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Report On
April 1994 Biomonitoring
for
Site 8 - Nitroglycerin Plant Office
Indian Head Division
Naval Surface Warfare Center
Indian Head, Maryland

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0117

July 1994

Halliburton NUS
CORPORATION

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REPORT ON APRIL 1994 BIOMONITORING
FOR
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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TABLE OF CONTENTS

SECTION		PAGE
1.0	**INTRODUCTION**	**1-1**
1.1	BACKGROUND	1-2
1.2	SITE DESCRIPTION	1-3
1.3	OBJECTIVES	1-5
1.4	REPORT FORMAT	1-5
2.0	**BIOMONITORING SAMPLING LOCATIONS AND METHODS**	**2-1**
2.1	WATER QUALITY MEASUREMENTS	2-1
2.2	PERIPHYTON SAMPLING	2-1
2.3	BENTHIC MACROINVERTEBRATE SAMPLING	2-5
2.4	FISH SAMPLING	2-5
2.4.1	Fish Surveys	2-5
2.4.2	Fish Sampling for Lead and Mercury Residues	2-6
2.4.3	Turtle Sampling for Lead and Mercury Residues	2-7
3.0	**BIOMONITORING RESULTS AND DISCUSSION**	**3-1**
3.1	WATER QUALITY	3-1
3.2	PERIPHYTON	3-3
3.3	BENTHIC MACROINVERTEBRATES	3-8
3.4	FISH DIVERSITY	3-13
3.5	ANALYSIS OF MERCURY AND LEAD IN TISSUE OF AQUATIC ORGANISMS	3-17
4.0	**SUPPLEMENTAL SEDIMENT SAMPLING AND ANALYSIS**	
4.1	SAMPLING METHODS	4-1
4.1.1	Site 8 Sediment Sampling	4-1
4.1.2	Control Site 1 Sediment Sampling	4-2
4.2	SAMPLE HANDLING	4-2
4.3	ANALYTICAL METHODS	4-4
4.4	QUALITY ASSURANCE/QUALITY CONTROL	4-4
4.5	ANALYTICAL RESULTS	4-4
4.5.1	Analytical Results from the Site 8 Sediment Sampling	4-4
4.5.2	Analytical Results from the Control Site 1 Sampling	4-8
5.0	**SUMMARY AND CONCLUSIONS**	**5-1**
5.1	SUMMARY	5-1
5.2	CONCLUSIONS	5-2
REFERENCES		R-1

APPENDICES

A	**PERIPHYTON SAMPLING RESULTS**
B	**BENTHIC MACROINVERTEBRATE SAMPLING RESULTS**
C	**ANALYTICAL RESULTS OF SUPPLEMENTAL SEDIMENT SAMPLING**

TABLES

TABLE		PAGE
3-1	Water Quality Data - April 28, 1994	3-2
3-2	Density (No./m^2) and Relative Abundance (%) of Benthic Macroinvertebrates	3-9
3-3	Fish Collected From Site 8 And Control Sites	3-14
3-4	Mercury Concentrations, Site 8 And Control Sites, October 1992 - April 1994	3-19
3-5	Lead Concentrations In Fish And Turtles - April 1994	3-21
4-1	Analytical Program Summary	4-5
4-2	Site 8 Sediment Analytical Results For Indian Head Division, Naval Surface Warfare Center	4-6
4-3	Sediment/Soil Analytical Results Beaver Pond, Control Site 1 - Stump Neck Annex Beaver Pond	4-7

FIGURES

FIGURE		PAGE
1-1	Location Map, Site 8 and Control Site 1 Biomonitoring Program, Installation Restoration Program, Site 8 - Nitroglycerin Plant Office	1-4
2-1	Site 8 - Nitroglycerin Plant Office, Biomonitoring and Supplemental Sediment Sampling Locations	2-3
3-1	Periphyton Density (Cells/cm^2)	3-6
3-2	Periphyton Diversity	3-7
4-1	Supplemental Sediment Sampling Locations And Results, Control Site 1 - Stump Neck Annex Beaver Pond	4-3

1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command issued Contract Task Order Number 0117 (CTO 117) to Halliburton NUS Corporation (Halliburton NUS) in 1993 under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. CTO 117 is for quarterly biomonitoring at the Navy Installation Restoration Program Site 8 Nitroglycerin Plant Office (Site 8), at the Indian Head Division, Naval Surface Warfare Center (NSWC) in Indian Head, Maryland. NSWC is part of the Engineering Field Activity, Chesapeake (EFA Chesapeake), of the Naval Facilities Engineering Command. Under CTO 117, Halliburton NUS is performing eight rounds of quarterly biomonitoring, from April 1993 until January 1995. The objective of the Biomonitoring Program is to assess the impact of mercury contamination in the biota of Site 8 and evaluate the potential ecological impacts of the Site 8 interim removal action. Design work for the interim removal action was performed by Halliburton NUS under CTO 99; interim removal at Site 8 in June 1994. In addition, as requested and authorized by the Navy, Halliburton NUS also performed supplemental sediment sampling and analysis at the Site 8 pond and Control Site 1 during the April 1994 round of biomonitoring.

Under a previous CTO (CTO 64), Halliburton NUS developed a Biomonitoring Program for Site 8 that was presented to EFA Chesapeake in a site-specific Biomonitoring Plan (Halliburton NUS, 1992a). The plan outlined procedures for conducting quarterly biomonitoring at Site 8 through two distinct phases: Phases I and II. The program was designed so that it could be modified (particularly during Phase I) to achieve the overall objective of the Biomonitoring Program. Phase I was performed under CTO 064. During Phase I, which consisted of preliminary [U.S. Fish and Wildlife Service (USFWS)] sampling in July 1992 and two quarterly sampling events (October 1992 and January 1993), sample collection and analytical techniques were established and subsequently modified to better suit actual site conditions. Based on the results of Phase I, a revised (Revision 1) Biomonitoring Plan was prepared and issued in April 1993 (Halliburton NUS, 1993c). Phase II of the Biomonitoring Program, which was initiated in April 1993, is to be performed under CTO 117. While Phase II is expected to be completed in 1995, work will continue as long as EFA Chesapeake deems necessary.

This report presents the results of the April 1994 biomonitoring, which was performed in accordance with an approved Biomonitoring Plan (Revision 1), and briefly summarizes previous biomonitoring results. This revised Biomonitoring Plan reflects modifications in the biomonitoring program that were made following Phase I sampling efforts. The Biomonitoring Plan currently in use is not expected to change substantively over the course of Phase II biomonitoring; however, changes in environmental variables (e.g., water levels,

water quality, abundance of particular plant and animal species) or practical considerations may dictate the need for minor changes in sampling procedures and analytical methods.

This biomonitoring report also presents the results of supplemental sediment sampling and analysis that was performed at both Site 8 and the Beaver Pond Control Site (Control Site 1). Sediment samples collected at Site 8 were analyzed for lead and sediment samples collected at Control Site 1 were analyzed for mercury. This analysis was performed to provide supplemental information to further assess the results of the biomonitoring program and to provide general information on the extent of lead contamination at Site 8. Sediment sampling was performed in accordance with procedures contained in a Letter Report that was issued by Halliburton NUS on May 17, 1994.

1.1 BACKGROUND

For approximately 20 years, mercury was inadvertently released in small amounts from sink and floor drains in Building 766 of the Site 8 Nitroglycerin Plant Office. The Building 766 sink and floor drains emptied into a storm drain system that discharged into a small (unnamed) stream that flows south and east for approximately 1/4 mile, enters a cattail marsh and pond, then empties into Mattawoman Creek. Previous investigations determined that sediments and surface waters of the stream, marsh, and pond contain elevated concentrations of mercury (ABB-ES, 1992a; 1992b). The actual quantity of mercury that was released is unknown; however, it has been estimated that between 200 and 500 pounds of mercury were released to the environment at Site 8 (ABB-ES, 1992a).

In August 1992, Halliburton NUS began investigating the extent of mercury contamination in the soils, sediment, and surface water of Site 8 in accordance with an approved Abbreviated Field Sampling Plan (Halliburton NUS, 1992b). Mercury concentrations in sediments and soils in the upper stream section (near Building 766) ranged from non-detectable (lower than detection limits) to 671 mg/kg (Halliburton NUS, 1993a). Sediments in the marsh and pond had mercury concentrations ranging from non-detectable to 13.8 mg/kg. Background mercury concentrations (i.e., mercury levels in sediment and soil samples from the general vicinity of Site 8 but outside of the impacted stream corridor) ranged from non-detectable to 0.34 mg/kg.

The biomonitoring program developed by Halliburton NUS was designed to be carried out only in the marsh/pond area of Site 8. Because the velocity of the stream is reduced as it widens and flows into the marsh and pond, the pond is a natural sediment trap, holding silt, detritus, and organic matter from upstream. Unlike the stream, which is subject to extreme fluctuations in temperature, flow, and turbidity, the marsh and pond support an abundant growth of aquatic vegetation as well as a variety of planktonic

organisms, aquatic insects, fish, reptiles, amphibians, wading birds, and waterfowl (personal observation, P. R. Moore - Halliburton NUS). Thus, the potential for contaminant (specifically mercury) exposure and bioaccumulation is considered to be higher in the marsh and pond than in the stream, and the biomonitoring effort focuses on this area.

Some elevated levels of lead were detected in Site 8 sediments during previous sampling (Halliburton NUS, 1993a). This lead may have been discharged into Site 8 through a tributary stream. Supplemental sediment sampling and analysis was performed at Site 8 to assess the extent of lead contamination at Site 8. In addition, supplemental sediment sampling and analysis was performed for mercury at Control Site 1 to determine background levels of mercury in the sediments.

