LONG-4046-SW	B809161-09	Water													1			1	1						
98DOE-LONG-4047-SD	B809162-12	Soil			1			1		1	1	1	1												
98DOE-LONG-4047-SD	B809162-12RE1	Soil								1															
98DOE-LONG-4048-SW	B809157-01	Water												1		1									
98DOE-LONG-4048-SW	B809161-08	Water													1			1	1						
98DOE-LONG-4049-SD	B809162-10	Soil			1			1		1	1	1	1												
98DOE-LONG-4049-SD	B809162-10RE1	Soil								1															
98DOE-LONG-4050-SW	B809156-02	Water												1		1									
98DOE-LONG-4050-SW	B809165-06	Water													1			1	1						
98DOE-LONG-4051-SD	B809153-03	Soil				1	1																		
98DOE-LONG-4051-SD	B809165-08	Soil			1			1		1	1	1	1												
98DOE-LONG-4052-SW	B809157-02	Water												1		1									
98DOE-LONG-4052-SW	B809165-05	Water													1			1	1						
98DOE-LONG-4053-SD	B809165-09	Soil	Orig		1			1		1	1	1	1												
98DOE-LONG-4054-SD	B809165-07	Soil	FD		1			1		1	1	1	1												
98DOE-LONG-4115-SW	B809372-02	Water												1		1									
98DOE-LONG-4115-SW	B809388-07	Water													1			1	1						
98DOE-LONG-4116-SD	B809375-04	Soil			1			1		1	1	1	1												
98DOE-LONG-4116-SD	B809375-04RE1	Soil								1															
98DOE-LONG-4116-SD	B809375-04RE2	Soil									1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4117-SW	B809370-01	Water												1		1									
98DOE-LONG-4117-SW	B809388-05	Water													1			1	1						
98DOE-LONG-4118-SD	B809375-01	Soil			1			1		1	1	1	1												
98DOE-LONG-4118-SD	B809375-01RE1	Soil								1															
98DOE-LONG-4118-SD	B809375-01RE2	Soil									1														
98DOE-LONG-4119-SW	B809372-03	Water												1		1									
98DOE-LONG-4119-SW	B809388-06	Water													1			1	1						
98DOE-LONG-4120-SD	B809375-05	Soil			1			1		1	1	1	1												
98DOE-LONG-4120-SD	B809375-05RE1	Soil								1															
98DOE-LONG-4120-SD	B809375-05RE2	Soil									1														
98DOE-LONG-4120-SD	B809421-18	Soil				1																			
98DOE-LONG-4121-SW	B809372-01	Water												1		1									
98DOE-LONG-4121-SW	B809388-04	Water													1			1	1						
98DOE-LONG-4122-SD	B809375-02	Soil			1			1		1	1	1	1												
98DOE-LONG-4122-SD	B809375-02RE1	Soil								1															
98DOE-LONG-4122-SD	B809375-02RE2	Soil									1														
98DOE-LONG-4123-SW	B809370-03	Water												1		1									
98DOE-LONG-4123-SW	B809388-08	Water													1			1	1						
98DOE-LONG-4124-SD	B809375-03	Soil			1			1		1	1	1	1												
98DOE-LONG-4124-SD	B809375-03RE1	Soil								1															
98DOE-LONG-4124-SD	B809375-03RE2	Soil									1														
98DOE-LONG-4071-F1	1341-1	Fish																						1	
98DOE-LONG-4071-F1	1341-38	Fish																						1	
98DOE-LONG-4071-F1	P904267-01	Fish																		1	1		1		
98DOE-LONG-4072-F1	1341-2	Fish																						1	

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4072-F1	P904267-02	Fish																		1	1		1		
98DOE-LONG-4073-F1	1341-6	Fish																						1	
98DOE-LONG-4073-F1	P904267-06	Fish																		1	1		1		
98DOE-LONG-4074-F1	1341-7	Fish																						1	
98DOE-LONG-4074-F1	P904267-07	Fish																		1	1		1		
98DOE-LONG-4111-F1	1341-8	Fish																						1	
98DOE-LONG-4111-F1	P904267-08	Fish																		1	1		1		
98DOE-LONG-4155-FS	1341-37	Fish																						1	
98DOE-LONG-4155-FS	P904267-37	Fish																		1	1		1		
98DOE-LONG-4157-FS	1341-36	Fish																						1	
98DOE-LONG-4157-FS	P904267-36	Fish																					1		
Milrow Site																									
98DOE-MILR-1001-SW	B809034-01	Water												1	1										
98DOE-MILR-1001-SW	B809039-01	Water														1									
98DOE-MILR-1001-SW	B809040-03	Water																1	1						
98DOE-MILR-1002-SW	B809034-02	Water												1	1										
98DOE-MILR-1002-SW	B809039-02	Water														1									
98DOE-MILR-1002-SW	B809040-04	Water																1	1						
98DOE-MILR-1003-SW	B809034-03	Water												1	1										
98DOE-MILR-1003-SW	B809039-03	Water														1									
98DOE-MILR-1003-SW	B809040-05	Water																1	1						
98DOE-MILR-1004-SD	B809037-01	Soil			1			1			1														
98DOE-MILR-1004-SD	B809037-01RE1	Soil								1															
98DOE-MILR-1004-SD	B809037-01RE2	Soil								1															
98DOE-MILR-1004-SD	B809041-01	Soil				1	1																		

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-MILR-1005-SD	B809037-02	Soil			1			1			1														
98DOE-MILR-1005-SD	B809037-02RE1	Soil								1															
98DOE-MILR-1005-SD	B809037-02RE2	Soil								1															
98DOE-MILR-1005-SD	B809041-02	Soil				1	1																		
98DOE-MILR-1006-SD	B809037-03	Soil			1			1			1														
98DOE-MILR-1006-SD	B809037-03RE1	Soil								1															
98DOE-MILR-1006-SD	B809037-03RE2	Soil								1															
98DOE-MILR-1006-SD	B809041-03	Soil				1	1																		
98DOE-MILR-1007-SD	B809037-04	Soil			1			1			1														
98DOE-MILR-1007-SD	B809037-04RE1	Soil								1															
98DOE-MILR-1007-SD	B809037-04RE2	Soil								1															
98DOE-MILR-1007-SD	B809041-04	Soil				1	1																		
98DOE-MILR-1008-SD	B809037-05	Soil			1			1			1														
98DOE-MILR-1008-SD	B809037-05RE1	Soil								1															
98DOE-MILR-1008-SD	B809037-05RE2	Soil								1															
98DOE-MILR-1008-SD	B809041-05	Soil				1	1																		
98DOE-MILR-4007-SW	B809107-01	Water												1		1									
98DOE-MILR-4007-SW	B809111-11	Water													1			1	1						
98DOE-MILR-4008-SD	B809115-04	Soil	Orig		1			1		1	1	1	1												
98DOE-MILR-4009-SD	B809115-03	Soil	FD		1			1		1	1	1	1												
98DOE-MILR-4011-SW	B809106-02	Water												1		1									
98DOE-MILR-4011-SW	B809111-13	Water													1			1	1						
98DOE-MILR-4012-SD	B809115-01	Soil			1			1		1	1	1	1												
98DOE-MILR-4013-SW	B809107-02	Water												1		1									
98DOE-MILR-4013-SW	B809111-12	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-MILR-4014-SD	B809115-02	Soil			1			1		1	1	1	1												
98DOE-MILR-4015-SW	B809106-03	Water												1		1									
98DOE-MILR-4015-SW	B809111-06	Water													1			1	1						
98DOE-MILR-4016-SD	B809105-17	Soil	Orig				1																		
98DOE-MILR-4016-SD	B809115-06	Soil	Orig		1			1		1	1	1	1												
98DOE-MILR-4017-SD	B809105-18	Soil	FD			1	1																		
98DOE-MILR-4018-SW	B809106-01	Water												1		1									
98DOE-MILR-4018-SW	B809111-07	Water													1			1	1						
98DOE-MILR-4019-SD	B809115-05	Soil			1			1		1	1	1	1												
98DOE-MILR-4028-FS	1341-4	Fish																						1	
98DOE-MILR-4028-FS	P904267-04	Fish																		1	1		1		
98DOE-MILR-4029-FS	1341-3	Fish																						1	
98DOE-MILR-4029-FS	P904267-03	Fish																		1	1		1		1
98DOE-MILR-4095-FS	1341-5	Fish																						1	
98DOE-MILR-4095-FS	P904267-05	Fish																		1	1		1		
Rifle Range Road Mud Pits																									
98DOE-RRMP-1076-SL	B809303-13	Soil			1			1		1	1														
98DOE-RRMP-1076-SL	B809310-07	Soil				1																			
98DOE-RRMP-1077-SL	B809303-12	Soil			1			1		1	1														
98DOE-RRMP-1077-SL	B809310-10	Soil				1																			
98DOE-RRMP-1078-SL	B809303-11	Soil			1			1		1	1														
98DOE-RRMP-1078-SL	B809310-05	Soil				1																			
Reference Stream 1																									
98DOE-RS01-4083-SW	B809253-04RE1	Water												1											
98DOE-RS01-4083-SW	B809255-02	Water																1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS01-4084-SD	B809255-10	Soil			1				1	1	1	1	1												
98DOE-RS01-4086-SW	B809253-01	Water												1											
98DOE-RS01-4086-SW	B809255-05	Water																1	1						
98DOE-RS01-4087-SD	B809255-08	Soil			1					1	1	1	1												
98DOE-RS01-4088-SW	B809253-05	Water												1											
98DOE-RS01-4088-SW	B809255-01	Water																1	1						
98DOE-RS01-4089-SD	B809255-06	Soil			1					1	1	1	1												
98DOE-RS01-4090-SW	B809253-02	Water												1											
98DOE-RS01-4090-SW	B809255-03	Water																1	1						
98DOE-RS01-4091-SD	B809255-07	Soil			1					1	1	1	1												
98DOE-RS01-4092-SW	B809253-03	Water												1											
98DOE-RS01-4092-SW	B809255-04	Water																1	1						
98DOE-RS01-4093-SD	B809255-09	Soil			1					1	1	1	1												
98DOE-RS01-4094-FS	1341-19	Fish																						1	
98DOE-RS01-4094-FS	P904267-19	Fish																		1	1		1		
98DOE-RS01-4097-FS	1341-18	Fish																						1	
98DOE-RS01-4097-FS	P904267-18	Fish																		1	1		1		
98DOE-RS01-4099-FS	1341-17	Fish																						1	
98DOE-RS01-4099-FS	P904267-17	Fish																		1	1		1		
98DOE-RS01-4160-FS	1341-20	Fish																						1	
98DOE-RS01-4160-FS	P904267-20	Fish																		1	1		1		
Reference Stream 2																									
98DOE-RS02-4134-SW	B809378-05	Water												1											
98DOE-RS02-4134-SW	B809384-16	Water																	1						
98DOE-RS02-4134-SW	B809384-16RE1	Water																1							

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS02-4135-SD	B809385-03	Soil			1					1	1	1	1												
98DOE-RS02-4135-SD	B809385-03RE1	Soil								1															
98DOE-RS02-4135-SD	B809385-03RE2	Soil									1														
98DOE-RS02-4136-SW	B809378-04	Water												1											
98DOE-RS02-4136-SW	B809384-15	Water																	1						
98DOE-RS02-4136-SW	B809384-15RE1	Water																1							
98DOE-RS02-4137-SD	B809388-11	Soil			1					1	1	1	1												
98DOE-RS02-4138-SW	B809378-01	Water												1											
98DOE-RS02-4138-SW	B809385-04	Water																1	1						
98DOE-RS02-4139-SD	B809388-12	Soil	Orig		1					1	1	1	1												
98DOE-RS02-4140-SD	B809385-01	Soil	FD		1					1	1	1	1												
98DOE-RS02-4140-SD	B809385-01RE1	Soil	FD							1															
98DOE-RS02-4140-SD	B809385-01RE2	Soil	FD								1														
98DOE-RS02-4141-SW	B809378-03	Water												1											
98DOE-RS02-4141-SW	B809385-06	Water																1	1						
98DOE-RS02-4142-SD	B809388-13	Soil			1					1	1	1	1												
98DOE-RS02-4143-SW	B809378-02	Water												1											
98DOE-RS02-4143-SW	B809385-05	Water																1	1						
98DOE-RS02-4144-SD	B809385-02	Soil			1					1	1	1	1												
98DOE-RS02-4144-SD	B809385-02RE1	Soil								1															
98DOE-RS02-4144-SD	B809385-02RE2	Soil									1														
98DOE-RS02-4149-FS	1341-23	Fish																						1	
98DOE-RS02-4149-FS	P904267-23	Fish																		1	1		1		
98DOE-RS02-4151-FS	1341-22	Fish																						1	
98DOE-RS02-4151-FS	P904267-22	Fish																		1	1		1		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS02-4153-FS	1341-21	Fish																						1	
98DOE-RS02-4153-FS	P904267-21	Fish																		1	1		1		
Reference Stream 3																									
98DOE-RS03-3057-SW	B809371-03	Water												1											
98DOE-RS03-3057-SW	B809384-08	Water																	1						
98DOE-RS03-3057-SW	B809384-08RE1	Water																1							
98DOE-RS03-3060-SD	B809384-10	Soil	Orig		1					1	1	1	1												
98DOE-RS03-3061-SD	B809384-09	Soil	FD		1				1	1	1	1	1												
98DOE-RS03-3062-SW	B809371-01	Water												1											
98DOE-RS03-3062-SW	B809384-02	Water																	1						
98DOE-RS03-3062-SW	B809384-02RE1	Water																1							
98DOE-RS03-3063-SD	B809384-13	Soil			1				1	1	1	1	1												
98DOE-RS03-3064-SW	B809371-02	Water												1											
98DOE-RS03-3064-SW	B809384-06	Water																	1						
98DOE-RS03-3064-SW	B809384-06RE1	Water																1							
98DOE-RS03-3065-SD	B809384-14	Soil			1					1	1	1	1												
98DOE-RS03-3066-SW	B809376-03	Water												1											
98DOE-RS03-3066-SW	B809384-07	Water																	1						
98DOE-RS03-3066-SW	B809384-07RE1	Water																1							
98DOE-RS03-3067-SD	B809384-12	Soil			1					1	1	1	1												
98DOE-RS03-3068-SW	B809376-02	Water												1											
98DOE-RS03-3068-SW	B809384-01	Water																	1						
98DOE-RS03-3068-SW	B809384-01RE1	Water																1							
98DOE-RS03-3069-SD	B809384-11	Soil			1					1	1	1	1												
98DOE-RS03-3070-FS	1341-26	Fish	Orig																					1	

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS03-3070-FS	P904267-26	Fish	Orig																	1	1		1		
98DOE-RS03-3071-FS	1341-27	Fish	FD																					1	
98DOE-RS03-3071-FS	P904267-27	Fish	FD																	1	1		1		
98DOE-RS03-3073-FS	1341-25	Fish																						1	
98DOE-RS03-3073-FS	P904267-25	Fish																		1	1		1		
98DOE-RS03-3075-FS	1341-24	Fish																						1	
98DOE-RS03-3075-FS	P904267-24	Fish																		1	1		1		
Reference Stream 4																									
98DOE-RS04-3044-SD	B809309-07	Soil			1				1	1	1	1	1												
98DOE-RS04-3044-SD	B809309-07RE1	Soil								1	1														
98DOE-RS04-3044-SW	B809306-02	Water	Orig											1											
98DOE-RS04-3044-SW	B809309-15	Water	Orig															1	1						
98DOE-RS04-3044-SW	B809309-15RE1	Water	Orig																1						
98DOE-RS04-3045-SW	B809304-04	Water	FD											1											
98DOE-RS04-3045-SW	B809309-20	Water	FD															1	1						
98DOE-RS04-3045-SW	B809309-20RE1	Water	FD																1						
98DOE-RS04-3047-SD	B809309-08	Soil			1				1	1	1	1	1												
98DOE-RS04-3047-SD	B809309-08RE1	Soil								1	1														
98DOE-RS04-3047-SW	B809306-04	Water												1											
98DOE-RS04-3047-SW	B809309-16	Water																1	1						
98DOE-RS04-3047-SW	B809309-16RE1	Water																	1						
98DOE-RS04-3048-SD	B809309-21	Soil			1				1	1	1	1	1												
98DOE-RS04-3048-SD	B809309-21RE1	Soil									1														
98DOE-RS04-3048-SD	B809309-21RE2	Soil								1															
98DOE-RS04-3048-SW	B809306-03	Water												1											

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS04-3048-SW	B809309-17	Water																1	1						
98DOE-RS04-3048-SW	B809309-17RE1	Water																	1						
98DOE-RS04-3049-SD	B809309-10	Soil			1					1	1	1	1												
98DOE-RS04-3049-SD	B809309-10RE1	Soil									1														
98DOE-RS04-3049-SD	B809309-10RE2	Soil								1															
98DOE-RS04-3049-SW	B809304-03	Water												1											
98DOE-RS04-3049-SW	B809309-13	Water																1	1						
98DOE-RS04-3049-SW	B809309-13RE1	Water																	1						
98DOE-RS04-3050-SD	B809309-09	Soil			1					1	1	1	1												
98DOE-RS04-3050-SD	B809309-09RE1	Soil									1														
98DOE-RS04-3050-SD	B809309-09RE2	Soil								1															
98DOE-RS04-3050-SW	B809306-01	Water												1											
98DOE-RS04-3050-SW	B809309-14	Water																1	1						
98DOE-RS04-3050-SW	B809309-14RE1	Water																	1						
98DOE-RS04-3051-FS	1341-35	Fish																						1	
98DOE-RS04-3051-FS	P904267-35	Fish																		1	1		1		
98DOE-RS04-3053-FS	1341-34	Fish																						1	
98DOE-RS04-3053-FS	P904267-34	Fish																		1	1		1		1
98DOE-RS04-3055-FS	1341-33	Fish																						1	
98DOE-RS04-3055-FS	P904267-33	Fish																		1	1		1		
Trip Blanks																									
98DOE-TB02-0000-TB	B809041-06	Soil				1																			
High/low level trip blank	B809458-16	Soil				1																			
TB-101	B809256-06	Soil				1																			
98DOE-TB-100	B809153-09	Soil					1																		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-TB02-0000-TB	B809041-06	Soil					1																		
Trip Blank	B809105-19	Soil					1																		
98DOE-MILR-1000-TB	B809034-08	Water													1										
98DOE-TB07-0000-SW	B809161-16	Water													1										
Trip Blank	B809111-15	Water													1										
TRIP BLANK	B809309-28	Water													1										
Trip Blank	B809385-10	Water													1										
Trip Blank	B809465-06	Water													1										
Trip Blank-100	B809265-05	Water													1										
Trip Blank-28	B809165-10	Water													1										

See Table C3-1 for definitions of analytical methods

Orig project sample

FD field duplicate

FR field replicate

QA quality assurance

QC quality control

1.0 Introduction

Amchitka Island, located near the western end of the Aleutian Islands, has been used by U.S. Government agencies for a variety of activities since 1943. These activities included a World War II military installation, a radio relay station as part of the Distant Early Warning Radar Network (Dew Line), and a site for underground nuclear tests. Currently, the island is uninhabited and access is restricted. In late summer 1998, a field sampling program sponsored by the U.S. Department of Energy was undertaken in order to evaluate present impacts, if any, from implacement hole drilling activities related to underground nuclear testing.

Sampling was conducted in eight streams that drain the six drilling locations. These locations included three sites where implacement holes were drilled but nuclear tests were not conducted (Drill Sites E, F, and D), and three sites where underground nuclear detonations took place (Cannikin, Milrow, and Long Shot). Sampling was also conducted in four unimpacted reference streams.

Sediment quality in the streams draining the three drill and three test sites was evaluated using a weight-of evidence approach known as the Sediment Quality Triad. The Triad approach, originally proposed by Long and Chapman (1985), incorporates three measures of sediment quality:

- Sediment chemistry
- Sediment bioassays
- Benthic macroinvertebrate community structure

It is difficult to make definitive statements about impacts to benthic habitats and biota with any of the three measurements taken alone. Sediment chemistry is a measure of chemical contamination, but does not measure biological effects. Sediment bioassays performed in the laboratory measure sediment toxicity but do not indicate the specific cause of toxicity, nor do the tests indicate actual field effects. The examination of benthic community structure indicates variability in the field, but does not identify the cause of the variability, which may be natural or anthropogenic. The three components of the Triad approach integrate chemical and biological response information, and can provide stronger evidence of degraded sediment quality than the evaluation of any single component.

If all three components indicate impact (i.e., contaminated sediments, toxic in laboratory tests, with altered benthic communities), then the weight of evidence strongly indicates negative impact. In the opposite case, unimpacted conditions are indicated if there is low chemical contamination, low toxicity, and unaltered benthic communities. Intermediate or mixed results can be meaningful but require careful interpretation (Chapman, 1992).

For each of the three Triad components, three individual measures were incorporated. The sediment chemistry component included the following:

- Normalized diesel-range organics (DRO)
- Total metals toxic units
- Total polyclyclic aromatic hydrocarbon (PAH) toxic units

The sediment toxicity component of the Triad included the following:

- *Chironomus tentans* normalized survival
- *Chironomus tentans* normalized growth
- *Chironomus tentans* normalized biomass

The benthic macroinvertebrate community component of the Triad included:

- Family Biotic Index
- Ephemeroptera-Plecoptera-Trichoptera (EPT) relative abundance
- Species Diversity (Shannon's Index)

Amchitka Island is approximately 40 miles long but is quite narrow (only about 3 miles wide in the study area). The island's streams, which arise in the higher terrain along the mid-spine of the island, are very short and flow only a mile or two before reaching either the North Pacific Ocean or Bering Sea. Benthic macroinvertebrate communities in the streams of Amchitka are affected by natural stream morphology and sediment characteristics, as well as by potential anthropogenic stressors. The substrate of the streams is variable and dependent on island topography. Near the headwaters, stream sediments were fine or peaty. In the lower stream reaches, gravel and cobbles were the predominant substrate types. Variability in the substrates made it necessary to compare site stream data to reference stream data based on similarity of location. That is,

up-stream stations in site streams were compared to up-stream reference stream stations, central to central, and down-stream to down-stream. Because of the substrate variability, four reference streams were sampled: two for lowland and two for upland comparisons. A ranking method was used in the Triad Analysis, wherein each location is ranked for each parameter in the analysis. Overall mean ranks for each sampling location and each Site stream were then calculated.

2.0 Methods

Evaluating the sediment quality involved measuring sediment chemistry, bioassays, and Benthic Macroinvertebrate community structure.

2.1 Sample Collection

Shannon & Wilson, Inc. collected benthic macroinvertebrate samples for biological analysis and sediment samples for chemical analysis and toxicity testing from Amchitka Island, during August and September 1998. Details regarding the collection of the benthic samples are addressed in the Shannon & Wilson report, *DOE 1998 Drill Site Characterization Report* (Shannon & Wilson, 1999). Five locations were sampled on each stream. Of these, three locations were selected for Triad Analysis sampling (four locations on White Alice Creek). At the Triad stations, additional sediment samples were collected for toxicity tests, and benthic macroinvertebrate sampling was conducted. Figures 2.1-1 – 2.1.4 show the Triad stations for upland streams, and Figures 2.1-5 – 2.1-7 show the lowland stream Triad locations.

The benthic macroinvertebrate samples were shipped to the IT Corporation Somerset, New Jersey laboratory facility for sorting, enumeration, and identification. Sediment samples on which toxicity tests were performed were shipped to American Aquatic Testing, Inc., in Allentown, Pennsylvania. Sediment samples collected for the analysis of contaminants of potential concern (COPCs) were shipped to North Creek Analytical in Bothell, Washington.

2.2 Sediment Chemistry

Sediment samples were analyzed for contaminants of potential concern including metals and total (PAHs). Diesel range organics analysis was also performed on the sediment samples. The sediment chemistry data were evaluated and incorporated into the Triad Analysis as described in the following sections.

2.2.1 Data Analysis

In order to evaluate the impact of the levels of COPCs in sediment, the following parameters were selected to be used in the sediment chemistry portion of the Triad: carbon-normalized DRO, total metals toxic units, and total PAH toxic units.

2.2.1.1 *Diesel Range Organics*

In order to adjust bulk concentrations for changes in bioavailability related to organic carbon adsorption, the DRO concentrations were normalized to the percent total organic carbon (TOC) in each sample. This was accomplished by dividing the DRO concentration by the percentage TOC in the sample.

2.2.1.2 *Total Metals Toxic Units*

Total metals toxic units were derived by dividing individual metals concentrations by the lowest (most conservative) screening level for each respective metal. For example, an aluminum concentration of 63,900 parts per million (ppm) was divided by 12.1 ppm (the threshold effect concentration). A sum of the metals toxic unit concentrations was derived for each sediment sample.

2.2.1.3 *PAH Toxic Units*

Polycyclic aromatic hydrocarbons were assessed using the additive toxicity index model developed by Swartz et al. (1995). The $\sum$PAH model was developed to predict the probability of acute sediment toxicity to amphipods caused by the additive effect of 13 PAHs (Swartz et al., 1995). The $\sum$PAH model uses equilibrium partitioning, quantitative structure-activity relationships (QSARs), and toxic unit additivity (Swartz et al., 1995).

Swartz et al. (1995) identified measured porewater concentrations lethal to 50% of test organisms (LC_{50}s) for three PAHs (acenaphthene, phenanthrene, and flouranthene) from controlled experiments measuring the toxicity of spiked sediment to several amphipod species. A QSAR was then used to estimate porewater LC_{50}s for the additional PAHs, based on an empirical relationship between LC_{50} and log K_{OW} (octanol-water partition coefficient). The resulting set of porewater LC_{50s} is applied to whole-sediment concentrations of PAHs using the equilibrium partitioning approach (Di Toro et al., 1991; Swartz et al., 1995) as follows:

$$SQB = f_{OC} \times K_{OC} \times WQB$$

where:

SQB = Sediment quality benchmark

f_{OC}= Fraction of the total mass of dry sediment that consists of organic carbon, set at 0.01 to provide SQBs that are normalized to 1% TOC

K_{OC}=Chemical-specific partition coefficient (ratio between amount of chemical adsorbed to organic carbon and amount in porewater at equilibrium)

WQB=Water quality benchmark; in this case, the porewater LC_{50}

To assess the toxicity of PAHs, the sediment quality benchmarks for individual PAHs are combined in an additive toxicity index. The PAH index provides a sum of sediment PAH concentrations, where the concentration of each PAH is weighted based on that congener's toxicity:

$$PAH\ index = \frac{[PAH_1]}{SQB_1} + \frac{[PAH_2]}{SQB_2} + ... + \frac{[PAH_{14}]}{SQB_{14}}$$

where:

$[PAH_n]$ = Concentration of the *n*th congener

SQB_n = Sediment quality benchmark for the *n*th congener

Using individual PAH data from each sample, the PAH index was developed for each station.

2.3 Toxicity Tests

The 10-day freshwater sediment bioassay tests were performed according to American Society for Testing and Materials (ASTM), Method E 1706-95b (ASTM, 1997), using larvae of the midge *Chironomus tentans*. The test procedures are summarized in the following sections.

2.3.1 Preparation of Sediment Samples for Testing

Once the samples arrived at the laboratory, they were stored at 4 degrees Celsius (°C) until used for testing. Due to the high percentage of gravel and large pieces of plant material in the samples, sediment samples used for toxicity testing were not sieved prior to use. Control sediments were collected from Spruce Run Reservoir in Clinton, New Jersey. The control sediments were sieved prior to transport to the laboratory and stored at 4 °C prior to use.

2.3.2 Test Organisms

Test organisms (*Chironomus tentans*) used in the toxicity tests were obtained from stock cultures maintained by ABS, Inc. of Fort Collins, Colorado. Prior to testing, the organisms were held under conditions similar to testing conditions. Once daily, the chironomids were fed approximately 4.0 milligrams (mg) of flake fish food. Reference toxicant tests, using potassium

chloride as the toxicant, were conducted concurrently with each of the ten-day exposures to verify the health of the lot of organisms used in the tests. The 48-hour (hr) LC_{50} values of 1,800 ppm, 1,125 ppm, and 1,203.1 ppm for the three lots of test organisms were within ranges of a round robin study conducted by the U.S. Environmental Protection Agency in 1992 (Ingersoll, 1994).

2.3.3 Experimental Procedures

Test chambers were filled with 100 milliliters (ml) of sediment, which was covered with 175 ml of laboratory reconstituted fresh water with a hardness of 100 mg/L. All test chambers were allowed to settle for 24 hours prior to test initiation. After the settling period, water changes were performed and alkalinity, ammonia, conductivity and pH were measured within each test chamber prior to the introduction of the organisms. Dissolved oxygen and temperature were measured initially and every 24 hours for the duration of the 10-day exposure.

The exposure period began by placing 10 randomly selected test organisms into each of the eight replicate test chambers for each sample location and control sample.

Approximately 4.0 mg of fish food was then added to each test chamber. Each day during the exposure period, the number of dead organisms was observed and recorded. The overlying water was siphoned off twice per day and replaced.

At the end of the 10-day exposure period, the physical water quality parameters were recorded from each test chamber. Each chamber was gently stirred and poured through a #60 mesh sieve and rinsed in a shallow pan. The remaining contents on the sieve were placed into a second shallow pan of water over a light table. The material was sorted to remove surviving test organisms. All surviving organisms were transferred to a 30-ml cup to record the number of survivors and prepare them for dry weight analysis.

After all test chambers had been sorted and the number of surviving organisms from each test chamber had been recorded, 0.5 ml of ethanol was added to each cup to kill the test organisms. The organisms were then transferred to a previously dried and weighed aluminum pan and placed in a drying oven maintained at 105 °C for six hours. Upon removal from the oven, the pans were placed into a dessicator to cool. The organisms were weighed to the nearest 0.01 mg.

2.3.4 Data Analysis

Data analysis was performed following procedures published by the EPA (Ingersoll,1994). Data for each sample replicate chamber consisted of survival (percentage of initial organisms surviving to the end of the test), growth (average dry weight of surviving organisms), and biomass (total dry weight of surviving organisms). Since the toxicity tests were conducted in three batches, the data were control normalized in order to make appropriate comparisons. Normalization consisted of expressing the results as a percentage of the average laboratory control response for the laboratory control sample tested concurrently with the particular sample.

2.4 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected and analyzed for calculation of appropriate benthic metrics. The procedures used are summarized in the following sections.

2.4.1 Benthic Macroinvertebrate Sorting, Enumeration and Identification

The benthic macroinvertebrate samples were subsampled and sorted to remove organisms from the vegetative debris. Organisms removed from the debris were identified to a minimum of family-level taxonomic classification. Lower classification was not practical in most cases because of the early life stages (instars) of the organisms present in the samples.

2.4.2 Subsampling and Sorting

The contents of multiple containers from each sampling location were poured into a 0.25-millimeter (mm) sieve and rinsed with cold tap water to remove formalin and silt/clay particles from the sample. The sample was then removed from the sieve and placed into a stainless steel mixing bowl to be homogenized by stirring with a spoon. The bowl was then emptied into a white enamel pan partially filled with water. Large pieces of grass and rock were removed from the pan after any adhering organisms were removed and placed with the remainder of the sample. The remaining residue in the pan, containing gravel, algae, small bits of vegetation and invertebrates, was emptied into a plankton splitter and homogenized. Each time the sample was poured into the splitter it was separated into equal volumes. A 100-organism target subsample size was used in order to expedite laboratory processing and to ensure valid comparability of individual metrics. All organisms were removed from each successive fraction (e.g., 1/8, 1/4, ½) until 100 organisms were removed, and were placed into glass vials containing ethanol. Each vial containing invertebrates was labeled with the station identification number.

2.4.3 Macroinvertebrate Identification

Organisms were identified using keys developed by Merritt and Cummins (1984), Peckarsky et al. (1990), and Pennak (1989). Each taxon of organisms identified at each location was placed into separate vials containing ethanol as a preservative in order to assemble a reference collection for this project. The organisms identified from each station location were enumerated and recorded on laboratory data sheets.

2.4.4 Data Analysis

In order to evaluate the benthic macroinvertebrate component of the Triad, the following three metrics were calculated: diversity, percent relative abundance of EPT taxa, and modified family biotic index. These metrics are described in detail below.

2.4.4.1 Diversity

Diversity (H'), also known as the Shannon's Index, was calculated using the program SPDIVERS.BAS from Ludwig and Reynolds (1988). For this investigation, H' was calculated using logarithmic base *e*. The equation for estimating H' is:

$$H' = \sum_{i=1}^{S}\left[\left(\frac{n_i}{n}\right) \ \ln\left(\frac{n_i}{n}\right)\right]$$

Shannon's Diversity Index is based on information theory and is a measure of the average degree of uncertainty in predicting the taxon of an individual chosen at random from a collection of S (taxa) and n (individuals). The average uncertainty increases as the number of taxa increases and as the distribution of individuals among the taxa becomes even. Therefore, H' incorporates both the number of taxa and the relative abundance of organisms among the taxa. H' is equal to zero if, and only if, there is one taxon in the sample. The maximum possible value of H' for a particular sample is the log of the total number of taxa in the sample. H' is maximum only when all taxa contain the same number of individuals (i.e., when there is a perfectly even distribution of abundances).

2.4.4.2 Percent Relative Abundance of EPT Taxa

The EPT taxa, Mayflies (Ephemeroptera), Stoneflies (Plecoptera) and Caddisflies (Trichoptera), are generally more abundant in areas of higher water quality (i.e., they are pollution sensitive). The relative abundance of organisms within the EPT taxa was calculated by dividing the number

of organisms within the Families Ephemeroptera, Plecoptera, and Trichoptera, by the total number of organisms in the sample and is expressed as a percentage.

2.4.4.3 Modified Family Biotic Index

The Modified Family Biotic Index (FBI) metric was calculated from the benthic macroinvertebrate data from each location as part of the procedures outlined in EPA Rapid Bioassessment Protocol II (Plafkin et al., 1989). This index, developed by Hilsenhoff (1988), summarizes the tolerances of the benthic macroinvertebrate community to pollutants with a single value. Tolerance values used in the calculation of FBI were obtained from Hilsenhoff (1988) and Bode (1988). The FBI is calculated by multiplying the number of organisms in each taxon by the tolerance value for that taxon, summing the products, and dividing by the total number of organisms in the sample for which an index exists. Values for the FBI range from 0.00 to 10.00 with higher values corresponding to greater levels of pollution tolerance. Therefore, higher FBI values are indicative of greater levels of environmental stress.

2.5 Triad Approach

The calculation of risk to benthic communities from sediment contamination follows a weight-of-evidence approach to interpret the implications of the different measurement endpoints. The approach used, often referred to as the Sediment Quality Triad, incorporates the results of three investigative areas: sediment chemistry, sediment toxicity, and *in situ* benthic community effects. The three components of the Triad approach integrate chemical and biological response data. They also provide the strongest evidence for identifying contaminant-induced degradation.

Because multiple reference streams with variable sediment chemistry, toxicity and benthic community results were sampled on Amchitka, RTR normalization was not employed in the present analysis. Rather, a ranking method was used, where each location is ranked for each parameter in the analysis. Overall mean ranks for each sampling location and each site stream were then calculated. Mean rankings were assigned to each sample location for each of the three Triad components (benthic macroinvertebrates, sediment chemistry, and toxicity test results). Lowland streams were ranked separately from upland streams. Using toxicity data in lowland streams as an example, the location with the highest mean of the survival, growth, or biomass was assigned a rank of one for that endpoint. The sample with the lowest mean of the survival, growth or biomass was assigned a rank of 22 for that endpoint, indicating that this sample was rated last among 22 locations/samples. When ties occurred, locations were scored by calculating the average of the numerical ranks. A rank for each Triad component was calculated by

averaging the ranks of the three endpoints of that component and then ranking the average ranks. An overall mean rank for each station was calculated by averaging the rank for each of the three Triad components.

The mean ranks for each Site station were compared to the mean average ranks for the reference stations for either upland streams or lowland streams. A probability analysis was also conducted for the mean ranks. The probability of obtaining mean ranks were determined. From this the mean rank, for which there is a 10% probability of randomly obtaining a higher mean rank, was calculated. This was considered the level which indicates rare poor quality ranks. Similarly, the 20% probability was considered the level of uncommon poor quality ranks. The 10% and 20% probability for lower mean ranks was considered the level of rare and uncommon good quality ranks.

Each site stream was also compared individually to the two reference streams in its geomorphic region. The test site streams (Clevenger Creek, Cloudberry Creek, Rainbow Creek, Bridge Creek, and White Alice Creek), which drain relatively lower elevations, were compared to Reference Streams 1 and 2. The drill site streams (Streams D, E, and F), which drain relatively higher elevations, were compared to Reference Streams 3 and 4. This was done by creating radial plots of the Triad ranks for each Site station, and then comparing them to the radial plots for the appropriate reference stations. Each leg of the radial plots represents the rank for one of the Triad components: biology, chemistry, or toxicity. If a leg of a Site station radial plot extends out further than the legs of the reference station radial plots, then the Site station is considered to have poorer than reference quality for that Triad component.

A site station, which has all legs of the radial plot extending further than the legs of the reference station radial plots, has a weight-of-evidence indicating that chemical contamination is impacting the benthic community. However, there are many instances where one or two legs of the radial plots for a station are worse (or better) than the legs of the reference station and the other leg is better (or worse). The conclusions for such stations are less definitive. The radial plots can also be used to compare the area defined by the plots between the Site stations and the reference stations. Since numerically lower ranks indicate higher quality, a triangle with its vertices at the ranks of the three components will enclose a smaller area when sediment quality is relatively good. Conversely, large Triad areas reflect poorer quality sediments.

The ranking method of Triad Analysis discussed previously is informative, but it does not illustrate the degree of magnitude of differences between sites. To better understand the magnitude of difference between stations that appear to show a negative impact and the non-impacted stations, particularly the reference locations, a multi-dimensional scaling approach was applied. In essence, this technique is used to represent the differences between stations as measured in many parameters (FBI, benthic diversity, EPT taxa, *Chironomus* survival, *Chironomus* biomass, *Chironomus* growth, PAHs, metals, and DRO) into a two-dimensional display.

The method chosen for the multi-dimensional scaling is called Principal Component Analysis (PCA) (Ludwig and Reynolds, 1988). First, the individual parameters are standardized and normalized (i.e., expressed in terms of standard deviations from the mean, with the mean established as zero). The distances between the samples are then calculated, and the two axes are determined which can best present the differences between the points in two dimensions and leave the least amount of difference unrepresented. In mathematical terms, the procedure calculates the principal eigenvectors. The first two principal eigenvectors are referred to as Principal Component I and Principal Component II and are represented as the x-axis and the y-axis. The mathematical equation of the eigenvectors describes the contribution of each parameter to the axes.

3.0 Results

The results of the sediment chemistry, toxicity, and benthic macroinvertebrate analysis are presented individually in this section, followed by the Triad Analysis which incorporates the three components into the overall sediment quality evaluation.

3.1 Sediment Chemistry

A summary of benchmarks for the sediment chemistry analytes is presented in Table 3.1-1. The results of the chemical analyses are presented in Tables 3.1-2 and 3.1-3 for upland streams, and in Tables 3.1-4 and 3.1-5 for lowland streams. Data is presented only for analytes for which at least one sediment sample had a detected concentration.

3.1.1 Upland Streams

As shown in Table 3.1-2, PAHs were detected in two of the streams: Drill Site D Stream Location 1 and Drill Site E Stream Location 1. The Drill Site E location had detectable levels of three PAHs: acenaphthene, fluorene, and phenanthrene. The Drill Site D location had detectable levels of 12 PAHs, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene.

Diesel range organics were detected in four of the five upland streams. It was not detected in Drill Site F Stream. Lowest concentrations were in Reference Stream 4, with concentrations of 9.95 milligrams per kilogram (mg/kg) at Location 3 and 10.7 mg/kg at Location 4. The highest concentrations were in Reference Stream 3, with a concentration of 206 mg/kg at Location 1. The detection of DRO in reference streams (where it was found in 5 of 10 sediment samples) indicates that biogenic DRO is common in Amchitka stream sediments. Diesel Range Organics were also detected at 22.1 mg/kg in Drill Site E Stream Location 2 and 176 mg/kg in Drill Site D Stream Location 1.

Carbon disulfide was not detected in any of the upland stream sediments. Total organic carbon content ranged from 1.2% at Drill Site D Stream Location 1 and Reference Stream 4 Location 3 to 15.9% at Reference Stream 3 Location 1.

Acid volatile sulfides (AVS) were detected in only half of the upland stream samples. Detected concentrations ranged from 2.63 millimole-per-kilogram (mmol/kg) at Reference Stream 3

Location 1 to 170 mmol/kg at Drill Site D Stream Location 1. Simultaneously extracted metals (SEM) were detected in all samples, with concentrations ranging from 0.553 mmol/kg at Drill Site D Stream Location 2 to 6.12 mmol/kg at Drill Site E Stream Location 1. The AVS concentrations exceeded SEM in only five locations: Drill Site D Locations 1 and 4, Drill Site F Stream Location 5, and Reference Stream 3 Locations 2 and 4. This indicates reduced metal bioavailability due to the presence of sulfides is not expected to be a major consideration.

A total of 23 metals were detected in upland streams: aluminum, arsenic, barium, boron, cadmium, calcium, cerium, chromium, cobalt, copper, iron, lithium, magnesium, manganese, molybdenum, nickel, potassium, selenium, strontium, thallium, titanium, uranium, vanadium, and zinc. Beryllium, cesium, thallium, and thorium were not detected in upland streams. Most metals were detected in all samples except for the following. Uranium was only detected at Drill Site D Stream Location 1 (2.49 mg/kg). Cadmium was only detected at Drill Site E Stream Location 1 (8.5 mg/kg). Molybdenum was only detected at Drill Site D Stream Location 2 (0.555 mg/kg) and Drill Site F Stream Location 3 (1.63 mg/kg). Boron was detected in five samples: all three Drill Site D Stream samples, one Drill Site F Stream sample, and one Reference Stream 3 sample. Selenium was detected in seven samples: two of three Drill Site E Stream samples, one Drill Site F Stream sample, one Reference Stream 3 sample, and all three Reference Stream 4 samples. Lithium was detected in all samples except for Reference Stream 3 Location 1.

All detected concentrations were compared to conservative sediment benchmarks (see Table 3.1-1) based on both bulk chemistry and, for organics, carbon normalized concentrations. Carbon disulfide was not detected above its benchmark value and was not included in further analyses. Many of the PAHs were detected above the benchmark values; therefore, all PAHs were retained for further evaluation. Nine of the metals detected have benchmark values: aluminum, arsenic, cadmium, chromium, copper, iron, manganese, nickel, and zinc. At least one sample for each of these metals had a detected concentration above the benchmark except for aluminum. However, all nine metals were retained for further analysis.

A PAH index was calculated as described in Section 2.2.1.3 for each upland stream station. Since only two upland stream samples had detectable levels of PAHs, the PAH index was calculated for these samples only: 0.021 for Drill Site D Stream Location 1 and 0.001 for Drill Site E Stream Location 1. These are presented in Table 3.1-3.

The DRO concentrations were carbon-normalized in order to get a relative idea of the bioavailability of DROs in each of the samples. The carbon-normalized DRO concentrations for the five stations at which DROs were detected are 2.1 mg/percent organic carbon (%OC) at Drill Site E Stream Location 2, 5.9 and 8.3 mg/%OC at Reference Stream 4 Locations 4 and 3, 13.0 mg/%OC at Reference Stream 3 Location 1, and 152 mg/%OC at Drill Site D Stream Location 1 (Table 3.1-3).

Total metals toxic units were calculated for each upland stream sample as the sum of the individual metal concentrations divided by the conservative sediment benchmark. These ranged from 2.9 at Drill Site F Stream Location 3 to 31.4 at Reference Stream 3 Location 2. These are also shown in Table 3.1.3.