1.2 SITE DESCRIPTION

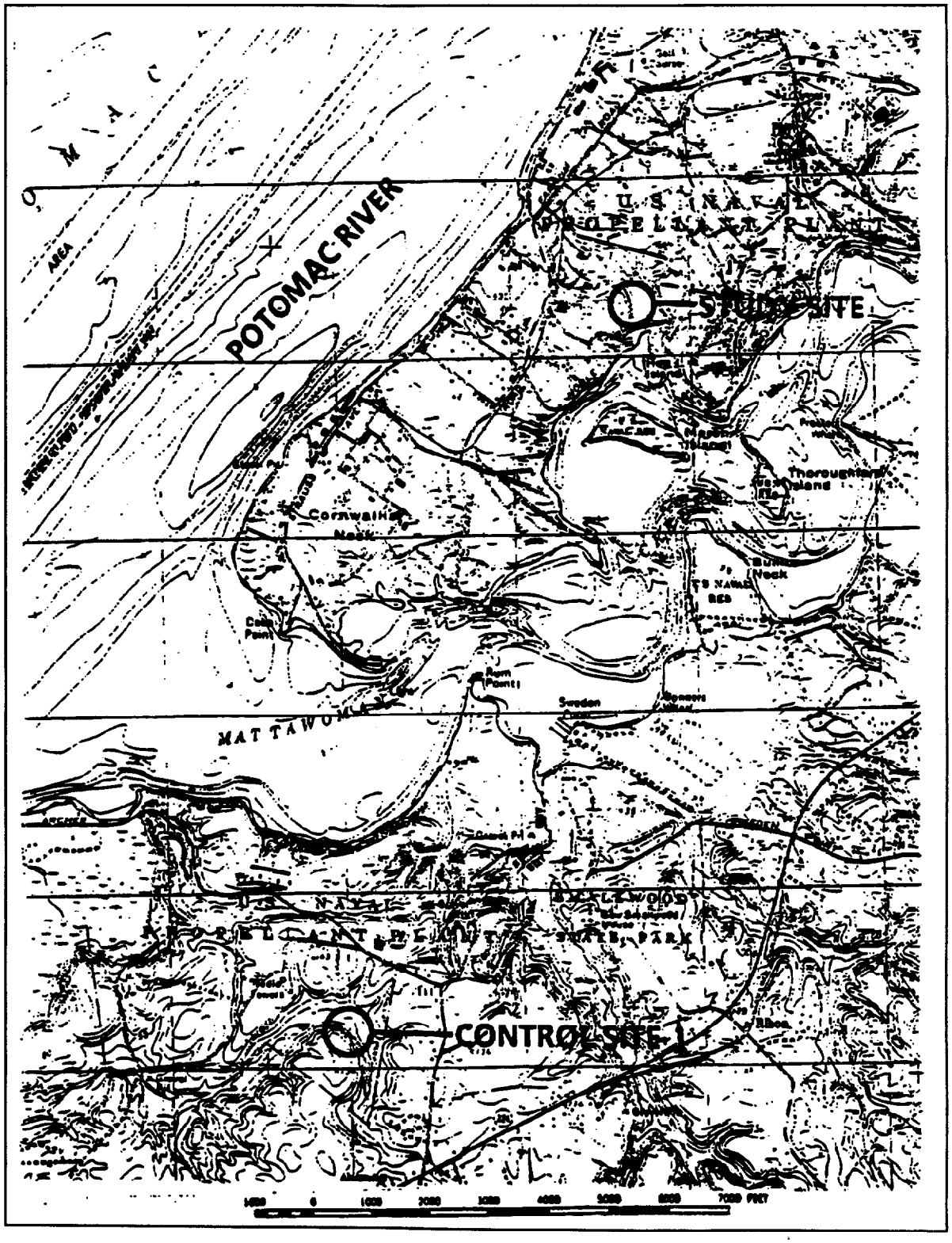
The study site (Site 8 marsh/pond) lies within the main (or northern) NSWC area. The Site 8 marsh/pond discharges into Mattawoman Creek via a 6-foot-diameter culvert running under Noble Road. In addition, two control sites have been identified and incorporated into the biomonitoring program. Control Site 1 is a beaver pond on the Stump Neck Annex of NSWC, approximately 3 miles southeast of Site 8 and 1/2 mile northwest of Alexandria Church. Control Site 1 was designated a control site in October 1992. Control Site 2 is in Mattawoman Creek, approximately 3 miles east of the NSWC, just upstream of the Maryland Highway 225 bridge. It was added prior to the January 1993 sampling round. The locations of Site 8 and Control Site 1 are shown on Figure 1-1.

Control Site 1 (Stump Neck beaver pond) is located on an unnamed tributary of the Chicamuxen Creek, the drainage to the south of Mattawoman Creek. This beaver pond was chosen as a control site because it offers security (access to the area is restricted and controlled by NSWC) and reasonably approximates the Site 8 pond in terms of water chemistry, water level, topography, and resident plants and animals. Control Site 2 (Mattawoman Creek) was selected because it appeared to offer better fish habitat than the beaver pond control site, and lies in the same drainage basin as the Site 8 stream and pond. Both the Mattawoman and the Chicamuxen are tributaries of the Potomac River.

Because Control Site 1 is approximately 2 miles upstream from Chicamuxen Creek and approximately 3 miles upstream from the Potomac River, it has not been contaminated by mercury from Site 8. Any pollutants (e.g., mercury) in its water, sediments, and biota are presumed to be from atmospheric or geologic sources rather than from Site 8. As later described in this report supplemental sediment sampling

FIGURE 1-1

LOCATION MAP - SITE 8 AND CONTROL SITE 1
BIOMONITORING PROGRAM
INSTALLATION RESTORATION PROGRAM, SITE 8 - NITROGLYCERIN PLANT OFFICE



and analysis did not detect elevated mercury contamination in the sediments of Control Site 1. Control Site 2, which is approximately 4 miles upstream of the Site 8 outfall and 3 miles east of the NSWC boundary, is also presumably unaffected by Indian Head Division NSWC operations.

Until the summer of 1992, the Site 8 pond was approximately 4 feet deep at its deepest point, the water level being maintained by a beaver dam lying just upstream of the culvert that drains the marsh/pond. The beaver dam was removed in the summer of 1992 and normal pool was lowered approximately 3 feet. During the October 1992 and January 1993 rounds of biomonitoring, the water level in the Site 8 pond was generally 1 to 2 feet deep. A weir was installed just upstream of the Noble Road culvert in April 1993, raising the water level in the pond by approximately 1 foot. Thus, permanent pool elevation will be intermediate between the high (pre-summer 1992) level maintained by the beaver dam and the extreme low level that existed in fall 1992 and winter 1993 after removal of the beaver dam.

1.3 OBJECTIVES

The primary objectives of the biomonitoring program are to assess the impact that mercury contamination at Site 8 has had on the biota of the Site 8 marsh/pond and to evaluate potential environmental impacts of the interim removal action. The October 1992 and January 1993 rounds of biomonitoring were intended to establish baseline conditions at Site 8 and provide information to refine and improve methods in subsequent phases of biomonitoring. The April 1993 round of biomonitoring was significant because it marked the first time that sampling was conducted in the Site 8 pond under normal (full-pool) conditions. The water level in the Site 8 pond has remained at full pool since July 1993. Barring unforeseen problems with the Noble Road dam and weir, the water level in the pond should remain relatively stable for the remainder of the study, and biological communities should, in time, reach an equilibrium.

The primary objectives of the supplemental sediment sampling and analysis was to obtain additional information about sediment contamination at Site 8 and Control Site 1. Sediment samples from Site 8 were analyzed for lead to assess the extent of lead contamination at Site 8. Sediment samples from Control Site 1 were analyzed for mercury to verify that it is not overly contaminated with mercury and to determine background levels of mercury in the general area of Site 8.

1.4 REPORT FORMAT

In order to incorporate the results of the supplemental sediment sampling and analysis, the format of this report has been revised slightly from previous biomonitoring reports. Section 1.0 contains general introduction and background information; Sections 2.0 and 3.0 present biomonitoring sampling locations

and methods, and biomonitoring results and discussion, respectively. The results of the supplemental sediment sampling and analysis are presented in Section 4.0. A summary and conclusions are presented in Section 5.0.

2.0 BIOMONITORING SAMPLING LOCATIONS AND METHODS

The spring 1994 round of biomonitoring was conducted on April 28 and 29, 1994. Coastal Environmental Services, Inc. (Coastal), a subcontractor to Halliburton NUS, performed field sampling at seven transects in the main area of the Site 8 marsh/pond (Transects 1, 2, 3, 4, 5, 6, and 7) and at a location on the north side of Atkins Road Extension (Transect 10). The sampling locations are shown on Figure 2-1 (see full-size drawing pocket). Sampling was also performed at the two control sites.

The following ecological components were sampled and evaluated for the April 1994 round of biomonitoring:

- Surface water
- Periphyton
- Benthic Macroinvertebrates
- Fish
- Turtles

2.1 WATER QUALITY MEASUREMENTS

Water temperature, dissolved oxygen (DO), pH, and conductivity measurements were taken in the field with a Hydrolab Surveyor II at a single, mid-water-column depth at the Site 8 pond and the two control sites. Salinity was measured in the field with a portable Yellow Springs Instruments (YSI) Salinity-Conductivity-Temperature meter. Grab samples of water were taken at the surface for total hardness and total organic carbon (TOC) and shipped to the Pittsburgh laboratory of Halliburton NUS for analysis.

2.2 PERIPHYTON SAMPLING

Periphyton was sampled with an artificial substrate similar to that described in Standard Methods for Analysis of Water and Wastewater (APHA, 1985). This sampler consists of 8 glass slides in a frame supported by styrofoam floats. Two sets of periphyton samplers (a total of 16 slides) were placed at Transects 1-4 of Site 8 and the two control sites. After 14 days, the samplers were retrieved and transported to the laboratory for analysis.