3.1.2 Lowland Streams

Lowland stream sediment chemistry analytical results are shown in Table 3.1-4. PAHs were not detected in any of the lowland stream samples. The DROs were detected in eleven of the 22 samples ranging from 9.47 mg/kg at Reference Stream 2 Location 5 to 2,110 mg/kg at Rainbow Creek Location 3. The DROs were not detected in any of the Bridge Creek, Cloudberry Creek, or Reference Stream 1 samples. However, DRO was detected in four of ten lowland reference stream samples, indicating that biogenic DRO is present in Amchitka stream sediments. The maximum DRO concentration detected in lowland reference streams was 15.3 mg/kg. The maximum concentration detected at a Triad reference location was 13.6 mg/kg at Reference Stream 2 Location 2.

Carbon disulfide was detected in two of the lowland stream samples. Clevenger Creek Location 2 had 0.136 mg/kg CS_2 and Cloudberry Creek Location 2 had 0.025 mg/kg. Total Organic Carbon ranged from 0.8% in White Alice Creek Location 3 to 28.4% in Rainbow Creek Location 2. Carbon Disulfide was detected in trip blank samples and is not certified as non-detect by the manufacturer of the sample containers. Therefore, the detected concentrations of carbon disulfide are attributable to contaminated sample containers and are not believed to be site-related.

The AVS were detected in 12 of the lowland stream samples. They were not detected in Rainbow Creek. Detected concentrations ranged from 0.132 mmol/kg in Reference Stream 2 Location 2 to 1,375 mg/kg in Cloudberry Creek Location 1. The AVS concentrations exceeded SEM in nine of the lowland stream samples. Therefore, AVS may play a role in reducing metals

bioavailability in a significant portion of the lowland streams. However, the AVS are insufficient to completely reduce bioavailability of these metals in more than half of the stream locations.

All 27 metals for which analyses were conducted were detected in at least one lowland stream sample. Beryllium was only detected in Cloudberry Creek Location 5 (2.9 mg/kg). Thorium and uranium were only detected in Reference Stream 2 Location 5 (0.5 mg/kg and 2.11 mg/kg, respectively). Cadmium and thallium were only detected in Cloudberry Creek Location 5 and Reference Stream 2 Location 5. Cesium was detected in Clevenger Creek Location 5 and Cloudberry Creek Location 5. Boron was detected in Clevenger Creek Locations 2 and 5, Rainbow Creek Location 5, and Reference Stream 2 Location 5. Molybdenum was detected in Cloudberry Creek Location 5, Reference Stream 1 Location 3, and Reference Stream 2 Location 5. Selenium was detected in seven of the 22 samples. Cobalt and lithium were detected in all but two samples (Rainbow Creek Locations 2 and 3). And chromium was detected in all but one sample (Rainbow Creek Location 2).

All detected concentrations were compared to conservative sediment benchmarks (see Table 3.1-1) based on both bulk chemistry and, for organics, carbon-normalized concentrations. Carbon disulfide was not detected above its benchmark value and was not included in further analyses. The PAHs were not detected in any of the lowland stream samples and are, therefore, not above the benchmark values. Nine of the metals detected have benchmark values: aluminum, arsenic, cadmium, chromium, copper, iron, manganese, nickel, and zinc. At least one sample for each of these metals had a detected concentration above the benchmark except for chromium. However, all nine metals were retained for further analysis.

The PAH toxic units, metals toxic units, and carbon-normalized DRO concentrations for the Lowland stream locations are presented in Table 3.1-5. A PAH index was assumed to be zero for all lowland stream locations since they were not detected in any lowland stream sample.

The DRO concentrations were carbon-normalized in order to get a relative idea of the bioavailability of DROs in each of the samples. The carbon-normalized DRO concentrations for the eleven stations at which DROs were detected ranged from 2.2 mg/%OC at Clevenger Creek Location 5 to 141 mg/%OC at White Alice Creek Location 3.

Total metals toxic units were calculated for each lowland stream sample as the sum of the individual metal concentrations divided by the conservative sediment benchmark. These ranged from 2.7 at Rainbow Creek Location 2 to 84.4 at Reference Stream 2 Location 5. These are also presented in Table 3.1.5.

3.2 Sediment Toxicity

The results of the sediment toxicity tests are presented in Table 3.2-1 and Table 3.2-2 and are discussed in the following sections.

3.2.1 Upland Streams

Survival in the upland stream samples ranged from 26.25% in Stream D Location 2 to 91.25% in Reference Stream 3 Location 4 and Reference Stream 4 Location 3. The control-normalized survival ranged from 27.99% in Stream D Location 2 to 102.82% in Reference Stream 4 Location 3. Growth in these samples ranged from an average dry weight per surviving organism of 0.280 mg in Stream E Location 4 to 1.367 mg in Stream D Location 1. The control-normalized growth ranged from 55.6% in Stream E Location 4 to 185.1% in Stream D Location 1. The total surviving biomass ranged from 1.82 mg in Reference Stream 3 Location 1 and Location 2 to 6.37 mg in Stream D Location 1. The control-normalized biomass ranged from 33.2% in Stream D Location 2 to 92.2% in Stream D Location 1.

3.2.2 Lowland Streams

Survival in the lowland stream samples ranged from 0% in Rainbow Creek Location 3 to 92.5% in White Alice Creek Location 2. The control-normalized survival ranged from 0% in Rainbow Creek Location 3 to 104.23% in White Alice Creek Location 2. Growth in these samples ranged from 0 mg in Rainbow Creek Location 3 to 1.315 mg in Cloudberry Creek Location 1. The control-normalized growth ranged from 0% in Rainbow Creek Location 3 to 177.9% in Cloudberry Creek Location 1. The total surviving biomass ranged from 0 mg in Rainbow Creek Location 3 to 6.77 in Cloudberry Creek Location 1. The control normalized-biomass ranged from 0% in Rainbow Creek Location 3 to 116.3% in White Alice Creek Location 2.

3.3 Benthic Macroinverterbrate Community Analysis

The results of the benthic macroinvertebrate community analysis are presented in Tables 3.3-1 and 3.3-2 and are summarized in the following sections.

3.3.1 Upland Streams

A summary of taxa identified at the upland stations is shown in Table 3.3-1. The FBI, EPT, and species diversity values are also shown on Table 3.3-1. The FBI ranged from 4.38 at Site E Stream Location 1 to 7.94 at Reference Stream 4 Location 3. The relative abundance of EPT taxa ranged from 1.1% at Reference Stream 4 Location 3 to 70.8% at Site E Stream Location 1. Species diversity values ranged from 0.12 at Reference Stream 4 Location 3 to 1.47 at Site D Stream Location 2.

3.3.1.1 Site D Stream

A total of nine taxa were identified at the Stream D stations. The dominant organisms at Stream D were two Families of amphipods (Gammaridae and Talitridae). Of the six taxa identified at Station D1, *Hyalella* sp. were the dominant organisms. Chironomidae larvae and Gammarid amphipods were also present in abundance at Location D1. Five taxa were identified at D2 where the dominant organism was Chironomidae larva. Five taxa were identified at D4 where Tubifex worms were dominant. The FBI ranged from 5.54 at D2 to 7.09 at D4. The overall FBI values at the Stream D stations were higher than the overall values at Reference Stream 3 and lower than the overall FBI values at the Reference Stream 4 stations. The relative abundance of EPT taxa ranged from 6.10% at D1 to 25.7% at D2. The overall relative abundance of EPT taxa at the Stream D stations was lower than the overall values at Reference Stream 3 and higher than the overall values at Reference Stream 4. Species diversity ranged from 0.98 at D4 to 1.47 at D2. Overall species diversity values at the Stream D stations were higher than the overall values at Reference Streams 3 and 4.

3.3.1.2 Site E Stream

A total of six taxa were identified in the Stream E samples, where mayfly nymphs (*Pseudocloeon* sp.) were the most abundant organisms. (An adult arachnid, a terrestrial spider, was also found in the Stream E samples.) A total of four taxa were identified at Stream E Location 1 and caddisfly larvae (Limnephilidae) were numerically dominant. Three taxa were identified at E2, where Mayfly nymphs were dominant. Two taxa were identified at E4 where Caddisfly larvae and Tubifex worms were identified. The FBI ranged from 4.38 at E1 to 5.33 at E4. Overall FBI values at Stream E were lower than the overall FBI values at Reference Stream 3 or 4. The relative abundance of EPT taxa ranged from 70.8% at E1 to 66.7% at E4. The overall relative abundance of EPT taxa at Stream E was higher than the overall relative abundance of EPT taxa at Reference Streams 3 and 4. Species diversity decreased from 1.23 at E1 to 0.64 at E4. Overall

species diversity values for the Stream E were lower than the overall Reference Stream 3 diversity values, but higher than the overall diversity values at Reference Stream 4.

3.3.1.3 Site F Stream

A total of eight taxa were identified at Stream F (Limpet Creek). A total of five taxa were present at Site F Location 1. Clams (Sphaeriidae) and amphipods (*Hyalella sp.*) were dominant at F1. Three taxa were identified at F3, and Tubifiex worms were the dominant taxon. Four taxa were identified at F5 where Tubifex worms were also the dominant taxon. The FBI ranged from 7.09 at F5 to 7.84 at F1. Overall FBI values at the Stream F sampling locations were higher than the overall values at Reference Stream 3 and similar to the overall values at Reference Stream 4. The relative abundance of EPT taxa ranged from 1.3% at F1 to 22.7% at F5. The overall relative abundance of EPT taxa for the Stream F were lower than the overall values at Reference Stream 3, but greater than the overall values at the Reference Stream 4 stations.

3.3.2 Lowland Streams

A summary of the taxa identified at the lowland stations is shown in Table 3.3-2. The FBI, EPT, and species diversity values are also shown in Table 3.3-2. The FBI ranged from 4.14 at Reference Stream 2 Location 5 to 7.72 at Bridge Creek Location 3. The percent relative abundance of EPT taxa ranged from 86.40% at Reference Stream 2 Location 5 to 0% at White Alice Creek Location 4 and Cloudberry Creek Location 1. Species diversity values varied from 1.6 at Clevenger Creek Location 2 to 0.31 at Reference Stream 1 Location 1.

3.3.2.1 Bridge Creek

A total of nine taxa were identified in the Bridge Creek samples. Chironomid larvae and Caddisfly larvae (Limniphilidae) were the most abundant taxa in terms of relative abundance. Of the seven taxa identified at Bridge Creek Location 2, Chironomidae and Limniphilidae larvae were numerically dominant. Tubificid worms were the most abundant organisms of the four taxa identified at Bridge Creek Location 3. Of the four taxa identified at Bridge Creek Location 5, Chironomid larvae and clams (Sphaeriidae) were most abundant. The family biotic index ranged from 5.76 at the upstream station Bridge Creek 2 to 7.72 at Bridge Creek 3. The FBI value of 5.76 at Bridge Creek 2 is lower than the FBI values at all Reference Stream 1 sampling stations. The FBI calculated at Bridge Creek 3 is higher than the FBI values calculated at Reference Streams 1 and 2. The relative abundance of EPT taxa ranged from 28.20% at Bridge Creek 2 to 1.5% at Bridge Creek 3. The EPT abundance at Bridge Creek 2 was higher than that at Reference Stream 1 Location 1 and Reference Stream 2 Location 2, which had EPT percentages

of 7.9% and 4.7%, respectively. Species diversity ranged from 1.29 at Bridge Creek 2 to 0.34 at Bridge Creek 3. Species diversity was higher at Bridge Creek 2 than at the upstream reference locations, Reference Stream 1 Location 1 and Reference Stream 2 Location 2, which had diversity values of 0.31 and 0.65 respectively. Diversity at Bridge Creek Location 3 was lower than at the corresponding reference stations (Reference Stream 1 Location 3 and Reference Stream 2 Location 3) which had values of 1.22 and 0.73.

3.3.2.2 Cloudberry Creek

A total of 14 taxa were identified in the Cloudberry Creek samples. Chironomid larvae and isopods (Asellidae) were the most abundant taxa in terms of relative abundance. Five taxa were identified at Cloudberry Creek Location 1 with Chironomidae larvae being the most abundant. Nine taxa were present at Cloudberry Location 2, with Chironomidae larva and isopods being most abundant. Of the seven taxa identified at Cloudberry 5, Chironomidae larva were numerically dominant. Significantly fewer Chironomidae larva were present at Cloudberry 5 as compared to Cloudberry Locations 1 and 2. Family Biotic Index values ranged from 6.10 at Cloudberry 1 to 6.94 at Cloudberry 2. Overall FBI values for Cloudberry Creek were higher than those calculated from the Reference Streams 1 and 2 data. The relative abundance of EPT taxa ranged from 0% at Cloudberry 1 to 13.9% at Cloudberry 5. The overall percentage of EPT taxa was lower for Cloudberry Creek than for Reference Streams 1 or 2. Species diversity values ranged from 0.67 at Cloudberry 1 to 1.45 at Cloudberry 2. Overall species diversity values for Cloudberry Creek were higher than those calculated for Reference Streams 1 and 2.

3.3.2.3 Clevenger Creek

A total of 12 taxa were identified at the Clevenger Creek stations. The most abundant taxa identified in the Clevenger Creek samples were Chironomidae larvae. Six taxa were identified at Clevenger Creek Location 1 and Chironomidae larvae and isopods were dominant. Seven taxa were identified in Clevenger Creek Location 2 where Mayfly nymphs (*Pseduocloeon* sp.) were dominant. Five taxa were identified at Clevenger 5 where Tubifex worms were present in the greatest number. Overall abundance of organisms decreased from upstream station Clevenger 2 to downstream station Clevenger 5. The FBI values ranged from 5.45 at Clevenger 2 to 6.83 at Clevenger 5. The FBI values calculated for the Clevenger Creek samples fall within the range of FBI values at Reference Streams 1 and 2. The relative percent abundance of EPT taxa increased from 2.4% at Clevenger 1 to 38% at Clevenger 2. Overall EPT abundance at the Clevenger Creek stations were greater than that at Reference Stream 1 but lower than Reference Stream 2.

Species diversity increased from 0.93 at Clevenger 1 to 1.6 at Clevenger 2. Overall species diversity values at the Clevenger Creek stations were higher than at Reference Streams 1 or 2.

3.3.2.4 Rainbow Creek

A total of eight taxa of benthic macroinvertebrates were identified in the Rainbow Creek samples. A terrestrial arachnid was also found in the Location 2 sample. The most abundant organisms were Chironomidae larvae. Six taxa were identified at Rainbow Creek Location 2 and Diamesinae midge larvae were numerically dominant. Chironomidae larvae were dominant at Rainbow Creek 3, where a total of three taxa were identified. Four taxa were identified at Rainbow Creek 5 where Chironomidae larva were also dominant. The FBI index ranged from 5.89 at Rainbow Creek 3 to 6.15 at Rainbow Creek 5. Overall FBI values at the Rainbow Creek stations were lower than Reference Streams 1 or 2. The relative abundance of EPT taxa increased in a downstream direction from 3.1% at Rainbow Creek 2 to 8.9% at Rainbow Creek 5. The overall relative abundance of EPT taxa were higher at Reference Streams 1 and 2 than in Rainbow Creek. Species diversity ranged from 0.34 at Rainbow Creek 3 to 1.01 at Rainbow Creek 5. Overall species diversity values at the Rainbow Creek stations were within the range of the values obtained at Reference Stream 1 and lower than the overall species diversity values at Reference Stream 2.

3.3.2.5 White Alice Creek

A total of twelve taxa were identified from the White Alice Creek samples. Amphipods (Gammaridae) were dominant in terms of relative abundance followed by Chironomidae larvae. Chironomidae larvae were dominant at White Alice Creek Location 2 where four taxa were identified. Eight taxa were identified at White Alice Creek 3 where midge larvae and blackfly larvae were dominant. Amphipods (Gammaridae) were dominant at White Alice 4 where five taxa were identified. Chironomidae larva and amphipods were dominant at White Alice 5 where eight taxa were identified. Benthic macroinvertebrate abundance generally increased from the upstream stations towards the downstream stations. The FBI ranged from 4.23 at White Alice 4 to 6.27 at White Alice 3. Overall FBI values at the White Alice Creek stations were lower than Reference Streams 1 or 2. The relative abundance of EPT taxa ranged from 0% at White Alice 4 to 21.1% at White Alice 2. Overall EPT abundance at the White Alice Creek stations was lower than Reference Streams 1 or 2. Species diversity ranged from 0.42 at White Alice 4 to 1.41 at White Alice 3. Overall species diversity at the White Alice Creek stations was lower than the overall diversity at the Reference Stream 1 stations and higher that the overall diversity values at the Reference Stream 2 stations.

3.4 Triad Analysis

Due to the need to sample various reference streams with different characteristics, the RTR method of evaluating site locations with the Triad approach was not employed. An approach using ranking of the lowland stations and of the upland stations was used. The following sections describe the results of those rankings.

3.4.1 Upland Streams

The following sections present the results of the Triad Analysis for the upland streams, which include Site D Stream, Site E Stream, Site F Stream, as well as Reference Streams 3 and 4.

3.4.1.1 Benthic Macroinvertebrates

The numerical ranking for the 15 upland stations is presented in Table 3.4-1. Lower number ranks represent better conditions. Reference stream station ranks ranged from 3 to 15 for the Family Biotic Index. Reference Stream 4 Locations 3 and 4 were ranked 15 and 13, respectively. Drill Site E Stream Locations 1 and 2 were ranked better than all reference stream locations with ranks of 1 and 2, respectively. Drill Site F had the poorest FBI ranks overall of the upland site streams with ranks of 14, 12, and 10.5 for Locations 1, 3, and 5, respectively.

Reference stream station ranks ranged from 4 to 15 for relative percentage of EPT taxa. Reference Stream 4 Locations 3 and 4 were ranked 15 and 11, respectively, and Reference Stream 3 Location 1 was ranked 13. Drill Site E Stream Locations 1, 2, and 3 were ranked better than all reference stream locations with ranks of 1, 2, and 3, respectively. Drill Site F Stream Location 1 had the poorest EPT rank among the upland site streams with a rank of 14.

Reference stream station ranks ranged from 4 to 15 for species diversity. Reference Stream 4 Locations 3 and 4 were ranked 15 and 13, respectively. Drill Site D Stream Locations 1 and 2 and Drill Site E Stream Location 1 had diversity rankings better than all upland reference stream locations with ranks of 2, 1, and 3, respectively.

The upland stream stations were ranked with regard to average benthic endpoint rank. The reference stream station ranks ranged from 2.5 to 15. Reference Stream 4 Locations 3 and 4 were ranked 15 and 14, respectively. Drill Site E had the best ranks overall with ranks of 1, 4, and 5 for Locations 1, 2, and 4. Drill Site F had the worst ranks overall of the upland site streams with ranks of 12.5, 12.5, and 9 for Locations 1, 3, and 5, respectively.

Each of the site stream locations was compared to the appropriate reference stream locations in order to determine whether the site stream location had ranks within the range of (or better than) the appropriate reference stream locations. Up-stream stations were compared to up-stream reference stations, central stations were compared to central reference stream stations, and down-stream stations were compared to down-stream reference stream stations. These comparisons are presented symbolically in Table 3.4-2. A "+" is presented if the site stream station was ranked better than or within the range of the appropriate reference stations. A "-" is presented if the site stream station was ranked worse than both of the appropriate reference stations. The up-stream station (Location 1) on Drill Site F Stream was ranked worse than the up-stream reference stations for both FBI and EPT relative abundance, as well as for overall benthic quality. No other upland stream locations were ranked worse than the reference stations for any endpoints.

3.4.1.2 Sediment Chemistry

Reference stream station ranks ranged from 5.5 to 14 for DRO. Reference Stream 3 Location 1 and Reference Stream 4 Locations 3 and 4 had DRO ranks of 14, 12, and 12, respectively. All other reference stream stations had ranks of 5.5 due to nondetectable levels of DRO. Drill Site D Stream Location 1 and Drill Site E Stream Location 2 had DRO ranks of 15 and 11, respectively. All other site stream stations had ranks of 5.5 due to nondetectable levels of DRO.

Reference stream station ranks ranged from 2 to 15 for metals. Reference Stream 3 had higher values with ranks of 13, 15, and 10 for Locations 1, 2, and 4, respectively, whereas Reference Stream 4 had ranks of 9, 5, and 2 for Locations 2, 3, and 4, respectively. Drill Site F Stream had the lowest overall metals ranks with ranks of 6, 1, and 4 for Locations 1, 3, and 5, respectively. The highest metals ranks for site samples were found at Drill Site E Location 1 and Drill Site D Locations 1 and 4 with ranks of 14, 11, and 12, respectively.

Reference stream stations all had ranks of 7 for PAHs due to nondetectable levels of PAHs. Drill Site D Location 1 and Drill Site E Location 1 had PAH ranks of 15 and 14, respectively. All other site stream stations had ranks of 7 due to nondetectable levels of PAHs.

The overall chemistry ranks for the reference stream stations ranged from 6 to 14. Reference Stream 3 Locations 1 and 2 had ranks of 14 and 12, respectively. Drill Site F Stream had the best overall chemistry ranks with ranks of 4, 1, and 3 for Locations 1, 3, and 5, respectively. The worst chemistry ranks in upland site samples were at Drill Site D Stream Location 1 and Drill Site E Locations 1 and 2 with ranks of 15, 13, and 11, respectively.

A comparison of ranks for up-stream, central, and downstream site stations to the appropriate reference stations for chemistry is presented in Table 3.4-2. For up-stream stations, Drill Site D Location 1 had ranks for DROs and PAHs worse than the reference streams and Drill Site E Location 1 had ranks for metals and PAHs worse than the reference streams. Drill Site D Location 1 also had an overall chemistry rank worse than reference. None of the central site stream stations were ranked worse than the central reference stations for any of the chemistry endpoints. For down-stream stations, Drill Site D Location 4 was ranked worse that reference for metals as well as for overall chemistry.

3.4.1.3 Toxicity Testing

Reference stream station ranks ranged from 1 to 11 for toxicity test survival. All Drill Site D Stream stations ranked worse with ranks of 14, 15, and 12 for Locations 1, 2, and 4, respectively. Drill Site E Stream stations were ranked best of the upland site streams with ranks of 6, 4, and 3, for Locations 1, 2, and 4, respectively.

Reference stream station ranks ranged from 7 to 13 for toxicity test growth. Drill Site E Stream Locations 2 and 4 had ranks of 14 and 15, respectively. Drill Site D Stream had the best ranks among the site streams with ranks of 1, 2, and 5 for Locations 1, 2, and 4, respectively.

Reference stream station ranks ranged from 2 to 13.5 for toxicity test biomass. Reference Stream 3 Locations 1 and 2 had ranks of 13.5. Drill Site D Stream Location 2 had the worst site rank with a rank of 15 and Drill Site D Stream Location 1 had the best site rank with a rank of 1.

The overall toxicity ranks for the reference stream stations ranged from 1.5 to 15. Reference Stream 3 Locations 1 and 2 had overall toxicity ranks of 14 and 15, respectively. Reference Stream 4 had overall toxicity ranks of 1.5, 3.5, and 5 for Locations 2, 3, and 4, respectively. For the site streams, the four worst site overall toxicity ranks were found at Drill Site D Location 2, Drill Site E Locations 2 and 4, and Drill Site F Location 3 with ranks of 13, 11, 12, and 10, respectively.

A comparison of ranks for up-stream, central, and down-stream site stations to the appropriate reference stations for toxicity is presented in Table 3.4-2. For up-stream stations, Drill Site D Stream Location 1 and Drill Site F Stream Location 1 had ranks for survival worse than the reference streams. Overall toxicity ranks were within the range of reference stations. For central stations, Drill Site D Location 2 had worse ranks for survival and biomass, Drill Site E Location

2 had worse ranks for growth, and Drill Site F Stream Location 3 had a worse rank for survival. None of the central site stream stations were ranked worse than the central reference stations for average toxicity. For down-stream stations, Drill Site D Location 4 was ranked worse that reference for survival and biomass. Drill Site E Location 4 was ranked worse than reference for growth and biomass. Drill Site F Location 5 was ranked worse than reference for survival and biomass. All three of the site down-stream locations were ranked worse than reference for overall toxicity.

3.4.2 Lowland Streams

The following sections present the results of the Triad Analysis for lowland streams, which include White Alice Creek, Bridge Creek, Rainbow Creek, Cloudberry Creek, Clevenger Creek, and Reference Streams 1 and 2.

3.4.2.1 Benthic Macroinvertebrates

The numerical ranking for the 22 lowland stations is presented in Table 3.4-3. Reference stream station ranks ranged from 1 to 21 for the Family Biotic Index. Reference Stream 2 Locations 2 and 3 were ranked 20 and 21, respectively, whereas Reference Stream 2 Location 5 had an FBI ranking of 1. White Alice Creek Locations 4 and 5 were ranked best of the site stream locations with ranks of 2 and 3, respectively. Bridge Creek Location 3 had the worst rank of the site streams with a rank of 22.

Reference stream station ranks ranged from 1 to 15 for relative percentage of EPT taxa. Reference Stream 2 Locations 2 and 3 were ranked 14 and 15, respectively, and Reference Stream 2 Location 5 was ranked 1. White Alice Creek Locations 4 and 5 and Cloudberry Creek Locations 1 and 2 had the worst ranks for site stations with ranks of 21.5, 19.5, 21.5, and 19.5, respectively. Clevenger Creek Location 2 and Bridge Creek Location 2 had the best ranks among the site stations with ranks of 2 and 3, respectively.

Reference stream station ranks ranged from 8 to 22 for species diversity. Reference Stream 1 Location 1 was ranked 22. Clevenger Creek 2 and Cloudberry Creek 2 were ranked best with ranks of 1 and 2, respectively. Bridge Creek 3 and Rainbow Creek 3 were ranked worst among the site stations with a rank of 20.5.

The lowland stream stations were ranked with regard to average benthic endpoint rank. The reference stream station ranks ranged from 2 to 20.5. Reference Stream 2 Locations 2 and 3

were both ranked 20.5. Reference Stream 2 Location 5 was ranked 2. Clevenger Creek Location 2 had the best rank of 1 and Bridge Creek Location 3 had the worst average benthic rank of 22.

The up-stream stations Cloudberry Creek Location 1, Clevenger Creek Location 1, and Rainbow Creek Location 2 were ranked worse than the up-stream reference stations for EPT relative abundance. They were within the range of the up-stream reference streams for overall benthic quality.

3.4.2.2 Sediment Chemistry

Reference stream station ranks ranged from 6 to 18 for DRO. Reference Stream 2 Locations 2 and 5 had DRO ranks of 17 and 18, respectively. All other reference stream stations had ranks of 6 due to nondetectable levels of DRO. Clevenger Creek Locations 1, 2, and 5 had ranks of 20, 19, and 12, respectively. Rainbow Creek Locations 2 and 3 had ranks of 14 and 21, respectively. White Alice Creek Locations 2, 3, 4, and 5 had ranks of 16, 22, 13, and 15, respectively. All other site stream stations had ranks of 6 due to nondetectable levels of DRO.

Reference stream station ranks ranged from 9 to 22 for metals. Reference Stream 2 Location 5 had a rank of 22, and Reference Stream 1 Location 5 had a rank of 9. White Alice Creek Location 2 and Rainbow Creek Location 5 had the worst site station metals ranks with ranks of 21 and 20, respectively. The best metals ranks for site samples were found at Rainbow Creek Location 2, Cloudberry Creek Location 1, and Rainbow Creek Location 3 with ranks of 1, 2, and 3, respectively.

All lowland stations had PAH ranks of 11.5. PAHs were not detected in lowland streams.

The overall chemistry ranks for the reference stream stations ranged from 6.5 to 21.5. Reference Stream 2 Locations 5 and 2 had ranks of 21.5 and 16, respectively. White Alice Creek had the worst overall chemistry ranks with ranks of 20, 21.5, 17.5, and 19 for Locations 2, 3, 4, and 5, respectively. The best chemistry ranks in site samples were at Cloudberry Creek with ranks of 1, 5, and 4 at Locations 1, 2, and 5, respectively, and Bridge Creek with ranks of 3 and 2 at Locations 2 and 5, respectively.

A comparison of ranks for up-stream, central, and down-stream site stations to the appropriate reference stations for chemistry is presented in Table 3.4-4. For up-stream stations, Clevenger Creek Location 1 had a rank for DROs worse than the reference streams and White Alice Creek

Location 2 had a rank for metals worse than the reference streams. Both of these up-stream stations had an overall chemistry rank worse than reference. For the central site stream stations, Clevenger Creek Location 2, Rainbow Creek Location 3, and White Alice Creek Locations 3 and 4 were ranked worse than the central reference stations for DRO. All of these except for the Rainbow Creek station had overall chemistry ranks worse than the central reference stations. For down-stream stations, none of the site stations were ranked worse than the reference stations. None of the Bridge Creek or Cloudberry Creek stations were ranked worse than their respective reference stations on any of the chemistry endpoints.

3.4.2.3 Toxicity Testing

Reference stream station ranks ranged from 2 to 18 for toxicity test survival. White Alice Creek Location 2 was ranked best for the site stations with a rank of 1. Rainbow Creek Location 3, White Alice Creek Location 4, and Clevenger Creek Locations 1 and 5 were ranked worse with ranks of 22, 21, 19.5, and 19.5, respectively. White Alice Creek Locations 2 and 5 were ranked best of the site streams with ranks of 1 and 3, respectively.

Reference stream station ranks ranged from 4 to 19 for toxicity test growth. Cloudberry Creek Location 1, Clevenger Creek Location 1, and White Alice Creek Location 4 had the best ranks among the site streams with ranks of 1, 2, and 3, respectively. Rainbow Creek Locations 3 and 5 and Cloudberry Creek Location 5 had the worst growth ranks with ranks of 22, 20, and 21, respectively.

Reference stream station ranks ranged from 6.5 to 17 for toxicity test biomass. Rainbow Creek Locations 3 and 5, Cloudberry Creek Location 5, Clevenger Creek Location 5, and White Alice Creek Location 4 had the worst site ranks with ranks of 22, 19, 21, 20, and 18, respectively. White Alice Creek Locations 2 and 5, Cloudberry Creek Location 1, and Bridge Creek Locations 5 and 3 had the best site ranks with ranks of 1, 3, 2, 4, and 5, respectively.

The overall toxicity ranks for the reference stream stations ranged from 6 to 18. Reference Stream 2 Locations 2 and 3 had overall toxicity ranks of 16 and 18, respectively. Reference Stream 1 Location 3 had an overall toxicity rank of 6. The four worst site stream overall toxicity ranks were found at Rainbow Creek Locations 3 and 5, Clevenger Creek Location 5, and Cloudberry Creek Location 5 with ranks of 22, 19, 21, and 20, respectively.

A comparison of ranks for up-stream, central, and down-stream site stations to the appropriate reference stations for toxicity is presented in Table 3.4-4. For up-stream stations, Bridge Creek Location 2, Cloudberry Creek Location 1, Clevenger Creek Location 1 and Rainbow Creek Location 2 were ranked worse than their respective up-stream reference stations. For central stations, Rainbow Creek Location 3 was ranked worse than the respective reference stations on all endpoints and White Alice Creek Location 4 was ranked worse on survival and biomass, but not overall toxicity. No other central stream locations were ranked worse than the reference for any toxicity endpoints. For down-stream stations, Cloudberry Creek Location 5 and Rainbow Creek Location 5 were ranked worse than the down-stream reference stations for growth and biomass. Clevenger Creek Location 5 was ranked worse than reference for survival and biomass. All three of these site down-stream locations were ranked worse than reference for overall toxicity.

3.5 Analysis of Results

Over their relatively short lengths, the streams of Amchitka are quite variable in gradient, flow velocity and substrate, with habitats ranging from ponded areas with silty substrates to rocky riffles, waterfalls and pools. All streams sampled included an up-stream location, a location in the central reach of the stream, and a down-stream location near the mouth. (The sample location designated number one was the furthest up-stream location, number five the furthest down-stream location.)

The upstream sampling areas in site streams were most similar to upstream reference locations, central areas in site streams closely resembled reference stream central areas, and downstream portions of the site streams were most similar to downstream reference areas. For this reason, most comparisons in this analysis compare specific sampling locations to the corresponding locations on reference streams. Comparisons incorporating all stations were also made in order to evaluate overall habitat quality of site streams in comparison to reference streams. Upland and Lowland sites were analyzed separately.

3.5.1 Upland Streams

Of the total of 15 sampling locations on upland streams (9 stations on site streams, 6 stations on reference streams), four of the five highest overall ranked locations were on Drill Site Streams. Site E Stream Location 1 ranked second overall, Stream E Location 4 was third, Stream F Location 5 ranked fourth, and Stream D Location 2 ranked fifth. All three of the Drill Site streams had locations ranked as high quality in relation to the reference streams. The three

lowest ranked locations were on reference streams, which were unimpacted by contaminants from the Drill Sites. The mean ranks for the upland sampling locations are shown in the table below.

Upland Stream Station Mean Ranks			
Rank	**Station**	**Rank**	**Station**
1	RS4 2	9	F 3
2	E 1	10	RS4 4
3	E 4	11	E 2
4	F 5	12	D 4
5	D 2	13	RS4 3
6	RS3 4	14	RS3 2
7.5	F 1	15	RS3 1
7.5	D 1		

No obvious pattern of differences is apparent between sampling stations on site streams and those on reference streams. Factors controlling the mean ranks were variable for both site stations and test stations.

3.5.1.1 Upland Stream Probability Analysis

The ranking data were used to calculate the probability of randomly receiving a certain rank. From this, the Triad stations with average ranks that are unlikely to occur by chance alone can be determined. The 10th percentile was chosen to represent the rare occurrences and the 20th percentile was chosen to represent uncommon occurrences. These data are plotted in Figure 3.5-1. In this analysis, the upstream station on Reference Stream 3 was in the poorer 10th percentile. Upstream Stations on Stream E and Reference Stream 4 were of uncommon good quality rank. All central and downstream sampling stations fell in the "common rank" probability range. The probability analysis did not indicate any difference in quality among the Drill Site stream and reference stream sampling stations.

3.5.1.2 Upland Stream Triad Area Plots

The area of radial plots of the Triad ranks can also be used to evaluate sediment quality. For upland streams, these area plots are presented in Figures 3.5-2 – 3.5-13. Each figure presents data for site streams compared to the appropriate reference stream data. The ranks for the Triad components are plotted on the axes of the radial plot. Since numerically lower ranks indicate higher quality, a triangle with its vertices at the ranks of the three components will enclose a smaller area when sediment quality is relatively good. Conversely, large Triad areas reflect poorer quality sediments. The calculated areas are shown in each figure. The figure showing the mean rank for the stream as a whole is described first, followed by a description of the individual station area plots.

Drill Site D Stream

Figure 3.5-2 shows the area plots for the Site D Stream mean ranks along with the mean ranks for the two upland reference streams. As indicated by the areas enclosed by the triangles, sediment quality (as evaluated from all components of the Triad Analysis) was within the range of overall quality found in the reference streams.

Triad plots of the individual Stream D stations are shown in Figures 3.5-3 through 3.5-5. As shown in Figure 3.5-3, the quality range in the upstream reference stations was quite large, with poorer sediment quality found in Reference Stream 3. The area of the Stream D upstream station was in the range of the reference stations, but closer to the higher quality Reference Stream 4 upstream location.

In Figure 3.5-4, the central Triad station on Stream D (Station 2) is compared to the central stations on the upland reference streams. The areas indicate that overall sediment quality at the central Stream D station is quite good relative to the comparable reference stations. The central reference stations were similar in plotted Triad area, but the individual component rankings varied considerably.

Figure 3.5-5 shows the Triad plot of the downstream station on Site D Stream compared to the appropriate upland reference stations. Although none of the three Triad components ranked very poorly, the area of the Site D Triad plot is greater than both of the comparable upland reference stations. This was the only upland Drill Site sampling station that ranked lower in area than both of the appropriate reference locations.

Drill Site E Stream

Figure 3.5-6 presents the area plots for the Site E Stream mean ranks along with the mean ranks for the two upland reference streams. Overall Stream E sediment quality, as evaluated from all components of the Triad Analysis, was higher than overall quality found in the two reference streams. As evaluated by the Triad area plots, the overall sediment quality in the Site E Stream was the best of the five upland streams included in this investigation.

The Site E upstream station comparisons are shown in Figure 3.5-7. This location had a relatively poor sediment chemistry ranking but the benthic and toxicological rankings were quite good, resulting in a Triad area lower than both reference locations.

The Site E Stream central and downstream station comparisons are shown in Figure 3.5-8 and 3.5-9, respectively. The area plots for both of these locations indicate that sediment quality in the Site E Stream is higher than in the comparable areas of the reference streams.

Drill Site F Stream

Figure 3.5-10 presents the area plots for the Site F Stream mean ranks along with the mean ranks for the two upland reference streams. Overall Stream F sediment quality, as evaluated from all components of the Triad Analysis, was higher than overall quality found in the two reference streams.

Figure 3.5-11 shows the area plot of the upstream Site F location compared to the upstream locations on the two upland reference streams. The sediment quality as indicated by the areas is within the range of the reference locations, and closer to the better of the two reference stations.

Triad plots of the central and downstream locations on Site F Stream are shown in Figures 3.5-12 and 3.5-13, respectively. Sediment quality as indicated by the area plots was higher at both Site F Stream locations than at the comparable upland reference locations.

3.5.1.3 Upland Stream Principal Component Analysis

A weakness of the ranking method of Triad Analysis is that it loses the degree of magnitude of differences between sites. To better understand the differences between stations that appear to show a negative impact and the other stations, particularly the reference locations, a multi-dimensional scaling approach was applied. In essence, this technique is used to represent the differences between stations as measured in many parameters (FBI, benthic diversity, EPT taxa,

Chironomus survival, *Chironomus* biomass, *Chironomus* growth, PAHs, metals, and DRO) into a two-dimensional display.

The method chosen for the multi-dimensional scaling is called Principal Component Analysis (PCA) (Ludwig and Reynolds, 1988). First, the individual parameters are standardized and normalized (i.e., expressed in terms of standard deviations from the mean with the mean established as zero). The distances between the samples are then calculated and the two axes are determined which can best present the differences between the points in two dimensions and leave the least amount of difference unrepresented. In mathematical terms, the procedure calculates the principal eigenvectors. The first two principal eigenvectors are referred to as Principal Component I and Principal Component II and are represented as the x-axis and the y-axis. The mathematical equation of the eigenvectors describes the contribution of each parameter to the axes.

Figure 3.5-14 presents the results of the PCA for the upland sampling locations. All stations are plotted with respect to the two Principal Components. Principal Component I, as determined by the eigenvector equations, represents increasing PAHs and DRO in the positive (right) direction and decreasing toxicity test growth and biomass in the negative (left) direction. Principal Component II represents increasing metals in the positive (up) direction and increasing FBI, and decreasing EPT and diversity in the negative (down direction).

There is essentially one main grouping of stations on the PCA plot with two pairs of stations and two isolated stations. The two pairs consist of Stream E Stations 2 and 4, and Stream E Station 1 and Reference Stream 3 Station 2. These all lie in the upper left quadrant indicating slight toxicity test effects and increased metals. Stream D Stations 2 and 1 lie in the upper right quadrant with Station 1 well removed from the rest. These represent increases in metals, DRO and PAHs with D1 showing a large separation due to DRO and PAH concentrations. The important conclusion to be drawn from the PCA of the upland stream data is that the biological parameters are not included in the same eigenvectors as the chemical parameters. In other words, elevated metals and organic chemicals do not appear to be related to variation in benthic macroinvertebrate community structure in the upland streams.

3.5.2 Lowland Streams

A total of 22 locations were analyzed on the lowland streams, 16 locations were on the five Test Site streams and six locations were on the two lowland reference streams. The mean ranks for the lowland sampling locations are shown in the table below.

Lowland Stream Station Mean Ranks			
Rank	**Station**	**Rank**	**Station**
1	Bridge 5	11.5	RS1 1
2	Bridge 2	13	RS2 5
3	CB 1	14	Bridge 3
4	RS1 5	15	Clev. 5
5.5	RB 2	16	Clev. 1
5.5	Clev. 2	17	RB 5
7	Wh. A. 2	18	Wh. A. 3
8.5	CB 5	19	RS2 3
8.5	RS1 3	20	RB 3
10	CB 2	21	Wh. A. 4
11.5	Wh. A. 5	22	RS2 2

Of the seven locations whose ranking indicated the highest sediment quality, six were on Test Site streams, and all five of the Test Site Streams had at least one high ranked sampling location. Bridge Creek, Rainbow Creek, and Cloudberry Creek drain the Long Shot test area. Bridge Creek Locations 2 and 5 were ranked second and first overall, respectively. On Cloudberry Creek, the up-stream location had an overall rank of three, and on Rainbow Creek, the up-stream location had an overall rank of 5.5, a rank tied with Location 2 on Clevenger Creek, which drains the Milrow Test Site. The three poorest ranked locations were Location 2 on Reference Stream 2, White Alice Creek Location 4 and Rainbow Creek Location 3. There is no clear indication of lower mean ranks for site stream stations, and, as in the upland stream analysis, controlling factors (i.e., the individual Triad components) were variable among the site stream and reference stream stations.

3.5.2.1 Lowland Stream Probability Analysis

As was done for the upland stations, the ranking data for lowland stations were used to calculate the probably of randomly receiving a certain rank. The Triad stations with average ranks that are

unlikely to occur by chance alone were then determined. Again, the 10th percentile was chosen to represent the rare occurrences and the 20th percentile was chosen to represent uncommon occurrences. These data are plotted in Figure 3.5-15.

For the upstream stations on the lowland streams, Bridge Creek and Cloudberry Creek had better than normal quality; all other upstream stations had common ranks except for Reference Stream 2 which had a rank within the rare, poor quality 10th percentile. In the central stream stations, White Alice Creek Station 4 and Rainbow Creek were in the poorer 10th percentile and White Alice Creek Station 3 was in the poorer 20th percentile; however, the Reference Stream 2 central location was also in the poorer 20th percentile. All downstream stations were either of common rank or good quality ranks. The downstream location on Bridge Creek was above the 90th percentile showing good sediment quality.

3.5.2.2 Lowland Stream Triad Area Plots

The area of radial plots of the Triad ranks can be used to evaluate sediment quality, as previously described for upland streams (Section 3.5.1.2). For lowland streams, these area plots are presented in Figures 3.5-16 – 3.5-36. The mean rank plot for each stream is described first, followed by the individual station figures.

White Alice Creek, the stream that drains the area of the Cannikin Test Site, is different from the other Amchitka streams studied in that it flows into and out of two lakes on its way to the Bering Sea. Four Triad stations were sampled on this stream: one station upstream of Ice Box Lake, one Station between Ice Box Lake and Cannikin Lake, and two stations downstream of Cannikin Lake.

The area plot of the mean ranks for White Alice Creek and the lowland reference streams is shown in Figure 3.5-16. Although the mean chemistry ranking the stream was poor, the benthic and toxicological rankings were average, and the area of the plot is within the range of the two lowland reference streams.

The area plot of the upstream station on White Alice Creek and the appropriate lowland stream reference stations is shown in Figure 3.5-17. The chemistry ranking was poor, but the area of the plot is low in relation to reference stations indicating relatively good sediment quality. Figure 3.5-18 shows the Triad area plot for White Alice Station 3, one of two central stations

sampled. Again, the chemistry rank was poor, but the overall sediment quality as indicated by the area plot is within the reference station range.

Station 4 on White Alice Creek is also best compared to central reference stations. This comparison is shown in Figure 3.5-19. This location ranked relatively poorly in all three Triad components, and thus the area plot was greater than both reference locations. This was one of only four lowland stations that had Triad areas greater than the reference locations.

Figure 3.5-20 shows the area plot for the downstream station, White Alice Creek Station 5. This location had a very good toxicological ranking and a Triad area within the range of the reference stations.