For the second consecutive sampling round, a periphyton sampler deployed at Control Site 2 (Mattawoman Creek) was missing when the Coastal field crew returned to retrieve it (on May 13, 1994). There were a

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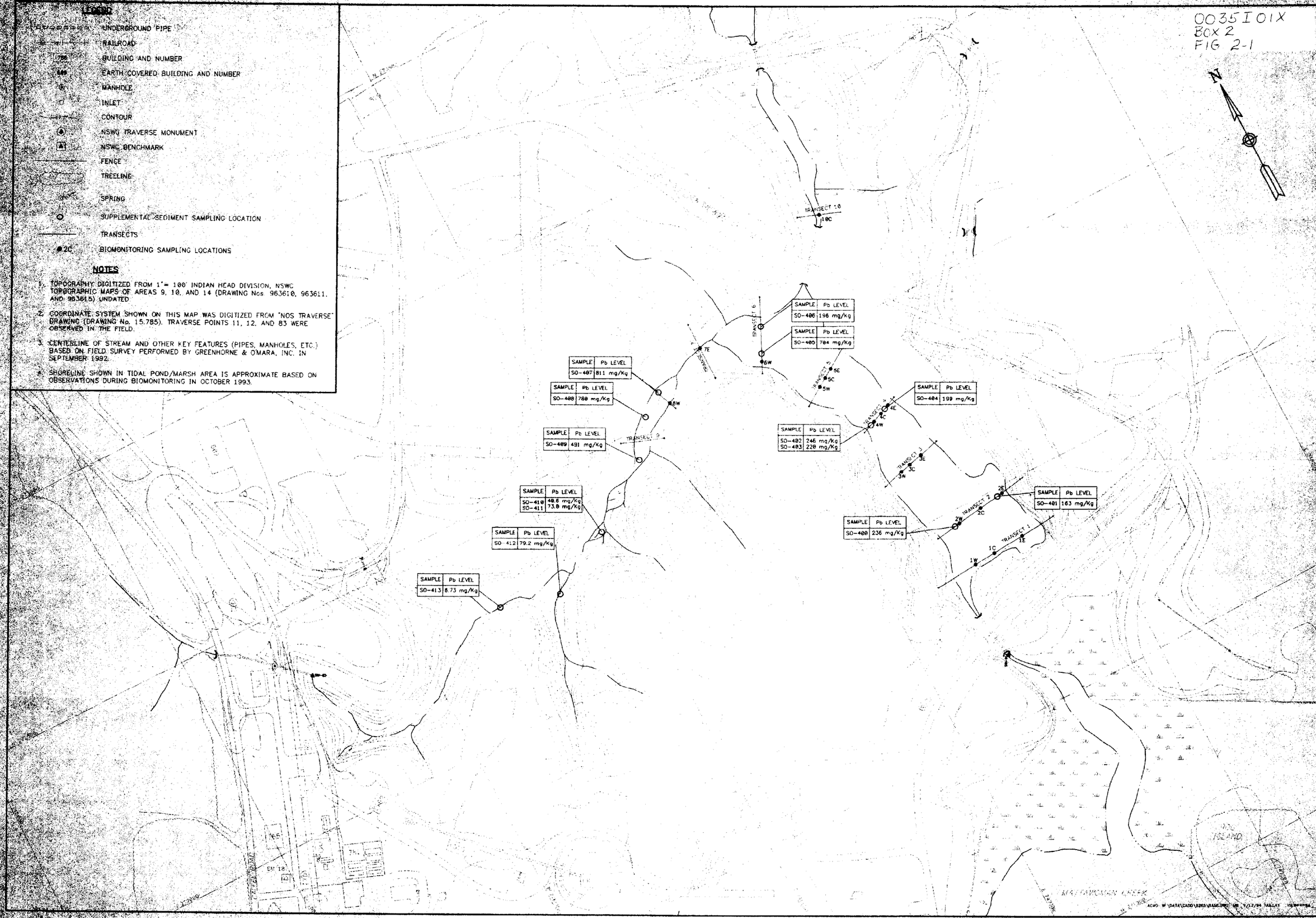
0035I01X
Box 2
FIG 2-1

LEGEND

- UNDERGROUND PIPE
- RAILROAD
- BUILDING AND NUMBER
- EARTH COVERED BUILDING AND NUMBER
- MANHOLE
- INLET
- CONTOUR
- NSWC TRAVERSE MONUMENT
- NSWC BENCHMARK
- FENCE
- TREELINE
- SPRING
- SUPPLEMENTAL SEDIMENT SAMPLING LOCATION
- TRANSECTS
- 2C BIOMONITORING SAMPLING LOCATIONS

NOTES

1. TOPOGRAPHY DIGITIZED FROM 1"= 100' INDIAN HEAD DIVISION, NSWC TOPOGRAPHIC MAPS OF AREAS 9, 10, AND 14 (DRAWING Nos 963610, 963611, AND 963615) UNDATED.
2. COORDINATE SYSTEM SHOWN ON THIS MAP WAS DIGITIZED FROM "NOS TRAVERSE" DRAWING (DRAWING No. 15.785). TRAVERSE POINTS 11, 12, AND 83 WERE OBSERVED IN THE FIELD.
3. CENTERLINE OF STREAM AND OTHER KEY FEATURES (PIPES, MANHOLES, ETC.) BASED ON FIELD SURVEY PERFORMED BY GREENHORNE & O'MARA, INC. IN SEPTEMBER 1992.
4. SHORELINE SHOWN IN TIDAL POND/MARSH AREA IS APPROXIMATE BASED ON OBSERVATIONS DURING BIOMONITORING IN OCTOBER 1993.



DEPARTMENT OF THE NAVY
WASHINGTON NAVY YARD

NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

ENGINEERING FIELD ACTIVITY, CHESAPEAKE

INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
SITE 8, NITROGLYCERIN PLANT, SEPTIC
BIOMONITORING AND SUPPLEMENTAL
SEDIMENT SAMPLING LOCATIONS

REV.	DESCRIPTION	PREP. BY	DATE	APPRVD

SEAL AREA

SAT TO: DATE

CODE I.D. NO. 80091
SCALE AS SHOWN
SPEC. NO. 84 NA
CONSTRN. CONTR. NO. NA
NAVFAC DRAWING NO. NA
SHEET 1 OF 1
SIZE D
DIS. SH. NO. FIGURE 2-1

large number of fishermen in the area when the samplers were set out, suggesting that the primary sampler was stolen, vandalized, or moved after the Coastal crew left the area on April 29. The back-up sampler, which contained four slides, was retrieved, however, permitting an analysis of species composition, abundance, and biomass. No determination of ash-free dry weight was possible from this site.

Three randomly-selected slides from each 16-slide array were analyzed to determine ash-free dry weight, three were analyzed to determine chlorophyll-a content, and three were examined for species composition and abundance. One slide from each periphyton sampler was preserved and archived, in the event that additional analysis or verification of periphyton identification is required. Any remaining slides collected at a given sampling location were discarded.

2.3 BENTHIC MACROINVERTEBRATE SAMPLING

Benthic macroinvertebrates were sampled with a Petite Ponar grab sampler at Transects 1 through 7, 10, and the two control sites. Samples were sieved in the field, preserved, and transported to the laboratory for identification and enumeration. Standard methods described in APHA (1985) and Lind (1979) for collecting benthos with a Ponar grab sampler and counting benthic macroinvertebrates were employed.

2.4 FISH SAMPLING

2.4.1 Fish Surveys

No systematic fish surveys have been conducted at the three study sites since October 1992. Surveys carried out in July 1992 (by the U.S. Fish and Wildlife Service) and October 1992 (by Halliburton NUS) indicated that fish species diversity and abundance were very low at all sites and that electrofishing samples revealed little about community structure. In October 1992, for example, two species [*Gambusia holbrooki* (eastern mosquitofish) and *Fundulus heteroclitus* (mummichog)] comprised approximately 90 percent of the more than 300 fish collected at the Site 8 pond (Coastal Environmental Services, 1992; Halliburton NUS, 1993a). No fish were collected from the Stump Neck beaver pond control site in October 1992. In January 1993, more intensive sampling resulted in the capture of four species from the Site 8 pond, and only one species from each of the two control sites.

Although the systematic fish surveys (i.e., timed surveys at fixed sampling transects that yield catch-per-unit-effort values and estimates of population abundance) were abandoned after two quarters, a species list and notes on occurrence have been maintained for each of the three sampling locations, based on fish collections made for mercury analyses. This provides a measure of fish species richness (the total number

of species captured at each site) and a crude measure of population abundance (i.e., "common," "uncommon," or "rare") for fish species at each of the three study areas.

2.4.2 Fish Sampling for Lead and Mercury Residues

A combination of sampling techniques was employed in April 1994 in an effort to collect enough fish for a thorough comparative analysis of lead and mercury body burdens. Baited trap nets were set at the Site 8 pond, left overnight, and retrieved the following day. Trap nets were set perpendicular to shore in 1 to 3 feet of water, just below the surface. Trap nets were of conventional design with a leader and two wings directing fish to the baited heart of the net.

Minnow traps baited with cottonseed cake were set at the Site 8 study site and both control sites, left overnight, and were retrieved the following day. A 100-foot-long floating monofilament gill net was also used to collect fish at the Stump Neck beaver pond control site. The gill net was hung between two snags in a relatively open part of the pond in the afternoon and retrieved the following morning.

Attempts were made to collect fish by electroshocking at the Site 8 study site and the Mattawoman Creek control site. Electrofishing proved to be ineffective in the Site 8 pond (high turbidity made stunned fish difficult to see), but was fairly effective in Mattawoman Creek. However, electrofishing was discontinued in Mattawoman Creek after a short time because large numbers of spawning river herring were being shocked, and there was concern that onlooking fishermen would be offended.

The original Biomonitoring Plan (Halliburton NUS, 1992a) called for collections of four fish species (large-mouth bass, brown bullhead, and mosquitofish/mummichog) representing three trophic levels for analysis of mercury residues. When it became apparent that the target species would be difficult to collect consistently, designated surrogate species [such as bluegill and warmouth for large-mouth bass and Notropid (shiner) minnows for mosquitofish/mummichog] were often employed (Halliburton NUS, 1993b; 1993d). Since October 1993, the goal of the fish sampling has been to collect sufficient numbers of fish to adequately characterize the extent of mercury (and now lead) contamination. To the extent practicable, fish representing three trophic levels are collected: top-of-the-food-chain predator, bottom-feeding omnivore, and surface-feeding insectivore.

In April 1994, 23 fish representing 7 species were collected at the 3 sites and analyzed for mercury and lead residues. No effort was made to assign fish to trophic levels, but a variety of species with very different feeding strategies were collected. Three species from the Site 8 pond (common carp, pumpkinseed, and bluegill), four species from Mattawoman Creek (pumpkinseed, brown bullhead, bluegill, and spottail shiner),

and three species from the Stump Neck beaver pond [creek chubsucker, *Notropis* (unidentified shiner), and pumpkinseed] were captured. All fish collected were placed on ice and shipped to Gascoyne Laboratories, Incorporated, for analysis of lead and mercury residues in tissue.

2.4.3 Turtle Sampling for Lead and Mercury Residues

Two painted turtles (*Chrysemys picta*) that were unintentionally drowned in trap nets at Site 8 (incident to fish sampling) were retained for analysis of mercury and lead levels in liver tissue. Several other turtles were released unharmed. The turtles were dissected, the livers removed, placed in a glass vial on ice, and shipped to Gascoyne Laboratories, Inc., for analysis of lead and mercury residues in tissue.

3.0 BIOMONITORING RESULTS AND DISCUSSION

3.1 WATER QUALITY

Water quality data for April 1994 are presented in Table 3-1. Water temperatures in the Site 8 pond on April 28, 1994, ranged from 22.7°C to 23.9°C. The water temperature at Transect 10, which is located in a tributary stream northeast of Site 8, was 26.0°C. The lowest water temperature was observed at Control Site 2 (Mattawoman Creek), which is a deep, well-shaded stream, while the highest water temperature was observed at Control Site 1 (Stump Neck beaver pond), a shallow, roughly 1-acre pond that warms quickly during the day in the spring and summer. Control Site 1 tends to have warmer measured water temperatures than the Site 8 pond because the field team typically samples first at Site 8 in the morning and later in the afternoon at Control Site 1, after the sun has been directly overhead for several hours. Water temperatures were lower in the Site 8 pond during the spring 1993 sampling round (on April 29, 1993) ranging from 17.7°C to 18.8°C, while water temperatures at Control Sites 1 and 2 were 17.9°C and 13.6°C, respectively.

DO concentrations in the Site 8 pond in April 1994 ranged from 5.0 mg/L to 13.4 mg/L. DO concentrations observed at Control Sites 1 and 2 averaged 7.8 and 6.5 mg/L, respectively. In April 1993, DO concentrations ranged from 9.4 to 10.6 mg/L in the Site 8 pond, while DO concentrations at Control Sites 1 and 2 were 6.5 and 9.2 mg/L, respectively. DO concentrations in the spring in the Site 8 pond are more than adequate to support a variety of aquatic life. DO concentrations in the Site 8 pond have typically been lower (<5.0 mg/L) in the summer, when high water temperatures result in lower DO levels, and in fall when increased biological oxygen demand (from decaying vegetation and shed leaves) depresses dissolved oxygen levels. Annual temperature and DO regimes in the Site 8 pond are not suitable for sensitive macroinvertebrate and fish species with demanding habitat requirements.

The high DO concentration (13.4 mg/L) at Transect 1 appears to have been the result of an algae bloom. This hypothesis is supported by two pieces of evidence, the high pH (8.3) and the high algae densities and biomass (discussed later in Section 3.2) observed at Transect 1. When algae populations expand in the spring in ponds and lakes, there is often an attendant increase in daytime DO concentrations caused by photosynthetic activity. The high DO inputs drive the carbon dioxide-carbonic acid/carbonate-bicarbonate equilibrium in the water to the basic side of the equation. This process is reversed at night, when respiratory processes release free carbon dioxide into the water, lowering the pH (Cole, 1975; Boyd, 1979).

TABLE 3-1

WATER QUALITY DATA - APRIL 28, 1994
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Station	DO (mg/L)	Temp (°C)	pH	Cond (μmhos)	TOC (mg/L)	Total Hardness (as $CaCO_3$) (mg/L)
Transect 1	13.4	23.9	8.3	295	6.0	52.0
Transect 4	10.2	23.1	7.3	298	6.0	56.0
Transect 7	5.0	22.7	6.6	312	7.0	50.0
Transect 10	5.0	26.0	6.7	295	6.0	54.0
Control Site 1 (Stump Neck Beaver Pond)	7.8	26.7	6.1	73	7.0	21.0
Control Site 2 (Mattawoman Creek)	6.5	21.1	6.6	104	6.0	20.0

As in earlier quarterly rounds of biomonitoring, water samples were taken from the Site 8 pond and the two control sites in April for measurements of total organic carbon (TOC) and total hardness (as $CaCO_3$). TOC values ranged from 6.0 to 7.0 mg/L at the three transects in the Site 8 pond (see Table 3-1). TOC was 6.0 mg/L at Transect 10, just upstream of the Site 8 pond. TOC levels averaged 7.0 mg/L at Control Site 1 and 6.0 mg/L at Control Site 2. Total organic carbon is a measure of the total amount of organic material in a sample, such as suspended organic matter in the water column. In aquatic systems, organic carbon reduces the uptake and toxicity of contaminants through adsorption of contaminants to particle surfaces.

Total hardness ranged from 50.0 to 56.0 mg/L at Transects 1, 5, 7, and 10. Before January 1994, hardness measurements at all sampling stations were below 60 mg/L, a value indicative of relatively soft water (low in dissolved ions, with minimal buffering capacity) (Lind, 1979; Drever, 1982). In January 1994, samples from Transects 1, 4, and 10 exceeded 60 mg/L $CaCO_3$, a hardness level which is indicative of moderately hard water (van der Leeden et al., 1990). TOC and hardness values in April were consistent with those recorded in 1992 and 1993. Total hardness values at the two control sites were lower than Site 8. Control Site 1 hardness measurements averaged 21.0 mg/L. Hardness in samples from Control Site 2 averaged 20.0 mg/L.

The toxicity of lead, which has been identified as a possible contaminant in Indian Head Division NSWC waters, decreases as water hardness increases (USEPA, 1984). Solubility of lead in water also decreases with increased hardness, suggesting that reduced solubility is in part responsible for the reduction in toxicity (Sorensen, 1991). Given the hardness levels measured in the Site 8 pond and the two control sites, lead should be slightly less soluble and less available to biota at Site 8 than at the two control sites, assuming the same contaminations in water and sediments.

3.2 PERIPHYTON

In April 1994, average periphyton densities in the Site 8 pond ranged from 5,385 cells/cm^2 at Transect 4 to 412,078 cells/cm^2 at Transect 1. The apparent density gradient -- low periphyton densities uplake grading to high densities downlake -- may be due to some intrinsic physical or chemical influence (e.g., nutrients washing out of the watershed and settling out in the basin at the base of the dam). It may also be a chance occurrence or a sampling artifact. This longitudinal pattern of densities was not evident in 1993 or in the first quarter of 1994 (Halliburton NUS, 1994b). The unusually high densities observed at Transect 1 in April 1994 are characteristic of an algae bloom, as noted earlier in Section 3.1. Tables A-1 through A-24, Appendix A, contain results of the April 1994 periphyton sampling.

The average periphyton density per sample (mean of 12 samples from 4 transects) at Site 8 was 128,615 cells/cm^2 in April 1994, little changed from April 1993 when 100,460 cells/cm^2 were recorded. Diversity measures (numbers of genera and divisions/phyla present) were consistently higher in 1994, however. A total of 19 unique genera (unidentified genera not counted) representing 4 divisions were present in Site 8 periphyton samples in April 1993, while 32 unique genera from 6 divisions were collected in April 1994.

In April 1993, 94.9 percent of all periphyton collected in the Site 8 pond were diatoms (Halliburton NUS, 1993d). *Synedra* (a genus that is common in spring algae blooms) and *Navicula* (a pollution-tolerant genus) were the two most common genera. In April 1994, in keeping with the greatly-increased diversity noted earlier, three divisions of algae were well represented: Bacillariophyta (diatoms) 51.3 percent, Chlorophyta (green algae) 29.7 percent, and Cyanophyta (blue-green algae) 17.6 percent.

The green alga *Spirogyra* and the diatom *Navicula* were the most common genera in April 1994 Site 8 samples, largely because they dominated Transect 1 samples, and Site 8 data were skewed by the extraordinarily high densities at this transect. *Spirogyra*, which ranked first in density at Transect 1, was not even collected at Transects 2, 3, and 4. *Navicula* ranked first in diatom density at all four transects, however, and was a major component of the Site 8 periphyton community.

In April 1994, the periphyton community at Control Site 1 (Stump Neck beaver pond) was characterized by high measures of density and diversity. The average density (3 samples) was 42,292 cells/cm^2, the highest observed at this site since biomonitoring began in 1992 (Halliburton NUS 1993a, 1993b, 1993d, 1993e; Halliburton NUS 1994a, 1994b). The number of periphyton genera collected (23 from 6 divisions) was also the highest recorded to date. In April 1993, by contrast, only five genera (all diatoms) were collected. The average density in April 1993 was 763.3 cells/cm^2.

The 55-fold increase in periphyton density from April 1993 to April 1994 and the similarly striking increase in diversity at this site may be due in part to water quality differences. Although water quality measurements are only available for the days the periphyton samplers were set out (April 29, 1993, and April 28, 1994), conditions appear to have been more conducive to growth and reproduction in 1994. Water temperatures were considerably warmer (26.7°C versus 17.9°C), DO concentrations were higher (7.8 mg/L versus 6.5 mg/L), the pH was higher (6.1 versus 5.6), and conductivities were higher (73 μmhos versus 55 μmhos) in 1994. This may explain, in part, the great differences in 1993 and 1994 Control Site 1 periphyton populations.

Successional changes may also have contributed to increased periphyton productivity. As noted in the April 1993 Biomonitoring Report (Halliburton NUS, 1993d):

> "The Stump Neck beaver pond lies in a forested watershed with stained, acidic water . . . and biological productivity (is) low. The beaver pond has only been in existence for a few years, and should be more productive as the canopy opens up (beavers continue to fell trees around the pond), allowing more sunlight to reach the pond surface, and additional nutrients are released by submerged soils and decomposing plant material."

This prediction appears to have been borne out.

Density and diversity of periphyton at Control Site 2 (Mattawoman Creek) were also higher in April 1994 than April 1993, but differences were relatively small. Average density (3 samples) in 1994 was 11,646 cells/cm^2, compared to 5,786 cells/cm^2 in 1993. Fifteen periphyton genera representing 4 divisions were collected in 1994, while 14 genera from 3 divisions were collected in 1993. Diatoms were the most abundant group in both years, making up 69.1 percent of algae in 1994 and 63.8 percent in 1993. *Navicula* was the most common genus in both years.

Total periphyton density at Control Site 2 (Mattawoman Creek) was relatively low in April 1994 (11,646 cells/cm^2), approximately one-tenth (9.1 percent) of the density measured at the Site 8 pond and one-fourth (27.5 percent) of the density measured at Control Site 1. Streams like the Mattawoman may appear to have heavy populations of periphyton (there may be dense growth on rocks and aquatic vegetation), but the rate at which periphyton colonize artificial substrates -- such as the periphytometer employed in this study -- is generally higher in ponds, lakes, and reservoirs.