Bridge Creek is one of three streams associated with the Longshot Test Site, all of which flow into the Bering Sea. Figure 3.5-21 shows the Triad plot of the mean ranks for Bridge Creek compared to the lowland reference stations. Overall, Bridge Creek appears to have good quality sediments, as indicated by a Triad area lower than both of the reference streams.

Figure 3.5-22 shows the area plots for Bridge Creek's upstream station compared to the upstream reference stations. This station had very good chemistry and benthic rankings and consequently had a very low Triad area relative to the two reference stations. The central station area plot for Bridge Creek is shown in Figure 3.5-23. Although this location had a relatively poor rank for benthic invertebrates, the area was within that of the reference locations. The downstream Bridge Creek station area plot is shown in Figure 3.5-24. The area plots indicate that sediments at this station were of very good quality relative to the reference stations.

Rainbow Creek also drains the Long Shot Test Site. This stream contained two of the four lowland sampling stations where the Triad area plots indicated sediment quality to be lower than the appropriate reference locations. However, the area plot of the mean ranks showing overall sediment quality for this stream was within the range of the two lowland reference streams (Figure 3.5-25). The upstream station area plot for this stream (Figure 3.5-26) showed sediment quality to be higher than found at the appropriate reference stations.

The central area plot for Rainbow Creek is shown in Figure 3.5-27. This station had a poor toxicological ranking, and the Triad Analysis indicated sediment quality to be lower than the appropriate reference stations. The downstream Rainbow Creek area plot (Figure 3.5-28) also

indicated sediment quality to be lower than the comparable lowland downstream reference locations.

Cloudberry Creek, the third stream that drains the Longshot Test Site, had overall sediment quality higher than the lowland reference streams (Figure 3.5-29). As shown in Figure 3.5-30, the upstream sampling location had very good chemistry rank, good toxicological rank, and very good sediment quality relative to upstream reference locations.

The central station on Cloudberry Creek (Figure 3.5-31) had intermediate rankings for the Triad components, and a Triad area within that of the central reference locations. The downstream Cloudberry station had a plotted Triad area slightly smaller that the better of the two downstream reference locations, indicating comparable sediment quality
(Figure 3.5-32).

Clevenger Creek drains the Milrow Test Site and flows into the Pacific Ocean. The Triad area plot of the mean ranks for this stream is presented in Figure 3.5-33. The plotted area indicating overall sediment quality is within the range of the two lowland reference streams. Similarly, the area for the upstream location on Clevenger Creek (Figure 3.5-34) indicates sediment quality within the reference range.

The central Clevenger Creek station Triad area plot (Figure 3.5-35) showed sediment quality to be higher than that at the comparable reference stations. However, at the downstream station (Figure 3.5-36), the Triad area indicated sediment quality to be lower than at the comparable reference locations, primarily because of a low toxicological ranking.

3.5.2.3 Lowland Stream Principal Component Analysis

Figure 3.5-37 presents the results of the PCA for the lowland sampling locations. The principal components for the lowland stream plots are different from those identified for the upland streams. For the lowland streams, Principal Component I, as determined by the eigenvector equations, represents increasing metals in the positive (right) direction and increasing FBI, decreasing EPT, increasing DRO, and decreasing toxicity test survival and biomass in the negative (left) direction. Principal Component II represents increasing FBI and decreasing EPT in the positive (up) direction and increasing DRO and metals, and decreasing toxicity test growth and biomass in the negative (down direction).

There is essentially one main grouping of stations on the PCA plot with six stations lying outside this grouping. Cloudberry Creek Station 1 is separated from this cluster in the direction of poorer benthic communities (increasing FBI and decreasing EPT). White Alice Creek Stations 2 and 5 are separated in the direction of increasing metals, and White Alice Creek Station 3 is slightly removed in the direction of poorer benthic communities and toxicity test results, and increasing DRO. Rainbow Creek Station 3 is well removed from the general cluster in the direction of poorer benthic communities, toxicity test results, and increasing DRO, and Reference Stream 2 Station 5 is well removed in the direction of increasing metals and poorer toxicity test results.

Unlike the PCA of upland stream data, where the biological parameters are not included in the same eigenvectors as the chemical parameters, the PCA of lowland stream data shows some alignment of chemical and biological vectors. Toxicological vectors are aligned with increasing DRO and metals in Principal Component 1, and both benthic community and toxicological vectors align with increasing DRO in Principal Component II.

4.0 Conclusions

Chemical analyses indicated only a few drill or test site stations with higher contaminant concentrations than the reference locations. PAHs were only detected at two locations in the upland streams and were not detected in any samples from lowland streams. Detected PAH concentrations were low with respect to effect levels of these substances. Biogenic DRO was found to be common in the reference streams of Amchitka Island. DRO was found at concentrations greater than reference areas predominantly in the lowland streams, where Clevenger Creek, Rainbow Creek, and White Alice Creek had individual stations with DRO concentrations above the reference concentrations. In both upland and lowland areas, metals concentrations were high in the reference streams in relation to Site stream concentrations. Sulfides, though present at many locations, were not always sufficient to effectively reduce all bioavailability of metals, particularly in the lowland streams.

The results of the *Chironomus tentans* toxicity tests found very few locations that showed greater toxicity than reference locations. Several upland stations showed moderate reduction in organism survival, though growth-related endpoints were not affected. At lowland sampling locations, Rainbow Creek Location 3 was shown to be toxic in the laboratory tests, with no survival of test organisms.

The benthic macroinvertebrate community at Site stream sampling stations was generally comparable to the reference stations. At the upland sites, similar species composition was found in both Drill Site streams and reference streams. Diversity was low throughout all upland locations, and no Drill Site stream location exhibited significant effects relative to upland reference locations. Similarly, in the lowland streams, species composition was similar in Test Sites and reference sites. The benthic investigation did not indicate major impacts at any Test Site stream or individual location. Rainbow Creek Station 3, which was found to be toxic in the *Chironomus tentans* laboratory tests, had numerous Chironomid larvae in the field samples, indicating that the sediments are not very toxic under field conditions.

The Triad Analysis did not find clear indication of degraded conditions at any of the upland Drill Site Streams. The great majority of endpoint rankings were within or better than the range of the reference locations. No upland Triad location showed strong evidence of pollution-induced degradation, as would be indicated by poorer than reference ranks for all three Triad components at a single location.

Merritt, R.W., and K.W. Cummins (eds.). 1984. *An Introduction to the Aquatic Insects of North America*, Second Edition. Dubuque, Iowa: Kendall/Hunt Publishing Co.

Merritt, M.L., and R.G. Fuller (eds.). 1977. *The Environment of Amchitka Island, Alaska*, TID-26712. Washington DC: Technical Information Center, U.S. Energy Research and Development Administration.

Ontario Ministry of the Environment and Energy. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Prepared by Persaud, D., R. Jaagumagi, and A. Hayton.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin Jr. 1990. *Freshwater Macroinvertebrates of Northeastern North America*. New York, NY: Cornell University Press, Ithaca.

Pennak, R.W. 1989. *Freshwater Invertebrates of the United States*, Third Edition. New York, NY: John Wiley & Sons, Inc.

Pennak, R.W. 1978. *Freshwater Invertebrates of the United States*, Second Edition. New York, NY: Ronald Press Co.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid Bioassessment protocols for use in streams and rivers: Benthic Invertebrates and fish*, EPA 440-4-89-001. Washington, DC: U.S. Environmental Protection Agency, Office of Water Regulations and Standards.

Shannon & Wilson, Inc. 1998. *Management Plan, Department of Energy, 1998 Drill Site Investigation, Amchitka Island, Alaska*. Prepared for the U.S. Department of Energy, under contract to U.S. Department of the Army, Alaska District Corps of Engineers. Anchorage, Alaska.

Shannon & Wilson, Inc. 1999. Draft, *Department of Energy 1998 Drill Site Characterization Report, Amchitka Island, Alaska*. Prepared for U.S. Department of Energy, under contract to U.S. Department of the Army, Alaska District Corps of Engineers, Anchorage, Alaska.

Suter, G.W. and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision*, ES/ER/TM-96/R2. Oak Ridge, TN: Risk Assessment Program, Health Sciences Research Division, Lockheed Martin Energy Systems, Inc.

Swartz, R.C., D.W. Schults, R.J. Ozretich, J.O. Lamberson, F.A. Cole, T.H. DeWitt, M.S. Redmond, and S.P. Ferraro. 1995. *ΣPAH: A Model to Predict the Toxicity of Polynuclear Aromatic Hydrocarbon Mixtures in Field-Collected Sediments*, Environmental Toxicology and Chemistry, Vol. 14, No. 11. pp. 1977-1987.

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSF-1028-SD	B809105-10	Soil					1																		
98DOE-DRSF-1028-SD	B809113-10	Soil			1			1		1	1														
98DOE-DRSF-1028-SD	B809113-10RE1	Soil								1															
98DOE-DRSF-1028-SD	B809113-10RE3	Soil								1															
98DOE-DRSF-1029-SD	B809105-12	Soil				1	1																		
98DOE-DRSF-1029-SD	B809113-11	Soil			1			1		1	1														
98DOE-DRSF-1029-SD	B809113-11RE1	Soil								1															
98DOE-DRSF-1029-SD	B809113-11RE3	Soil								1															
98DOE-DRSF-1030-SD	B809105-05	Soil				1	1																		
98DOE-DRSF-1030-SD	B809113-12	Soil			1			1		1	1														
98DOE-DRSF-1030-SD	B809113-12RE1	Soil								1															
98DOE-DRSF-1030-SD	B809113-12RE3	Soil								1															
98DOE-DRSF-3009-SD	B809158-06	Soil			1			1		1	1	1	1												
98DOE-DRSF-3009-SD	B809158-06RE1	Soil								1															
98DOE-DRSF-3009-SD	B809158-06RE2	Soil								1															
98DOE-DRSF-3009-SW	B809155-01	Water												1		1									
98DOE-DRSF-3009-SW	B809165-02	Water													1			1	1						
98DOE-DRSF-3010-SD	B809162-06	Soil			1			1		1	1	1	1												
98DOE-DRSF-3010-SD	B809162-06RE1	Soil								1															
98DOE-DRSF-3010-SW	B809148-03	Water												1		1									
98DOE-DRSF-3010-SW	B809165-01	Water													1			1	1						
98DOE-DRSF-3011-SD	B809162-08	Soil			1			1		1	1	1	1												
98DOE-DRSF-3011-SD	B809162-08RE1	Soil								1															
98DOE-DRSF-3011-SW	B809147-02	Water												1		1									
98DOE-DRSF-3011-SW	B809161-07	Water													1			1	1						

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-DRSF-3012-SD	B809153-02	Soil				1	1																		
98DOE-DRSF-3012-SD	B809162-07	Soil			1			1		1	1	1	1												
98DOE-DRSF-3012-SD	B809162-07RE1	Soil								1															
98DOE-DRSF-3012-SW	B809150-01	Water												1		1									
98DOE-DRSF-3012-SW	B809161-10	Water													1			1	1						
98DOE-DRSF-3013-SD	B809162-11	Soil			1			1		1	1	1	1												
98DOE-DRSF-3013-SD	B809162-11RE1	Soil								1															
98DOE-DRSF-3013-SW	B809147-03	Water												1		1									
98DOE-DRSF-3013-SW	B809165-03	Water													1			1	1						
98DOE-DRSF-3014-F1	1341-16	Fish																						1	
98DOE-DRSF-3014-F1	P904267-16	Fish																		1	1		1		
98DOE-DRSF-3015-F1	1341-15	Fish																						1	
98DOE-DRSF-3015-F1	P904267-15	Fish																		1	1		1		1
98DOE-DRSF-3016-F1	1341-14	Fish																						1	
98DOE-DRSF-3016-F1	P904267-14	Fish																		1	1		1		
Long Shot Site																									
98DOE-LONG-1009-SW	B809034-04	Water												1	1										
98DOE-LONG-1009-SW	B809039-04	Water														1									
98DOE-LONG-1009-SW	B809040-06	Water																1	1						
98DOE-LONG-1010-SW	B809034-05	Water													1										
98DOE-LONG-1010-SW	B809035-01	Water												1											
98DOE-LONG-1010-SW	B809040-01	Water														1		1	1						
98DOE-LONG-1011-SW	B809034-06	Water	Orig												1										
98DOE-LONG-1011-SW	B809035-02	Water	Orig											1											
98DOE-LONG-1011-SW	B809039-05	Water	Orig													1									

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-1011-SW	B809040-07	Water	Orig															1	1						
98DOE-LONG-1012-SW	B809034-07	Water	FD												1										
98DOE-LONG-1012-SW	B809035-03	Water	FD											1											
98DOE-LONG-1012-SW	B809040-02	Water	FD													1		1	1						
98DOE-LONG-1120-SW	B809465-03	Water													1										
98DOE-LONG-1120-SW	B809468-02	Water												1		1									
98DOE-LONG-1120-SW	B809470-03	Water																1	1						
98DOE-LONG-1121-SW	B809465-04	Water													1										
98DOE-LONG-1121-SW	B809470-02	Water												1		1		1	1						
98DOE-LONG-1122-SW	B809465-05	Water													1										
98DOE-LONG-1122-SW	B809468-01	Water														1									
98DOE-LONG-1122-SW	B809470-01	Water												1		1		1	1						
98DOE-LONG-1123-SD	B809458-14	Soil	Orig			1																			
98DOE-LONG-1123-SD	B809475-02	Soil	Orig		1			1		1	1														
98DOE-LONG-1124-SD	B809458-05	Soil	FD			1																			
98DOE-LONG-1124-SD	B809475-03	Soil	FD		1			1		1	1														
98DOE-LONG-1125-SD	B809458-04	Soil				1																			
98DOE-LONG-1125-SD	B809475-04	Soil			1			1		1	1														
98DOE-LONG-1126-SD	B809458-09	Soil				1																			
98DOE-LONG-1126-SD	B809475-07	Soil			1			1		1	1														
98DOE-LONG-1127-SD	B809458-02	Soil				1																			
98DOE-LONG-1127-SD	B809475-05	Soil			1			1		1	1														
98DOE-LONG-1128-SD	B809458-06	Soil				1																			
98DOE-LONG-1128-SD	B809475-06	Soil			1			1		1	1														
98DOE-LONG-1129-SD	B809458-03	Soil				1																			

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-1129-SD	B809475-01	Soil			1			1		1	1														
98DOE-LONG-1130-SD	B809458-10	Soil				1																			
98DOE-LONG-1130-SD	B809485-06	Soil			1			1		1	1														
98DOE-LONG-1131-SD	B809458-07	Soil				1																			
98DOE-LONG-1131-SD	B809485-02	Soil			1			1		1	1														
98DOE-LONG-1132-SD	B809458-11	Soil				1																			
98DOE-LONG-1132-SD	B809485-04	Soil			1			1		1	1														
98DOE-LONG-1133-SD	B809458-13	Soil				1																			
98DOE-LONG-1133-SD	B809485-01	Soil			1			1		1	1														
98DOE-LONG-1134-SD	B809458-08	Soil				1																			
98DOE-LONG-1134-SD	B809485-03	Soil			1			1		1	1														
98DOE-LONG-1135-SD	B809458-12	Soil				1																			
98DOE-LONG-1135-SD	B809485-05	Soil			1			1		1	1														
98DOE-LONG-1136-RB	B809468-03	Water												1		1									
98DOE-LONG-1137-SW	B809462-01	Water													1			1	1						
98DOE-LONG-1137-SW	B809466-01	Water												1		1									
98DOE-LONG-1138-SW	B809462-02	Water													1			1	1						
98DOE-LONG-1138-SW	B809466-02	Water												1		1									
98DOE-LONG-1139-SD	B809457-02	Soil				1	1																		
98DOE-LONG-1139-SD	B809479-05	Soil			1			1		1	1														
98DOE-LONG-1140-SD	B809457-01	Soil				1	1																		
98DOE-LONG-1140-SD	B809479-04	Soil			1			1		1	1														
98DOE-LONG-4034-SW	B809151-01	Water												1		1									
98DOE-LONG-4034-SW	B809161-14	Water													1			1	1						
98DOE-LONG-4035-SD	B809153-01	Soil				1	1																		

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4035-SD	B809158-01	Soil			1			1		1	1	1	1												
98DOE-LONG-4035-SD	B809158-01RE1	Soil								1															
98DOE-LONG-4035-SD	B809158-01RE2	Soil								1															
98DOE-LONG-4036-SW	B809147-01	Water														1									
98DOE-LONG-4036-SW	B809151-02	Water												1											
98DOE-LONG-4036-SW	B809161-15	Water													1			1	1						
98DOE-LONG-4037-SD	B809158-02	Soil			1			1		1	1	1	1												
98DOE-LONG-4037-SD	B809158-02RE1	Soil								1															
98DOE-LONG-4037-SD	B809158-02RE2	Soil								1															
98DOE-LONG-4038-SW	B809148-02	Water												1		1									
98DOE-LONG-4038-SW	B809161-13	Water													1			1	1						
98DOE-LONG-4039-SD	B809158-05	Soil			1			1		1	1	1	1												
98DOE-LONG-4039-SD	B809158-05RE1	Soil								1															
98DOE-LONG-4039-SD	B809158-05RE2	Soil								1															
98DOE-LONG-4040-SW	B809148-01	Water												1											
98DOE-LONG-4040-SW	B809149-01	Water														1									
98DOE-LONG-4040-SW	B809161-12	Water													1			1	1						
98DOE-LONG-4041-SD	B809158-04	Soil			1			1		1	1	1	1												
98DOE-LONG-4041-SD	B809158-04RE1	Soil								1															
98DOE-LONG-4041-SD	B809158-04RE2	Soil								1															
98DOE-LONG-4042-SW	B809151-03	Water												1		1									
98DOE-LONG-4042-SW	B809161-11	Water													1			1	1						
98DOE-LONG-4043-SD	B809158-03	Soil			1			1		1	1	1	1												
98DOE-LONG-4043-SD	B809158-03RE1	Soil								1															
98DOE-LONG-4043-SD	B809158-03RE2	Soil								1															

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4044-SW	B809156-01	Water												1		1									
98DOE-LONG-4044-SW	B809165-04	Water													1			1	1						
98DOE-LONG-4045-SD	B809162-09	Soil			1			1		1	1	1	1												
98DOE-LONG-4045-SD	B809162-09RE1	Soil								1															
98DOE-LONG-4046-SW	B809159-01	Water												1		1									
98DOE-LONG-4046-SW	B809161-09	Water													1			1	1						
98DOE-LONG-4047-SD	B809162-12	Soil			1			1		1	1	1	1												
98DOE-LONG-4047-SD	B809162-12RE1	Soil								1															
98DOE-LONG-4048-SW	B809157-01	Water												1		1									
98DOE-LONG-4048-SW	B809161-08	Water													1			1	1						
98DOE-LONG-4049-SD	B809162-10	Soil			1			1		1	1	1	1												
98DOE-LONG-4049-SD	B809162-10RE1	Soil								1															
98DOE-LONG-4050-SW	B809156-02	Water												1		1									
98DOE-LONG-4050-SW	B809165-06	Water													1			1	1						
98DOE-LONG-4051-SD	B809153-03	Soil				1	1																		
98DOE-LONG-4051-SD	B809165-08	Soil			1			1		1	1	1	1												
98DOE-LONG-4052-SW	B809157-02	Water												1		1									
98DOE-LONG-4052-SW	B809165-05	Water													1			1	1						
98DOE-LONG-4053-SD	B809165-09	Soil	Orig		1			1		1	1	1	1												
98DOE-LONG-4054-SD	B809165-07	Soil	FD		1			1		1	1	1	1												
98DOE-LONG-4115-SW	B809372-02	Water												1		1									
98DOE-LONG-4115-SW	B809388-07	Water													1			1	1						
98DOE-LONG-4116-SD	B809375-04	Soil			1			1		1	1	1	1												
98DOE-LONG-4116-SD	B809375-04RE1	Soil								1															
98DOE-LONG-4116-SD	B809375-04RE2	Soil									1														

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4117-SW	B809370-01	Water												1		1									
98DOE-LONG-4117-SW	B809388-05	Water													1			1	1						
98DOE-LONG-4118-SD	B809375-01	Soil			1			1		1	1	1	1												
98DOE-LONG-4118-SD	B809375-01RE1	Soil								1															
98DOE-LONG-4118-SD	B809375-01RE2	Soil									1														
98DOE-LONG-4119-SW	B809372-03	Water												1		1									
98DOE-LONG-4119-SW	B809388-06	Water													1			1	1						
98DOE-LONG-4120-SD	B809375-05	Soil			1			1		1	1	1	1												
98DOE-LONG-4120-SD	B809375-05RE1	Soil								1															
98DOE-LONG-4120-SD	B809375-05RE2	Soil									1														
98DOE-LONG-4120-SD	B809421-18	Soil				1																			
98DOE-LONG-4121-SW	B809372-01	Water												1		1									
98DOE-LONG-4121-SW	B809388-04	Water													1			1	1						
98DOE-LONG-4122-SD	B809375-02	Soil			1			1		1	1	1	1												
98DOE-LONG-4122-SD	B809375-02RE1	Soil								1															
98DOE-LONG-4122-SD	B809375-02RE2	Soil									1														
98DOE-LONG-4123-SW	B809370-03	Water												1		1									
98DOE-LONG-4123-SW	B809388-08	Water													1			1	1						
98DOE-LONG-4124-SD	B809375-03	Soil			1			1		1	1	1	1												
98DOE-LONG-4124-SD	B809375-03RE1	Soil								1															
98DOE-LONG-4124-SD	B809375-03RE2	Soil									1														
98DOE-LONG-4071-F1	1341-1	Fish																						1	
98DOE-LONG-4071-F1	1341-38	Fish																						1	
98DOE-LONG-4071-F1	P904267-01	Fish																		1	1		1		
98DOE-LONG-4072-F1	1341-2	Fish																						1	

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-LONG-4072-F1	P904267-02	Fish																		1	1		1		
98DOE-LONG-4073-F1	1341-6	Fish																						1	
98DOE-LONG-4073-F1	P904267-06	Fish																		1	1		1		
98DOE-LONG-4074-F1	1341-7	Fish																						1	
98DOE-LONG-4074-F1	P904267-07	Fish																		1	1		1		
98DOE-LONG-4111-F1	1341-8	Fish																						1	
98DOE-LONG-4111-F1	P904267-08	Fish																		1	1		1		
98DOE-LONG-4155-FS	1341-37	Fish																						1	
98DOE-LONG-4155-FS	P904267-37	Fish																		1	1		1		
98DOE-LONG-4157-FS	1341-36	Fish																						1	
98DOE-LONG-4157-FS	P904267-36	Fish																					1		
Milrow Site																									
98DOE-MILR-1001-SW	B809034-01	Water												1	1										
98DOE-MILR-1001-SW	B809039-01	Water														1									
98DOE-MILR-1001-SW	B809040-03	Water																1	1						
98DOE-MILR-1002-SW	B809034-02	Water												1	1										
98DOE-MILR-1002-SW	B809039-02	Water														1									
98DOE-MILR-1002-SW	B809040-04	Water																1	1						
98DOE-MILR-1003-SW	B809034-03	Water												1	1										
98DOE-MILR-1003-SW	B809039-03	Water														1									
98DOE-MILR-1003-SW	B809040-05	Water																1	1						
98DOE-MILR-1004-SD	B809037-01	Soil			1			1			1														
98DOE-MILR-1004-SD	B809037-01RE1	Soil								1															
98DOE-MILR-1004-SD	B809037-01RE2	Soil								1															
98DOE-MILR-1004-SD	B809041-01	Soil				1	1																		

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LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-MILR-1005-SD	B809037-02	Soil			1			1			1														
98DOE-MILR-1005-SD	B809037-02RE1	Soil								1															
98DOE-MILR-1005-SD	B809037-02RE2	Soil								1															
98DOE-MILR-1005-SD	B809041-02	Soil				1	1																		
98DOE-MILR-1006-SD	B809037-03	Soil			1			1			1														
98DOE-MILR-1006-SD	B809037-03RE1	Soil								1															
98DOE-MILR-1006-SD	B809037-03RE2	Soil								1															
98DOE-MILR-1006-SD	B809041-03	Soil				1	1																		
98DOE-MILR-1007-SD	B809037-04	Soil			1			1			1														
98DOE-MILR-1007-SD	B809037-04RE1	Soil								1															
98DOE-MILR-1007-SD	B809037-04RE2	Soil								1															
98DOE-MILR-1007-SD	B809041-04	Soil				1	1																		
98DOE-MILR-1008-SD	B809037-05	Soil			1			1			1														
98DOE-MILR-1008-SD	B809037-05RE1	Soil								1															
98DOE-MILR-1008-SD	B809037-05RE2	Soil								1															
98DOE-MILR-1008-SD	B809041-05	Soil				1	1																		
98DOE-MILR-4007-SW	B809107-01	Water												1		1									
98DOE-MILR-4007-SW	B809111-11	Water													1			1	1						
98DOE-MILR-4008-SD	B809115-04	Soil	Orig		1			1		1	1	1	1												
98DOE-MILR-4009-SD	B809115-03	Soil	FD		1			1		1	1	1	1												
98DOE-MILR-4011-SW	B809106-02	Water												1		1									
98DOE-MILR-4011-SW	B809111-13	Water													1			1	1						
98DOE-MILR-4012-SD	B809115-01	Soil			1			1		1	1	1	1												
98DOE-MILR-4013-SW	B809107-02	Water												1		1									
98DOE-MILR-4013-SW	B809111-12	Water													1			1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-MILR-4014-SD	B809115-02	Soil			1			1		1	1	1	1												
98DOE-MILR-4015-SW	B809106-03	Water												1		1									
98DOE-MILR-4015-SW	B809111-06	Water													1			1	1						
98DOE-MILR-4016-SD	B809105-17	Soil	Orig				1																		
98DOE-MILR-4016-SD	B809115-06	Soil	Orig		1			1		1	1	1	1												
98DOE-MILR-4017-SD	B809105-18	Soil	FD			1	1																		
98DOE-MILR-4018-SW	B809106-01	Water												1		1									
98DOE-MILR-4018-SW	B809111-07	Water													1			1	1						
98DOE-MILR-4019-SD	B809115-05	Soil			1			1		1	1	1	1												
98DOE-MILR-4028-FS	1341-4	Fish																						1	
98DOE-MILR-4028-FS	P904267-04	Fish																		1	1		1		
98DOE-MILR-4029-FS	1341-3	Fish																						1	
98DOE-MILR-4029-FS	P904267-03	Fish																		1	1		1		1
98DOE-MILR-4095-FS	1341-5	Fish																						1	
98DOE-MILR-4095-FS	P904267-05	Fish																		1	1		1		
Rifle Range Road Mud Pits																									
98DOE-RRMP-1076-SL	B809303-13	Soil			1			1		1	1														
98DOE-RRMP-1076-SL	B809310-07	Soil				1																			
98DOE-RRMP-1077-SL	B809303-12	Soil			1			1		1	1														
98DOE-RRMP-1077-SL	B809310-10	Soil				1																			
98DOE-RRMP-1078-SL	B809303-11	Soil			1			1		1	1														
98DOE-RRMP-1078-SL	B809310-05	Soil				1																			
Reference Stream 1																									
98DOE-RS01-4083-SW	B809253-04RE1	Water												1											
98DOE-RS01-4083-SW	B809255-02	Water																1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS01-4084-SD	B809255-10	Soil			1				1	1	1	1	1												
98DOE-RS01-4086-SW	B809253-01	Water												1											
98DOE-RS01-4086-SW	B809255-05	Water																1	1						
98DOE-RS01-4087-SD	B809255-08	Soil			1					1	1	1	1												
98DOE-RS01-4088-SW	B809253-05	Water												1											
98DOE-RS01-4088-SW	B809255-01	Water																1	1						
98DOE-RS01-4089-SD	B809255-06	Soil			1					1	1	1	1												
98DOE-RS01-4090-SW	B809253-02	Water												1											
98DOE-RS01-4090-SW	B809255-03	Water																1	1						
98DOE-RS01-4091-SD	B809255-07	Soil			1					1	1	1	1												
98DOE-RS01-4092-SW	B809253-03	Water												1											
98DOE-RS01-4092-SW	B809255-04	Water																1	1						
98DOE-RS01-4093-SD	B809255-09	Soil			1					1	1	1	1												
98DOE-RS01-4094-FS	1341-19	Fish																						1	
98DOE-RS01-4094-FS	P904267-19	Fish																		1	1		1		
98DOE-RS01-4097-FS	1341-18	Fish																						1	
98DOE-RS01-4097-FS	P904267-18	Fish																		1	1		1		
98DOE-RS01-4099-FS	1341-17	Fish																						1	
98DOE-RS01-4099-FS	P904267-17	Fish																		1	1		1		
98DOE-RS01-4160-FS	1341-20	Fish																						1	
98DOE-RS01-4160-FS	P904267-20	Fish																		1	1		1		
Reference Stream 2																									
98DOE-RS02-4134-SW	B809378-05	Water												1											
98DOE-RS02-4134-SW	B809384-16	Water																	1						
98DOE-RS02-4134-SW	B809384-16RE1	Water																1							

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS02-4135-SD	B809385-03	Soil			1					1	1	1	1												
98DOE-RS02-4135-SD	B809385-03RE1	Soil								1															
98DOE-RS02-4135-SD	B809385-03RE2	Soil									1														
98DOE-RS02-4136-SW	B809378-04	Water												1											
98DOE-RS02-4136-SW	B809384-15	Water																	1						
98DOE-RS02-4136-SW	B809384-15RE1	Water																1							
98DOE-RS02-4137-SD	B809388-11	Soil			1					1	1	1	1												
98DOE-RS02-4138-SW	B809378-01	Water												1											
98DOE-RS02-4138-SW	B809385-04	Water																1	1						
98DOE-RS02-4139-SD	B809388-12	Soil	Orig		1					1	1	1	1												
98DOE-RS02-4140-SD	B809385-01	Soil	FD		1					1	1	1	1												
98DOE-RS02-4140-SD	B809385-01RE1	Soil	FD							1															
98DOE-RS02-4140-SD	B809385-01RE2	Soil	FD								1														
98DOE-RS02-4141-SW	B809378-03	Water												1											
98DOE-RS02-4141-SW	B809385-06	Water																1	1						
98DOE-RS02-4142-SD	B809388-13	Soil			1					1	1	1	1												
98DOE-RS02-4143-SW	B809378-02	Water												1											
98DOE-RS02-4143-SW	B809385-05	Water																1	1						
98DOE-RS02-4144-SD	B809385-02	Soil			1					1	1	1	1												
98DOE-RS02-4144-SD	B809385-02RE1	Soil								1															
98DOE-RS02-4144-SD	B809385-02RE2	Soil									1														
98DOE-RS02-4149-FS	1341-23	Fish																						1	
98DOE-RS02-4149-FS	P904267-23	Fish																		1	1		1		
98DOE-RS02-4151-FS	1341-22	Fish																						1	
98DOE-RS02-4151-FS	P904267-22	Fish																		1	1		1		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS02-4153-FS	1341-21	Fish																						1	
98DOE-RS02-4153-FS	P904267-21	Fish																		1	1		1		
Reference Stream 3																									
98DOE-RS03-3057-SW	B809371-03	Water												1											
98DOE-RS03-3057-SW	B809384-08	Water																	1						
98DOE-RS03-3057-SW	B809384-08RE1	Water																1							
98DOE-RS03-3060-SD	B809384-10	Soil	Orig		1					1	1	1	1												
98DOE-RS03-3061-SD	B809384-09	Soil	FD		1				1	1	1	1	1												
98DOE-RS03-3062-SW	B809371-01	Water												1											
98DOE-RS03-3062-SW	B809384-02	Water																	1						
98DOE-RS03-3062-SW	B809384-02RE1	Water																1							
98DOE-RS03-3063-SD	B809384-13	Soil			1				1	1	1	1	1												
98DOE-RS03-3064-SW	B809371-02	Water												1											
98DOE-RS03-3064-SW	B809384-06	Water																	1						
98DOE-RS03-3064-SW	B809384-06RE1	Water																1							
98DOE-RS03-3065-SD	B809384-14	Soil			1					1	1	1	1												
98DOE-RS03-3066-SW	B809376-03	Water												1											
98DOE-RS03-3066-SW	B809384-07	Water																	1						
98DOE-RS03-3066-SW	B809384-07RE1	Water																1							
98DOE-RS03-3067-SD	B809384-12	Soil			1					1	1	1	1												
98DOE-RS03-3068-SW	B809376-02	Water												1											
98DOE-RS03-3068-SW	B809384-01	Water																	1						
98DOE-RS03-3068-SW	B809384-01RE1	Water																1							
98DOE-RS03-3069-SD	B809384-11	Soil			1					1	1	1	1												
98DOE-RS03-3070-FS	1341-26	Fish	Orig																					1	

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS03-3070-FS	P904267-26	Fish	Orig																	1	1		1		
98DOE-RS03-3071-FS	1341-27	Fish	FD																					1	
98DOE-RS03-3071-FS	P904267-27	Fish	FD																	1	1		1		
98DOE-RS03-3073-FS	1341-25	Fish																						1	
98DOE-RS03-3073-FS	P904267-25	Fish																		1	1		1		
98DOE-RS03-3075-FS	1341-24	Fish																						1	
98DOE-RS03-3075-FS	P904267-24	Fish																		1	1		1		
Reference Stream 4																									
98DOE-RS04-3044-SD	B809309-07	Soil			1				1	1	1	1	1												
98DOE-RS04-3044-SD	B809309-07RE1	Soil								1	1														
98DOE-RS04-3044-SW	B809306-02	Water	Orig											1											
98DOE-RS04-3044-SW	B809309-15	Water	Orig															1	1						
98DOE-RS04-3044-SW	B809309-15RE1	Water	Orig																1						
98DOE-RS04-3045-SW	B809304-04	Water	FD											1											
98DOE-RS04-3045-SW	B809309-20	Water	FD															1	1						
98DOE-RS04-3045-SW	B809309-20RE1	Water	FD																1						
98DOE-RS04-3047-SD	B809309-08	Soil			1				1	1	1	1	1												
98DOE-RS04-3047-SD	B809309-08RE1	Soil								1	1														
98DOE-RS04-3047-SW	B809306-04	Water												1											
98DOE-RS04-3047-SW	B809309-16	Water																1	1						
98DOE-RS04-3047-SW	B809309-16RE1	Water																	1						
98DOE-RS04-3048-SD	B809309-21	Soil			1				1	1	1	1	1												
98DOE-RS04-3048-SD	B809309-21RE1	Soil									1														
98DOE-RS04-3048-SD	B809309-21RE2	Soil								1															
98DOE-RS04-3048-SW	B809306-03	Water												1											

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-RS04-3048-SW	B809309-17	Water																1	1						
98DOE-RS04-3048-SW	B809309-17RE1	Water																	1						
98DOE-RS04-3049-SD	B809309-10	Soil			1					1	1	1	1												
98DOE-RS04-3049-SD	B809309-10RE1	Soil									1														
98DOE-RS04-3049-SD	B809309-10RE2	Soil								1															
98DOE-RS04-3049-SW	B809304-03	Water												1											
98DOE-RS04-3049-SW	B809309-13	Water																1	1						
98DOE-RS04-3049-SW	B809309-13RE1	Water																	1						
98DOE-RS04-3050-SD	B809309-09	Soil			1					1	1	1	1												
98DOE-RS04-3050-SD	B809309-09RE1	Soil									1														
98DOE-RS04-3050-SD	B809309-09RE2	Soil								1															
98DOE-RS04-3050-SW	B809306-01	Water												1											
98DOE-RS04-3050-SW	B809309-14	Water																1	1						
98DOE-RS04-3050-SW	B809309-14RE1	Water																	1						
98DOE-RS04-3051-FS	1341-35	Fish																						1	
98DOE-RS04-3051-FS	P904267-35	Fish																		1	1		1		
98DOE-RS04-3053-FS	1341-34	Fish																						1	
98DOE-RS04-3053-FS	P904267-34	Fish																		1	1		1		1
98DOE-RS04-3055-FS	1341-33	Fish																						1	
98DOE-RS04-3055-FS	P904267-33	Fish																		1	1		1		
Trip Blanks																									
98DOE-TB02-0000-TB	B809041-06	Soil				1																			
High/low level trip blank	B809458-16	Soil				1																			
TB-101	B809256-06	Soil				1																			
98DOE-TB-100	B809153-09	Soil					1																		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-TB02-0000-TB	B809041-06	Soil					1																		
Trip Blank	B809105-19	Soil					1																		
98DOE-MILR-1000-TB	B809034-08	Water													1										
98DOE-TB07-0000-SW	B809161-16	Water													1										
Trip Blank	B809111-15	Water													1										
TRIP BLANK	B809309-28	Water													1										
Trip Blank	B809385-10	Water													1										
Trip Blank	B809465-06	Water													1										
Trip Blank-100	B809265-05	Water													1										
Trip Blank-28	B809165-10	Water													1										

See Table C3-1 for definitions of analytical methods
Orig project sample
FD field duplicate
FR field replicate
QA quality assurance
QC quality control

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
Aircraft Graveyard																									
98DOE-ACGY-2003-SW	B809108-03	Water															1								
98DOE-ACGY-2004-SD	B809115-12	Soil							1																
98DOE-ACGY-2005-SW	B809108-02	Water															1								
98DOE-ACGY-2006-SD	B809115-14	Soil							1																
98DOE-ACGY-2007-SW	B809108-01	Water															1								
98DOE-ACGY-2008-SD	B809115-13	Soil							1																
98DOE-ACGY-2009-GW	B809111-16	Water															1								
98DOE-ACGY-2010-GW	B809111-14	Water															1								
Cannikin Site																									
98DOE-CANN-1013-SW	B809034-09	Water													1										
98DOE-CANN-1013-SW	B809036-01	Water												1		1									
98DOE-CANN-1013-SW	B809037-06	Water																1	1						
98DOE-CANN-1014-SW	B809034-10	Water													1										
98DOE-CANN-1014-SW	B809036-02	Water												1		1									
98DOE-CANN-1014-SW	B809037-07	Water																1	1						
98DOE-CANN-1015-SW	B809034-11	Water													1										
98DOE-CANN-1015-SW	B809036-03	Water												1		1									
98DOE-CANN-1015-SW	B809037-08	Water																1	1						
98DOE-CANN-1016-SD	B809105-03	Soil					1																		
98DOE-CANN-1016-SD	B809113-02	Soil			1			1	1	1	1														
98DOE-CANN-1016-SD	B809113-02RE1	Soil								1															
98DOE-CANN-1016-SD	B809113-02RE3	Soil								1															
98DOE-CANN-1017-SD	B809105-09	Soil					1																		

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

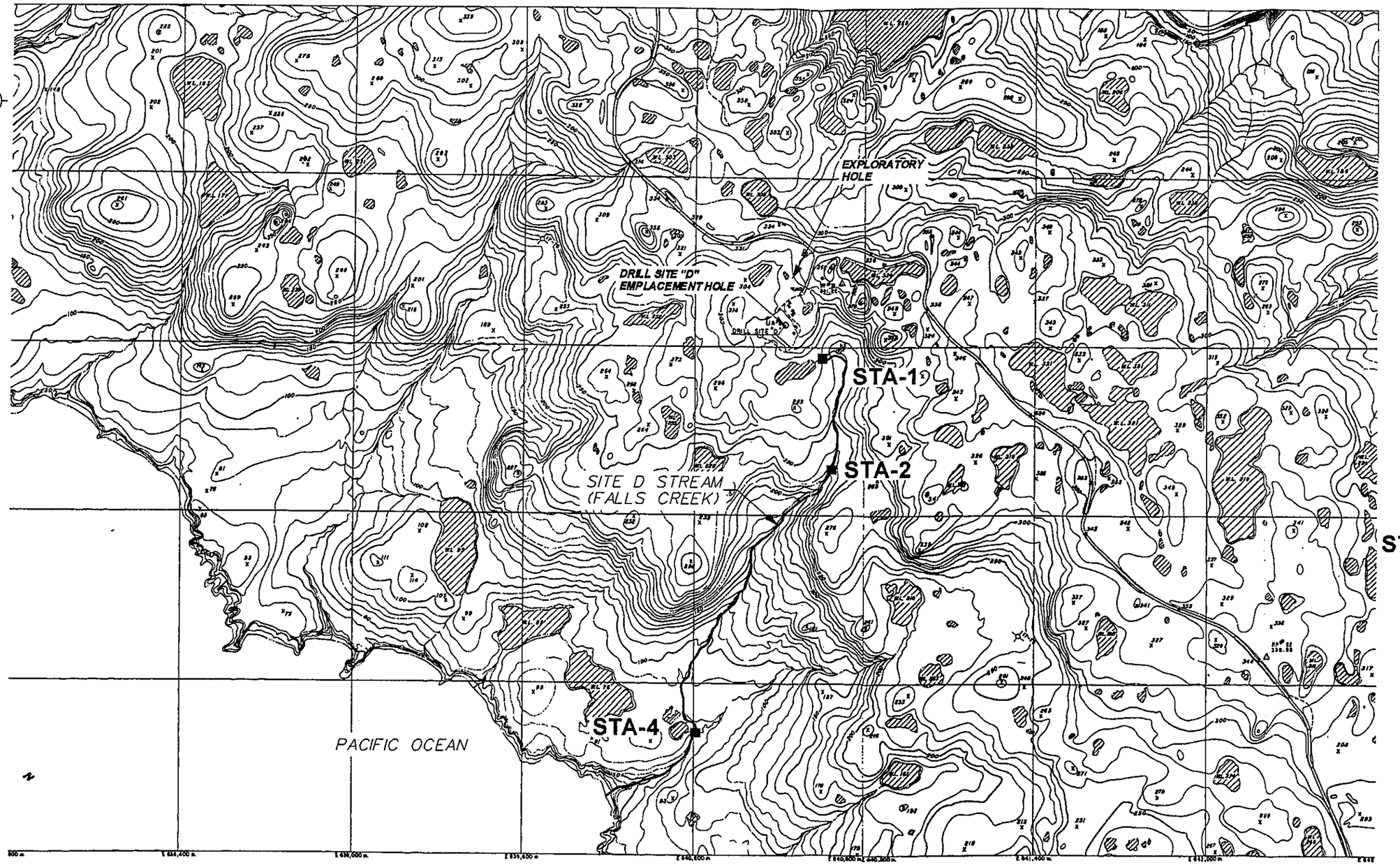
				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1017-SD	B809113-03	Soil			1			1	1	1	1														
98DOE-CANN-1017-SD	B809113-03RE1	Soil								1															
98DOE-CANN-1017-SD	B809113-03RE3	Soil								1															
98DOE-CANN-1018-SD	B809105-11	Soil					1																		
98DOE-CANN-1018-SD	B809113-04	Soil			1			1	1	1	1														
98DOE-CANN-1018-SD	B809113-04RE1	Soil								1															
98DOE-CANN-1018-SD	B809113-04RE3	Soil								1															
98DOE-CANN-1019-SD	B809105-01	Soil				1	1																		
98DOE-CANN-1019-SD	B809113-01	Soil			1			1	1	1	1														
98DOE-CANN-1019-SD	B809113-01RE1	Soil								1															
98DOE-CANN-1019-SD	B809113-01RE3	Soil								1															
98DOE-CANN-1020-SD	B809105-08	Soil	Orig				1																		
98DOE-CANN-1020-SD	B809113-05	Soil	Orig		1			1	1	1	1														
98DOE-CANN-1020-SD	B809113-05RE1	Soil	Orig							1															
98DOE-CANN-1020-SD	B809113-05RE3	Soil	Orig							1															
98DOE-CANN-1021-SD	B809105-06	Soil	FD				1																		
98DOE-CANN-1021-SD	B809113-06	Soil	FD		1			1	1	1	1														
98DOE-CANN-1021-SD	B809113-06RE1	Soil	FD							1															
98DOE-CANN-1021-SD	B809113-06RE3	Soil	FD							1															
98DOE-CANN-1022-SD	B809105-07	Soil					1																		
98DOE-CANN-1022-SD	B809113-07	Soil			1			1	1	1	1														
98DOE-CANN-1022-SD	B809113-07RE1	Soil								1															
98DOE-CANN-1022-SD	B809113-07RE3	Soil								1															
98DOE-CANN-1100-SW	B809376-01	Water												1		1	1								
98DOE-CANN-1100-SW	B809384-05	Water																	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1100-SW	B809384-05RE1	Water																1							
98DOE-CANN-1100-SW	B809388-02	Water													1										
98DOE-CANN-1101-SW	B809368-02	Water												1		1	1								
98DOE-CANN-1101-SW	B809384-03	Water																	1						
98DOE-CANN-1101-SW	B809384-03RE1	Water																1							
98DOE-CANN-1101-SW	B809388-01	Water													1										
98DOE-CANN-1102-SW	B809368-01	Water												1		1	1								
98DOE-CANN-1102-SW	B809384-04	Water																	1						
98DOE-CANN-1102-SW	B809384-04RE1	Water																1							
98DOE-CANN-1102-SW	B809388-03	Water													1										
98DOE-CANN-1103-SD	B809388-10	Soil			1			1	1	1	1														
98DOE-CANN-1103-SD	B809421-15	Soil				1																			
98DOE-CANN-1103-SD	B809479-02	Soil		1																					
98DOE-CANN-1104-SD	B809388-09	Soil			1			1	1	1	1														
98DOE-CANN-1104-SD	B809421-08	Soil				1																			
98DOE-CANN-1104-SD	B809479-01	Soil		1																					
98DOE-CANN-1105-SD	B809377-01	Soil			1			1	1	1	1														
98DOE-CANN-1105-SD	B809421-01	Soil				1																			
98DOE-CANN-1105-SD	B809479-03	Soil		1																					
98DOE-CANN-1106-SW	B809385-09	Water	Orig												1			1	1						
98DOE-CANN-1106-SW	B809387-02	Water	Orig											1		1									
98DOE-CANN-1107-SW	B809385-07	Water	FD												1			1	1						
98DOE-CANN-1107-SW	B809387-03	Water	FD													1									
98DOE-CANN-1107-SW	B809389-03	Water	FD											1											
98DOE-CANN-1108-SW	B809385-08	Water													1			1	1						

ATTACHMENT 1
LIST OF SAMPLE NUMBERS AND ASSOCIATED ANALYSES

				Soil										Water						Fish					
Sample Number	Lab Sample ID	Matrix	QC Code	AK 101/8021B	AK 102	SW5030/8260B	SW5035/8260B	SW8270C	SW8082	SW6010B	SW6020	AVS/SEM	E415.1 mod	AK 102	SW8260B	SW8270C	SW8082	SW6010B	SW6020	SW8270 SIM	SW8081	SW6010A	SW6020	EPA Draft Method 16	Lipids
98DOE-CANN-1108-SW	B809387-01	Water												1		1									
98DOE-CANN-1109-SD	B809377-02	Soil	Orig		1			1	1	1	1														
98DOE-CANN-1109-SD	B809421-04	Soil	Orig			1																			
98DOE-CANN-1110-SD	B809377-03	Soil	FD		1			1	1	1	1														
98DOE-CANN-1110-SD	B809421-06	Soil	FD			1																			
98DOE-CANN-1111-SD	B809377-04	Soil			1			1	1	1	1														
98DOE-CANN-1111-SD	B809421-02	Soil				1																			
98DOE-CANN-1112-SW	B809385-12	Water													1			1	1						
98DOE-CANN-1112-SW	B809389-02	Water												1		1									
98DOE-CANN-1113-SW	B809385-11	Water													1			1	1						
98DOE-CANN-1113-SW	B809389-01	Water												1		1									
98DOE-CANN-1114-SD	B809421-03	Soil				1																			
98DOE-CANN-1114-SD	B809475-09	Soil			1			1	1	1	1														
98DOE-CANN-1115-SD	B809421-05	Soil				1																			
98DOE-CANN-1115-SD	B809475-10	Soil			1			1	1	1	1														
98DOE-CANN-4101-SW	B809299-03	Water														1									
98DOE-CANN-4101-SW	B809302-02	Water												1											
98DOE-CANN-4101-SW	B809303-19	Water																1	1						
98DOE-CANN-4101-SW	B809303-19RE1	Water																1	1						
98DOE-CANN-4101-SW	B809309-27	Water													1										
98DOE-CANN-4102-SD	B809305-07	Soil			1			1	1	1	1	1	1												
98DOE-CANN-4102-SD	B809305-07RE1	Soil									1														
98DOE-CANN-4102-SD	B809305-07RE2	Soil								1															
98DOE-CANN-4103-SW	B809297-01	Water												1		1									
98DOE-CANN-4103-SW	B809309-12	Water													1			1	1						



LEGEND

STA-4 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

APPROXIMATE SCALE (FEET)

0 1300 2600

FIGURE 2.1-1

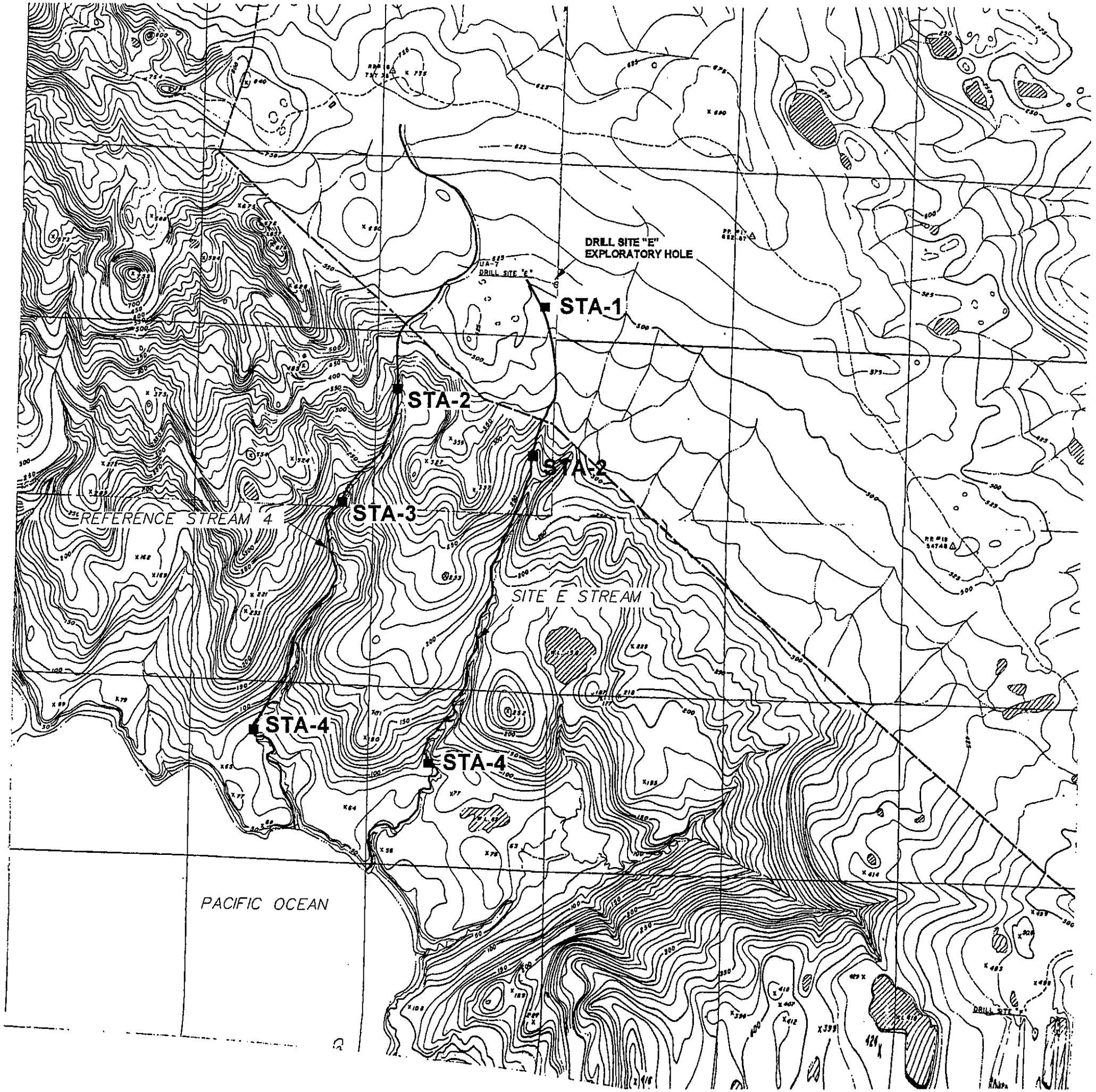
IT CORPORATION

DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
DRILL SITE D STREAM

DESIGNED BY			CHECKED BY	
DRAWN BY	A. YANAVICIUS	03/15/99	APPROVED BY	
SCALE:	DRAWING NO.		SHEET NO.	REVISION NO.

\\comnerse\fiamchitka\dstream.dgn
24-SEP-1999



LEGEND

STA-2 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

APPROXIMATE SCALE (FEET)

0 1000 2000

FIGURE 2.1-2

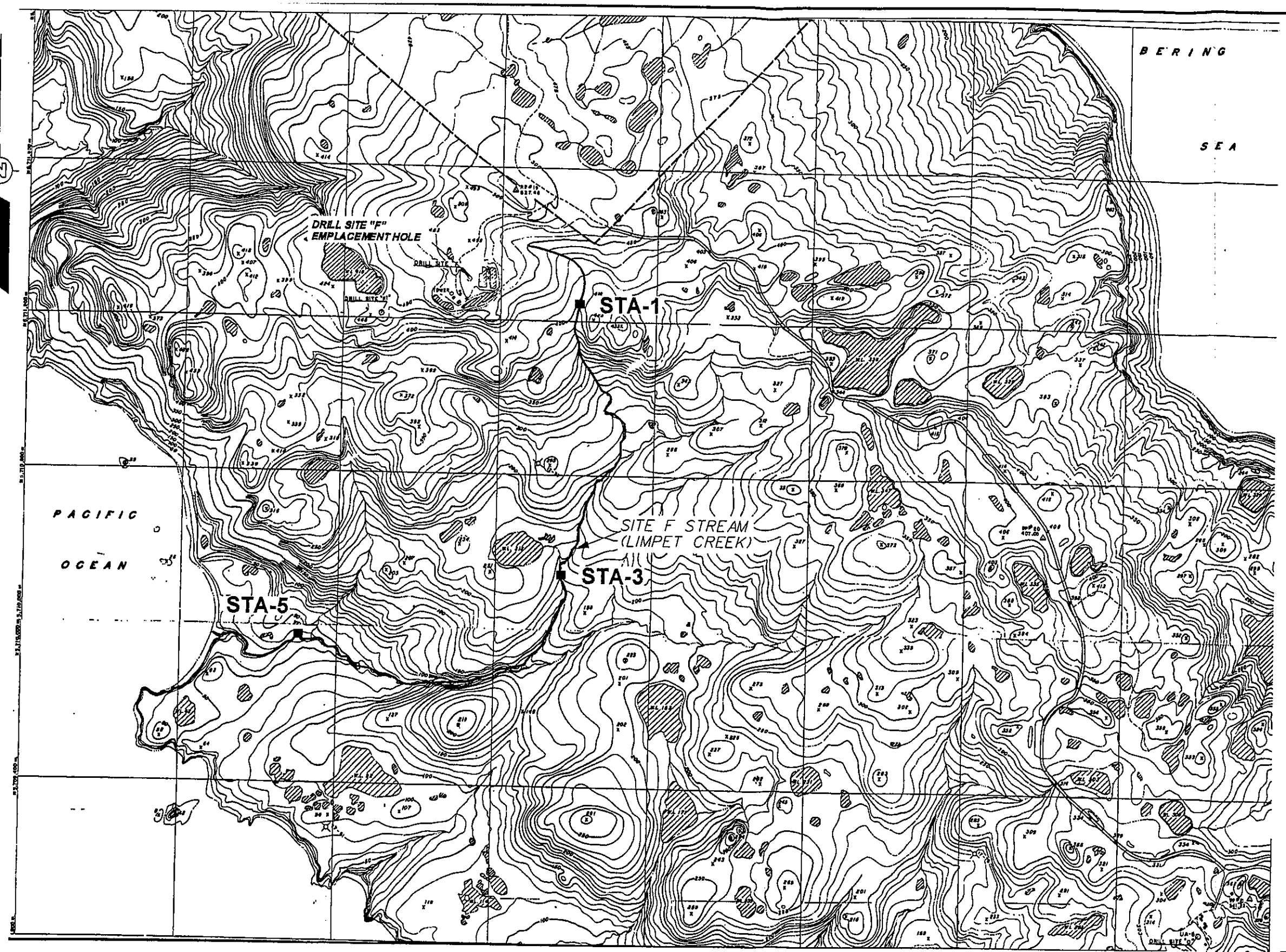
IT CORPORATION

DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
DRILL SITE E STREAM
AND REFERENCE STREAM 4

DESIGNED BY			CHECKED BY	
DRAWN BY	A. YANAVICIUS	09/15/99	APPROVED BY	
SCALE:	DRAWING NO.		SHEET NO.	REVISION NO.

21-SEP-1999 h \somerset\amchitka\stream4.dgn



LEGEND

STA-5 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

APPROXIMATE SCALE (FEET)

0 1300 2600

FIGURE 2.1-3

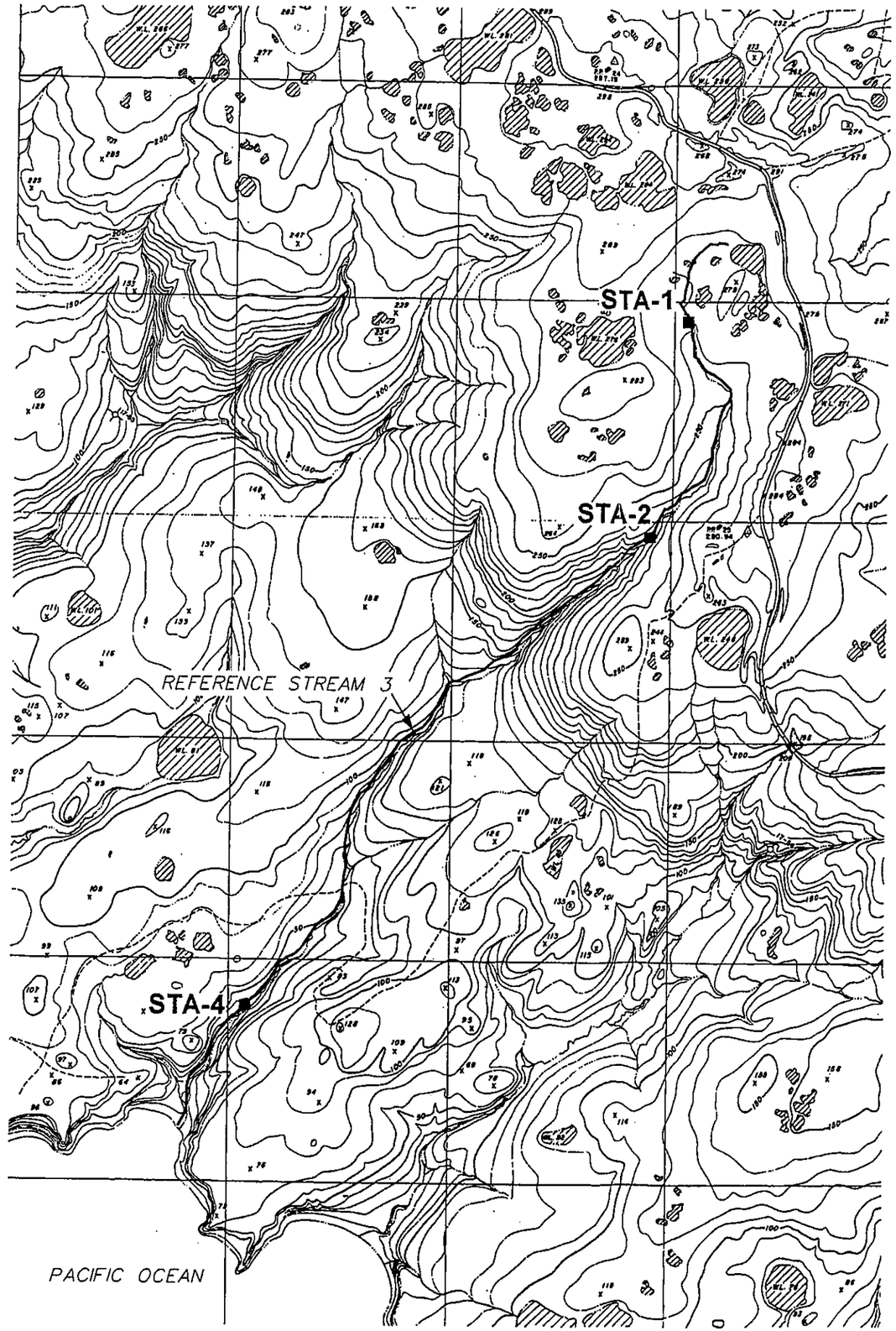
IT CORPORATION

DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
DRILL SITE F STREAM
(LIMPET CREEK)

DESIGNED BY		CHECKED BY	
DRAWN BY	A. YAMAVICIUS 09/15/99	APPROVED BY	
SCALE: AS SHOWN	DRAWING NO. Fstream	SHEET NO.	REVISION NO.

21-SEP-1999 h:\amchitka\somerset\amchitkafstream.dgn



LEGEND

STA-5 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

APPROXIMATE SCALE (FEET)

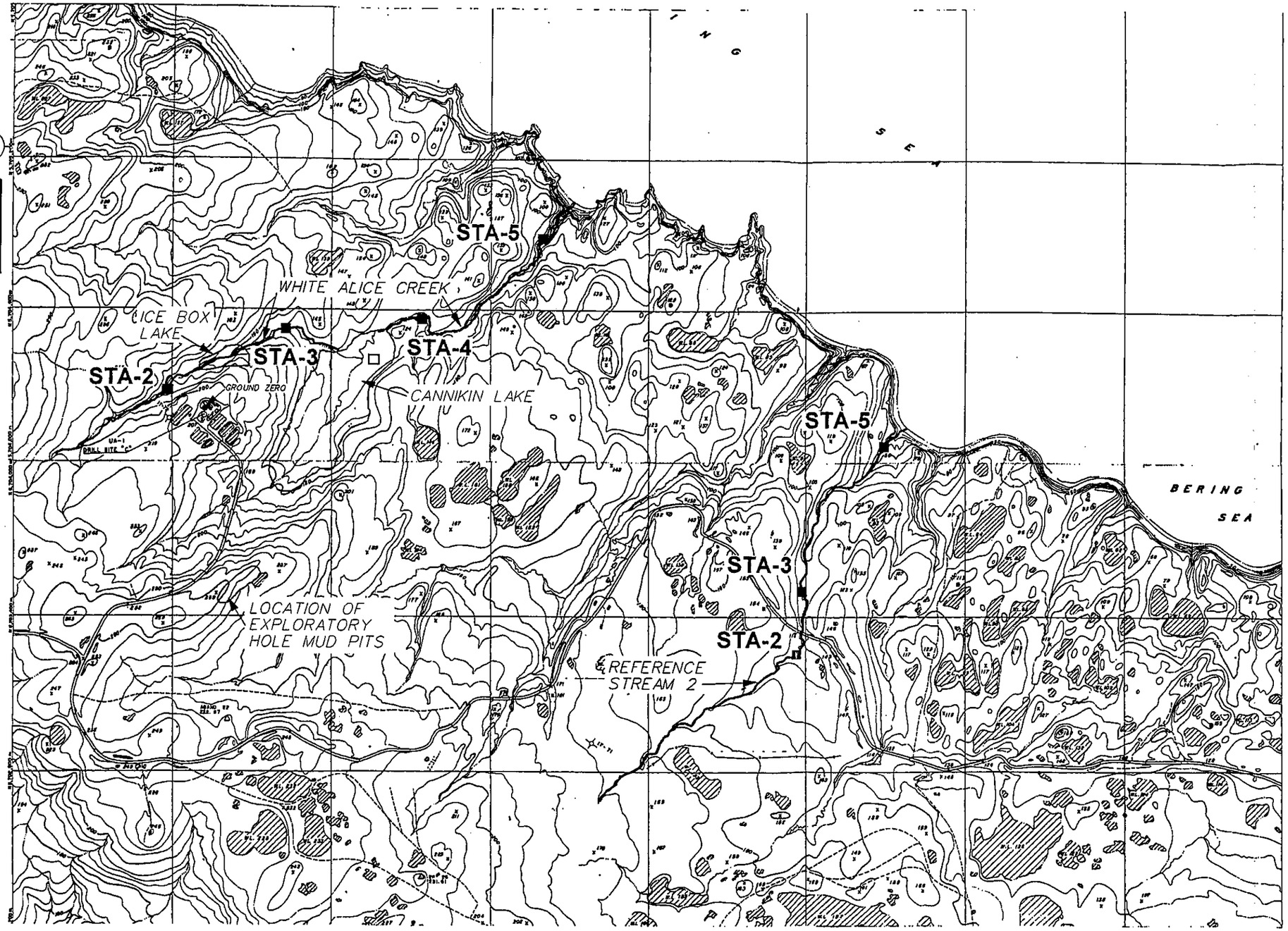
0 1000 2000

FIGURE 2.1-4

IT CORPORATION	DEPARTMENT OF ENERGY 1998 DRILL SITE INVESTIGATION AMCHITKA ISLAND, ALASKA
	TRIAD SAMPLING STATIONS REFERENCE STREAM 3

DESIGNED BY			CHECKED BY		
DRAWN BY	A. YAKAVICIUS	09/15/99	APPROVED BY		
SCALE: AS SHOWN	DRAWING NO. stream3		SHEET NO.		REVISION NO.

21-SEP-1999 h... :atsomersetamchitkatstream3.dgn



LEGEND

STA-5 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

LAKE

APPROXIMATE SCALE (FEET)

0 1000 2000

FIGURE 2.1-5

IT CORPORATION

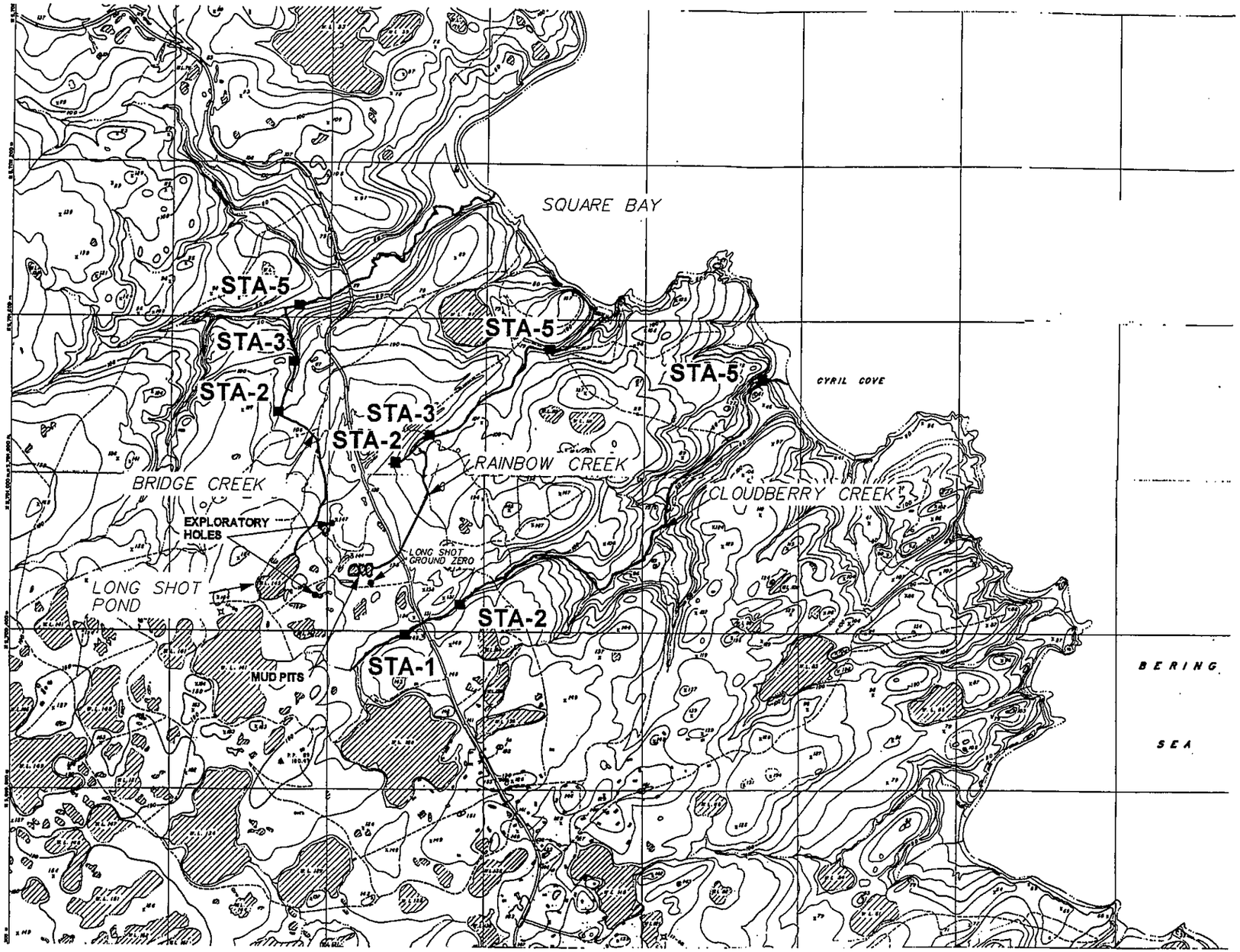
DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
WHITE ALICE CREEK
AND REFERENCE STREAM 2

DESIGNED BY		CHECKED BY	
DRAWN BY	A. YANAVICIUS 08/15/99	APPROVED BY	
SCALE: AS SHOWN	DRAWING NO. stream2	SHEET NO.	REVISION NO.

..\alsomerset\amchitka\alstream2.dgn

21-SEP-1999



LEGEND

STA-5 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

EXISTING LAKE

APPROXIMATE SCALE (FEET)

0 1400 2800

FIGURE 2.1-6

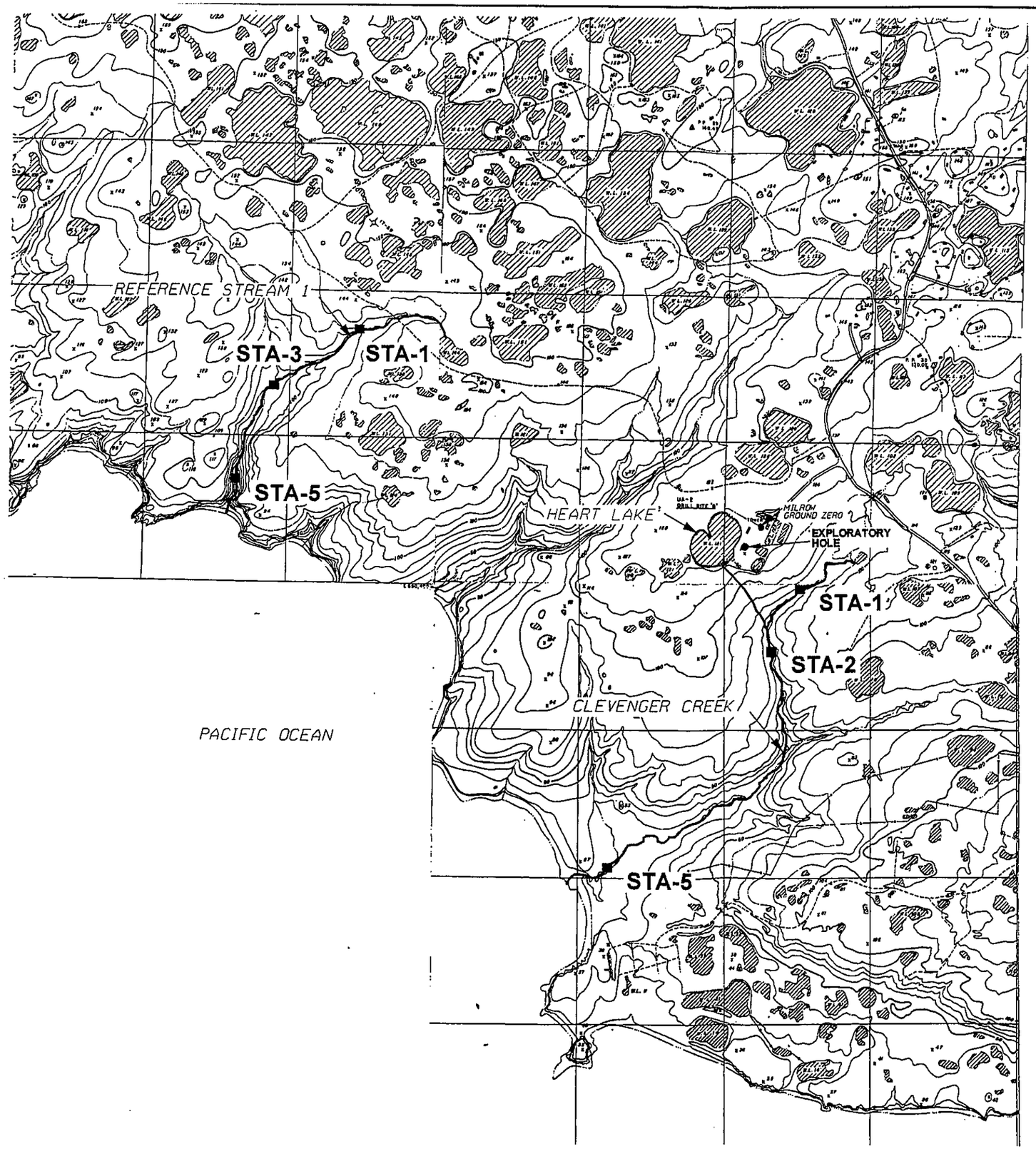
IT CORPORATION

DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
BRIDGE CREEK, RAINBOW CREEK
AND CLOUDBERRY CREEK

DESIGNED BY			CHECKED BY		
DRAWN BY	A. YANAVICIUS	09/15/99	APPROVED BY		
SCALE: AS SHOWN	DRAWING NO. bridgecr		SHEET NO.		REVISION NO.

21-SEP-1999 ifkatsomersetlamichitkalbridgecr.dgn



LEGEND

STA-5 ■ TRIAD SAMPLING STATION NUMBER AND LOCATION

INVESTIGATED STREAM COURSE

LAKE

APPROXIMATE SCALE (FEET)

0 1500 3000

FIGURE 2.1-7

IT CORPORATION

DEPARTMENT OF ENERGY
1998 DRILL SITE INVESTIGATION
AMCHITKA ISLAND, ALASKA

TRIAD SAMPLING STATIONS
CLEVENGER CREEK
AND REFERENCE STREAM 1

DESIGNED BY			CHECKED BY		
DRAWN BY	A. YANAVICIUS	09/17/99	APPROVED BY		
SCALE: AS SHOWN	DRAWING NO. stream1		SHEET NO.		REVISION NO.

21-SEP-1999 /ilfkalsomersetamchitkalstream1.dgn

Figure 3.5-1
Probability Analysis for Mean Relative Ranks
Upland Stream Sampling Stations