Periphyton density and diversity in samples collected from January 1993 through April 1994 are summarized in Figures 3-1 and 3-2. The periphyton of Site 8 have shown distinct seasonal differences in population abundance and community structure. Although the degree of change between seasons indicated by these data may be exaggerated, the trends are probably representative of periphyton community changes in the Site 8 pond and other small ponds in the region. Periphyton densities in ponds are typically highest in spring and fall (when moderate temperatures stimulate growth and reproduction of algae) and lowest in winter and summer (when temperature extremes limit growth and reproduction of algae). Community structure patterns (i.e., relative abundance of particular genera and divisions/phyla, presence or absence of pollution-tolerant and intolerant forms, proportions of benthic and planktonic genera) are much more difficult to interpret and have only been touched on in this quarterly biomonitoring report and earlier reports.

FIGURE 3-1

PERIPHYTON DENSITY (CELLS/cm^2)
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

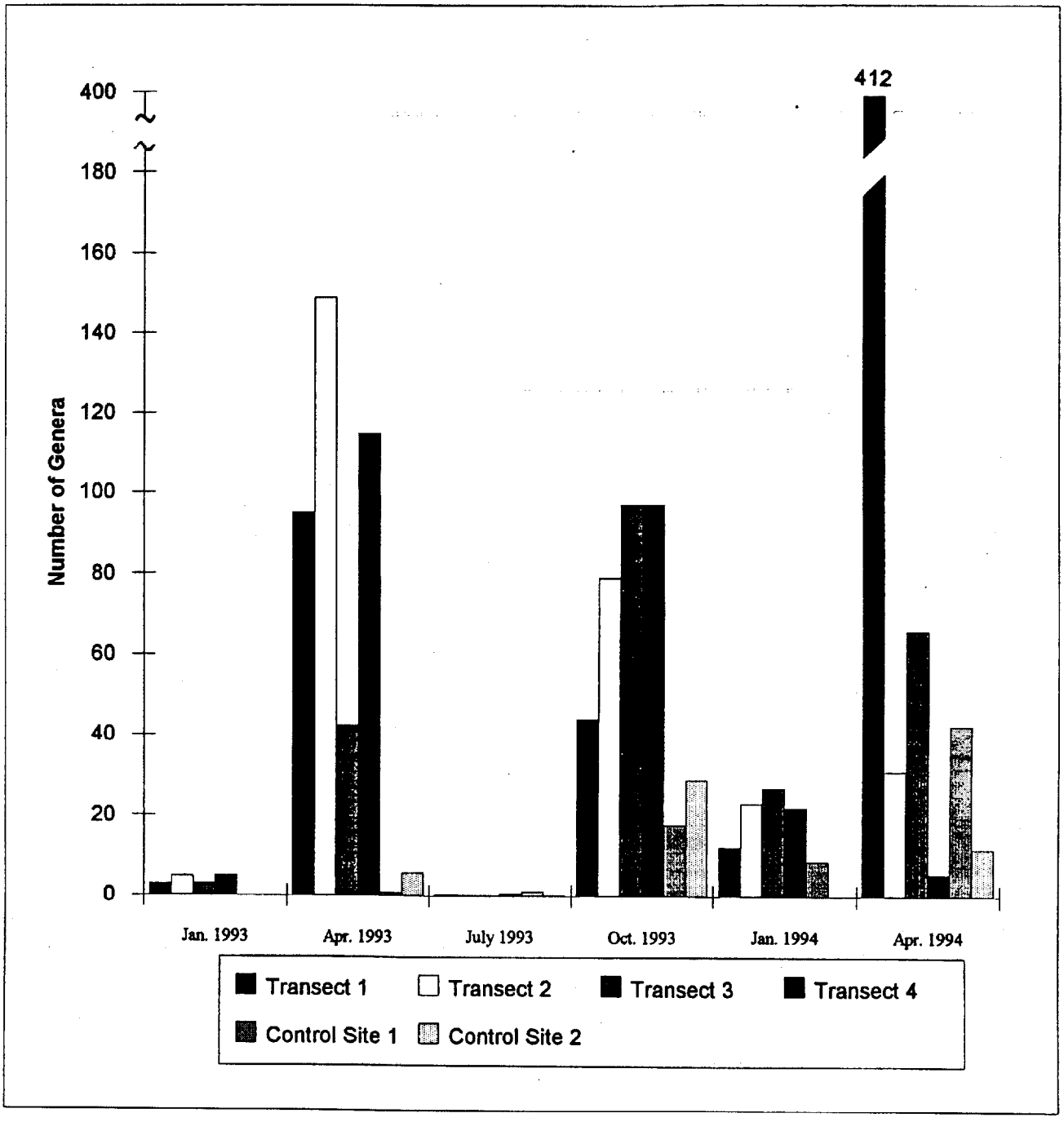
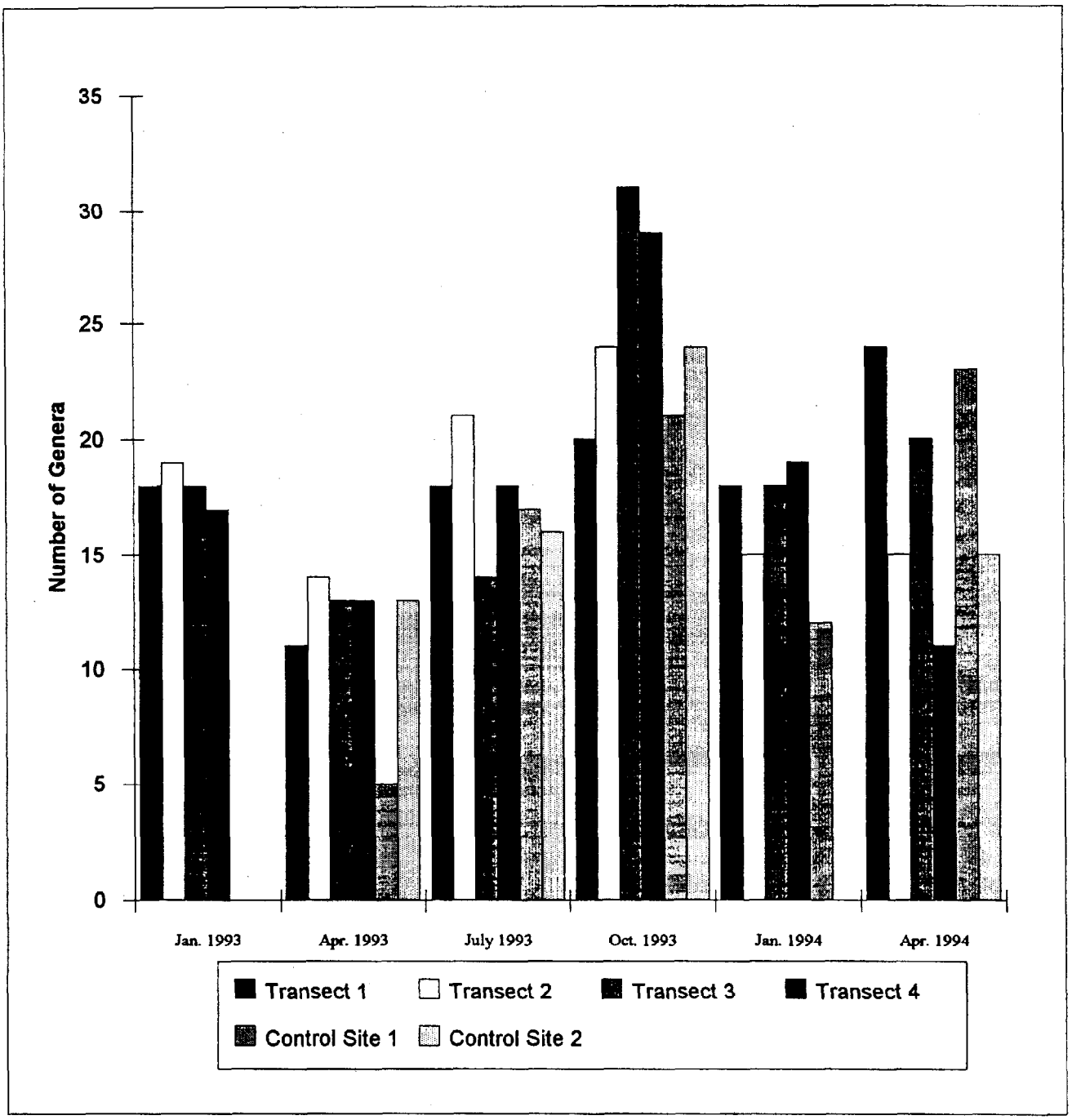


FIGURE 3-2

PERIPHYTON DIVERSITY
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND



Seasonal trends in periphyton community structure (i.e., numbers and relative proportions of algal taxa) at Site 8 and Control Site 1 have been very similar since July 1993. Each site supports a fairly diverse assemblage of pollution-tolerant and pollution-intolerant periphyton genera.

Note that the data presented in Figure 3-1 of this report reflect the actual (mean) densities of periphyton measured in January 1994 at the various transects. The "Mean Densities" shown in Figure 3-1 of the Report on January 1994 Biomonitoring for Site 8 - (Halliburton NUS, 1994b) were in fact total densities, not having been adjusted for the number of samples obtained at each transect.

3.3 BENTHIC MACROINVERTEBRATES

The Site 8 pond, with its rooted aquatic vegetation (in shallows and around pond margins) and soft, gently-sloping bottom (consisting of silt, muck, and organic detritus) is typical of tidally-influenced freshwater ponds in the Potomac River estuary (Maryland DNR, 1981). Since April 1993, the bottom substrate has been characterized as unconsolidated silt and mud (Coastal Environmental Services, 1993a; 1993b; 1993c; 1994). Table 3-2 lists densities and relative proportions of macroinvertebrates found in benthic sediments from Site 8 and the two control sites in January and April 1994. Appendix B contains results of macroinvertebrate sampling since January 1993. Note that Appendix B "lumps" rather than "splits" oligochaete families, orders, and general, in order to permit comparisons between Phase I and Phase II.