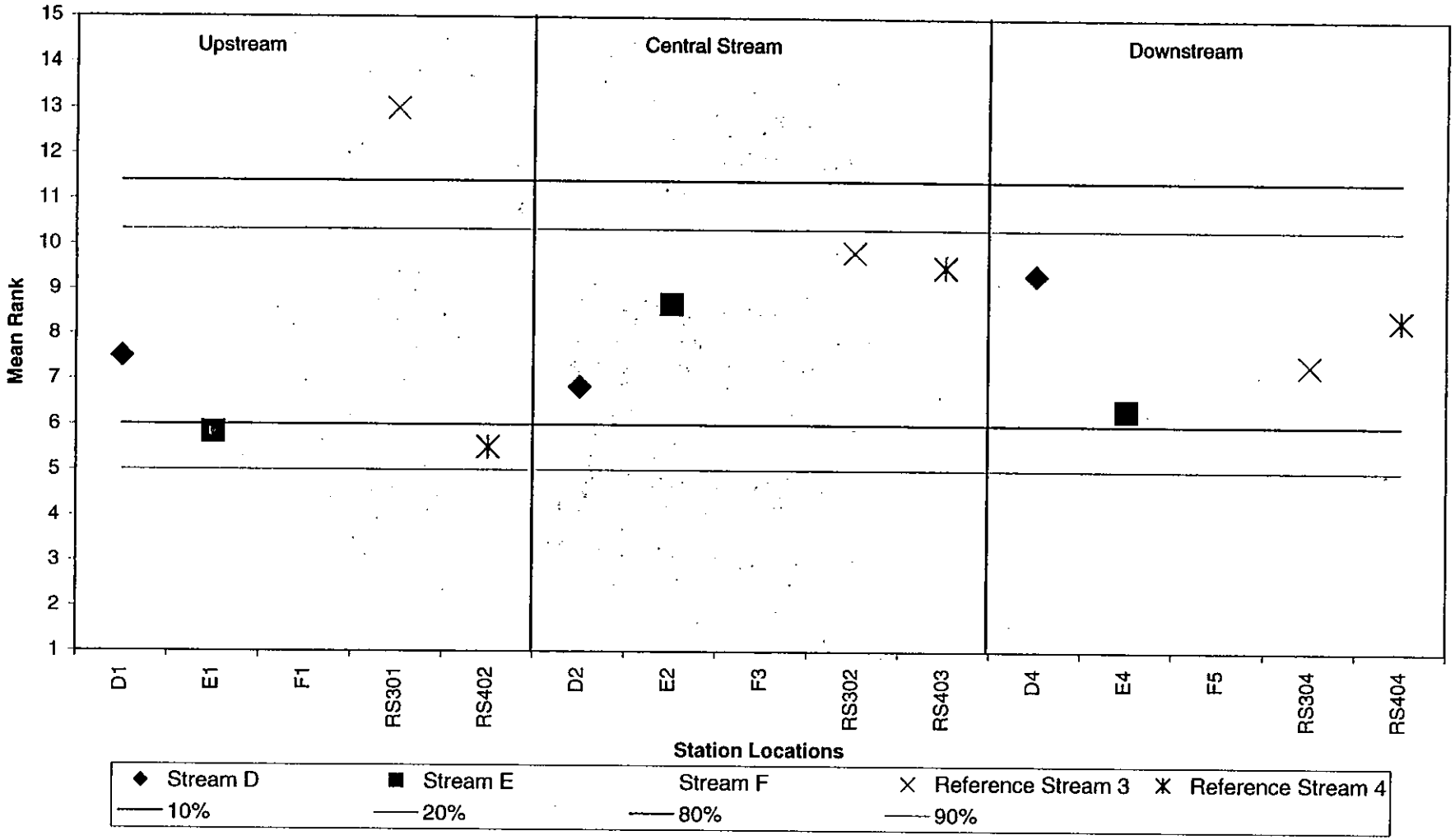


Figure 3.5-2
Triad Analysis
Upland Reference Streams vs. Site D Stream

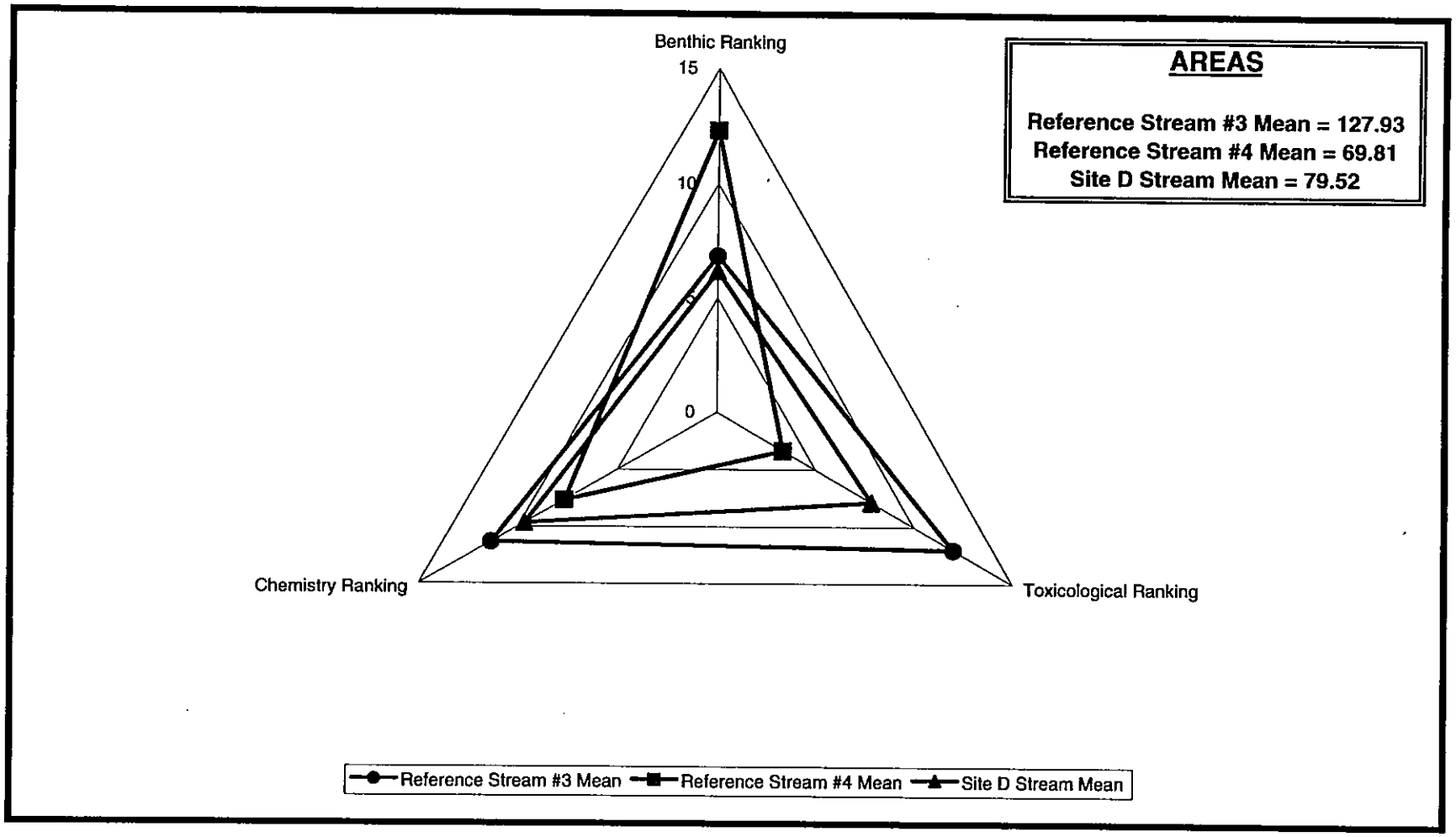


Figure 3.5-3
Triad Analysis
Upstream Reference Stations vs. Site D Station #1

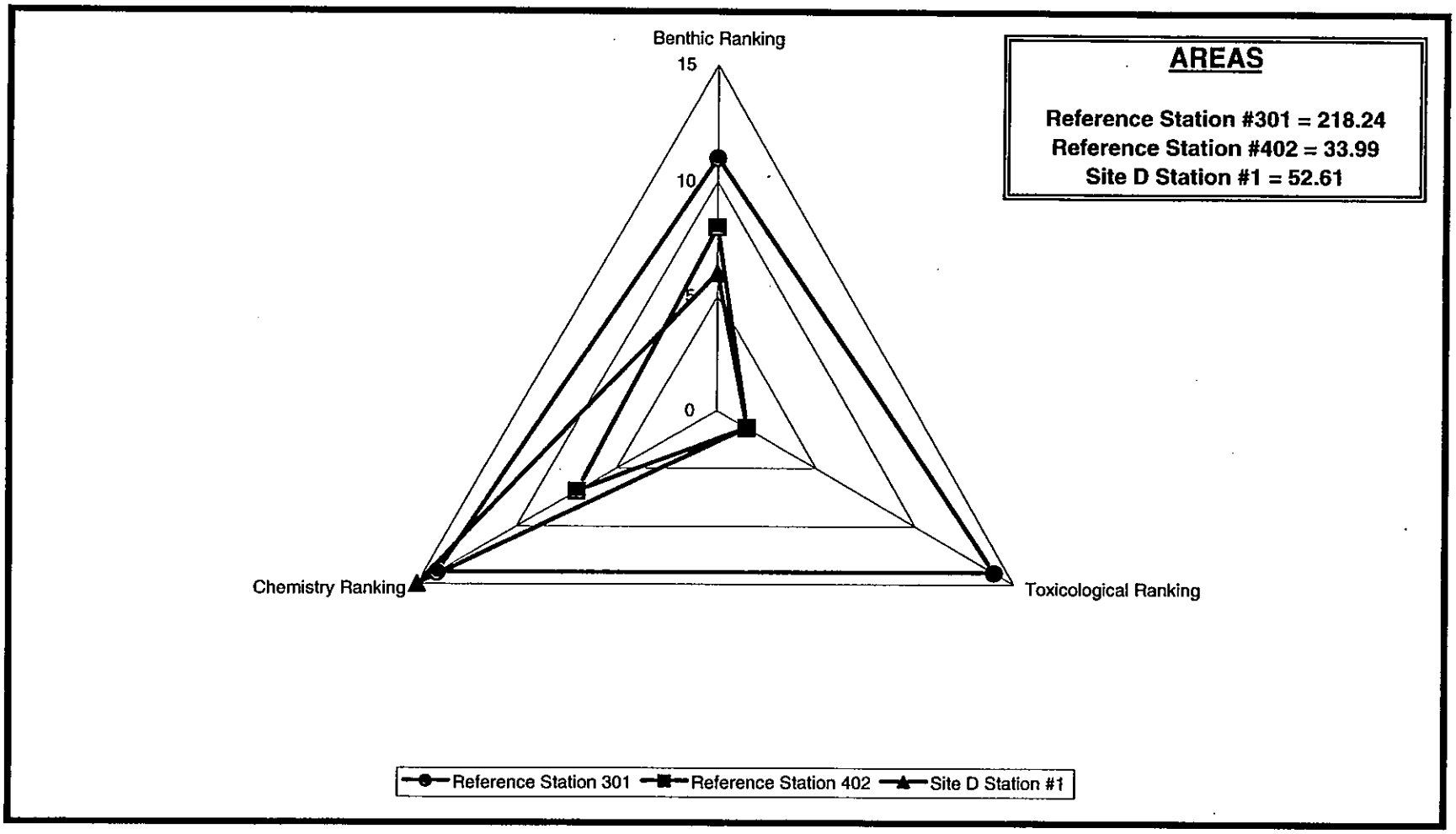


Figure 3.5-4
Triad Analysis
Central Reference Stations vs. Site D Station #2

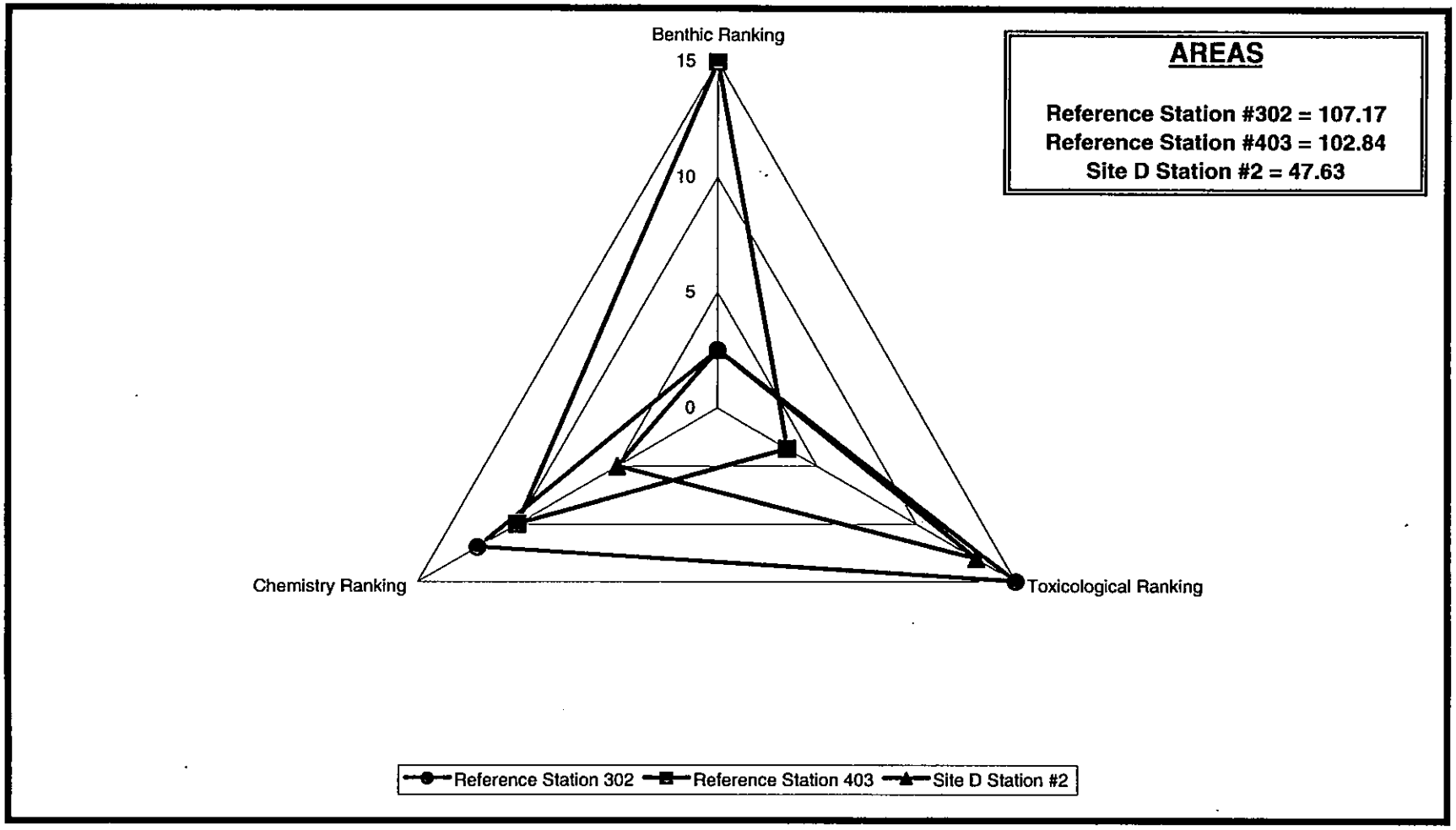


Figure 3.5-5
Triad Analysis
Downstream Reference Stations vs. Site D Station #4

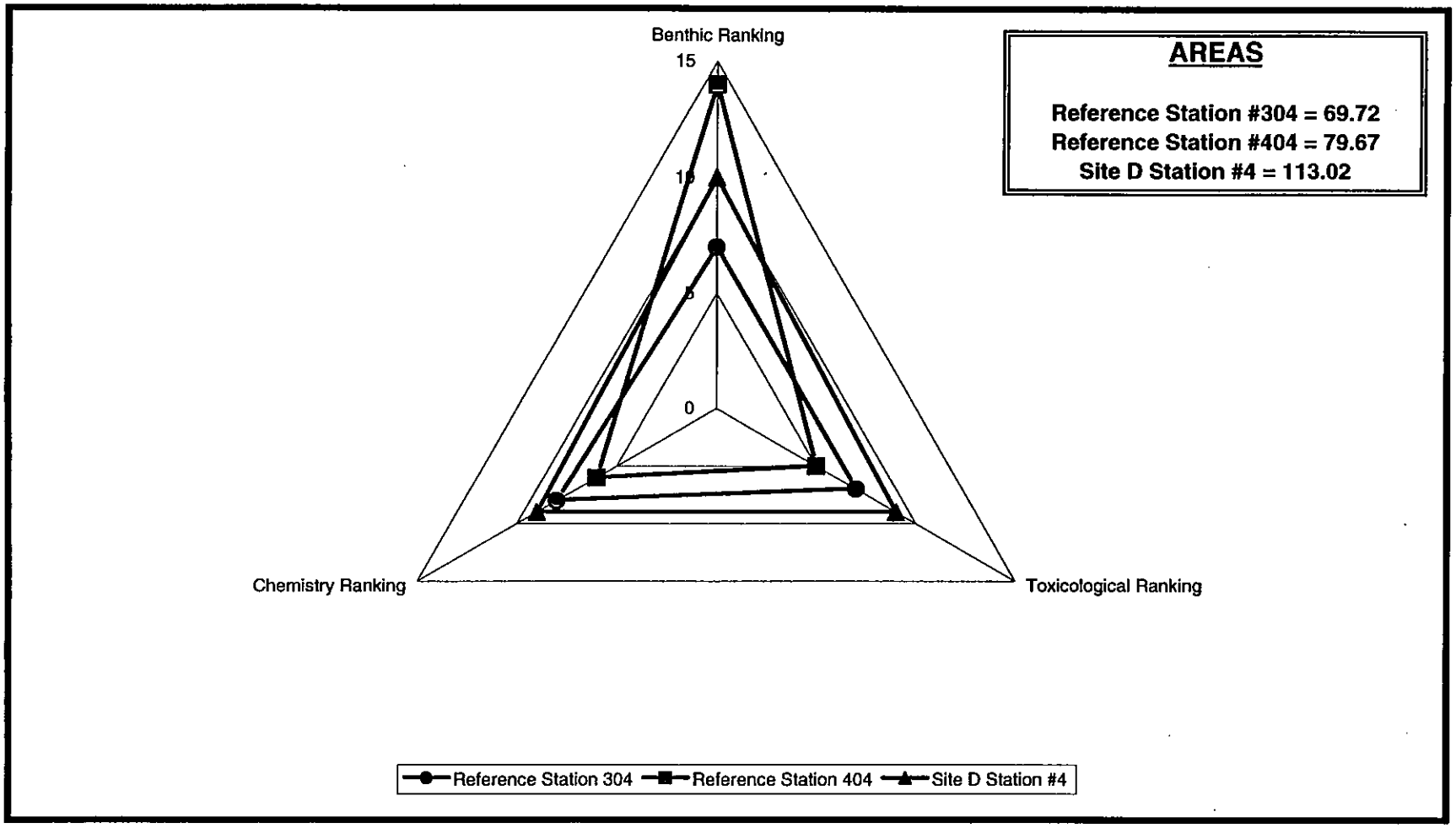


Figure 3.5-6
Triad Analysis
Upland Reference Streams vs. Site E Stream

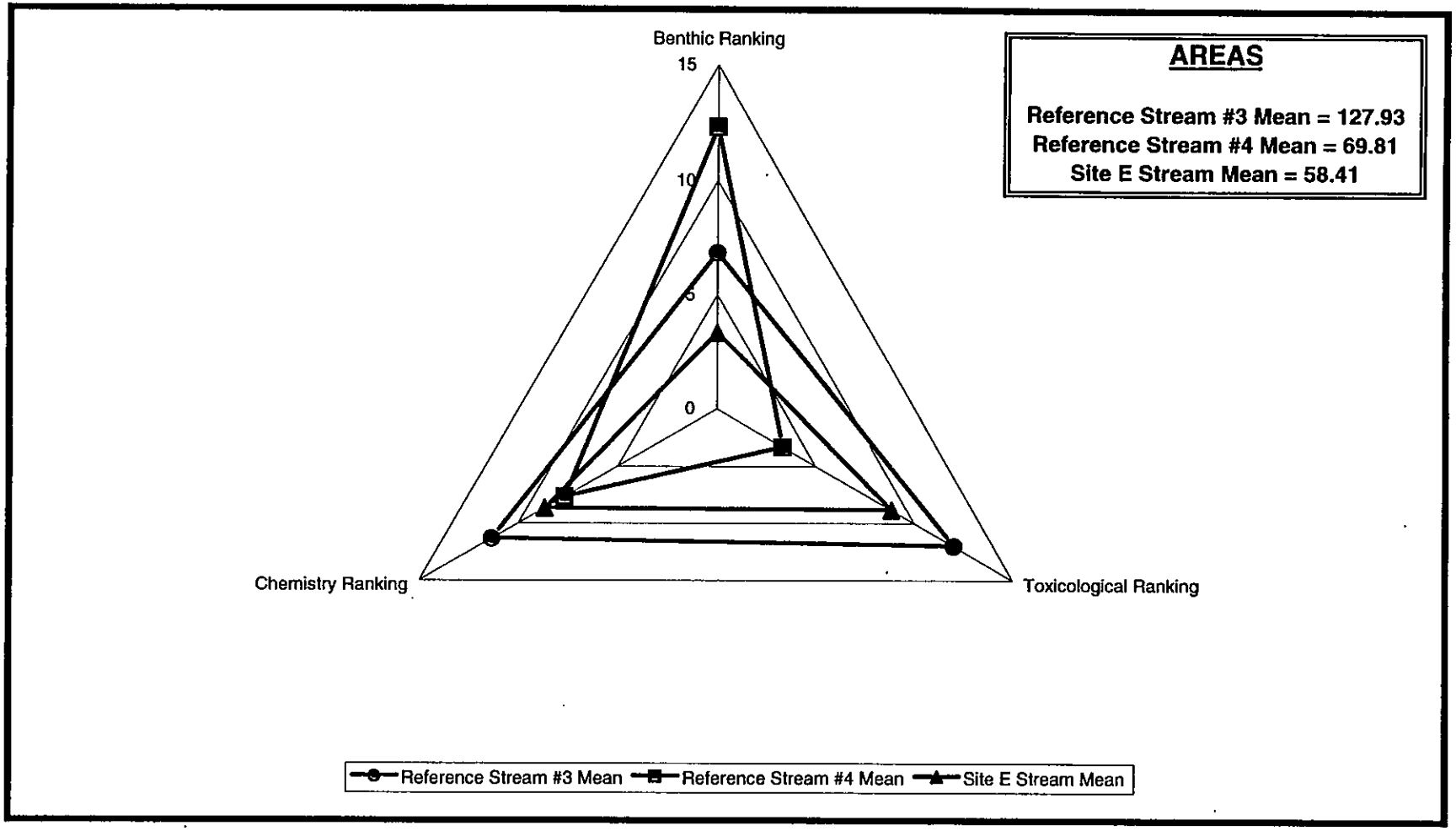


Figure 3.5-7
Triad Analysis
Upstream Reference Stations vs. Site E Station #1

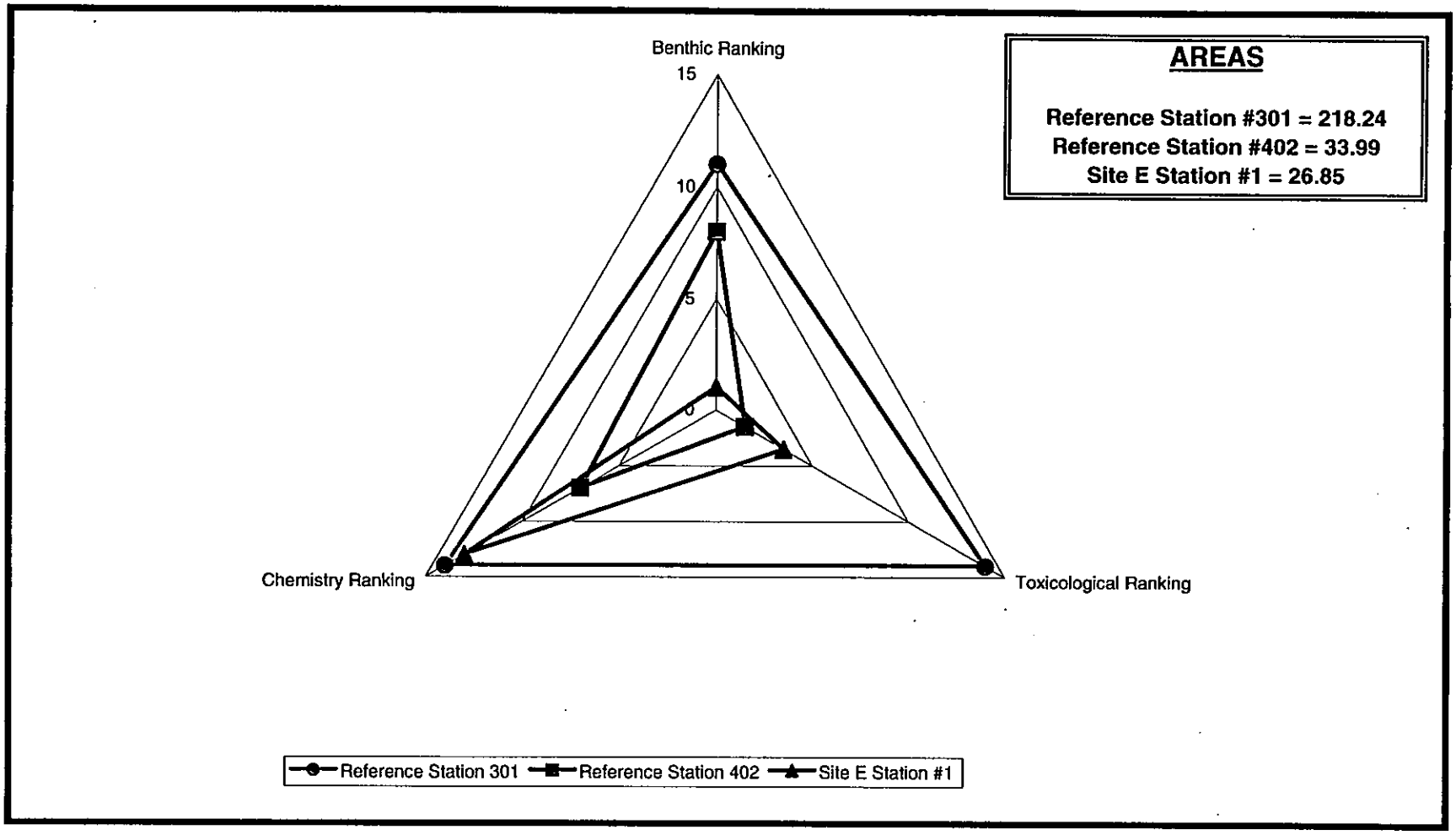


Figure 3.5-8
Triad Analysis
Central Reference Stations vs. Site E Station #2

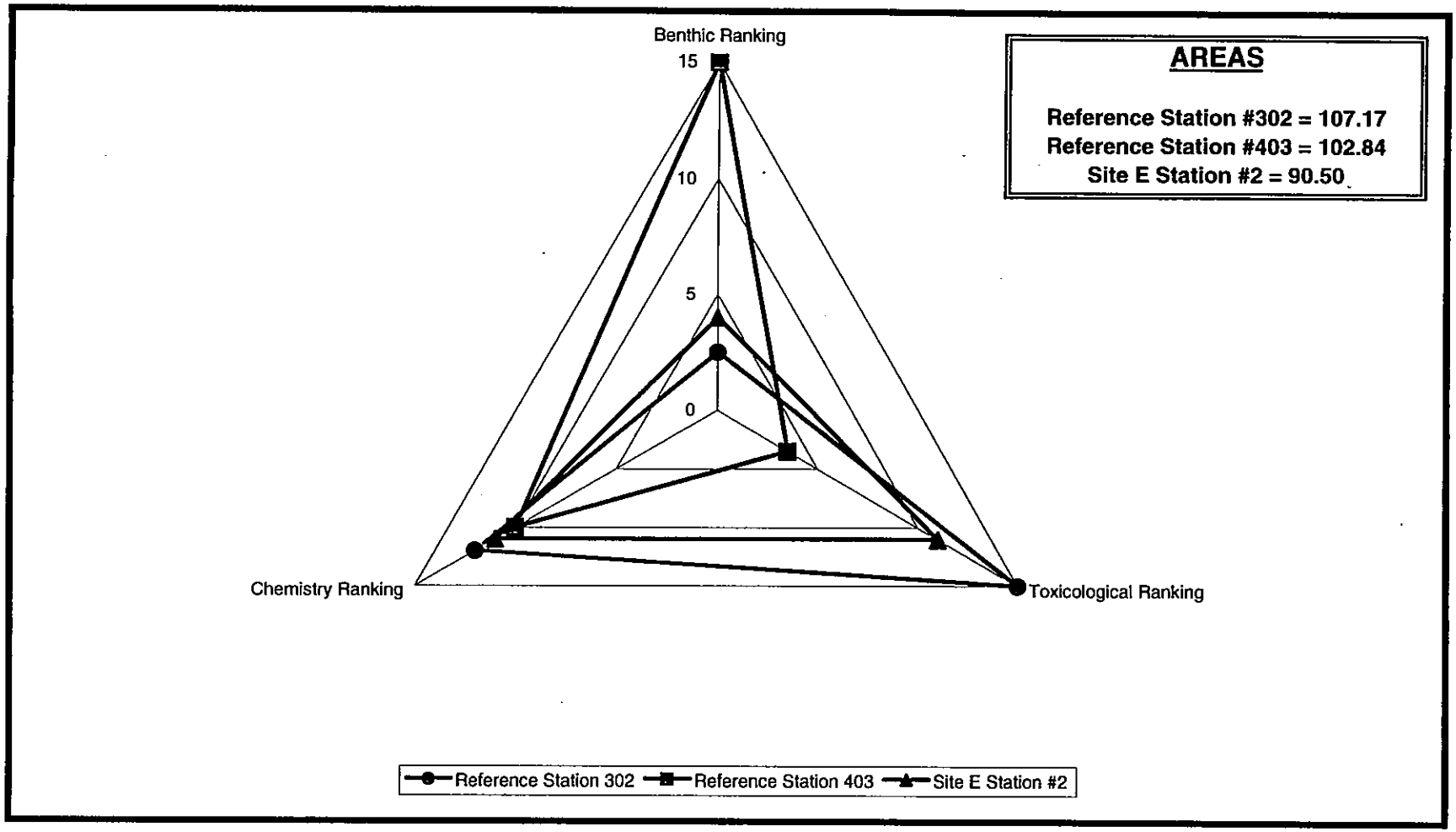


Figure 3.5-9
Triad Analysis
Downstream Reference Stations vs. Site E Station #4

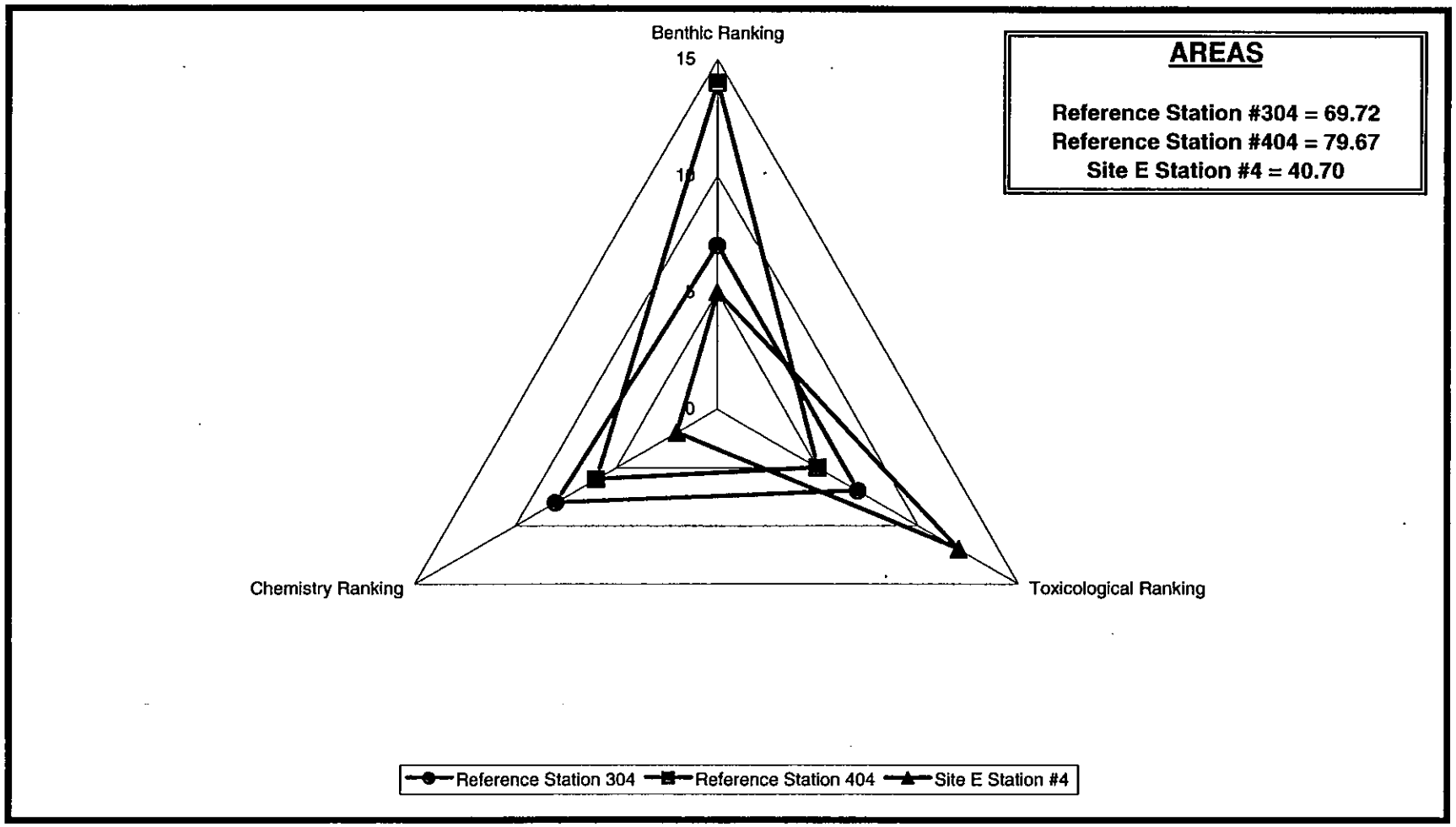


Figure 3.5-10
Triad Analysis
Upland Reference Streams vs. Site F Stream

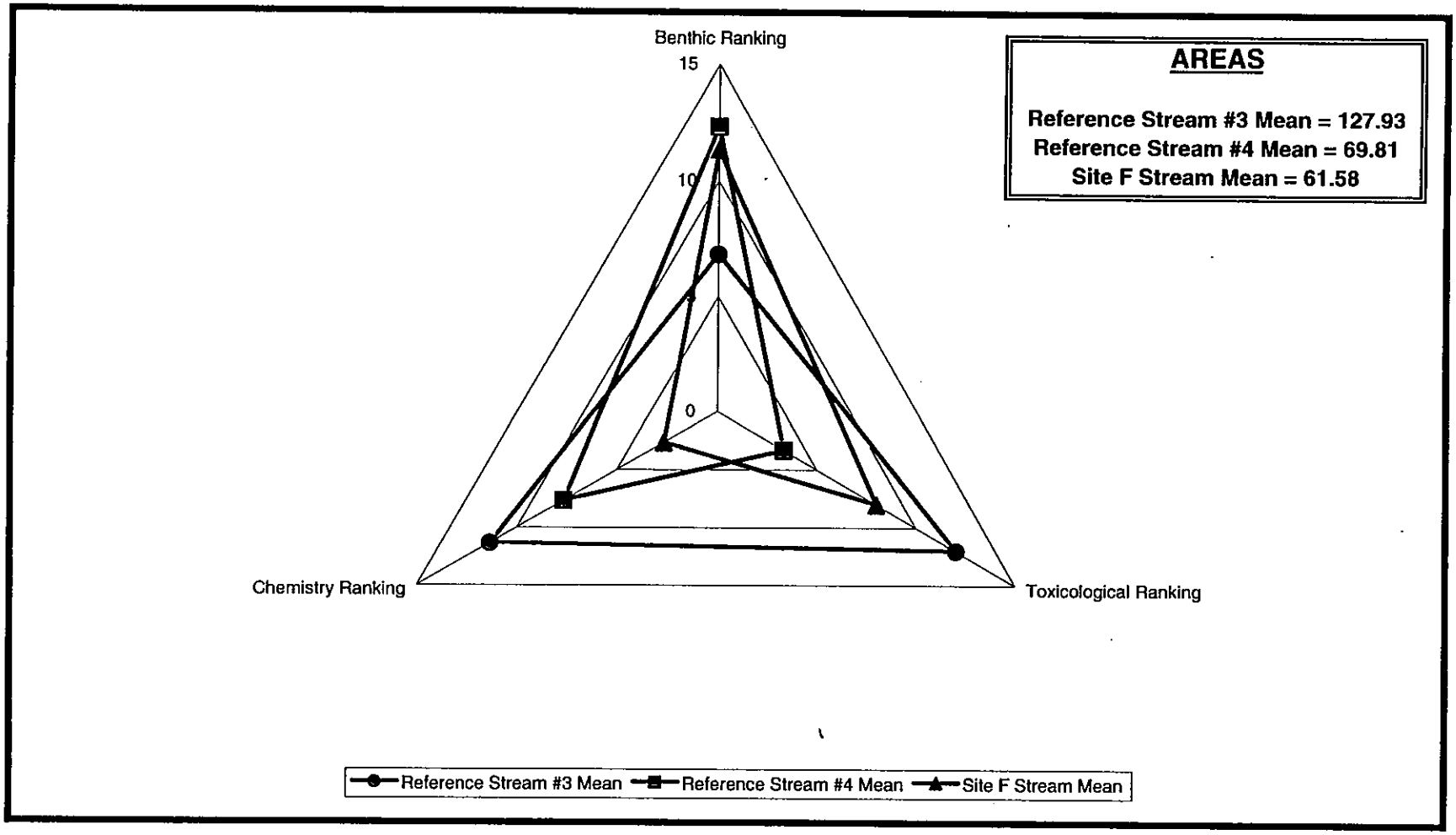


Figure 3.5-11
Triad Analysis
Upstream Reference Stations vs. Site F Station #1

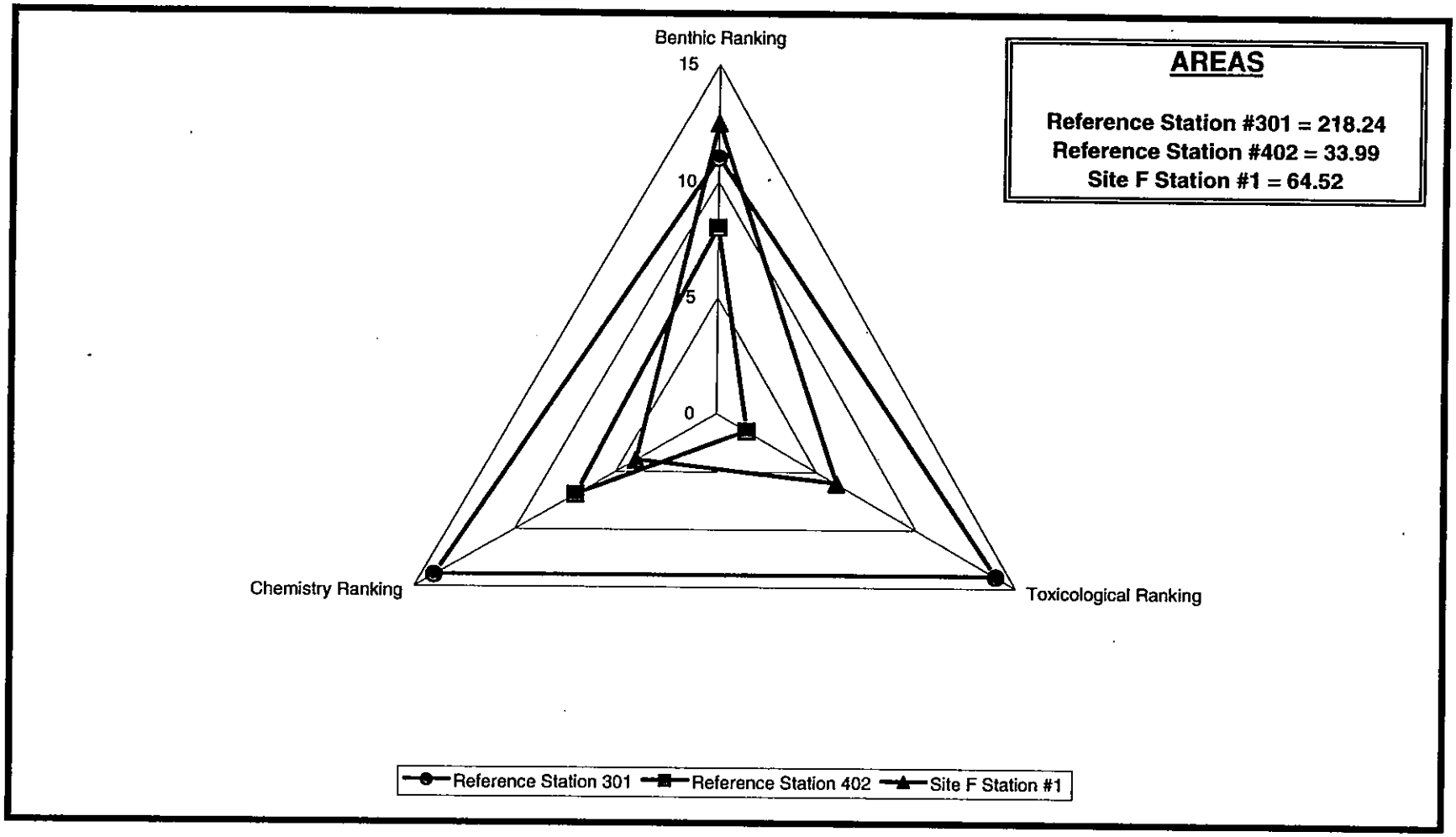


Figure 3.5-12
Triad Analysis
Central Reference Stations vs. Site F Station #3

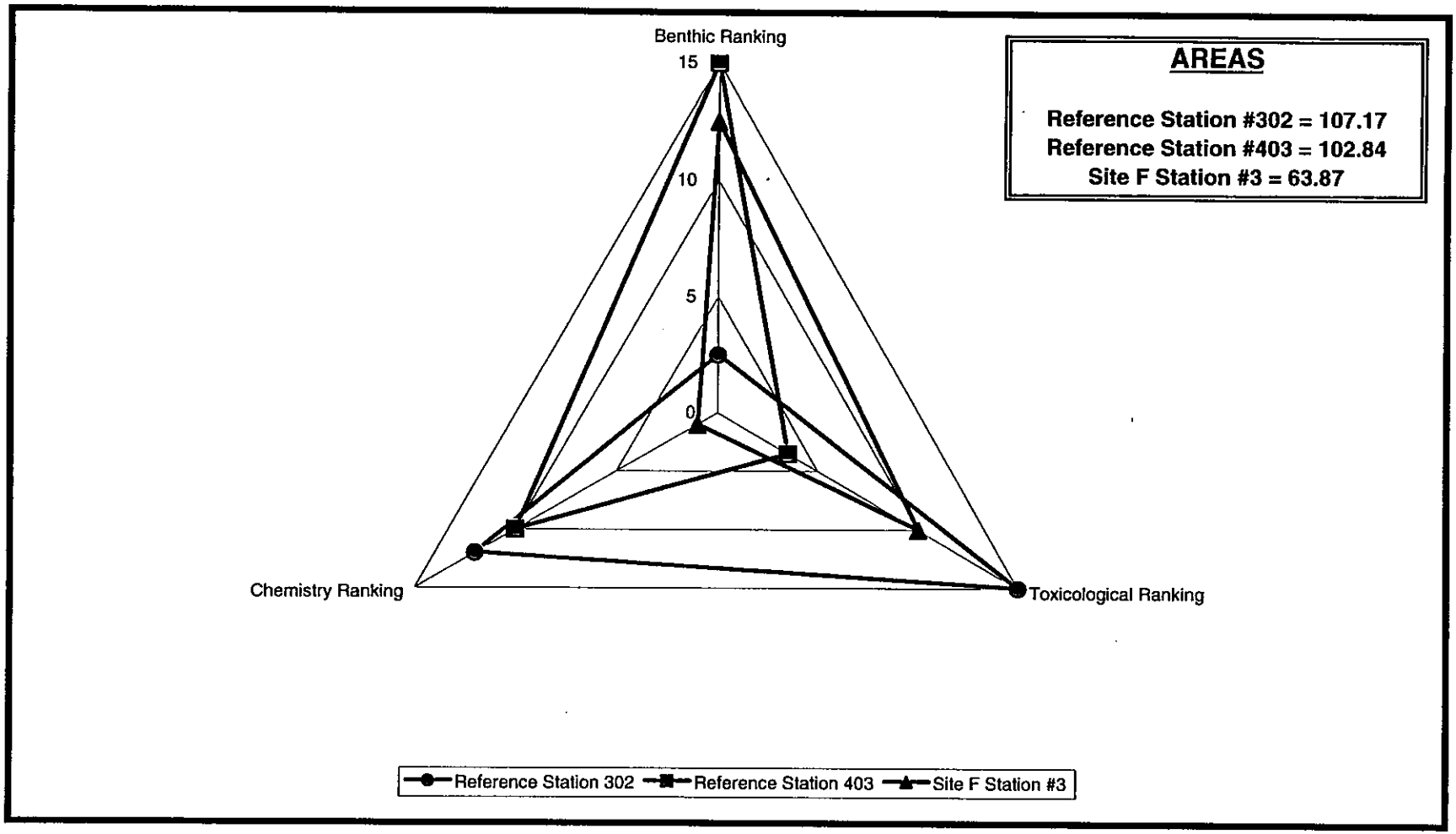


Figure 3.5-13
Triad Analysis
Downstream Reference Stations vs. Site F Station #5

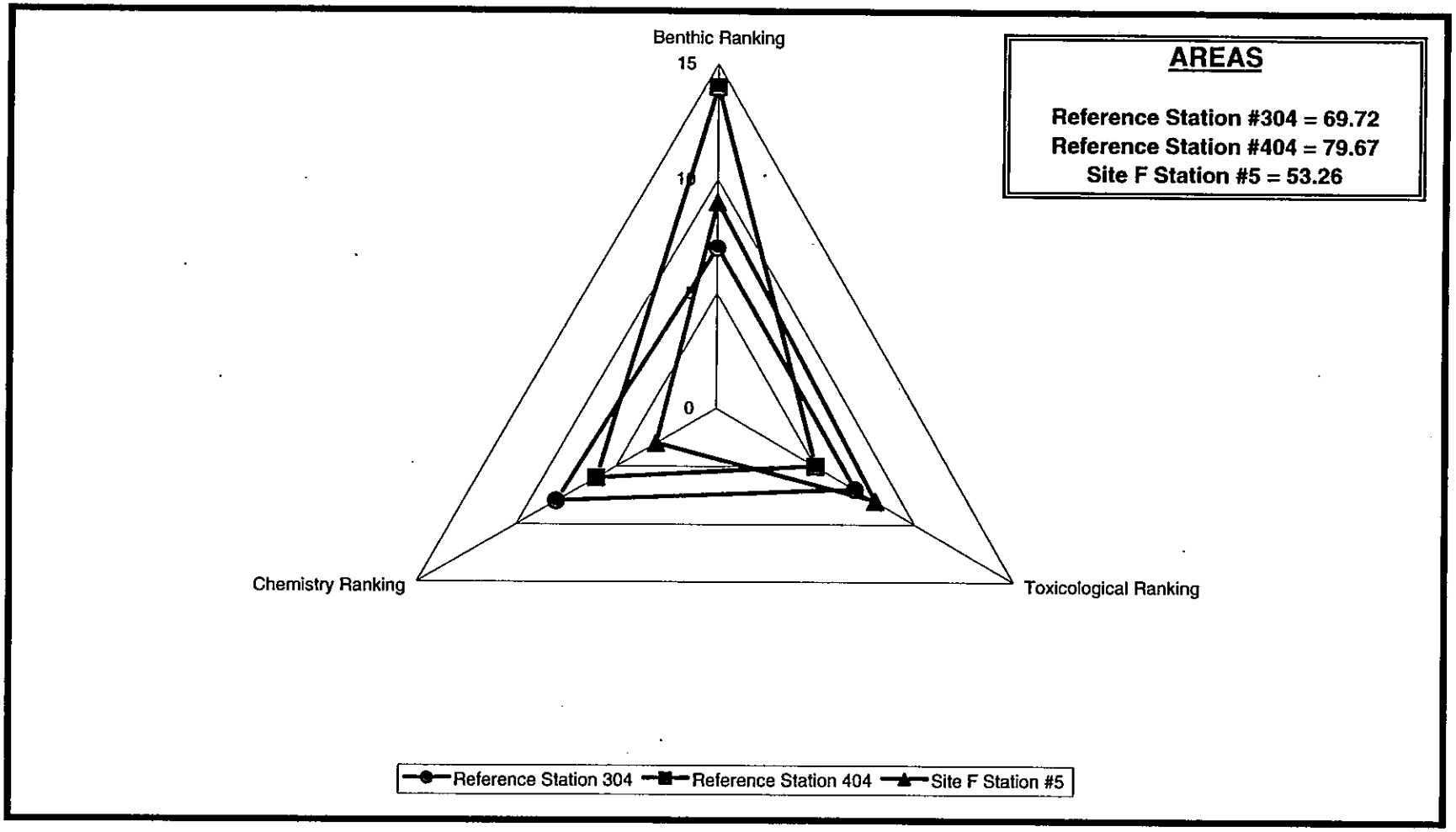


Figure 3.5-14
Upland Streams - Principal Components Analysis

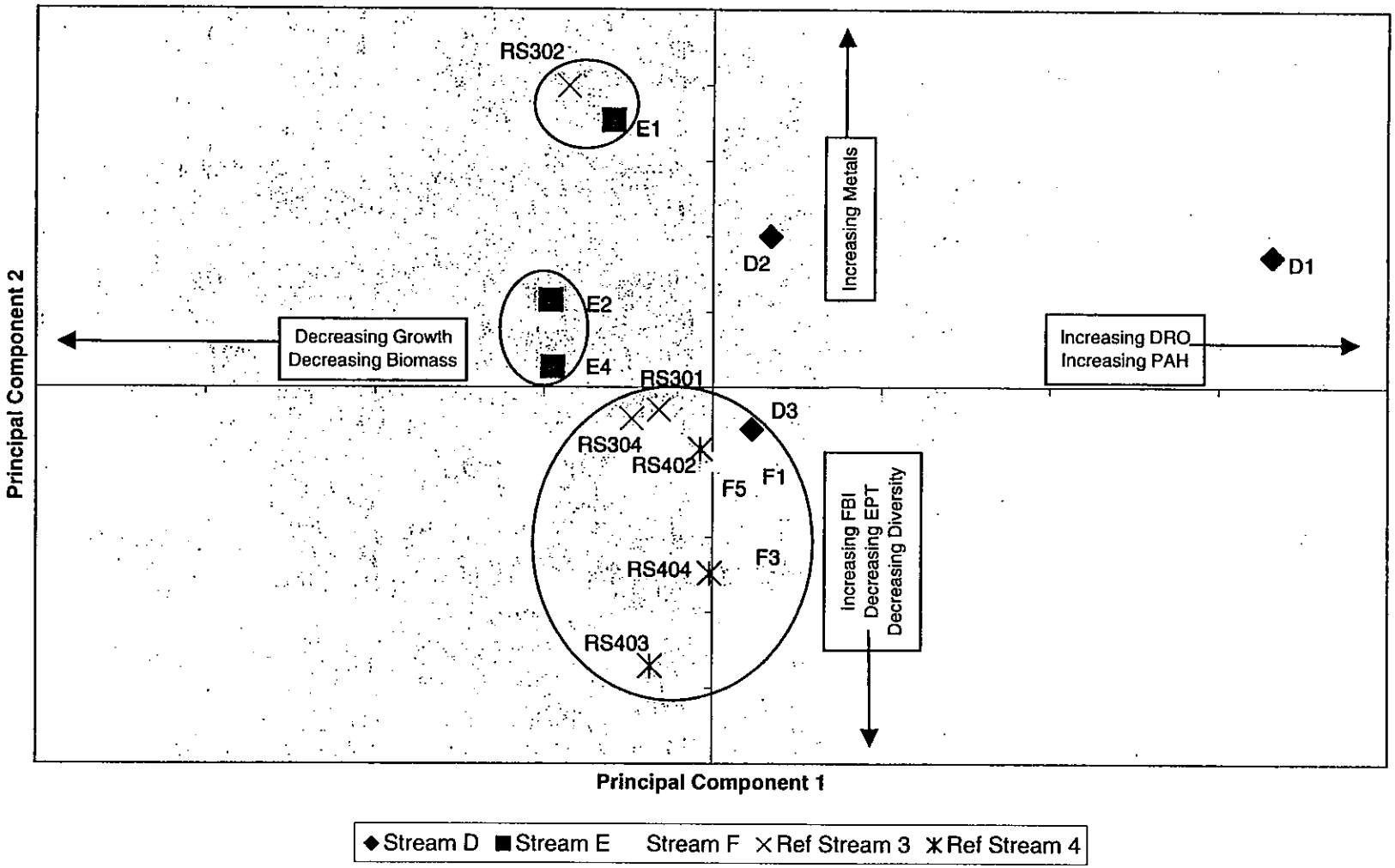


Figure 3.5-15
Probability Analysis for Mean Relative Ranks
Lowland Stream Sampling Stations