In January 1994, macroinvertebrate density and diversity were low in benthos collections from all Site 8 transects; the same pattern observed in April, July, and October 1993. Densities at the Site 8 transects ranged from 53 organisms/m^2 at Transect 2 to 654 organisms/m^2 at Transect 7. As in April, July, and October 1993, diversity was low in January 1994 at all Site 8 transects with no more than three taxa collected for any individual transect sampled. In this report, the term "diversity" is used in its loosest sense: the number of taxa observed at a given location is technically a measure of richness.

In April 1994, benthic macroinvertebrate densities were somewhat higher at all Site 8. Transects, ranging from 171 organisms/m^2 at Transect 5 to 751 organisms/m^2 at Transect 7. Macroinvertebrate densities were higher at Transect 10, 875 organisms/m^2. As in April 1993, July 1993, October 1993, and January 1994, macroinvertebrate density was low, with only groups represented: oligochaetes (the genus *Branchuria* and the families Tubificidae and Lumbriculida), chironomids (of the sub-family Chironominae) and a single dipteran (the sub-family Chaoborinae, presumably the phantom-midge larvae *Chaoborus*).

Oligochaetes and chironomids have been the most common organisms in Site 8 collections since January 1993. Oligochaetes made up 87 to 100 percent of animals collected from a given transect in

TABLE 3-2

DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	Transect 1		Transect 2		Transect 3		Transect 4		Transect 5	
	Jan 94	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94
Oligachaeta (unident)										
Branchiura sp.	63 (21.8)	5 (1.6)		23.8 (6.1)	10 (17.2)	38 (11.4)			10 (6.9)	
Tubificidae	125 (43.3)	273 (87.5)	29 (54.7)	347 (87.8)	10 (17.2)	285 (85.6)	58 (75.3)	532 (94.8)	96 (66.2)	161 (94.2)
Lumbriculidae	72 (24.9)	5 (1.6)		5 (1.3)	28 (48.3)	10 (3.0)	19 (24.7)		39 (26.9)	10 (5.8)
Polychaeta										
Asellus sp.										
Gammarus sp.										
Ephemerella sp.										
Helocordulia sp.										
Plathemis sp.								10 (1.8)		
Sympetrum sp.										
Gomphus sp.										
Calopteryx sp.										
Notonecta undulata										
Sialis										
Diptera (adult)										
Diptera (larvae)										
Chaoborinae			5 (9.4)							
Chironomidae (unident)										
Chironominae	29 (10.0)	29 (9.3)	19 (35.8)	19 (4.8)	10 (17.2)			19 (3.4)		
Helisoma sp.										
Gyraulus sp.										
Ferissia sp.										
Lymnaea sp.										
Physa sp.										
Physella sp.										
Corbicula sp.										
Pisidium sp.										
Sphaerium sp.										
Totals	289	312	53	395	58	333	77	561	145	171

TABLE 3-2 (Continued)
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	Transect 6		Transect 7		Transect 10		Control 1		Control 2	
	Jan 94*	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94	Jan 94	Apr 94
Oligachaeta (unident)										
Branchiura sp.					10 (2.6)	10 (1.1)				
Tubificidae		276 (90.5)	615 (94.1)	656 (87.4)	237 (62.2)	855 (97.7)	1,049 (90.7)	1,178 (81)	914 (56.5)	257 (74.9)
Lumbriculidae			10 (1.5)		134 (35.2)				67 (4.2)	
Polychaeta										
Asellus sp.										
Gammarus sp.							19 (1.6)	10 (0.7)	10 (0.6)	57 (16.6)
Ephemerella sp.										
Helocordulia sp.							10 (0.9)			
Plathemis sp.						10 (1.1)		10 (0.7)		
Sympetrum sp.								10 (0.7)		
Gomphus sp.									10 (0.6)	
Calopteryx sp.										
Notonecta undulata										
Sialis									10 (0.6)	
Diptera (adult)										
Diptera (larvae)							10 (0.9)			
Chaoborinae										
Chironomidae (unident)										
Chironominae		29 (9.5)	29 (4.4)	95 (12.6)			39 (3.4)	228 (15.7)	576 (35.6)	29 (8.5)
Helisoma sp.										
Gyraulus sp.										
Ferissia sp.									10 (0.6)	
Lymnaea sp.									10 (0.6)	
Physa sp.										
Physella sp.										
Corbicula sp.										
Pisidium sp.										
Sphaerium sp.							29 (2.5)	19 (1.3)	10 (0.6)	
Totals	0	305	654	751	381	875	1,156	1,455	1,617	343

* Results are not available from this location from January 1994.

April 1994 and were represented by two largely-aquatic families: Tubificidae and Lumbriculidae. Aquatic oligochaetes are burrowing detritivores, well suited for silt and mud substrates. Most aquatic oligochaetes are able to tolerate low DO concentrations (Pennak, 1978).

The tubificid oligochaete *Branchiura*, collected at Transects 1, 2, 3, and 10 in April 1994, is often found in oxygen-poor lake bottom sediments. This genus has unusual gill-like structures on the lower part of its body that supplement the "normal" respiration at the capillary-rich, body surface (Pennak, 1978). Oligochaete species are variable in their ability to withstand other environmental stresses. Several genera are very stress-resistant (e.g., *Tubifex* and *Limnodrilus*) and may develop tremendous populations in the absence of other aquatic organisms which have been destroyed by pollution. It is not true of all species in these genera, however. Nor is it true of all genera in the family Tubificidae (Whitley, 1982).

The phantom midge larvae *Chaoborus*, collected for the first time in April 1994, is a predator that catches microcrustaceans and insect larvae. *Chaoborus* is abundant in large ponds and reservoirs "everywhere" according to Pennak (1978) and shows pronounced daily migratory movements from bottom muds (during the day) to open water (at night). *Chaoborus* uses specialized hydrostatic organs to extract oxygen from sediments and water that are low in DO (Pennak, 1978).

The marked decrease in densities and diversity of macroinvertebrates at all Site 8 transects between January and April 1993 was attributed to: (1) unusually-heavy rains in the spring in the Indian Head area, and (2) the installation of a weir-water control structure in the pond (Halliburton NUS, 1993d). Heavy spring rains and flooding probably resulted in flushing of the drainage basin, with many macroinvertebrates (excluding certain burrowing forms, like oligochaetes) being driven downstream. The benthos of Site 8 is particularly vulnerable to displacement because there are few habitat-forming structures (stumps, logs, boulders, pilings) in the pond that provide refuge from the current. Also, the substrate is mostly loose, unconsolidated material that is easily disturbed, resuspended, and transported downstream.

The installation of a weir/water control structure in the Site 8 pond may have also contributed to the low numbers and diversities observed. A cofferdam was put in place on April 19, 1993, and the area behind the cofferdam was subsequently drained (J. Bossart, Indian Head Naval Ordnance Station, personal communication with P. Moore, Halliburton NUS). A permanent weir was installed on April 23, 1993. The pond level, which had been unusually high as a result of torrential spring rains, fell to the level of the weir after it was installed. The degree to which these activities resulted in displacement or disturbance of macroinvertebrates is unknown, but some displacement of macroinvertebrates may well have occurred.

Density of macroinvertebrates in the April 1994 Control Site 1 collection (1,455 organisms/m^2) was the highest observed to date. As in January 1994, six taxa (see Appendix B) were collected. Nearly 97 percent of macroinvertebrates collected were oligochaetes and chironomids. In previous quarters, three or four taxa were collected.

Two new odonate (dragonfly) genera, *Plathemis* and *Sympetrum*, were collected in April. Westfall (1984) describes *Plathemis* as a widespread genus, a predator that is typically found (as a nymph) in streams or the littoral zone of ponds and lakes. Nymphs of the genus *Sympetrum* are also predatory, and are generally pond or marsh dwellers (Huggins and Brigham, 1982). Both genera, which are closely-related taxonomically and ecologically, are "sprawlers" that lie in wait of prey in silt, organic debris, or (in the case of *Sympetrum*) among aquatic vegetation.

Macroinvertebrate densities at Control Site 2 (Mattawoman Creek), which were relatively high (1,617 organisms/m^2) in January 1994, returned to more typical levels (343 organism/m^2) in April. January 1994 collections were composed primarily of oligochaetes (60.7 percent) and chironomids (35.6 percent), as were April collections (74.9 percent oligochaetes and 8.5 percent chironomids). Only three taxa were present in April samples (see Appendix B), as compared to eight in January. Small numbers of snails (*Ferrissia* sp. and *Lymnae* sp.) and freshwater clams (*Sphaerium* sp.) were collected in January 1994, producing a higher-than-normal measure of diversity. No gastropods or pelecypods were collected in April.

Based on the results of 1993 and 1994 benthos surveys, the macroinvertebrate benthofauna of the Site 8 pond can only be described as depauperate, with low densities of benthic organisms and low taxa richness (or "diversity"). It is unknown whether these low densities are an indication of slow (post-flooding and weir installation) recolonization, or a long-term change in benthic community structure caused by changes in the composition of the bottom substrate of the pond.

Very few comprehensive studies of benthos in tidal freshwaters have been conducted (see review in Odum et al., 1984). Diaz and Boesch (1977) and VIMS (1978) investigated effects of development on benthos in the James River, Virginia, a river similar to the Potomac in terms of discharge and drainage area (van der Leeden, 1990) and, one presumes, trophic state, nutrient loads, water temperature regimes, and biota, given their geographical proximity and the similarity of the two watersheds.

Both investigations (Diaz and Boesch, 1977; VIMS, 1978) revealed that the benthos of the James River and adjacent freshwater marshes were dominated numerically by tubificid oligochaetes and larval chironomids, and both suggested that the asiatic clam *Corbicula* was the most important component of benthic biomass.

Members of the order Diptera (which includes flies, mosquitoes, and midges) are the only insect larvae found in significant numbers in the fresh-to-brackish waters of the Potomac estuary, which includes Mattawoman Creek and environs (Maryland DNR, 1981). Thus, the numerical dominance of oligochaetes and chironomids and the low diversity of aquatic insect larvae at Site 8 pond is not surprising, and is not necessarily indicative of a macroinvertebrate community that has been impacted by deteriorating water quality. *Corbicula* have been found in small numbers at Transect 10, the transect which lies in a tributary of the Site 8 pond, but the substrate of the pond does not appear to be firm enough or stable enough to support large numbers of these clams.