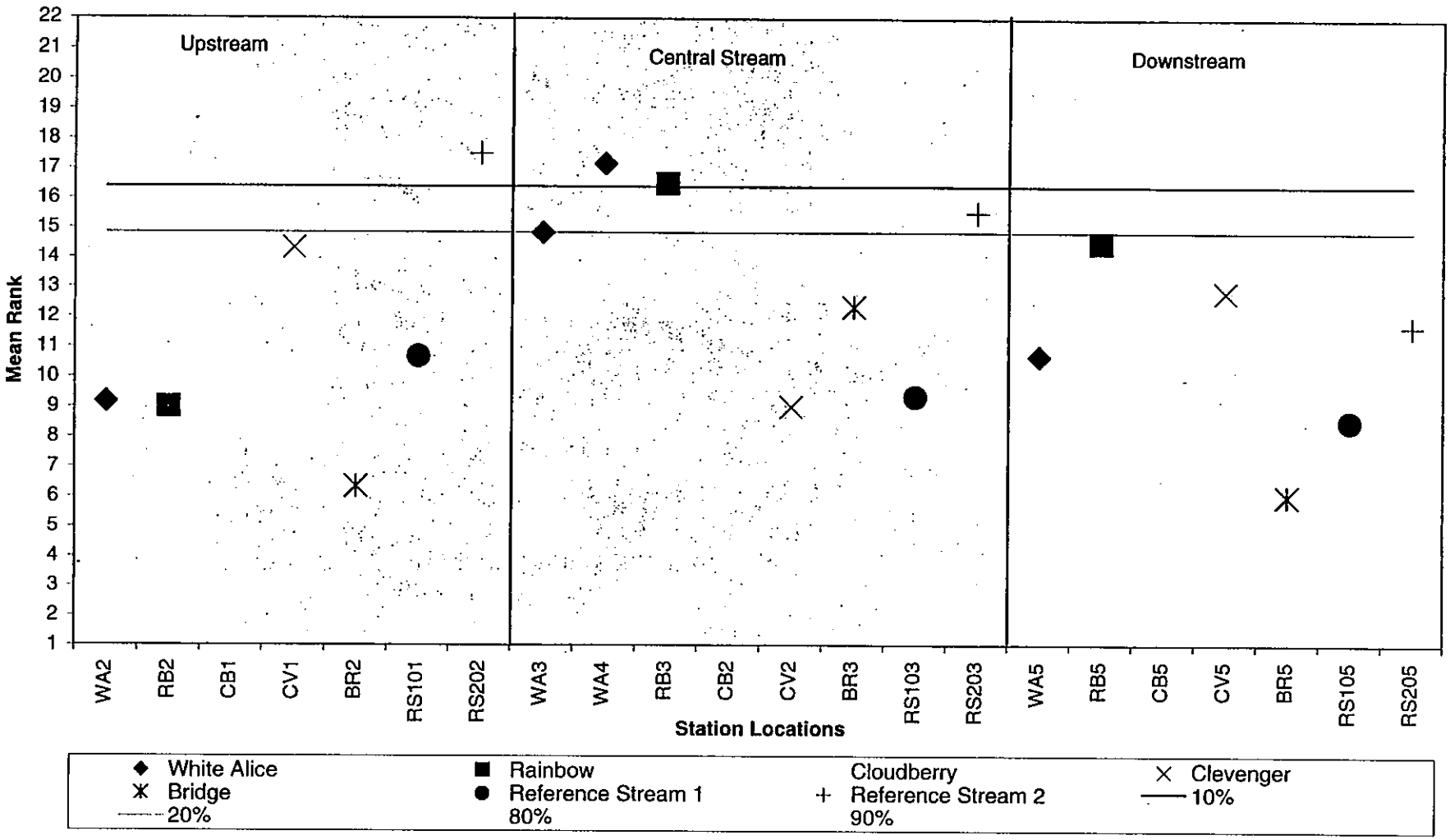


Figure 3.5-16
Triad Analysis
Reference Streams vs. White Alice Creek

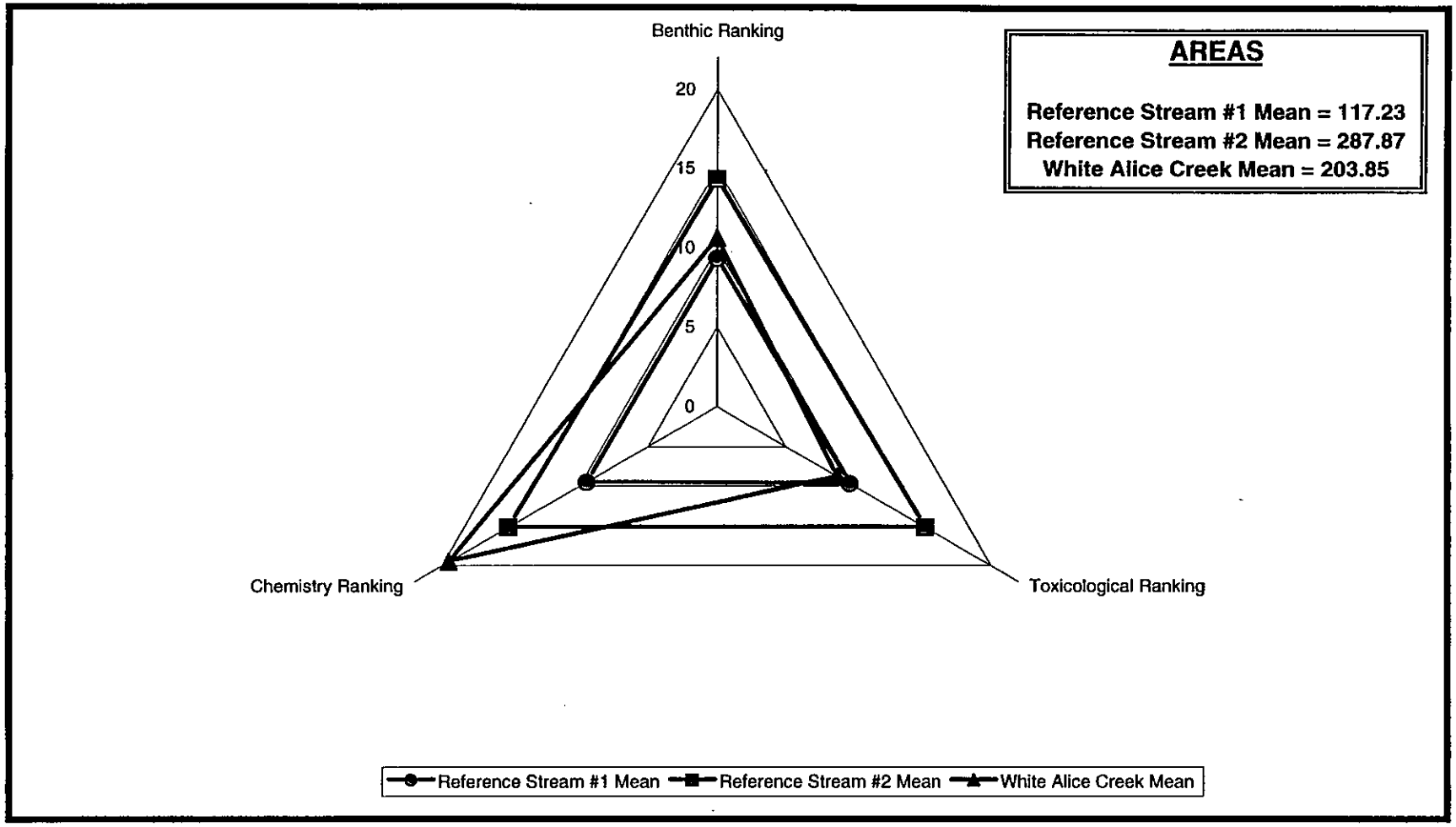


Figure 3.5.17
Triad Analysis
Upstream Reference Stations vs. White Alice Creek Station #2

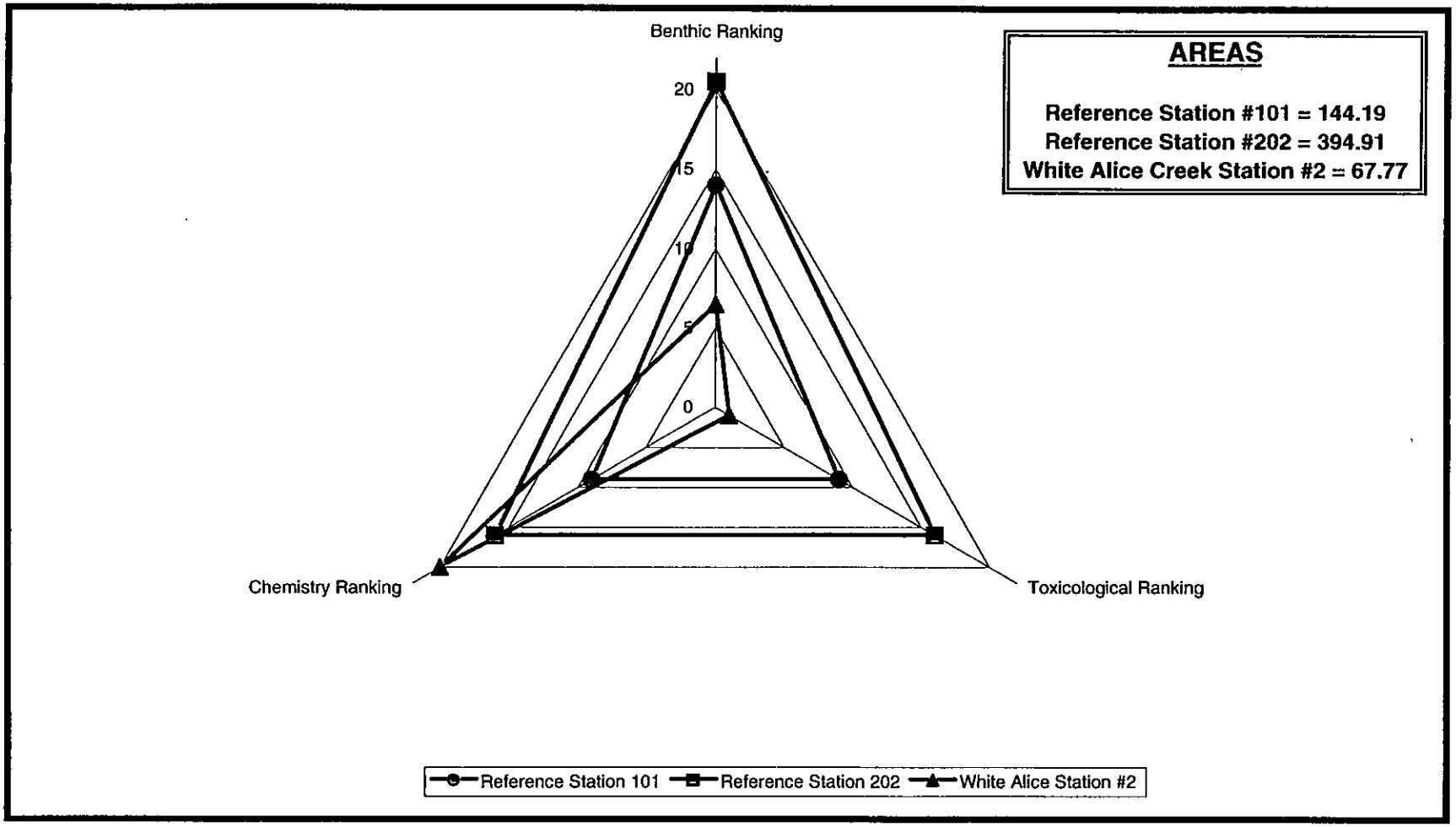


Figure 3.5-18
Triad Analysis
Central Reference Stations vs. White Alice Creek Station #3

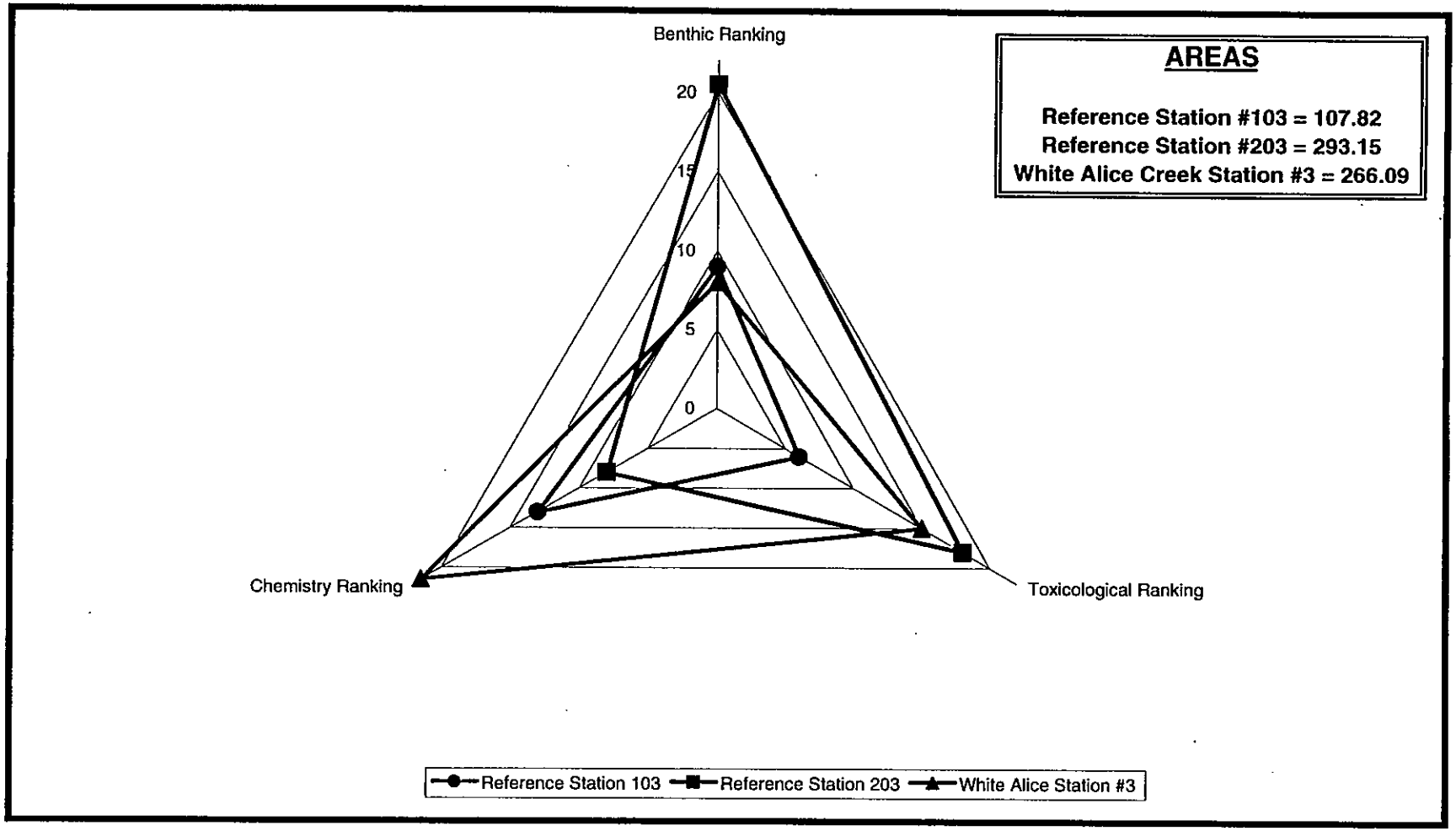


Figure 3.5-19
Triad Analysis
Central Reference Stations vs. White Alice Creek Station #4

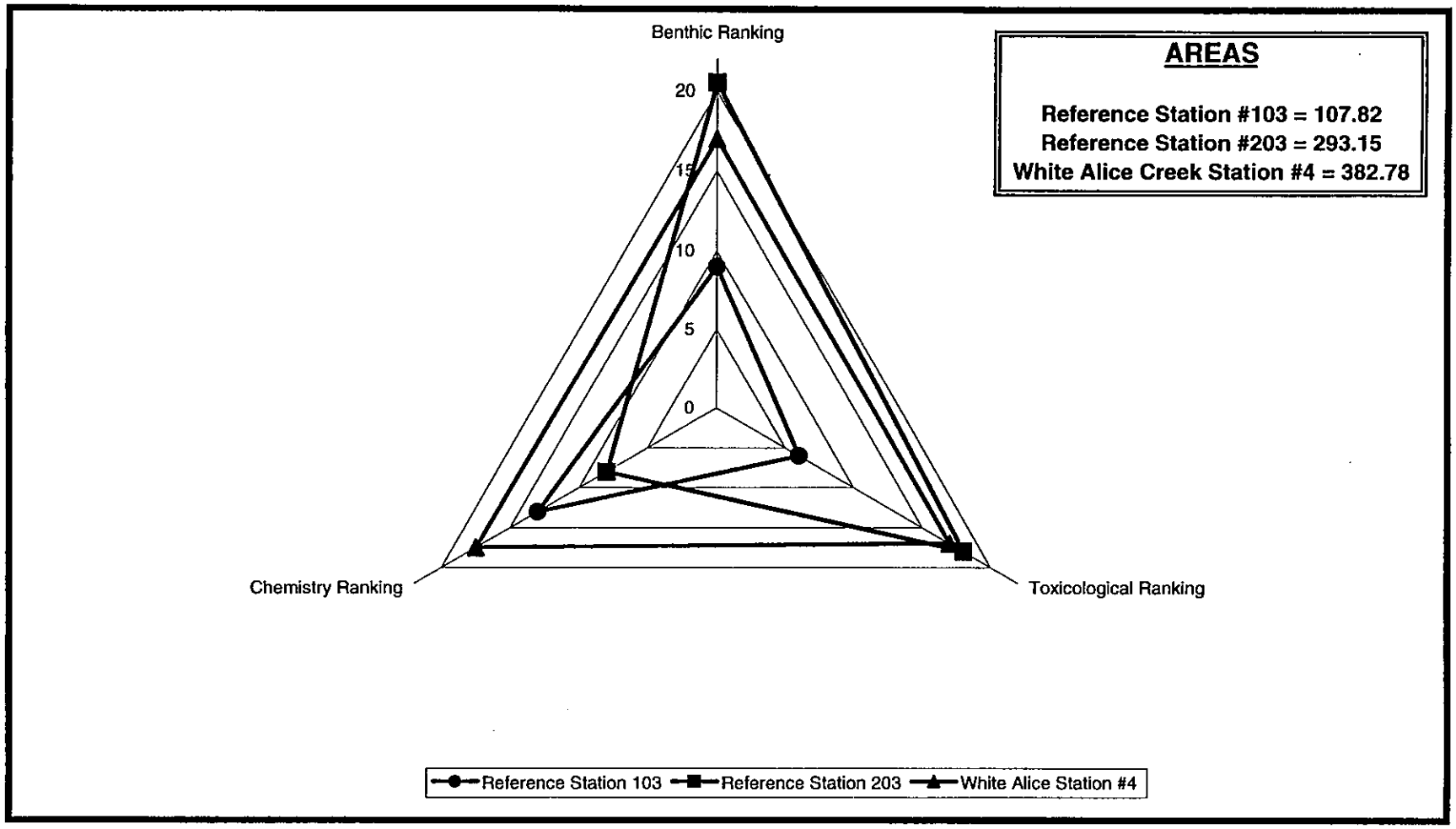


Figure 3.5-20
Triad Analysis
Downstream Reference Stations vs. White Alice Creek Station #5

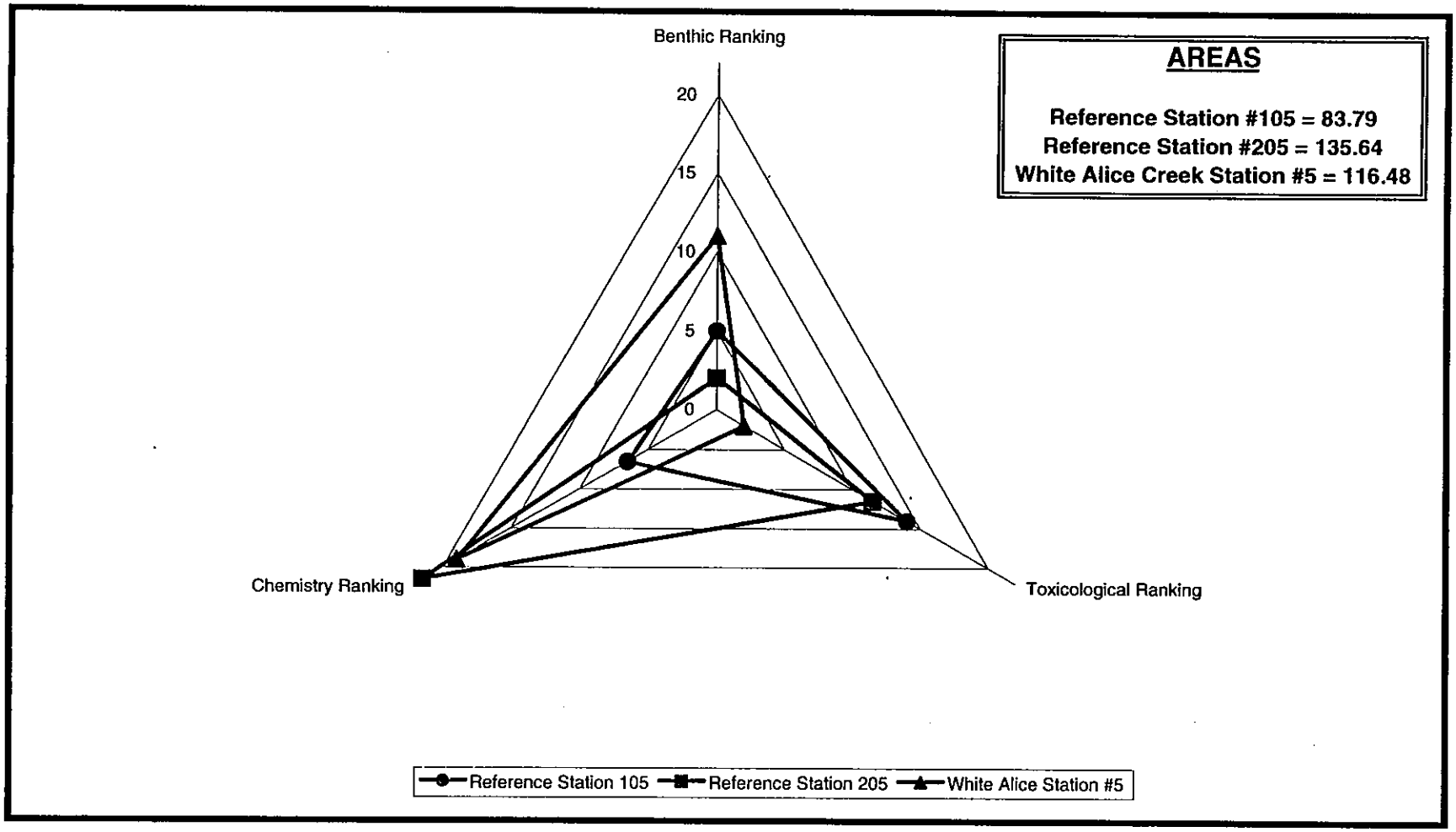


Figure 3.5-21
Triad Analysis
Reference Streams vs. Bridge Creek

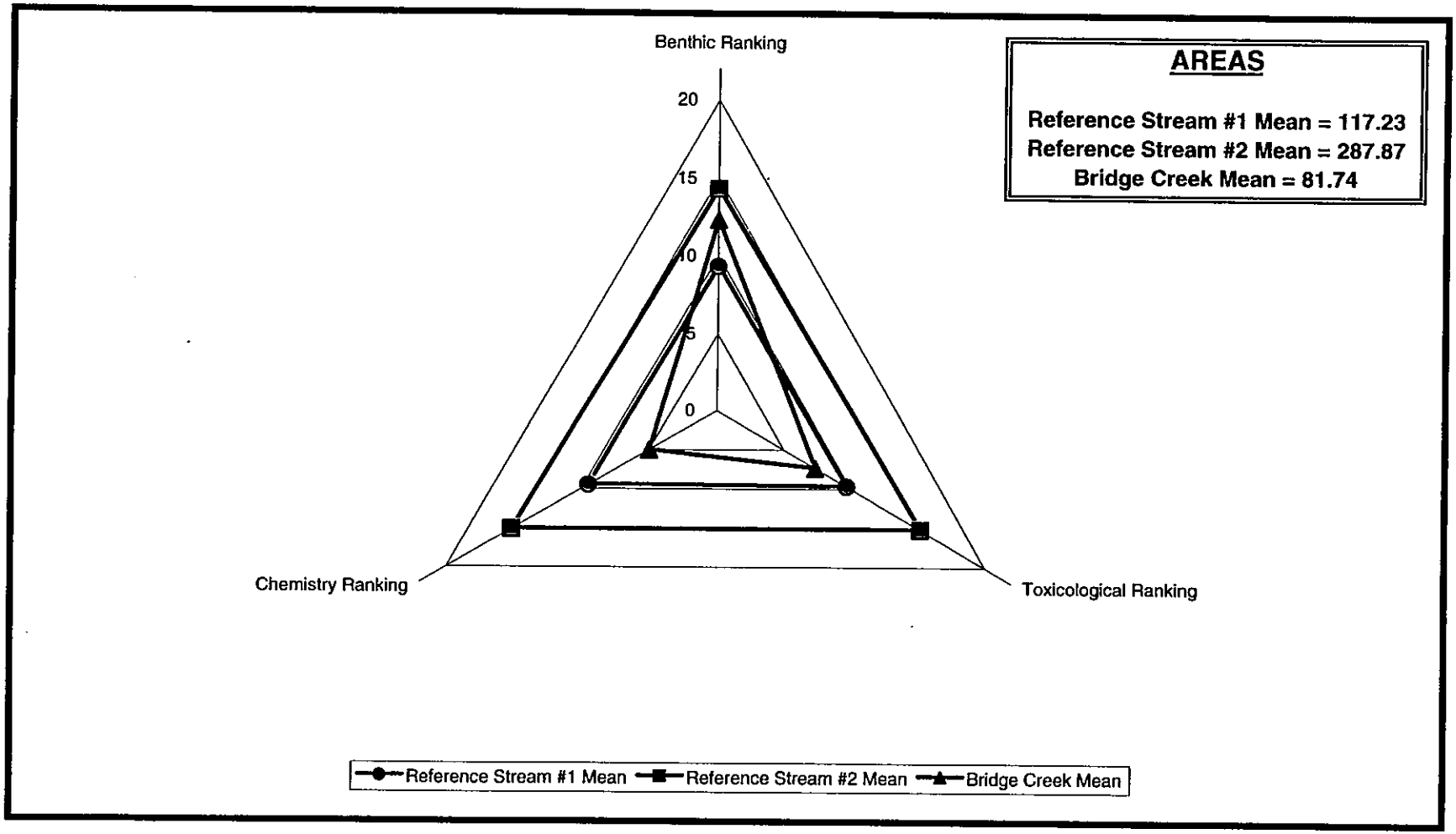


Figure 3.5-22
Triad Analysis
Upstream Reference Stations vs. Bridge Creek Station #2

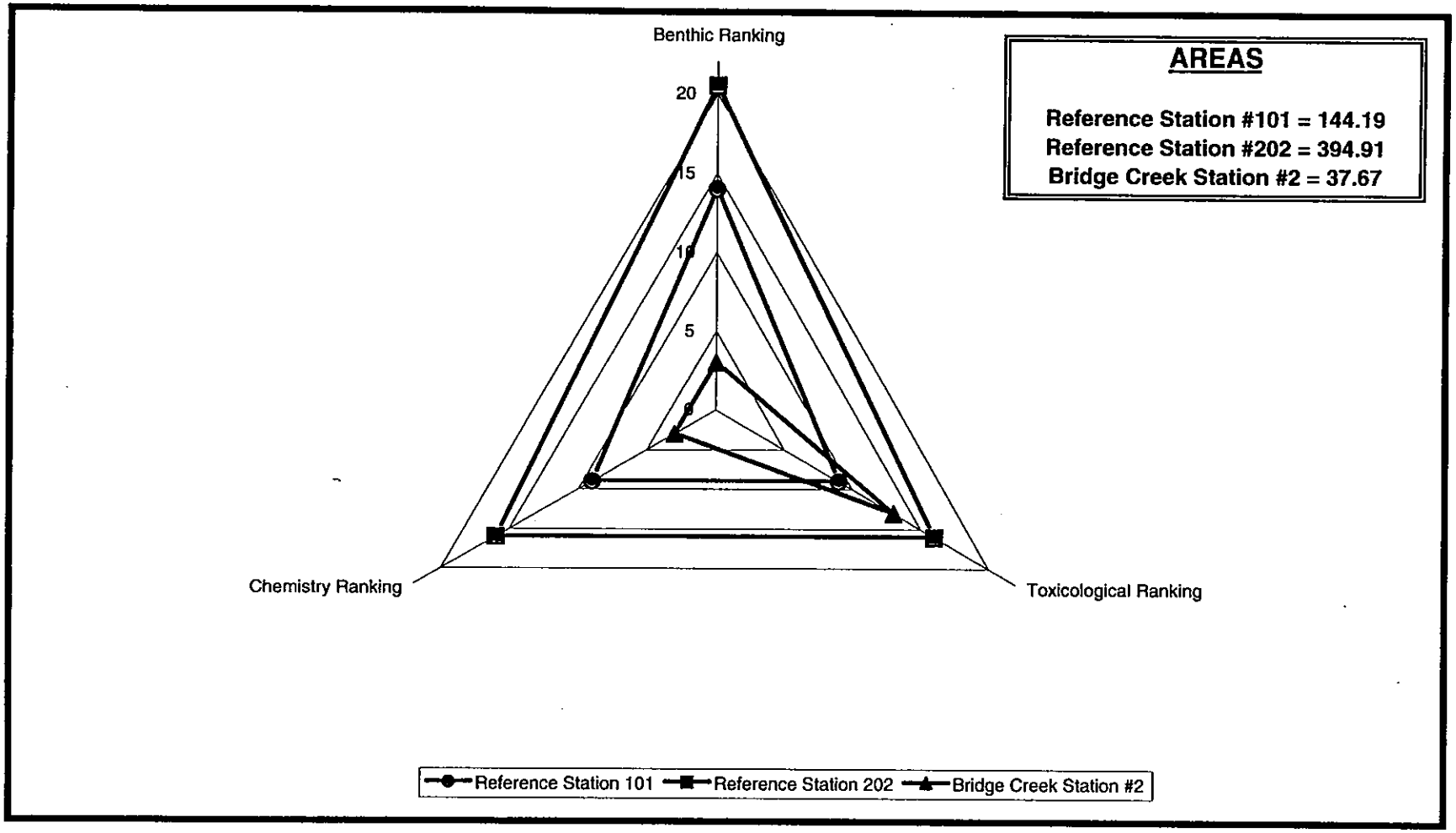


Figure 3.5-23
Triad Analysis
Central Reference Stations vs. Bridge Creek Station #3

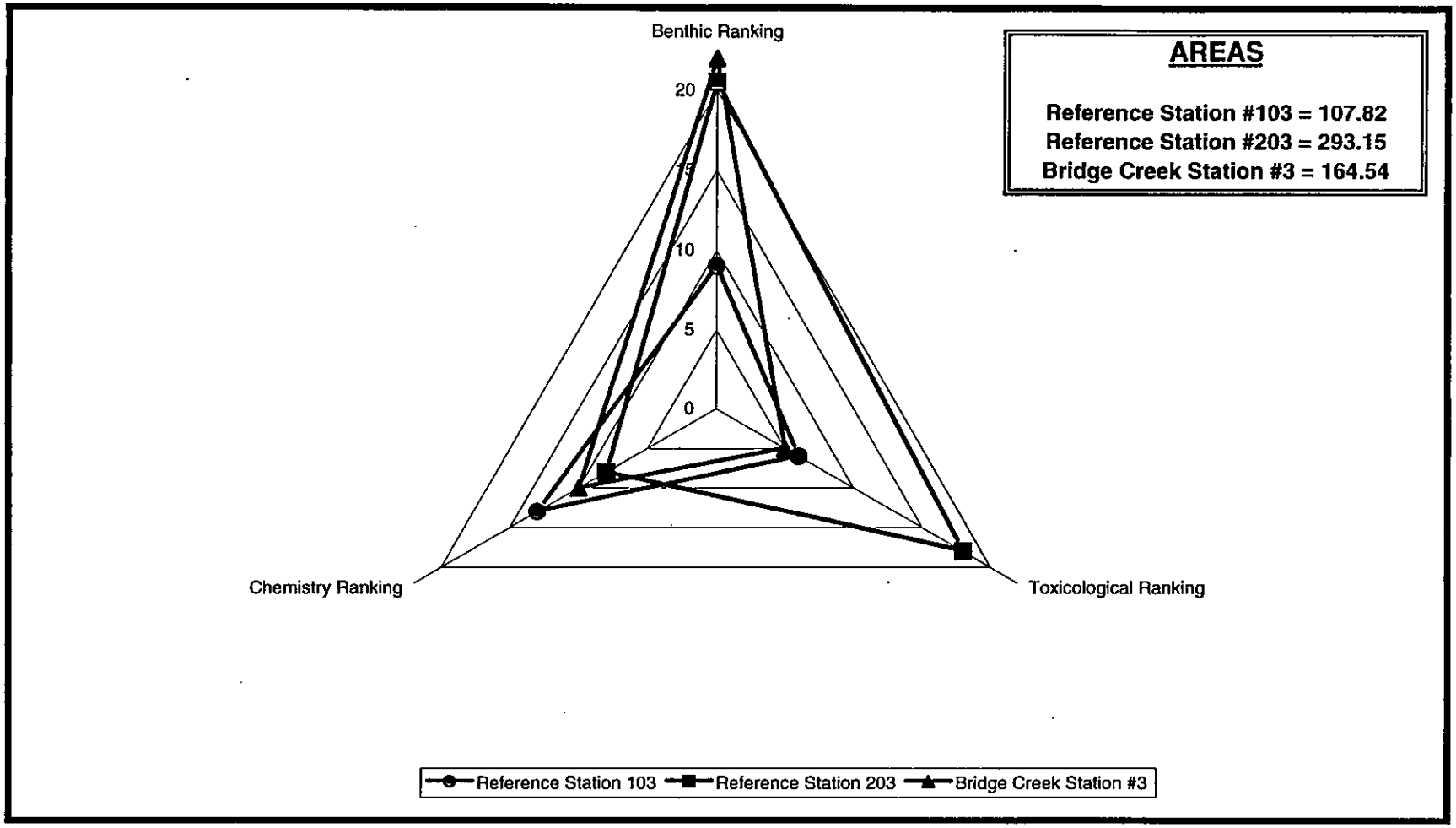


Figure 3.5-24
Triad Analysis
Downstream Reference Stations vs. Bridge Creek Station #5

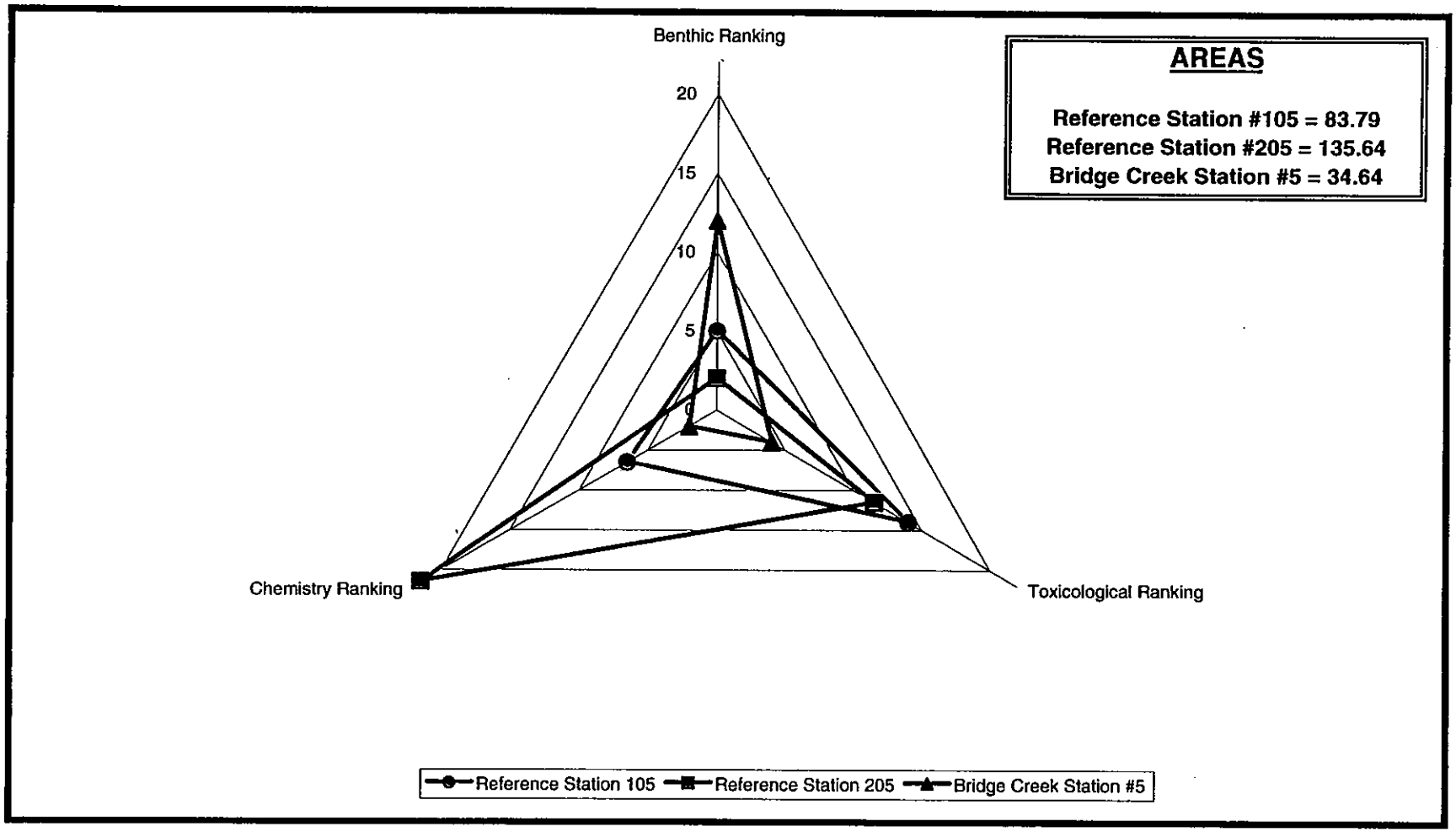


Figure 3.5-25
Triad Analysis
Reference Streams vs. Rainbow Creek

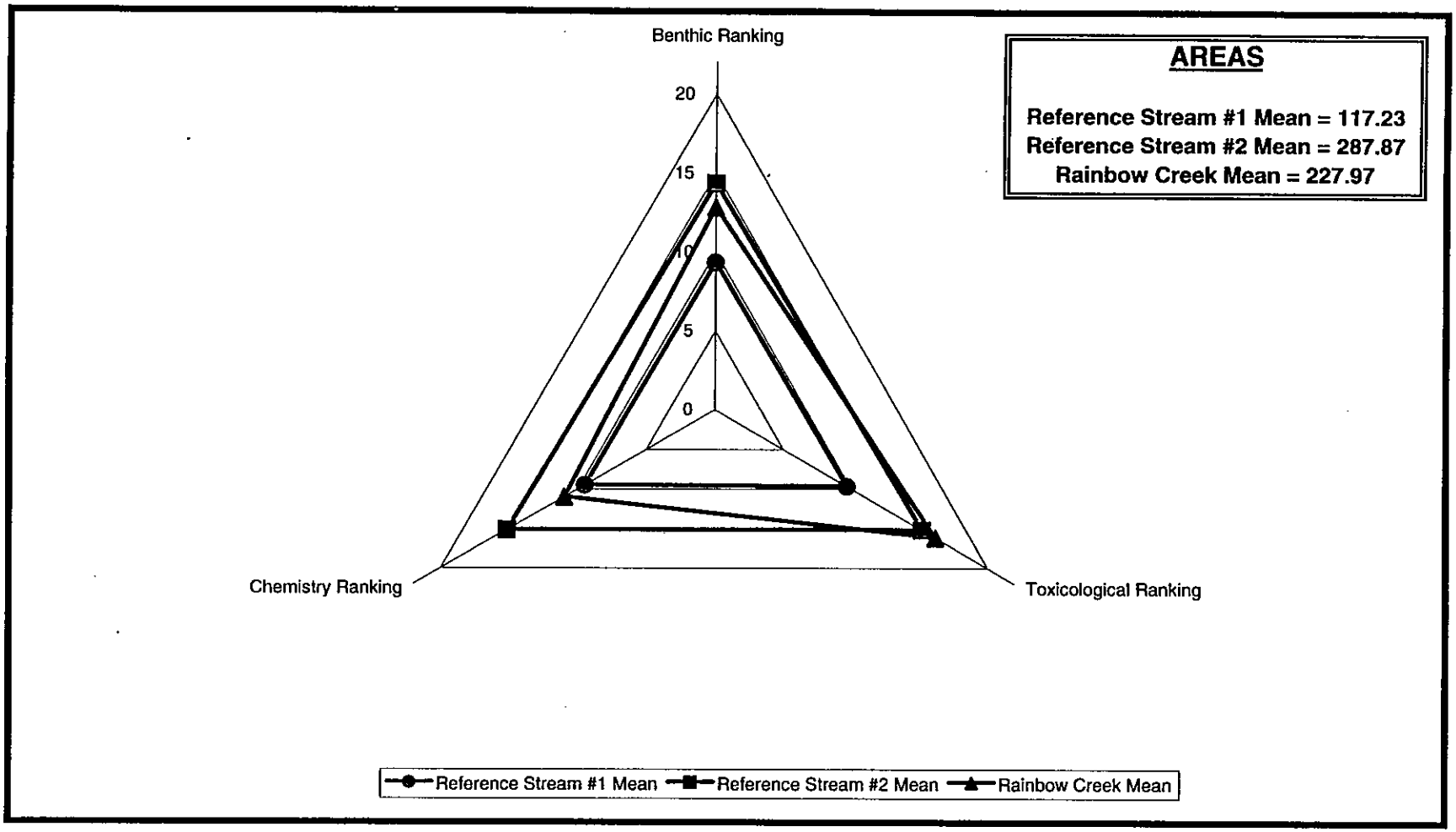


Figure 3.5-26
Triad Analysis
Upstream Reference Stations vs. Rainbow Creek Station #2

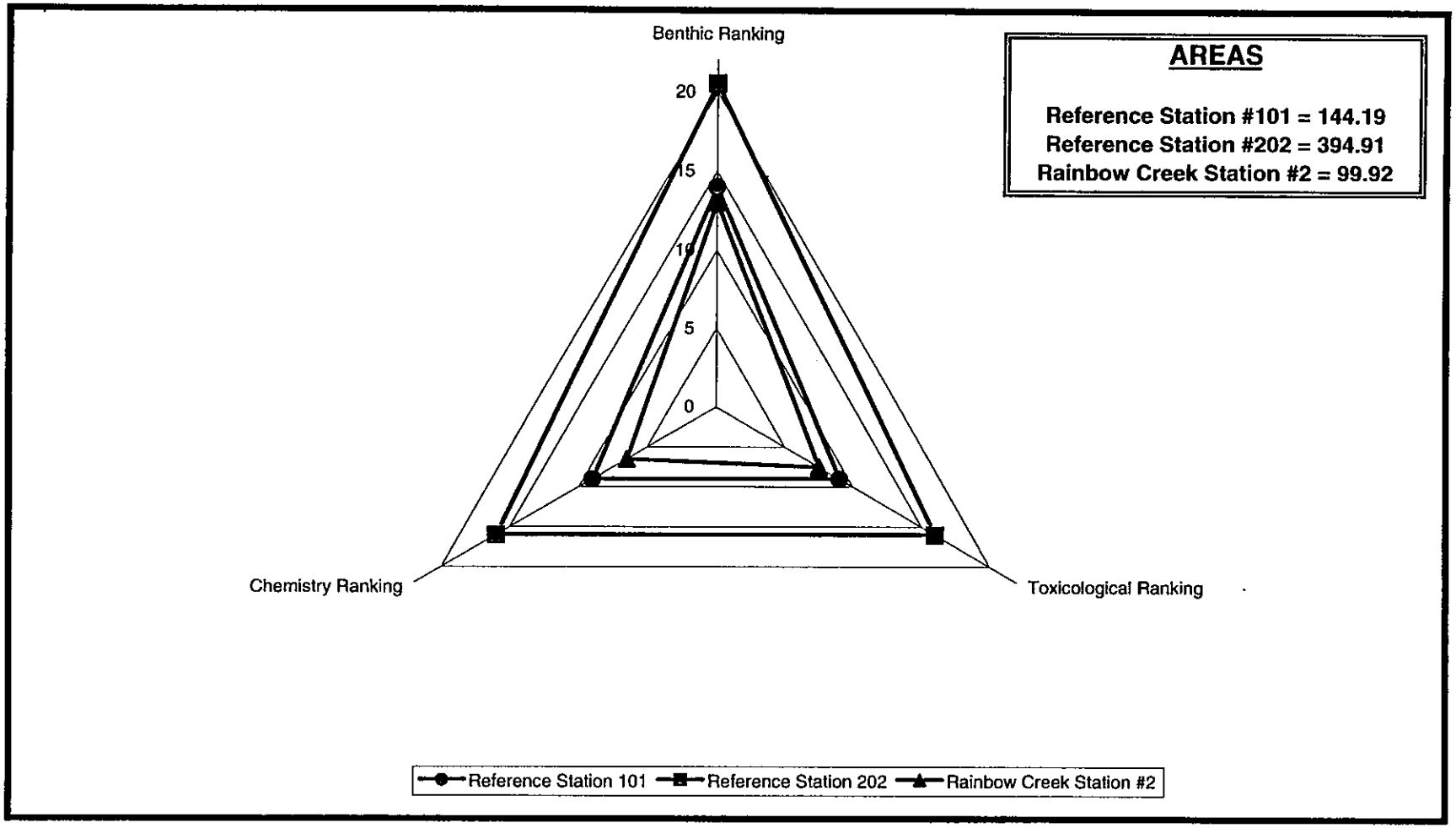


Figure 3.5-27
Triad Analysis
Central Reference Stations vs. Rainbow Creek Station #3