Diaz and Boesch (1977) suggested that the low species richness and simple community structure generally observed in benthic communities of tidal freshwater marshes and ponds result from the homogeneity of the habitat, and in particular featureless sand or mud substrates. Many aquatic insect larvae (e.g., many caddisfly, mayfly, and stonefly genera) are closely associated with debris, leaf litter, gravel, crevices in rocks, and roots, leaves, and stems of aquatic plants. Diverse communities of aquatic insects are typically found in areas providing a diversity of habitats (or "niches") with acceptable temperature and oxygen regimes and abundant food.

3.4 FISH DIVERSITY

As noted in Section 2.4.1, plans to conduct systematic fish population surveys were abandoned because of the low species diversity and general scarcity of fish observed in July (U.S. Fish and Wildlife Service) and October 1992 samples. However, species captured in the course of collecting fish for mercury and lead analyses are noted and compiled in site-specific species lists. Table 3-3 lists fish species collected to date from the Site 8 pond and the two control sites. No attempts were made to collect fish in January 1994.

Species richness (as indicated by the number of species captured) is highest at the Site 8 pond, with ten species collected since July 1992. All are common species of tidal freshwater creeks and ponds of the mid-Atlantic coast (Odum et al., 1984; Lee et al., 1980). The eastern mosquitofish, *Gambusia holbrooki*, appears to be the most abundant species in the Site 8 pond and its tributaries. Other species have been common [e.g., bluegill (*Lepomis macrochirus*) and brown bullhead (*Ameiurus nebulosus*)] to uncommon [e.g., large-mouth bass (*Micropterus salmoides*)] in Site 8 collections. A new species, the common carp (*Cyprinus carpio*), was collected at this site in April 1994. Carp could be seen thrashing in the shallows of the Site 8 (apparently spawning) pond and in Mattawoman Creek below the Site 8 dam (personal communication, B. Krinsky, Coastal Environmental Services, with P. Moore, Halliburton NUS, 1994).

TABLE 3-3

FISH COLLECTED FROM SITE 8 AND CONTROL SITES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Species	Site 8							Control Site 1 (Stump Neck Beaver Pond)						Control Site 2 (Mattawoman Creek)					
	7-92	10-92	1-93	4-93	7-93	10-93	4-94	10-92	1-93	4-93	7-93	10-93	4-94	10-92	1-93	4-93	7-93	10-93	4-94
Anguilla rostrata												●							
Cyprinus carpio							●												
Notropis sp.						●						●	●			●			
Notropis hudsonius																			●
Semotilus atromaculatus																		●	
Erimyzon oblongus			●								●	●	●		●				
Esox americanus											●								
Ameiurus nebulosus	●	●			●	●													●
Umbra pygmaea									●	●									
Fundulus heteroclitus	●	●	●	●															
Gambusia holbrooki	●	●	●			●													
Lepomis gibbosus		●					●					●	●					●	●
Lepomis gulosus					●														
Lepomis macrochirus	●		●	●	●		●											●	●
Micropterus salmoides	●																		
Morone americana																●			

Until July 1993, only a few individuals representing a single species, the eastern mud minnow (*Umbra pygmaea*), had been collected at Control Site 1 (Stump Neck beaver pond). In July 1993, two new species, *Erimyzon oblongus* and *Esox americanus*, were collected at this site. In October 1993, three more new species were collected: American eel (*Anguilla rostrata*), an unidentified shiner (*Notropis*) species, and pumpkinseed (*Lepomis gibbosus*). No new species were collected in April 1994.

Three new fish species were also collected at Control Site 2 (Mattawoman Creek) in October 1993: bluegill, pumpkinseed, and creek chub (*Semotilus atromaculatus*). These three species are all common inhabitants of Maryland waters (Lee et al., 1980; Maryland DNR, 1981). Because Control Site 2 is used year-round by a variety of freshwater fish species, is used in spring and summer by a number of anadromous (migratory) fish species that move into its waters to spawn, and is also used by the catadromous American eel (which spawns in salt water and grows to maturity in fresh water), the number of fish species collected from Control Site 2 is expected to increase steadily over the course of the biomonitoring study. Two new species were collected at Control Site 2 in April: spottail shiner (*Notropis hudsonius*) and brown bullhead (*Ameriurus nebulosus*).

Many spawning alosids ("river herring") were stunned, netted, and subsequently released unharmed when the Coastal field crew electrofished in Mattawoman Creek (personal communication, B. Krinsky, Coastal Environment Services, with P. Moore, Halliburton NUS, 1994). The Coastal crew chose to release these fish rather than collect them because several herring fishermen were in the vicinity. As a result, it was impossible to positively identify the species of the fish, which were either blueback herring (*Alosa aestivalis*), alewives (*A. pseudoharengus*), or both. In order to distinguish between the two species, it is necessary to examine the peritoneum or make meristic measurements and counts. In either case, the fish must be killed.

It was suggested in previous monitoring reports (Halliburton NUS, 1993b; 1993d) that the installation of a weir water-control structure at the Site 8 dam would reduce fish diversity in the Site 8 pond over time. This assumed that the weir would prevent fish (and invertebrates) from moving into the Site 8 pond from Mattawoman Creek, resulting in a fishery that is less diverse and more typical of a freshwater stream/pond than an estuary. It was also suggested that in the absence of recruitment from downstream, at least one species -- the mummichog, *Fundulus heteroclitus* -- would likely decrease in relative abundance. The mummichog is able to reproduce and maintain population levels in freshwater impoundments under certain circumstances, but is more likely to flourish in brackish tidal waters (Scott and Crossman, 1973; Lee et al., 1980). The mummichog has not been collected since April 1993, but it would be premature to suggest that this species has been eradicated from the Site 8 pond. The mummichog is a hardy species that can tolerate high water temperatures and low levels of dissolved oxygen (Scott and Crossman, 1973).

A number of authorities have suggested using the structural and functional attributes of fish communities as indicators of the health of aquatic ecosystems (Karr, 1981; Fausch et al., 1984; Angermeier and Karr, 1986; Fausch et al., 1990; Karr, 1991). These "rating" systems use different terminology (different metrics and indices) to measure aquatic habitat quality, but they have a number of criteria in common, among them:

- Species Richness and Composition
  - Total number of fish species/abundance of each species
  - Number/identity of darter species
  - Number/identity of sunfish species
  - Number/identity of sucker species
  - Number and identity of pollution-intolerant species
- Trophic Composition
  - Proportion of individuals as omnivores
  - Proportion of individuals as insectivorous
  - Proportion of individuals as top carnivores

Regardless of the rating system employed, the Site 8 pond would be classified as a degraded or impaired aquatic community ("poor" or "fair" habitat, depending on the classification scheme used). The Site 8 pond has: (1) low species richness (10 species collected to date) and generally low abundance of fish, (2) no darter (i.e., *Etheostoma* and *Percina*) species, (3) only three sunfish species (bluegill, pumpkinseed, and warmouth), (4) no "intolerant" species (species, such as trout and sculpin that are intolerant of eutrophication/siltation/pollution), (5) a high proportion of pollution-tolerant species, such as brown bullhead and mosquitofish, and (6) a high proportion of omnivorous species and almost no "top carnivores" (e.g., bass and pickerel).

The fish community of the Site 8 pond is composed of hardy, pollution-tolerant species, such as the brown bullhead, the mosquitofish, and the common carp. Fish species with more demanding habitat requirements (i.e., those that cannot tolerate high temperatures and low DO levels) are conspicuously absent. But, as noted elsewhere in this report, this appears to be a function of physical and chemical factors (e.g., siltation and low DO) rather than metals contamination.

3.5 ANALYSIS OF MERCURY AND LEAD IN TISSUE OF AQUATIC ORGANISMS

In April 1994, samples of selected fish species and turtle livers collected were shipped on ice to Gascoyne Laboratories, Inc., for analysis. EPA Method 7471 was used to determine the concentration of total inorganic mercury in each sample. EPA Method 7421 was used to determine the concentration of total inorganic lead in each sample. Analyses of fish were performed on homogenized whole body samples, rather than on fillets. The rationale for using whole body samples was the assumption that small prey species such as *Fundulus* and *Gambusia*, which have made up the majority of fish collected from Site 8 and both control stations, are almost always eaten whole by predatory fish, piscivorous birds, and piscivorous mammals. Analysis of turtle was limited to only turtle livers.

In previous quarterly reports (Halliburton NUS, 1993b; 1993d), it was suggested that the limited data did not exhibit any particular trends with respect to mercury concentrations in tissue. For example, the data failed to demonstrate a marked difference in the concentrations of mercury measured in different fish species collected at a particular site (e.g., Site 8). Because mercury exhibits a tendency to biomagnify (increase in concentration at higher levels of a food chain), detection of higher concentrations of mercury in bluegill (a mid-food chain organism that eats insects and small fish) than in *Gambusia* (an omnivore that eats zooplankton, insects, and some plant material) was anticipated. This was not the case, however; concentrations of mercury were higher in Site 8 *Gambusia* than bluegill in every quarter where both species were captured.

The tissue concentrations of mercury measured in the samples of Site 8 bluegill collected in January, April, and July 1993 (0.02, 0.06, and 0.09 mg/kg of mercury, respectively) and April 1994 (0.07 mg/kg of mercury) were similar to concentrations reported by the USFWS for this area between 1987 and 1991 (USFWS, 1991). As noted in these USFWS reports, the levels of mercury reported for Indian Head bluegill are similar to those reported for bluegill collected from other locations in Maryland and the United States. The combined bluegill data (1987 through 1994) suggest that the levels of mercury available to these organisms have remained relatively constant over the last 7 years, and that mercury tissue levels in bluegill have remained within the range reported for this species from other Maryland locations.

Eisler (1987) suggested that fish tissue levels of 0.1 mg/kg of mercury (wet weight) be used as a guideline for the protection of piscivorous birds (e.g., the common merganser, *Mergus merganser*), and recommended that 1.1 mg/kg of mercury serve as a guidance level for the intake of fish by piscivorous mammals (e.g., the river otter, *Lutra canadensis*). In the first three rounds of biomonitoring (October 1992, January 1993, and April 1993), the concentrations of mercury present in fish samples from Site 8 and the two control sites were almost always below these suggested guidance levels, indicating that piscivorous

birds and mammals that feed in these areas are not at risk (Halliburton NUS, 1993b; 1993d). Prior to July, only one sample (*Gambusia* in January 1993) exceeded the 0.1 mg/kg of mercury guidance level. No *Gambusia* were collected in April or July 1993. Table 3-4 shows trends in mercury concentration of fish since October 1992.