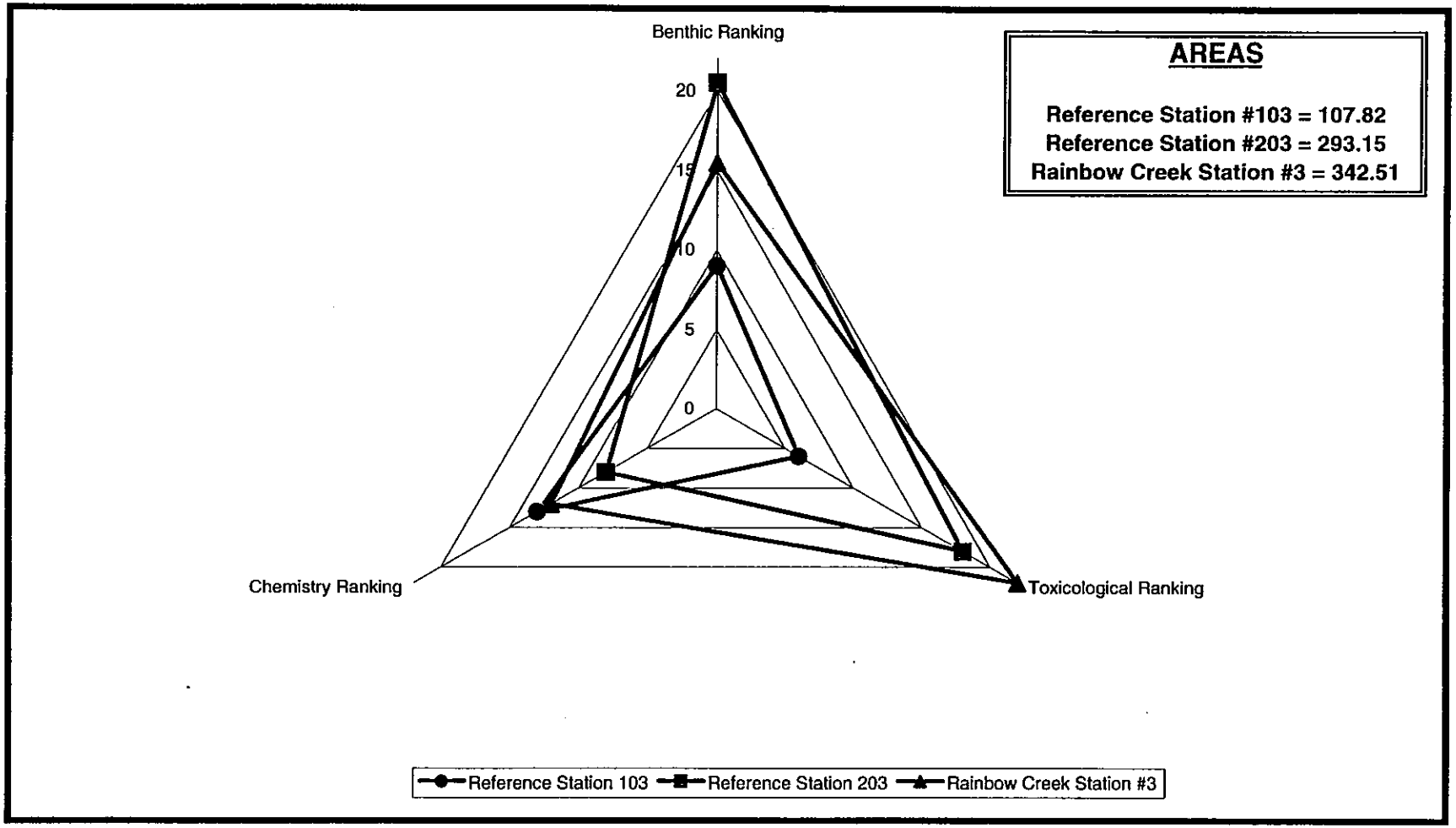


Figure 3.5-28
Triad Analysis
Downstream Reference Stations vs. Rainbow Creek Station #5

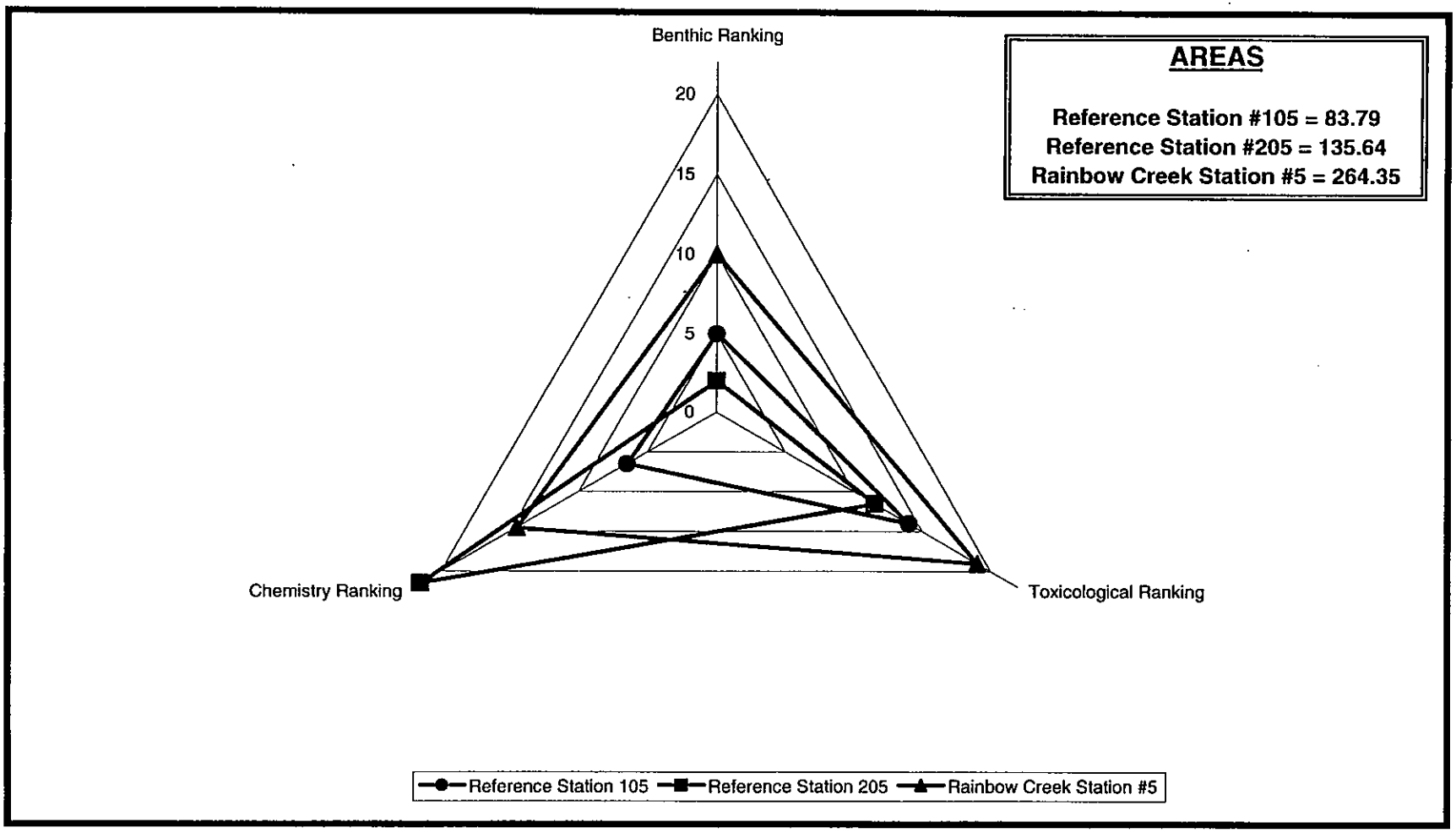


Figure 3.5-29
Triad Analysis
Reference Streams vs. Cloudberry Creek

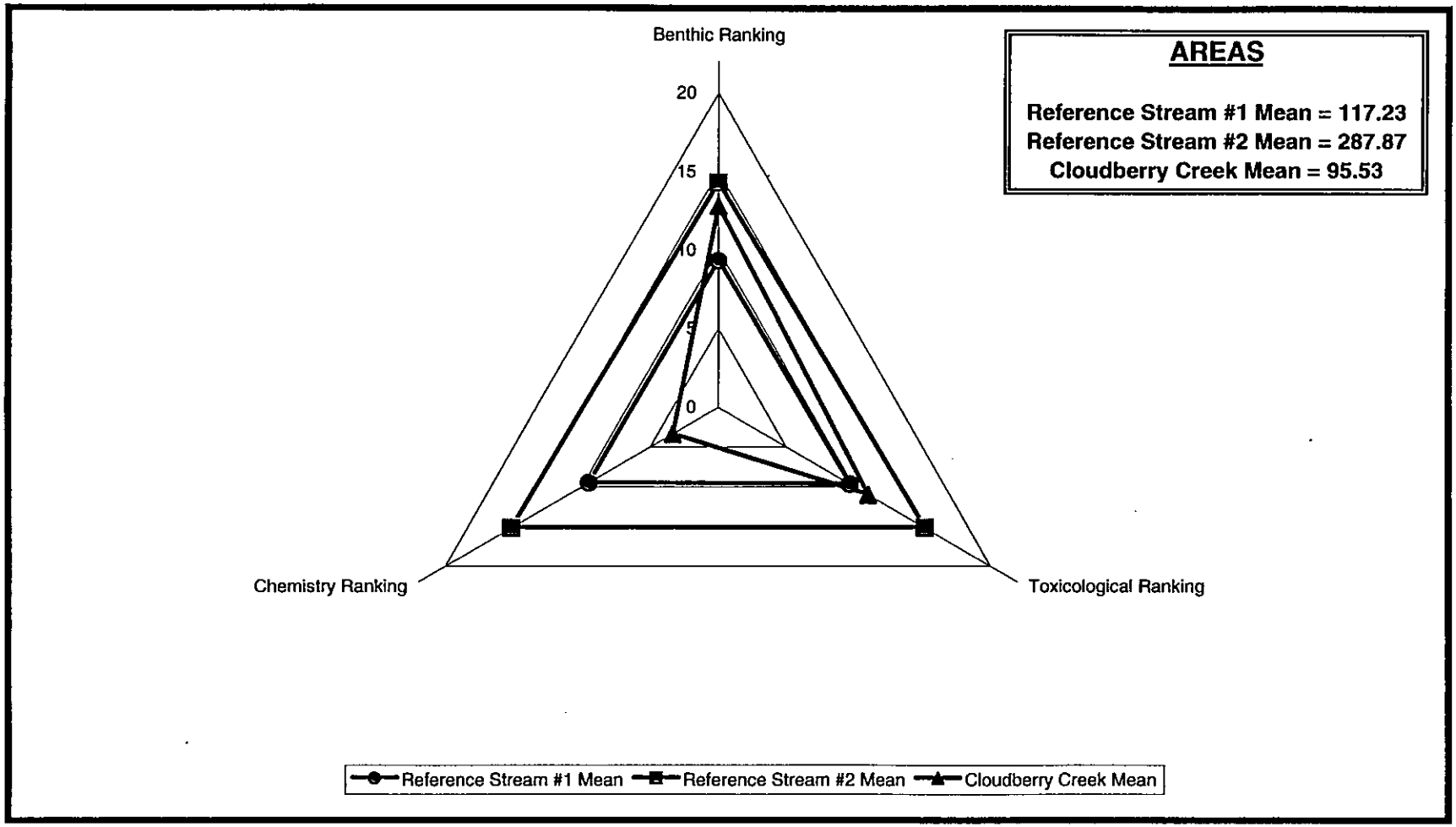


Figure 3.5-30
Triad Analysis
Upstream Reference Stations vs. Cloudberry Creek Station #1

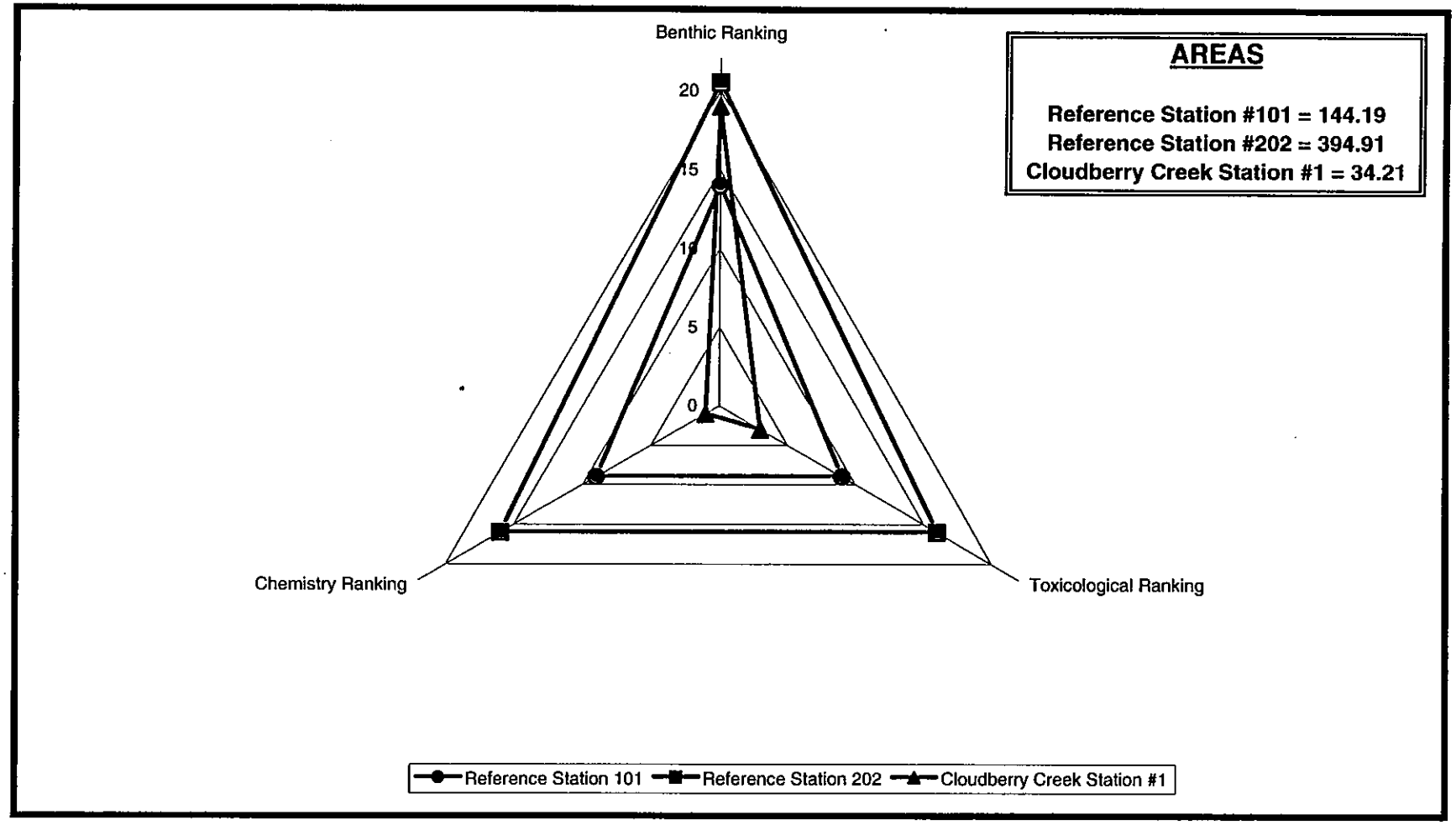


Figure 3.5-31
Triad Analysis
Central Reference Stations vs. Cloudberry Creek Station #2

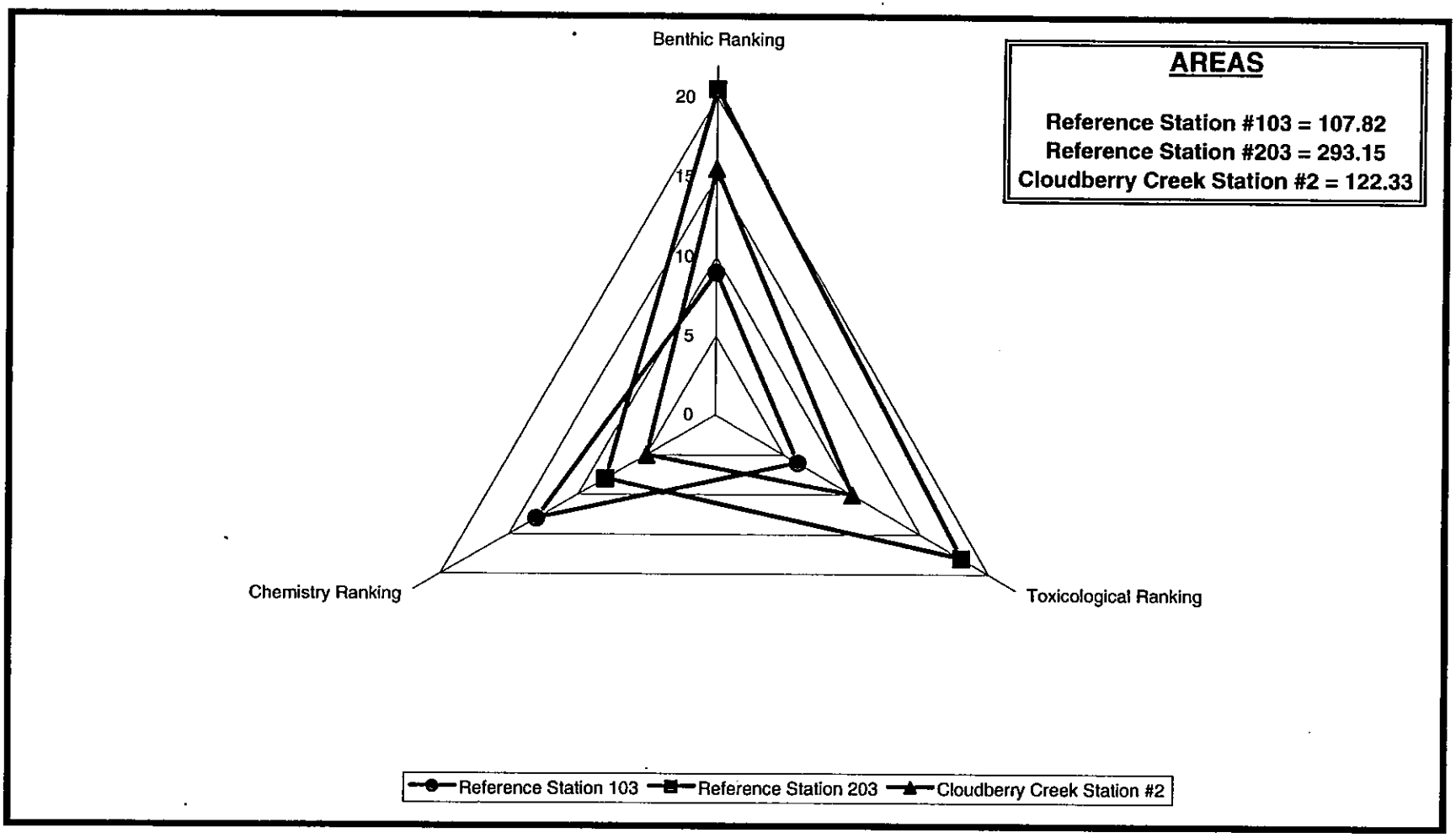


Figure 3.5-32
Triad Analysis
Downstream Reference Stations vs. Cloudberry Creek Station #5

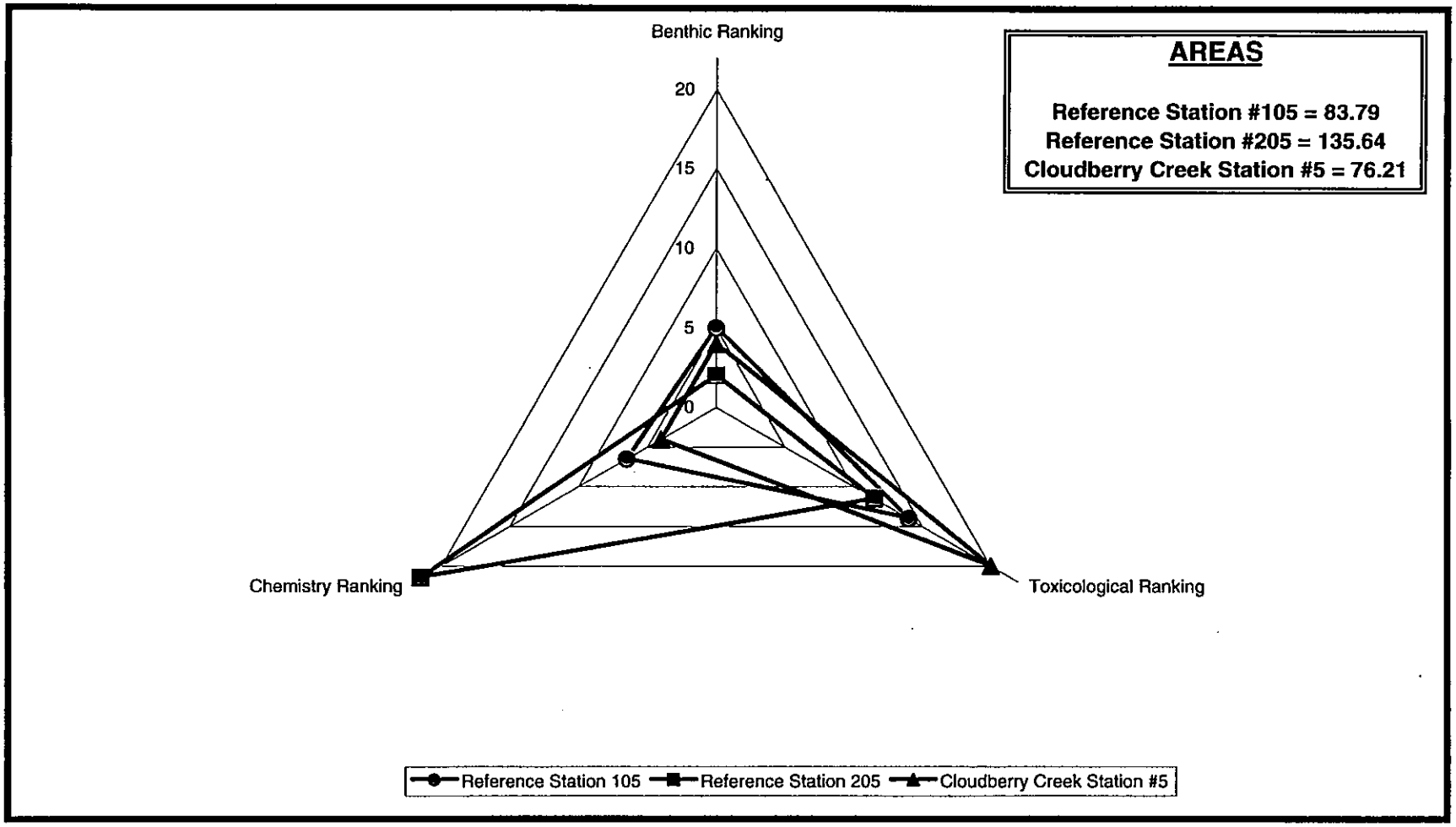


Figure 3.5-33
Triad Analysis
Reference Streams vs. Clevenger Creek

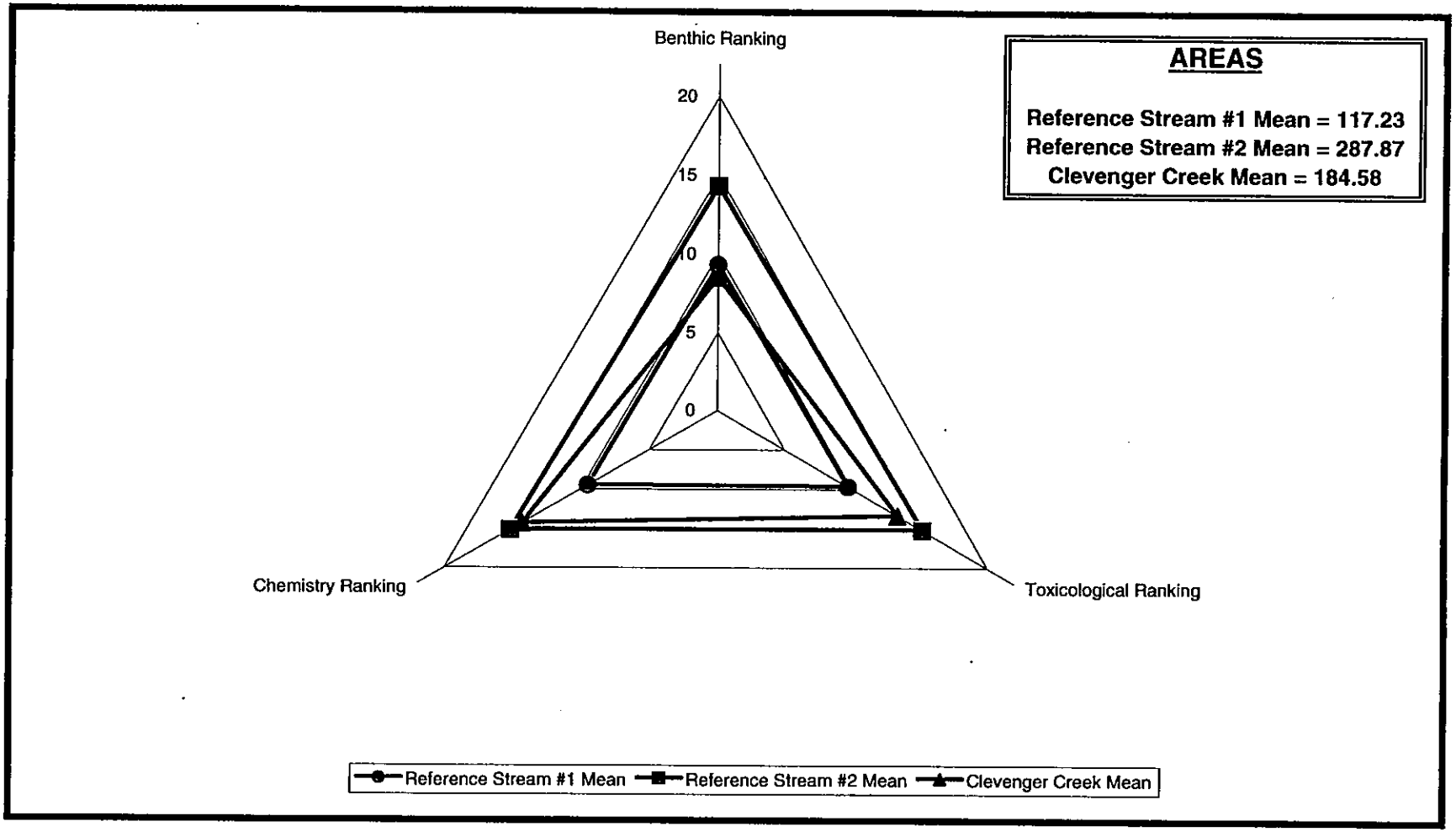


Figure 3.5-34
Triad Analysis
Upstream Reference Stations vs. Clevenger Creek Station #1

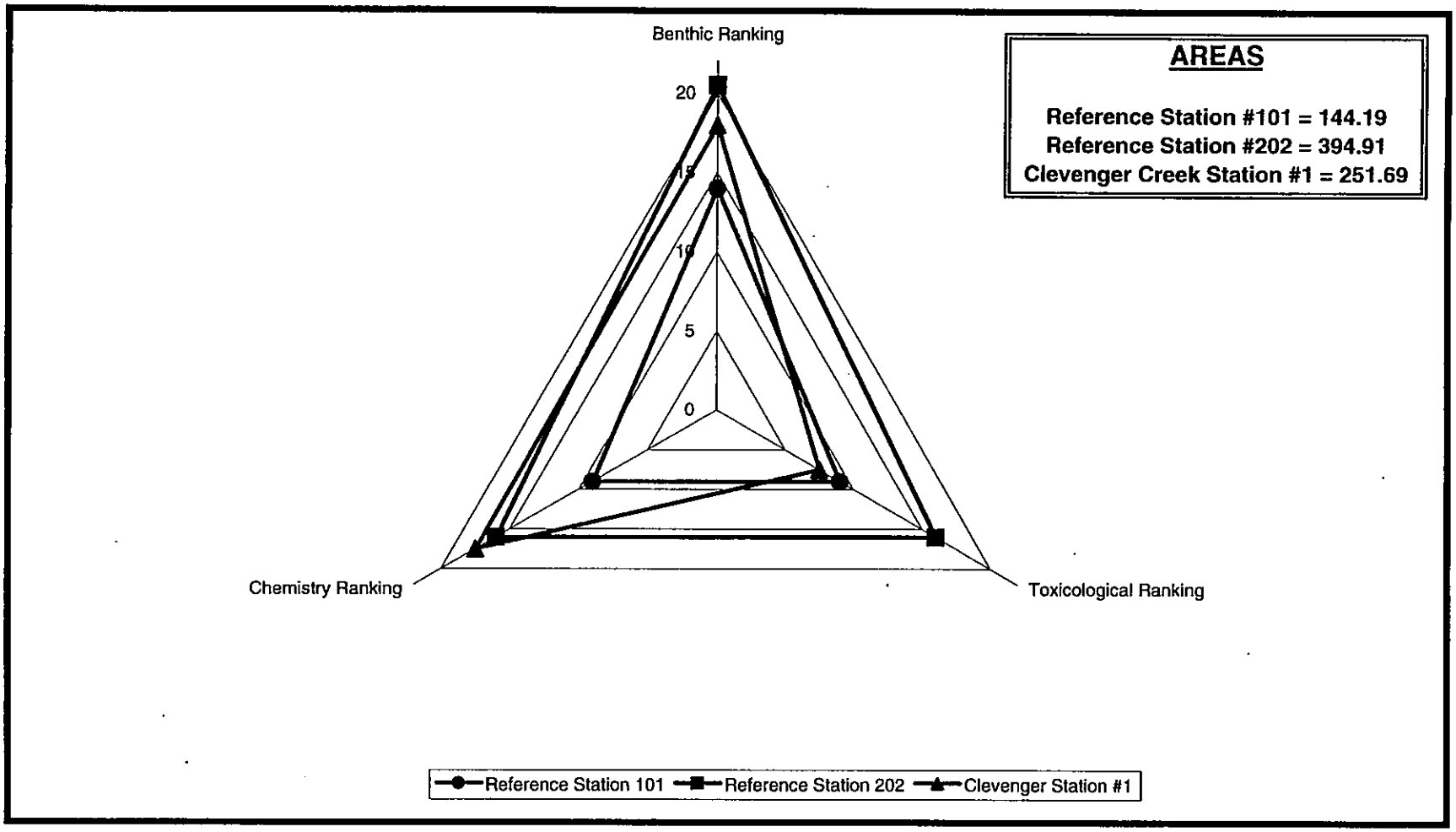


Figure 3.5-35
Triad Analysis
Central Reference Stations vs. Clevenger Creek Station #2

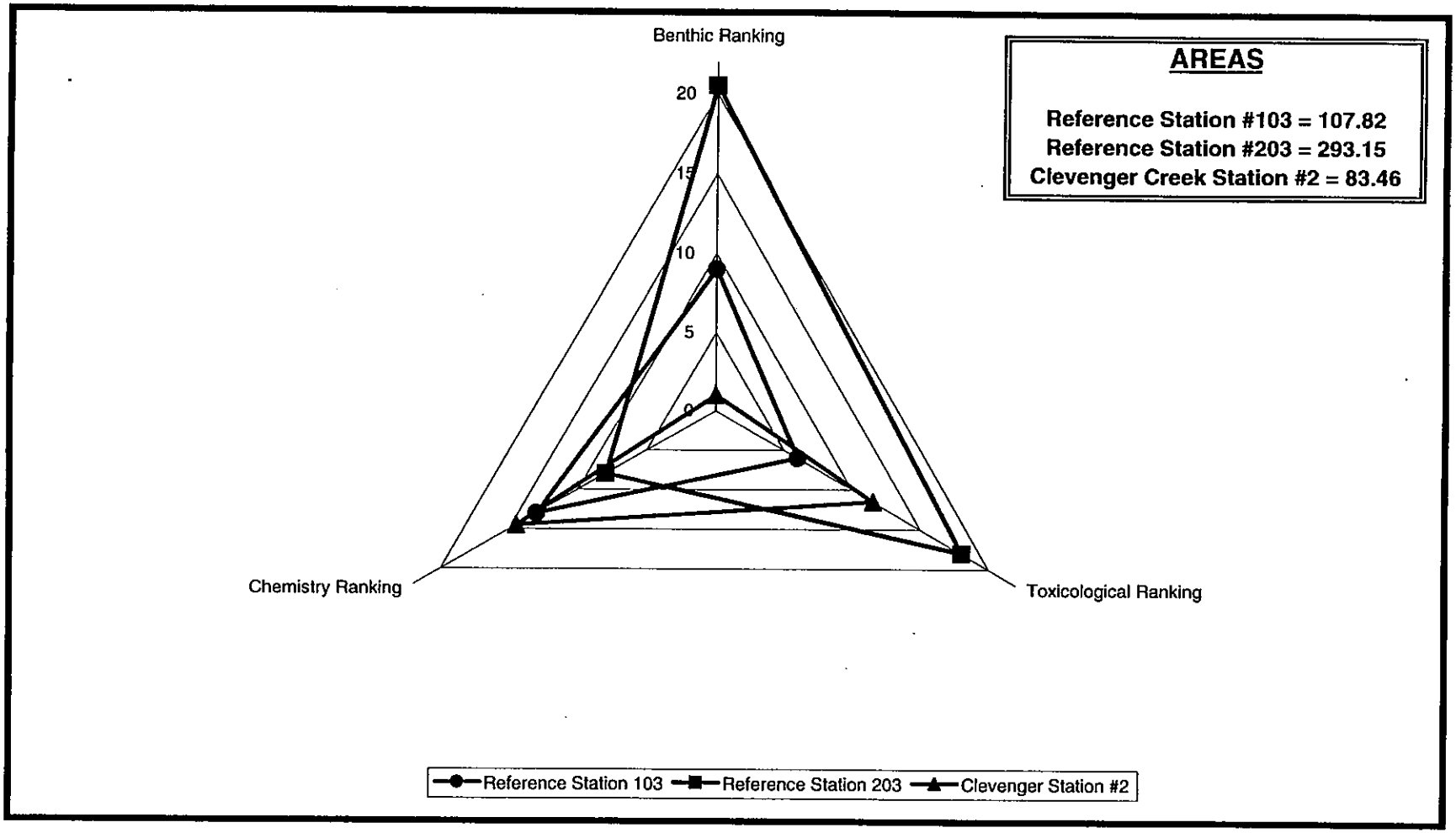


Figure 3.5-36
Triad Analysis
Downstream Reference Stations vs. Clevenger Creek Station #5

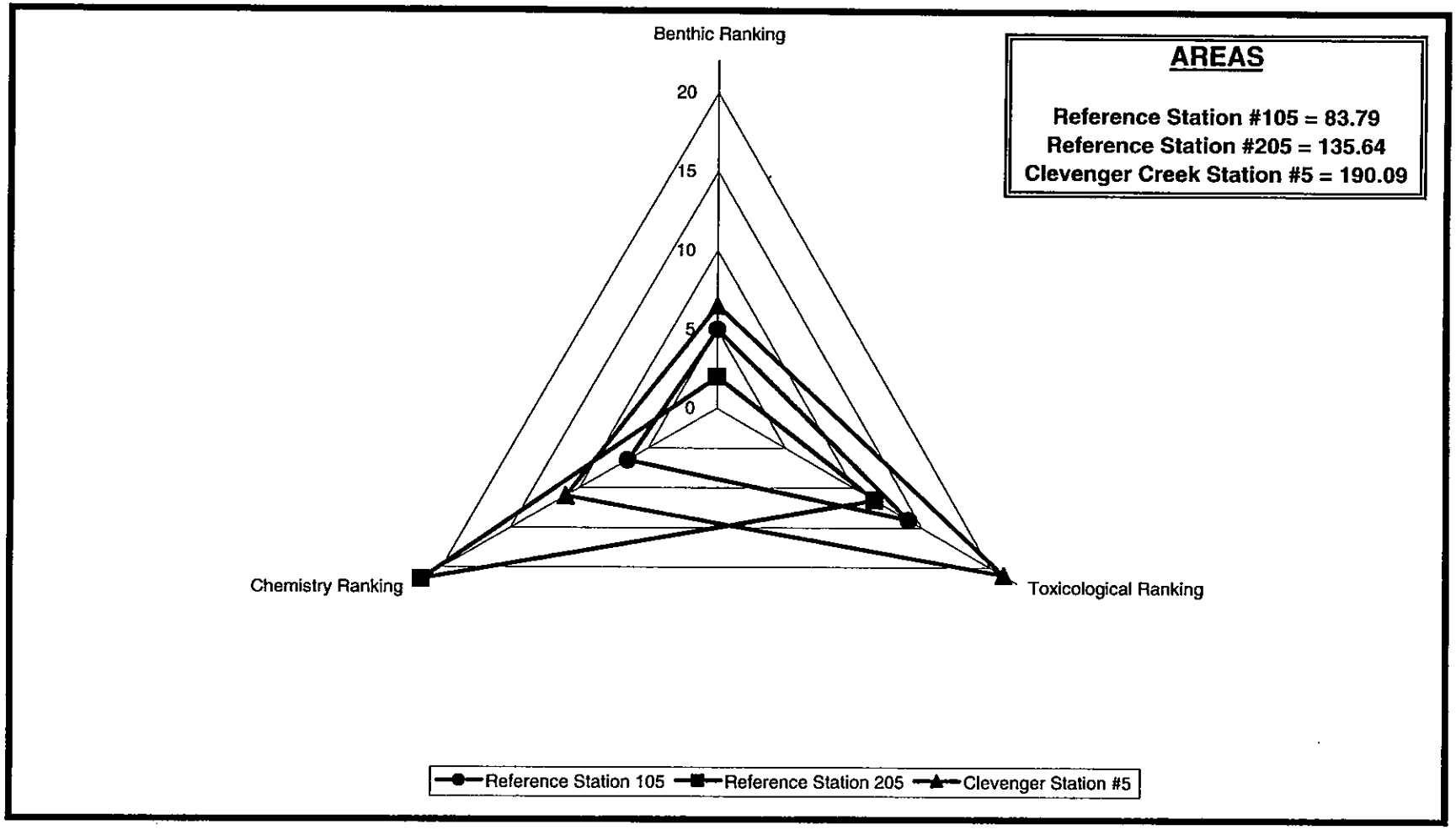


Figure 3.5-37
Lowland Streams - Principal Components Analysis

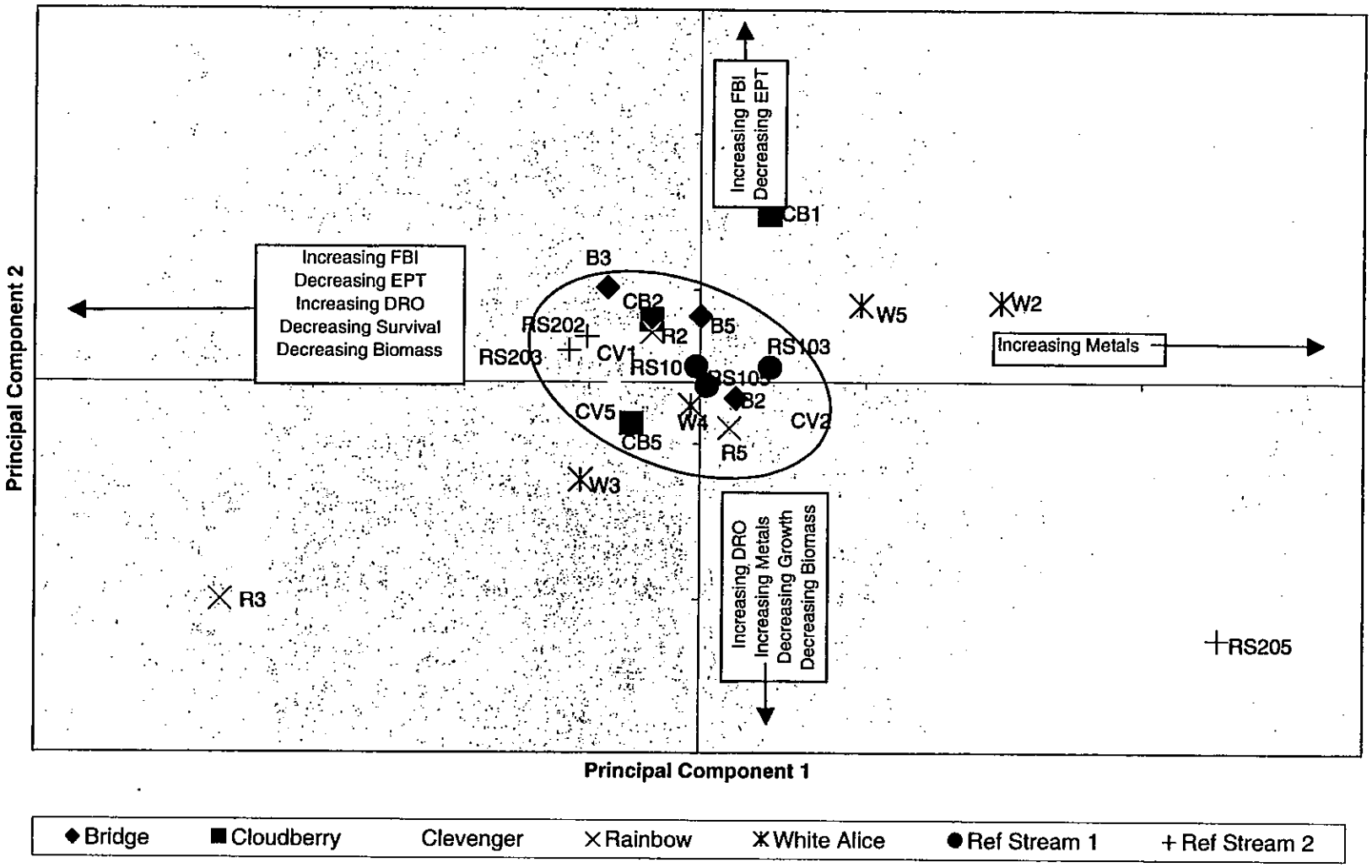


Table 3.1-1
Analyte Benchmark Summary
(Page 1 of 2)

ANALYTE	BENCHMARK	REFERENCE
PAHS (mg/kg)		
Acenaphthene	NA	
Anthracene	0.01	threshold effects level[1]
Benzo (a) anthracene	0.01572	threshold effects level[1]
Benzo (a) pyrene	0.0319	threshold effects level[1]
Benzo (b) fluoranthene	NA	
Benzo (g,h,i) perylene	NA	
Benzo (k) fluoranthene	0.0272	threshold effects level[1]
Chrysene	0.02683	threshold effects level[1]
Fluoranthene	0.03146	threshold effects level[1]
Fluorene	0.01	threshold effects level[1]
Indeno (1,2,3-cd) pyrene	0.01732	threshold effects level[1]
Naphthalene	0.01465	threshold effects level[1]
Phenanthrene	0.01873	threshold effects level[1]
Pyrene	0.04427	threshold effects level[1]
Diesel-Range Organics	NA	
Carbon disulfide	0.00085	secondary chronic value[2]
Total Organic Carbon	Not Applicable	
Acid Volatile Sulfides	Not Applicable	
Simultaneously Extracted Metals	$\sum$SEM-AVS=0	no observable effects level[3]
Metals (mg/kg)		
Aluminum	58,030	probable effect concentration (PEC)[2]
Arsenic	12.1	threshold effect concentration[2]
Barium	NA	
Beryllium	NA	
Boron	NA	
Cadmium	0.583	threshold effects level[1]
Calcium	NA	
Cerium	NA	
Cesium	NA	
Chromium	36.286	threshold effects level[1]
Cobalt	NA	
Copper	28	threshold effect concentration TEC[2]
Iron	40000	upper effects threshold UET (4%)[1]
Lithium	NA	

Table 3.1-1
Analyte Benchmark Summary
(Page 2 of 2)

ANALYTE	BENCHMARK	REFERENCE
Magnesium	NA	
Manganese	614.722	threshold effects level[1]
Molybdenum	NA	
Nickel	19.514	threshold effects level[1]
Potassium	NA	
Selenium	NA	
Strontium	NA	
Thallium	NA	
Thorium	NA	
Titanium	NA	
Uranium	NA	
Vanadium	NA	
Zinc	94.15	threshold effects level[1]
PAHs Normalized (mg/% OC)		
Acenaphthene	1.3	nawqc chronic[2]
Anthracene	0.027	fish[2]
Benzo (a) anthracene	0.11	secondary chronic value[2]
Benzo (a) pyrene	0.14	secondary chronic value[2]
Benzo (b) fluoranthene	NA	
Benzo (ghi) perylene	0.3	upper effects threshold[1]
Benzo (k) fluoranthene	NA	
Chrysene	0.8	upper effects threshold[1]
Fluoranthene	1.5	upper effects threshold[1]
Fluorene	0.3	upper effects threshold[1]
Indeno (1,2,3-cd) pyrene	0.33	upper effects threshold[1]
Naphthalene	0.6	upper effects threshold[1]
Phenanthrene	0.8	upper effects threshold[1]
Pyrene	1	upper effects threshold[1]
Diesel Range Organics	4.7	lowest LC 50, low persistence fuel oil, per 1 % TOC[4]

NA=Not Available

1. U.S. Environmental Protection Agency. 1996. Calculation and Evaluation of Sediment Eeffect Concentrations for the Amphipod *Hyalella* Azteca and the Midge *Chironomus Riparius*, EPA 905-R96- 008, Chicago, IL.

2. Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision, ES/ER/TM-95/R4. Oak Ridge, TN: Oak Ridge National Laboratory.

3. U.S. Environmental Protection Agency. 1995b. An SAB Report: Review of the Agency's Approach for Developing Sediment Criteria for Five Metals, EPA-SAB-EPEC-95-020.

4. American Petroleum Institute. 1994. A Critical Review of Toxicity Values and an Evaluation of the Persistence of Petroleum Products for Use in Natural Resource Damage Assessments. Publication Number 4594, Wilmington, DE.

Sediment Chemistry Data - Upland Stations

	Stream and Station Location														
	Drill Site D Stream			Drill Site E Stream			Drill Site F Stream			Reference Stream #3			Reference Stream #4		
Analyte Concentrations in mg/kg	1	2	4	1	2	4	1	3	5	1	2	4	2	3	4
PAHs															
Acenaphthene	ND	ND	ND	0.0103	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	0.0161	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	0.034	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	0.0501	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	0.0876	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	0.0143	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	0.0322	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.0215	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.0232	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	0.0125	ND	ND	0.0274	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	0.0197	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	0.125	ND	ND	0.0702	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	0.0554	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diesel-Range Organics	176	ND	ND	ND	22.1	ND	ND	ND	ND	206	ND	ND	ND	9.95	10.7
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon	11600	18600	82700	25600	103000	22800	44900	29300	19200	159000	108000	70400	38000	12000	18000
Acid Volatile Sulfides (mmol/kg)	170	ND	105	ND	ND	ND	ND	ND	11.3	2.63	50.9	5.94	ND	ND	ND
Simultaneously Extracted Metals (mmol/kg)	1.03	0.553	1.47	6.12	3.56	0.922	0.79	0.813	1.86	3.46	3.86	2.82	1.71	1.27	0.646
METALS															
Aluminum	11900	9490	17500	25100	17000	19500	16000	15500	18000	7400	29800	32800	28400	15600	17300
Arsenic	1.62	4.05	10	3.64	3.44	1.25	ND	3.73	2.49	11.2	23.6	11.7	3.01	1.15	0.982
Barium	86.9	53	139	76.7	36.5	49.9	58.9	36.8	93.1	91.1	232	145	44.3	38.5	43.2
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	17.2	45	149	ND	ND	ND	ND	30.6	ND	ND	ND	6.42	ND	ND	ND
Cadmium	ND	ND	ND	8.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	4160	1700	2720	3400	2710	4860	3710	5440	5770	4220	4650	5090	4450	4390	4180
Cerium	14.6	3.71	8.19	19.7	10.3	9.82	6.27	6.71	5.55	3.79	10.9	8.06	9.41	6.77	7.47
Cesium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	226	23.1	36.2	18.9	41.1	11.4	7.66	9.81	9.74	7.32	9.94	4.62	17.6	9.83	9.82
Cobalt	4.62	7.76	17.9	18.5	4.03	11.5	15.7	6.67	7.88	8.83	27.6	10.2	17.7	10.4	8.84
Copper	38.35	13.495	20.65	118	70.95	23.2	14.8	19.2	25.3	24.5	42.55	54.6	29.85	17.015	19.9
Iron	8960	20200	68600	23000	31000	23000	64800	13300	24200	52700	104000	70900	54200	26000	16000
Lithium	2.51	2.89	4.6	7.89	3.03	6.08	4.08	4.47	5.47	ND	8.29	12.2	15	11.6	10.1
Magnesium	2610	1660	2010	5320	1310	4980	839	859	3340	1280	7410	10800	11200	5810	6120
Manganese	256	1430	2310	748	350	840	1250	284	218	4910	13300	1420	2260	1500	786
Molybdenum	ND	0.555	ND	ND	ND	ND	ND	1.63	ND	ND	ND	ND	ND	ND	ND
Nickel	13.8	10.025	15.8	31.95	17.39	10.305	6.5	4.425	6.8	13.23	20.9	9.095	12.295	7.14	5.77
Potassium	442	175	415	556	123	345	236	202	260	179	373	644	371	181	213
Selenium	ND	ND	ND	1.66	3.31	ND	ND	2.31	ND	ND	3.15	ND	2.4	0.918	0.619
Strontium	35.2	19.8	38.1	38.2	47.9	43.4	30.3	25	37.4	45.9	70.3	107	29.1	37.4	38.3
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thorium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	650	376	755	940	715	937	1150	1030	865	285	1070	778	537	313	432
Uranium	2.49	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	49.2	60.9	205	90.6	89.5	79.9	165	102	92.5	162	263	126	90.4	49	47.7
Zinc	52	62.75	84.15	122.45	45.1	42.75	47.95	34	171.85	106.65	175	115	95.95	67.5	39.7

PAH Toxic Units, Metals Toxic Units, Normalized DRO - Upland Stations

		Stream and Station Location														
		Drill Site D Stream			Drill Site E Stream			Drill Site F Stream			Reference Stream #3			Reference Stream #4		
Analyte	Units	1	2	4	1	2	4	1	3	5	1	2	4	2	3	4
PAHs																
Acenaphthene	toxic units	ND	ND	ND	7E-05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	toxic units	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	toxic units	0.0015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	toxic units	0.0026	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	toxic units	0.0069	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	toxic units	3E-07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	toxic units	0.0031	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	toxic units	0.0009	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	toxic units	0.0006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	toxic units	0.0003	ND	ND	0.0003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	toxic units	1E-06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	toxic units	0.0023	ND	ND	0.0006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	toxic units	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH Toxic Units		0.0206	ND	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diesel-Range Organics	mg/%OC	151.72	ND	ND	ND	2.1456	ND	ND	ND	ND	12.956	ND	ND	ND	8.2917	5.9444
Metals Toxic Units																
Aluminum	toxic units	0.2051	0.1635	0.3016	0.4325	0.293	0.336	0.2757	0.2671	0.3102	0.1275	0.5135	0.5652	0.4894	0.2688	0.2981
Arsenic	toxic units	0.1339	0.3347	0.8264	0.3008	0.2843	0.1033	ND	0.3083	0.2058	0.9256	1.9504	0.9669	0.2488	0.095	0.0812
Cadmium	toxic units	ND	ND	ND	14.58	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	toxic units	6.2283	0.6366	0.9976	0.5209	1.1327	0.3142	0.2111	0.2704	0.2684	0.2017	0.2739	0.1273	0.485	0.2709	0.2706
Copper	toxic units	1.3696	0.482	0.7375	4.2143	2.5339	0.8286	0.5286	0.6857	0.9036	0.875	1.5196	1.95	1.0661	0.6077	0.7107
Iron	toxic units	0.224	0.505	1.715	0.575	0.775	0.575	1.62	0.3325	0.605	1.3175	2.6	1.7725	1.355	0.65	0.4
Manganese	toxic units	0.4164	2.3263	3.7578	1.2168	0.5694	1.3665	2.0334	0.462	0.3546	7.9874	21.636	2.31	3.6765	2.4401	1.2786
Nickel	toxic units	0.7072	0.5137	0.8097	1.6373	0.8912	0.5281	0.3331	0.2268	0.3485	0.678	1.071	0.4661	0.6301	0.3659	0.2957
Zinc	toxic units	0.5523	0.6665	0.8938	1.3006	0.479	0.4541	0.5093	0.3611	1.8253	1.1328	1.8587	1.2215	1.0191	0.7169	0.4217
Total Metals Toxic Units		9.8368	5.6283	10.039	24.778	6.9584	4.5057	5.5112	2.9138	4.8213	13.245	31.423	9.3795	8.9699	5.4154	3.7566

Sediment Chemistry Data - Lowland Stations

	Stream and Station Location																					
	Bridge Creek			Clevenger Creek			Cloudberry Creek			Rainbow Creek			White Alice Creek				Reference Stream #1			Reference Stream #2		
Analyte Concentrations in mg/kg	2	3	5	1	2	5	1	2	5	2	3	5	2	3	4	5	1	3	5	2	3	5
PAHs																						
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diesel-Range Organics	ND	ND	ND	542	90.3	14.8	ND	ND	ND	84.4	2110	ND	36.9	116	32.6	38	ND	ND	ND	13.6	ND	9.47
Carbon disulfide	ND	ND	ND	ND	0.136	ND	ND	0.0247	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Organic Carbon	169000	50200	95300	178000	120000	68450	188500	91900	81300	284000	192000	63300	70000	8250	126000	113000	91600	77600	67100	23300	15950	13800
Acid Volatile Sulfide (mmol/kg)	0.747	255	7.8	776	1110	56	1375	ND	ND	ND	ND	ND	ND	13.4	123	ND	61.3	ND	ND	0.132	0.1845	ND
Simultaneously Extracted Metals (mmol/kg)	2.58	2.22	1.52	4.05	2.56	1.2465	1.795	2	1.77	0.962	3.08	2.86	18.5	2.81	2.51	3.11	1.08	3.59	1.81	1.89	3.085	3.91
Metals																						
Aluminum	63900	22500	34200	16000	20100	62750	17550	41800	29500	3990	9900	28600	41000	60100	68300	48400	24400	18400	28000	17200	31600	35000
Arsenic	9	16.7	9.21	13.9	11.1	10.325	3.225	3.58	8.68	ND	9.15	32.1	48.4	15.4	109	57.7	7.57	15.5	11.4	2.48	21.86	20.3
Barium	144	271	206	104	146	238	74	131	151	ND	84.7	266	377	ND	249	150	99.6	175	109	303	74.5	339
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	2.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	ND	ND	ND	ND	101	134.9	ND	ND	ND	ND	ND	16.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.42
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	1.585	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.304
Calcium	7120	5570	5900	2880	3730	14190	7925	7000	5460	7300	2880	6470	5960	7940	6370	10800	1480	4580	4980	1950	2590	4090
Cerium	9.24	7.11	11.6	9.97	7.58	22.2	7.265	8.92	12	ND	6.19	9.58	13.3	13.5	20.9	9	9.89	8.12	10.9	6.05	8.185	8.72
Cesium	ND	ND	ND	ND	ND	3.03	ND	ND	3.51	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	5.82	6.56	10	22.2	20.6	17.25	3.225	6.84	11.3	ND	33.2	12.8	19.3	24.4	20.1	13.1	6.51	5.66	6.4	3.77	5.465	6.27
Cobalt	15.7	20.3	15.8	15.9	14.5	26.4	8.575	19.9	10	ND	ND	28	38.2	28.1	16.2	15	20.2	35.4	21.4	9.45	13.025	31.7
Copper	48.4	37.25	50.75	75.2	46.85	91.208	47.575	62.8	60.15	6.5	40.65	37	106.4	56.15	95.75	137.5	31.7	24.05	42.05	27.7	59.75	41.3
Iron	47400	98600	56500	50500	47700	64550	48900	51700	18700	8070	12400	192000	96800	70600	59800	67600	53600	81400	48100	37700	57200	56500
Lithium	14.5	10.3	17.5	5.84	10.6	29.3	11.1	17	14.1	ND	ND	9.52	8.86	20.1	22.7	19.2	7.83	7.02	15.5	37.8	14.3	15.1
Magnesium	7200	9070	11900	6290	6320	26500	7555	16800	9730	1890	3770	7650	9180	15600	25400	36600	3510	4280	8220	4010	5660	4990
Manganese	373	6320	605	1130	1450	545	638.5	1750	140	1320	588	14700	9390	10300	1360	2570	6740	14400	2260	4640	4200	46300
Molybdenum	ND	ND	ND	ND	ND	ND	ND	ND	3.79	ND	ND	ND	ND	ND	ND	ND	ND	5.5	ND	ND	ND	5
Nickel	7.56	9.075	4.73	3.33	6.315	6.5625	6.2425	10.765	8.775	ND	21.05	9.49	53.6	13.95	23.6	11.45	2.49	9.125	7.72	3.75	7.765	10.42
Potassium	4050	1650	688	462	925	2520	1150	2630	537	370	324	748	527	1310	791	3880	183	572	826	441	721.5	759
Selenium	ND	ND	3.88	ND	ND	ND	ND	ND	4.55	ND	ND	ND	4.52	2.21	ND	ND	3.74	3.37	ND	ND	ND	0.951
Strontium	142	178	135	44.4	82.4	435.5	55.2	221	114	59.5	70.7	94.1	106	531	94.9	547	39.6	89	101	63.8	57.45	65.3
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	4.08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Thorium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Titanium	1260	954	1460	657	865	4085	670.5	925	1640	285	640	1250	1140	1390	2010	1860	585	210	968	1520	1840	1790
Uranium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.11
Vanadium	230	294	217	151	186	287	128	197	230	54.7	141	296	645	239	175	210	194	245	239	99.7	120.3	479
Zinc	113.5	119.5	92.05	154	101.6	109.7	69.625	75.4	52.05	ND	60.5	144.5	608	151	73.6	88.55	44.5	184	95.05	72.65	100.98	249

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PAH Toxic Units, Metals Toxic Units, Normalized DRO - Lowland Stations

		Stream and Station Location																					
		Bridge Creek			Clevenger Creek			Cloudberry Creek			Rainbow Creek			White Alice Creek				Reference Stream #1			Reference Stream #2		
Analyte		2	3	5	1	2	5	1	2	5	2	3	5	2	3	4	5	1	3	5	2	3	5
PAHs Toxic Units																							
Acenaphthene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) anthracene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (b) fluoranthene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (g,h,i) perylene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAH Toxic Units		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diesel-Range Organics	mg/%OC	ND	ND	ND	30.449	7.525	2.1622	ND	ND	ND	2.9718	109.9	ND	5.2714	140.61	2.5873	3.3628	ND	ND	ND	5.8369	ND	6.8623
Metals Toxic Units																							
Aluminum	toxic units	1.1012	0.3877	0.5894	0.2757	0.3464	1.0813	0.3024	0.7203	0.5084	0.0688	0.1706	0.4928	0.7065	1.0357	1.177	0.8341	0.4205	0.3171	0.4825	0.2964	0.5445	0.6031
Arsenic	toxic units	0.7438	1.3802	0.7612	1.1488	0.9174	0.8533	0.2665	0.2959	0.7174	ND	0.7562	2.6529	4	1.2727	9.0083	4.7686	0.6256	1.281	0.9421	0.205	1.8066	1.6777
Cadmium	toxic units	ND	ND	ND	ND	ND	ND	ND	ND	2.7187	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5214
Chromium	toxic units	0.1604	0.1808	0.2756	0.6118	0.5677	0.4754	0.0889	0.1885	0.3114	ND	0.915	0.3528	0.5319	0.6724	0.5539	0.361	0.2345	0.156	0.2315	0.1039	0.1512	0.1728
Copper	toxic units	1.7286	1.3304	1.8125	2.6857	1.6732	3.2574	1.6991	2.2429	2.1482	0.2321	1.4518	1.3214	3.8	2.0054	3.4196	4.9107	1.1321	0.8589	1.5018	0.9893	2.1339	1.475
Iron	toxic units	1.185	2.465	1.4125	1.2625	1.1925	1.6138	1.2225	1.2925	0.4675	0.2018	0.31	4.8	2.42	1.765	1.495	1.69	1.34	2.035	1.2025	0.9425	1.43	1.4125
Manganese	toxic units	0.6068	10.281	0.9842	1.8382	2.3588	0.8866	1.0387	2.8468	0.2277	2.1473	0.9565	23.913	15.275	16.756	2.2124	4.1808	10.964	23.425	3.6765	7.5481	6.8324	75.319
Nickel	toxic units	0.3874	0.4651	0.2424	0.1706	0.3236	0.3363	0.4224	0.5527	0.4497	ND	1.0787	0.4863	2.7467	0.7149	1.2094	0.5868	0.1276	0.4676	0.3956	0.1922	0.3989	0.534
Zinc	toxic units	1.2055	1.2693	0.9777	1.6357	1.0791	1.1652	0.7395	0.8008	0.5528	ND	0.6426	1.5348	6.4578	1.6038	0.7617	0.9405	0.4727	1.9543	1.0096	0.7716	1.0725	2.6447
Total Metals Toxic Units		7.1186	17.759	7.0554	9.6291	8.4587	9.6692	5.78	8.9404	8.1018	2.65	6.2814	35.554	35.938	25.825	19.857	18.272	15.317	30.495	9.4421	11.049	14.37	84.36

Table 3.2-1
Toxicity Test Results - Upland Stations

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	**Result (mg)**	Normalized	**Result (mg)**	Normalized
Stream D Location 1	**46.25%**	49.35%	**1.367**	185.10%	**6.37**	92.20%
Stream D Location 2	**26.25%**	27.99%	**1.005**	136.00%	**2.30**	33.20%
Stream D Location 4	**53.75%**	57.35%	**0.748**	101.30%	**4.00**	57.90%
Stream E Location 1	**85.00%**	89.47%	**0.406**	77.80%	**3.32**	67.30%
Stream E Location 2	**83.75%**	94.37%	**0.291**	57.70%	**2.38**	53.10%
Stream E Location 4	**85.00%**	95.79%	**0.280**	55.60%	**2.37**	52.90%
Stream F Location 1	**57.50%**	61.33%	**0.776**	105.00%	**4.49**	65.00%
Stream F Location 3	**47.50%**	50.67%	**0.859**	116.20%	**3.79**	54.80%
Stream F Location 5	**62.50%**	66.68%	**0.681**	92.20%	**4.00**	57.90%
Reference Stream 3 Location 1	**62.50%**	65.79%	**0.324**	62.10%	**1.82**	36.90%
Reference Stream 3 Location 2	**57.50%**	60.50%	**0.318**	60.90%	**1.82**	36.90%
Reference Stream 3 Location 4	**91.25%**	96.05%	**0.320**	61.30%	**2.87**	58.20%
Reference Stream 4 Location 2	**87.50%**	92.11%	**0.377**	72.20%	**3.33**	67.50%
Reference Stream 4 Location 3	**91.25%**	102.82%	**0.315**	62.50%	**2.86**	63.80%
Reference Stream 4 Location 4	**76.25%**	85.90%	**0.396**	78.60%	**2.99**	66.70%

Table 3.2-2
Toxicity Test Results - Lowland Stations

Station	Toxicity Test Endpoints					
	Survival		Growth		Biomass	
	Result (%)	Normalized	**Result (mg)**	Normalized	**Result (mg)**	Normalized
Bridge Creek 2	**52.50%**	56.00%	**0.718**	97.20%	**3.74**	54.10%
Bridge Creek 3	**62.50%**	66.67%	**0.731**	98.90%	**4.65**	67.30%
Bridge Creek 5	**87.50%**	92.11%	**0.397**	76.10%	**3.45**	70.00%
Cloudberry Creek 1	**51.25%**	54.67%	**1.315**	177.90%	**6.77**	98.00%
Cloudberry Creek 2	**62.50%**	66.67%	**0.700**	94.70%	**4.29**	62.10%
Cloudberry Creek 5	**73.75%**	83.10%	**0.203**	40.30%	**1.56**	34.80%
Clevelnger Creek 1	**45.00%**	48.00%	**0.945**	127.90%	**4.17**	60.30%
Clevenger Creek 2	**51.25%**	54.67%	**0.741**	100.30%	**3.74**	54.10%
Clevenger Creek 5	**45.00%**	48.00%	**0.680**	92.00%	**2.93**	42.40%
Rainbow Creek 2	**67.50%**	71.05%	**0.459**	87.90%	**3.09**	62.70%
Rainbow Creek 3	**0.00%**	0.00%	**0.000**	0.00%	**0.00**	0.00%
Rainbow Creek 5	**83.75%**	88.16%	**0.262**	50.20%	**2.16**	43.80%
White Alice Creek 2	**92.50%**	104.23%	**0.567**	112.50%	**5.21**	116.30%
White Alice Creek 3	**77.50%**	81.58%	**0.345**	66.10%	**2.60**	52.70%
White Alice Creek 4	**32.50%**	36.60%	**0.606**	120.20%	**1.97**	44.00%
White Alice Creek 5	**87.50%**	98.59%	**0.499**	99.00%	**4.24**	94.60%
Reference Stream 1 Location 1	**90.00%**	101.40%	**0.280**	55.50%	**2.55**	56.90%
Reference Stream 1 Location 3	**47.50%**	53.52%	**0.588**	116.70%	**2.81**	62.70%
Reference Stream 1 Location 5	**83.75%**	94.37%	**0.281**	55.80%	**2.34**	52.20%
Reference Stream 2 Location 2	**87.50%**	92.11%	**0.299**	57.30%	**2.56**	51.90%
Reference Stream 2 Location 3	**75.00%**	78.95%	**0.301**	57.70%	**2.28**	46.20%
Reference Stream 2 Location 5	**76.25%**	80.26%	**0.360**	69.00%	**2.75**	55.80%

Table 3.3-1
Benthic Macroinvertebrate Community Analysis
Upland Stream Stations

Class	Order	Family	Genus	Common Name	Life Stage	Station ID														
						D1	D2	D4	E1	E2	E4	F1	F3	F5	RS301	RS302	RS304	RS402	RS403	RS404
Turbellaria	Tricladida	Planariidae		flatworm	adult		7	2								1				
Oligochaeta	Tubificida	Tubificidae		tubifex worm	adult	8	8	29			2		60	32	2	3	8	76	92	134
Gastropoda	Mesogastropoda	Lymnaidae		snail	juvenile							8								
		Planorbidae		snail	adult															
Peleycopoda	Spaeracea	Sphaeriidae		clam	juvenile	96						280			68					
Collembola	Collembola	Hypogasturidae		springtail	adult															
		Isotomidae		springtail	adult															
Insecta	Ephemeroptera	Baetidae	Pseudocloeon sp.	mayfly	nymph			1	5	54				4		13	4	6	1	4
	Hemiptera	Veliidae		ripple bug	nymph											1				
	Trichoptera	Limniphilidae		caddisfly	larva	48	9	2	12	3	4	8	8	6	4	41	6	6		6
	Lepidoptera			moth	larva															
	Diptera	Muscidae		fly	larva															
		Empididae		dance fly	larva													6	1	
		Chironomidae		midge	larva	152	10	10		26		32			90	36	46	54		16
		Chironominae		midge	larva				4											
		Diamesinae		midge	larva				3											
		Tanypodinae		midge	larva															
		Rhagionidae		snipefly	pupa															
		Simulidae		blackfly	larva		1						4							
		Tipulidae		cranefly	larva															
Hydracarina				watermite	adult															
Arachnoidea	Arachnida			spider	adult				1											
Crustacea	Amphipoda	Gammaridae		scud	adult	128														
		Talitridae	Hyalella sp.	scud	adult	360						272		2	2					
	Isopoda	Asellidae		isopod	adult															
					Total	**792**	**35**	**44**	**25**	**83**	**6**	**600**	**72**	**44**	**166**	**95**	**64**	**148**	**94**	**160**
					Family Biotic Index	6.73	5.54	7.09	4.38	4.63	5.33	7.84	7.44	7.09	6.82	4.89	5.94	6.86	7.94	7.55
					EPT Relative Abundance	6.1%	25.7%	6.8%	70.8%	68.7%	66.7%	1.3%	11.1%	22.7%	2.4%	56.8%	15.6%	8.1%	1.1%	6.3%
					Species Diversity	1.44	1.47	0.98	1.23	0.76	0.64	0.99	0.56	0.86	0.89	1.21	0.89	1.1	0.12	0.59

D = Drill Site D
E = Drill Site E
F = Drill Site F
RS = Reference Stream

Table 3.3-2
Benthic Macroinvertebrate Community Analysis
Lowland Stream Stations

Class	Order	Family	Genus	Common Name	Life Stage	Station ID																					
						BR2	BR3	BR5	CB1	CB2	CB5	CV1	CV2	CV5	RB2	RB3	RB5	WA2	WA3	WA4	WA5	RS101	RS103	RS105	RS202	RS203	RS205
Turbellaria	Tricladida	Planariidae		flatworm	adult		3			4			2				4						4	10			1
Oligochaeta	Tubificida	Tubificidae		tubifex worm	adult		60	8			9		6	7	8		15		80	8	8	4	164	102			
Gastropoda	Mesogastropoda	Lymnaidae		snail	juvenile	16				4				1	9	12											
		Planorbidae		snail	adult																8						
Peleycopoda	Spaeracea	Sphaeriidae		clam	juvenile	16		11	8	72	3									36	48				332	560	
Collembola	Collembola	Hypogasturidae		springtail	adult																						3
		Isotomidae		springtail	adult				2	4								2	8				4			8	
Insecta	Ephemeroptera	Baetidae	Pseudocloeon sp.	mayfly	nymph						4		13						8				4				54
	Hemiptera	Veliidae		ripple bug	nymph					20		2	1													8	1
	Trichoptera	Limniphilidae		caddisfly	larva	116	1	3		4	7	2		2	8	24	6	38	24		24	56	56	42	20	24	22
	Lepidoptera			moth	larva	4													1		8						
	Diptera	Muscidae		fly	larva	8									16												
		Empididae		dance fly	larva																						
		Chironomidae		midge	larva	204	1	14	136	152	49	53	8			396	42	138		96	1088	648	96	36	76	136	6
		Chironominae		midge	larva				10				1	3													
		Diamesinae		midge	larva										200				48					2			1
		Tanypodinae		midge	larva				8					1					248								
		Rhagionidae		snipefly	pupa					4		1			16												
		Simulidae		blackfly	larva							1	3					2	240	72	112						
		Tipulidae		cranefly	larva																		4				
Hydracarina				watermite	adult						1																
Arachnoidea	Arachnida			spider	adult										8												
Crustacea	Amphipoda	Gammaridae		scud	adult															2040	920						
		Talitridae	Hyalella sp.	scud	adult	52																					
	Isopoda	Asellidae		isopod	adult					84	6	24															
					Total	416	65	36	164	348	79	83	34	14	265	432	67	180	657	2252	2216	708	332	192	428	736	88
					Family Biotic Index	5.76	7.72	6.89	6.10	6.94	6.18	6.55	5.45	6.83	6.00	5.89	6.15	5.57	6.27	4.23	5.19	5.85	6.57	6.53	7.46	7.49	4.14
					EPT Relative Abundance	28.2%	1.5%	8.3%	0.0%	1.1%	13.9%	2.4%	38.0%	14.3%	3.1%	5.6%	8.9%	21.1%	4.9%	0.0%	1.1%	7.9%	16.9%	21.9%	4.7%	3.3%	86.4%
					Species Diversity	1.29	0.34	1.27	0.67	1.45	1.28	0.93	1.6	1.33	0.87	0.34	1.01	0.63	1.41	0.42	1.04	0.31	1.22	1.18	0.65	0.73	1.1

BR = Bridge Creek
CB = Cloudberry Creek
CV = Clevenger Creek
RB = Rainbow Creek

Table 3.3-2
Benthic Macroinvertebrate Community Analysis
Lowland Stream Stations

Class	Order	Family	Genus	Common Name	Life Stage	Station ID																					
						BR2	BR3	BR5	CB1	CB2	CB5	CV1	CV2	CV5	RB2	RB3	RB5	WA2	WA3	WA4	WA5	RS101	RS103	RS105	RS202	RS203	RS205
Turbellaria	Tricladida	Planariidae		flatworm	adult		3			4			2				4						4	10			1
Oligochaeta	Tubificida	Tubificidae		tubifex worm	adult		60	8			9		6	7	8		15		80	8	8	4	164	102			
Gastropoda	Mesogastropoda	Lymnaidae		snail	juvenile	16				4				1	9	12											
		Planorbidae		snail	adult																8						
Peleycopoda	Spaeracea	Sphaeriidae		clam	juvenile	16		11	8	72	3									36	48				332	560	
Collembola	Collembola	Hypogasturidae		springtail	adult																						3
		Isotomidae		springtail	adult				2	4								2	8				4			8	
Insecta	Ephemeroptera	Baetidae	Pseudocloeon sp.	mayfly	nymph						4		13						8				4				54
	Hemiptera	Veliidae		ripple bug	nymph					20		2	1													8	1
	Trichoptera	Limniphilidae		caddisfly	larva	116	1	3		4	7	2		2	8	24	6	38	24		24	56	56	42	20	24	22
	Lepidoptera			moth	larva	4													1		8						
	Diptera	Muscidae		fly	larva	8									16												
		Empididae		dance fly	larva																						
		Chironomidae		midge	larva	204	1	14	136	152	49	53	8			396	42	138		96	1088	648	96	36	76	136	6
		Chironominae		midge	larva				10				1	3													
		Diamesinae		midge	larva										200				48					2			1
		Tanypodinae		midge	larva				8					1					248								
		Rhagionidae		snipefly	pupa					4		1			16												
		Simulidae		blackfly	larva							1	3					2	240	72	112						
		Tipulidae		cranefly	larva																		4				
Hydracarina				watermite	adult						1																
Arachnoidea	Arachnida			spider	adult										8												
Crustacea	Amphipoda	Gammaridae		scud	adult															2040	920						
		Talitridae	Hyalella sp.	scud	adult	52																					
	Isopoda	Asellidae		isopod	adult					84	6	24															
					Total	416	65	36	164	348	79	83	34	14	265	432	67	180	657	2252	2216	708	332	192	428	736	88
					Family Biotic Index	5.76	7.72	6.89	6.10	6.94	6.18	6.55	5.45	6.83	6.00	5.89	6.15	5.57	6.27	4.23	5.19	5.85	6.57	6.53	7.46	7.49	4.14
					EPT Relative Abundance	28.2%	1.5%	8.3%	0.0%	1.1%	13.9%	2.4%	38.0%	14.3%	3.1%	5.6%	8.9%	21.1%	4.9%	0.0%	1.1%	7.9%	16.9%	21.9%	4.7%	3.3%	86.4%
					Species Diversity	1.29	0.34	1.27	0.67	1.45	1.28	0.93	1.6	1.33	0.87	0.34	1.01	0.63	1.41	0.42	1.04	0.31	1.22	1.18	0.65	0.73	1.1

BR = Bridge Creek
CB = Cloudberry Creek
CV = Clevenger Creek
RB = Rainbow Creek

Table 3.4-1
Rankings of Triad Components for Upland Stations

	Station ID														
Benthic Macroinvertebrates	D1	D2	D4	E1	E2	E4	F1	F3	F5	RS301	RS302	RS304	RS402	RS403	RS404
Family Biotic Index	6.73	5.54	7.09	4.38	4.63	5.33	7.84	7.44	7.09	6.82	4.89	5.94	6.86	7.94	7.55
FBI Ranking	7	5	10.5	1	2	4	14	12	10.5	8	3	6	9	15	13
EPT Relative Abundance	6.10%	25.70%	6.80%	70.80%	68.70%	66.70%	1.30%	11.10%	22.70%	2.40%	56.80%	15.60%	8.10%	1.10%	6.25%
EPT Ranking	12	5	10	1	2	3	14	8	6	13	4	7	9	15	11
Species Diversity	1.44	1.47	0.98	1.23	0.76	0.64	0.99	0.56	0.86	0.89	1.21	0.89	1.1	0.12	0.59
Diversity Ranking	2	1	7	3	11	12	6	14	10	8.5	4	8.5	5	15	13
Mean Rank	7	3.67	9.17	1.67	5	6.33	11.33	11.33	8.83	9.83	3.67	7.17	7.67	15	12.33
Benthic Ranking	6	2.5	10	1	4	5	12.5	12.5	9	11	2.5	7	8	15	14
Sediment Chemistry															
Normalized DRO	151.72	0	0	0	2.15	0	0	0	0	12.96	0	0	0	8.29	5.94
DRO Ranking	15	5.5	5.5	5.5	11	5.5	5.5	5.5	5.5	14	5.5	5.5	5.5	13	12
Metals Toxic Units	9.84	5.63	10.04	24.78	6.96	4.51	5.51	2.91	4.82	13.25	31.43	9.38	8.97	5.42	3.76
Metals Ranking	11	7	12	14	8	3	6	1	4	13	15	10	9	5	2
PAH Toxic Units	0.02	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0
PAH Ranking	15	7	7	14	7	7	7	7	7	7	7	7	7	7	7
Mean Rank	13.67	6.5	8.17	11.17	8.67	5.17	6.17	4.5	5.5	11.33	9.17	7.5	7.17	8.33	7
Chemistry Ranking	15	5	9	13	11	2	4	1	3	14	12	8	7	10	6
Toxicity Testing															
Normalized Survival	49.35%	27.99%	57.35%	89.47%	94.37%	95.79%	61.33%	50.67%	66.68%	65.79%	60.50%	96.05%	92.11%	102.82%	85.90%
Survival Ranking	14	15	12	6	4	3	10	13	8	9	11	2	5	1	7
Normalized Growth	185.10%	136.00%	101.30%	77.80%	57.70%	55.60%	105.00%	116.20%	92.20%	62.10%	60.90%	61.30%	72.20%	62.50%	78.60%
Growth Ranking	1	2	5	8	14	15	4	3	6	11	13	12	9	10	7
Normalized Biomass	92.20%	33.20%	57.90%	67.30%	53.10%	52.90%	65.00%	54.80%	57.90%	36.90%	36.90%	58.20%	67.50%	63.80%	66.70%
Biomass Ranking	1	15	8.5	3	11	12	5	10	8.5	13.5	13.5	7	2	6	4
Mean Rank	5.33	10.67	8.5	5.67	9.67	10	6.33	8.67	7.5	11.17	12.5	7	5.33	5.67	6
Toxicity Ranking	1.5	13	9	3.5	11	12	6	10	8	14	15	7	1.5	3.5	5
Mean Station Ranking	7.50	6.83	9.33	5.83	8.67	6.33	7.50	7.83	6.67	13.00	9.83	7.33	5.50	9.50	8.33
Overall Station Rank	7.5	5	12	2	11	3	7.5	9	4	15	14	6	1	13	10

D = Drill Site D
E = Drill Site E
F = Drill Site F
RS = Reference Stream

Table 3.4-2
Summary of Triad Results for Upland Stations

	Station								
	D1	D2	D4	E1	E2	E4	F1	F3	F5
Family Biotic Index	+	+	+	+	+	+	-	+	+
EPT Relative Abundance	+	+	+	+	+	+	-	+	+
Species Diversity	+	+	+	+	+	+	+	+	+
Benthic Macroinvertebrates	+	+	+	+	+	+	-	+	+
Normalized DRO	-	+	+	+	+	+	+	+	+
Metals Toxic Units	+	+	-	-	+	+	+	+	+
PAH Toxic Units	-	+	+	-	+	+	+	+	+
Sediment Chemistry	-	+	-	+	+	+	+	+	+
Normalized Survival	-	-	-	+	+	+	-	-	-
Normalized Growth	+	+	+	+	-	-	+	+	+
Normalized Biomass	+	-	-	+	+	-	+	+	-
Toxicity Testing	+	+	-	+	+	-	+	+	-

D = Drill Site D
E = Drill Site E
F = Drill Site F

Table 3.4-3
Rankings of Triad Components for Lowland Stations

	Station ID																					
Benthic Macroinvertebrates	BR2	BR3	BR5	CB1	CB2	CB5	CV1	CV2	CV5	RB2	RB3	RB5	WA2	WA3	WA4	WA5	RS101	RS103	RS105	RS202	RS203	RS205
Family Biotic Index	5.76	7.72	6.89	6.10	6.94	6.18	6.55	5.45	6.63	6.00	5.89	6.15	5.57	6.27	4.23	5.19	5.85	6.57	6.53	7.46	7.49	4.14
FBI Ranking	6	22	18	10	19	12	15	4	17	9	8	11	5	13	2	3	7	16	14	20	21	1
EPT Relative Abundance	28.20%	1.50%	8.30%	0.00%	1.10%	13.90%	2.40%	38%	14.30%	3.10%	5.60%	8.90%	21.10%	4.90%	0%	1.10%	7.90%	16.90%	21.90%	4.70%	3.30%	86.40%
EPT Ranking	3	18	10	21.5	19.5	8	17	2	7	16	12	9	5	13	21.5	19.5	11	6	4	14	15	1
Species Diversity	1.29	0.34	1.27	0.67	1.45	1.28	0.93	1.6	1.33	0.87	0.34	1.01	0.63	1.41	0.42	1.04	0.31	1.22	1.18	0.65	0.73	1.1
Diversity Ranking	5	20.5	7	16	2	6	13	1	4	14	20.5	12	18	3	19	11	22	8	9	17	15	10
Mean Rank	4.67	20.17	11.67	15.8	13.5	8.67	15	2.33	9.33	13	13.5	10.67	9.33	9.67	14.2	11.17	13.33	10	9	17	17	4
Benthic Ranking	3	22	12	19	15.5	4	18	1	6.5	13	15.5	10	6.5	8	17	11	14	9	5	20.5	20.5	2
Sediment Chemistry																						
Normalized DRO	0	0	0	0	0	0	30.45	7.53	2.16	2.97	109.9	0	5.27	140.61	2.59	3.36	0	0	0	5.84	0	6.86
DRO Ranking	6	6	6	6	6	6	20	19	12	14	21	6	16	22	13	15	6	6	6	17	6	18
Metals Toxic Units	7.12	17.76	7.06	5.78	8.94	8.1	9.63	8.46	9.67	2.65	6.28	35.55	35.94	25.83	19.86	18.27	15.32	30.5	9.44	11.05	14.37	84.36
Metals Ranking	5	15	4	2	8	6	10	7	11	1	3	20	21	18	17	16	14	19	9	12	13	22
PAH Toxic Units	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH Ranking	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Mean Rank	7.5	10.83	7.17	6.5	8.5	7.83	13.83	12.5	11.5	8.83	11.83	12.5	16.17	17.17	13.83	14.17	10.5	12.17	8.33	13.5	10.17	17.17
Chemistry Ranking	3	10	2	1	5	4	17.5	14.5	11	6.5	12	14.5	20	21.5	17.5	19	9	13	6.5	16	8	21.5
Toxicity Testing																						
Normalized Survival	56.00%	66.67%	92.11%	54.67%	66.67%	83.10%	48.00%	54.67%	48.00%	71.05%	0.00%	88.16%	104.23%	81.58%	36.60%	98.59%	101.40%	53.52%	94.37%	92.11%	78.95%	80.26%
Survival Ranking	15	13.5	5.5	16.5	13.5	8	19.5	16.5	19.5	12	22	7	1	9	21	3	2	18	4	5.5	11	10
Normalized Growth	97.20%	98.90%	76.10%	177.90%	94.70%	40.30%	127.90%	100.30%	92.00%	87.90%	0.00%	50.20%	112.50%	66.10%	120.20%	99.00%	55.50%	116.70%	55.80%	57.30%	57.70%	69.00%
Growth Ranking	9	8	13	1	10	21	2	6	11	12	22	20	5	15	3	7	19	4	18	17	16	14
Normalized Biomass	54.10%	67.30%	70.00%	98.00%	62.10%	34.80%	60.30%	54.10%	42.40%	62.70%	0.00%	43.80%	116.30%	52.70%	44.00%	94.60%	56.90%	62.70%	52.20%	51.90%	46.20%	55.80%
Biomass Ranking	12.5	5	4	2	8	21	9	12.5	20	6.5	22	19	1	14	18	3	10	6.5	15	16	17	11
Mean Rank	12.17	8.83	7.50	6.50	10.50	16.67	10.17	11.67	16.83	10.17	22.00	15.33	2.33	12.67	14.00	4.33	10.33	9.50	12.33	12.83	14.67	11.67
Toxicity Ranking	13.0	5.0	4.0	3.0	10.0	20.0	7.5	11.5	21.0	7.5	22.0	19.0	1.0	15.0	17.0	2.0	9.0	6.0	14.0	16.0	18.0	11.5
Mean Station Ranking	6.33	12.33	6.00	7.67	10.17	9.33	14.33	9.00	12.83	9.00	16.50	14.50	9.17	14.83	17.17	10.67	10.67	9.33	8.50	17.50	15.50	11.67
Overall Station Rank	2	14	1	3	10	8.5	16	5.5	15	5.5	20	17	7	18	21	11.5	11.5	8.5	4	22	19	13

BR = Bridge Creek
CB = Cloudberry Creek
CV = Clevenger Creek
RB = Rainbow Creek
WA = White Alice Creek
RS = Reference Stream

Table 3.4-4
Summary of Triad Results for Lowland Stations

	Station															
	BR2	BR3	BR5	CB1	CB2	CB5	CV1	CV2	CV5	RB2	RB3	RB5	WA2	WA3	WA4	WA5
Family Biotic Index	+	-	-	+	+	+	+	+	-	+	+	+	+	+	+	+
EPT Relative Abundance	+	-	-	-	-	-	-	+	-	-	+	-	+	+	-	-
Species Diversity	+	-	+	+	+	+	+	+	+	+	-	-	+	+	-	-
Benthic Macroinvertebrates	+	-	-	+	+	+	+	+	-	+	+	-	+	+	+	-
Normalized DRO	+	+	+	+	+	+	-	-	+	+	-	+	+	-	-	+
Metals Toxic Units	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
PAH Toxic Units	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sediment Chemistry	+	+	+	+	+	+	-	-	+	+	+	+	-	-	-	+
Normalized Survival	-	+	+	-	+	+	-	+	-	-	-	+	+	+	-	+
Normalized Growth	+	+	+	+	+	-	+	+	+	+	-	-	+	+	+	+
Normalized Biomass	+	+	+	+	+	-	+	+	-	+	-	-	+	+	-	+
Toxicity Testing	+	+	+	+	+	-	+	+	-	+	-	-	+	+	+	+

BR = Bridge Creek
CB = Cloudberry Creek
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RB = Rainbow Creek
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RS = Reference Stream