In July 1993, two samples (warmouth from Site 8 and redfin pickerel from Control Site 1) showed mercury levels higher than 0.2 mg/kg. These slightly elevated mercury concentrations are not surprising given the food habits of these species. Warmouth have a more piscivorous diet than most Lepomids (or "sunfish"), which is generally attributed to the warmouth's large, bass-like mouth (Carlander, 1977). Redfin pickerel are also carnivores -- eating insects, crayfish, and fish -- but are increasingly piscivorous as they attain larger sizes (Carlander, 1969; Lee et al., 1980). Piscivorous species such as the warmouth and redfin pickerel that feed high in the food chain tend to bioaccumulate mercury (Sorensen, 1991). In the latest round of sampling, a pumpkinseed sample from Control Site 2 (Mattawoman Creek) contained 0.29 mg/kg of mercury, the highest concentration measured to date from any of the sites.

It should be pointed out that all three samples with mercury concentrations higher than 0.2 mg/kg consisted of a single fish. The pitfalls of drawing inferences from a single observation are obvious. Mercury is notorious for accumulating in fish muscle and viscera at radically different rates, even within a population. This variability in rate of mercury accumulation has been attributed to genetic differences between fish, differences in sex and maturity, size-related differences, and the presence or absence of pesticides, organic wastes, and other chemical agents (Sorensen, 1991). Moreover, the fact that one sample with an elevated mercury level was from Site 8 and the others were from presumably uncontaminated Control Sites 1 and 2 suggests that these slightly elevated concentrations are caused by the tendency of carnivorous fish species to bioaccumulate mercury (whether the source be industrial, atmospheric, or geologic) rather than the presence of high levels of mercury in the water, sediment, or biota of either pond.

In the absence of more complete data (i.e., more fish samples from Site 8 and both control sites), it may be unwise to draw any conclusions from the fish tissue studies. Halliburton NUS will continue to employ a variety of conventional (e.g., nets, traps, and electrofishing equipment) and unconventional (e.g., trotlines) fish collecting techniques and step up the sampling intensity (to the extent practicable) in an effort to produce more data from representative and important fish species.

Supplemental samples of frogs collected in April 1993 and crayfish collected in July 1993 contained 0.03 and 0.07 mg/kg of mercury, respectively. A composite sample of four crayfish collected in October 1993 contained 0.09 mg/kg. As noted previously, Eisler (1987) suggests that for the protection of sensitive species of birds and mammals that "regularly consume fish and other aquatic organisms," that total mercury

TABLE 3-4

MERCURY CONCENTRATIONS, SITE 8 AND CONTROL SITES
OCTOBER 1992 - APRIL 1994
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Organism	Mercury Concentrations (mg/kg)					
	October 1992	January 1993	April 1993	July 1993	October 1993	April 1994
SITE 8 POND						
Carp	--	--	--	--	--	0.03
Notropis (shiner)	--	--	--	--	0.05	--
Creek chubsucker	--	0.03	--	--	--	--
Brown bullhead	0.04	--	--	0.05	0.05	--
Gambusia (mosquitofish)	0.06	0.15	--	--	0.12	--
Pumpkinseed	--	--	--	--	--	0.09
Warmouth	--	--	--	0.23	--	--
Bluegill	0.02	0.02	0.06	0.09	--	0.07
Crayfish	--	--	--	0.07	0.09	--
Frog	--	--	0.03	--	--	--
Turtle (Liver only)	--	--	--	--	--	1.3
CONTROL SITE 1 (STUMP NECK BEAVER POND)						
American eel	--	--	--	--	0.11	--
Eastern mudminnow	--	--	0.07	--	--	--
Redfin pickerel	--	--	--	0.21	--	--
Notropis (shiner)	--	--	--	--	0.07	0.04
Creek chub	--	0.03	--	0.09	0.11	--
Pumpkinseed	--	--	--	--	0.11	0.13
CONTROL SITE 2 (MATTAWOMAN CREEK)						
Notropis (shiner)	--	--	0.04	--	--	--
Spottail shiner	--	--	--	--	--	0.02
Creek chubsucker	--	--	--	--	0.02	--
Brown bullhead	--	--	--	--	--	0.05
White perch	--	--	0.02	--	--	--
Pumpkinseed	--	--	--	--	0.01	0.29
Warmouth	--	--	--	--	--	--
Bluegill	--	--	--	--	0.03	0.04

Note: No attempts to collect fish were made in January 1994.

concentrations in the prey items should not exceed 0.1 mg/kg wet weight for birds and 1.1 mg/kg for mammals. Thus, the mercury concentrations measured in crayfish and frogs are not indicative of a serious mercury contamination problem lower in the food chain.

Mercury concentrations in livers of turtles from Site 8 averaged 1.3 mg/kg of mercury. Because almost no information exists on background levels of mercury in turtles, interpreting these results is difficult. Eisler's (1987) review contains data on mercury levels in field collections of frogs, toads, and sea turtle eggs, but contains no information on mercury concentrations in turtle tissue. Frogs from a Florida lake had 0.5 to 1.1 mg/kg of mercury in liver tissue (Eisler, 1987). Toads from an unpolluted area in Yugoslavia had liver mercury concentrations of 1.5 mg/kg, while those from polluted mining areas had 21.8 to 25.5 mg/kg (Eisler, 1987). Mercury concentration in reptiles (frogs and toads), fish, birds, and mammals are typically 2 to 10 times higher in liver tissue than in muscle tissue.

Given the limited data that is available, it is impossible to determine if mercury concentrations in painted turtles from Site 8 are within normal limits. Halliburton NUS will, before the next round of biomonitoring, search the toxicological literature for additional information on typical background levels of mercury in aquatic and semi-aquatic species of turtles. Assuming such data is available, Halliburton NUS will be better able to evaluate the results of the April 1994 turtle bioassays and to present recommendation to EFA Chesapeake on the value of additional studies.

Composite fish and turtle liver samples from the April 1994 round of Biomonitoring were split and analyzed for both mercury and lead residues. Results of lead analyses are presented in Table 3-5. Lead levels in April 1994 fish samples from the Site 8 pond were low. Site 8 lead concentrations were either: (1) nondetected and below the analytical quantitation limit of 0.2 mg/kg or (2) detected at levels below the quantitation limit. Measurable concentrations of lead were present in Notropid (shiner) minnows from Control Site 1 (beaver pond) and two species (brown bullhead and pumpkinseed) from Control Site 2 (Mattawoman Creek). All three samples contained 0.3 mg/kg of mercury.

No clear-cut patterns of lead contamination or lead accumulation in fish emerged from this preliminary investigation. No fish from the Site 8 pond contained measurable levels of lead, whereas fish from both control sites contained measurable levels. Although bottom-feeding and bottom-dwelling species are more likely to accumulate significant body burdens of lead as a result of lead's tendency to bind to bottom sediment (Van Hassel et al., 1980; Eisler, 1988), no such pattern was observed in April 1994. Sample sizes were probably too small to detect any such tendencies, however. A sample of carp (two small fish) from the Site 8 pond contained low, but detectable (<0.3 mg/kg) concentrations of lead. A brown bullhead

TABLE 3-5

LEAD CONCENTRATIONS IN FISH AND TURTLES - APRIL 1994
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Fish Species	Lead Concentrations (mg/kg)		
	Site 8	Control Site 1 (Stump Neck Beaver Pond)	Control Site 2 (Mattawoman Creek)
Carp	BQ	---	--
Notropis sp.	--	0.3	---
Spottail shiner	--	---	*
Cheek chubsucker	--	*	--
Brown bullhead	--	---	0.3
Pumpkinseed	0.2 U	BQ	0.3
Bluegill	BQ	---	0.2 U
Turtle (liver only)	0.5	---	---

BQ Detected, but below measurable quantity.
U Value is nondetected as reported by laboratory. Value is the detection limit.

* Insufficient sample mass for analysis.

sample (one small fish) from the Mattawoman Creek control site contained a low, but measurable (0.3 mg/kg) concentration of lead. Both species are omnivorous bottom feeders (Scott and Crossman, 1973).

Notropid (unidentified shiners) minnows from the beaver pond control site also contained low, but measurable, concentrations of lead as did a pumpkinseed (one fish) from Mattawoman Creek. Notropid food habits vary with the species and the size/age of individual fish. Notropids feed on plant material, plankton, and both larval and adult insects (Tomelleri and Eberle, 1990). Some species feed on the bottom, while others feed primarily at the surface (Scott and Crossman, 1973). Pumpkinseed are opportunistic omnivores that feed at the surface, at various depths in the water column, and at the bottom (Scott and Crossman, 1973).

Unlike mercury, lead does not biomagnify (Eisler, 1988). Lead concentrations in aquatic ecosystems are often higher in sediments than in benthic macroinvertebrates, and higher in benthic macroinvertebrates than in surface-feeding or pelagic fish (Van Hassel et al., 1980; Eisler, 1988). Lead tends to concentrate in the bony tissues of individual fish, particularly species that forage on the bottom, and to accumulate in these tissues over time. Thus, older individuals may be at risk in a contaminated stream or lake, and in particular bottom-feeding groups such as bullheads, carpsuckers, and redhorse.

Lead concentrations in liver tissue from two painted turtles from the Site 8 pond averaged 0.5 mg/kg. Because almost no information on lead residues in reptiles is available, the significance of this data is difficult to assess. Eisler (1988) lists only one investigation of lead levels in turtles, but the species studied (the eastern box turtle, *Terrapene carolina*), is a largely terrestrial species, while the painted turtle is semi-aquatic. Perhaps more importantly, in terms of comparing body burdens of metals, the eastern box turtle is an unusually long-lived turtle species: 30- to 40-year-old individuals are common, and they may live as long as 100 years (Conant, 1975). Lead concentrations in a 17-year-old box turtle from an uncontaminated site in West Virginia were 4.0 mg/kg (long bones), 2.0 mg/kg (kidney), 1.0 mg/kg (liver), and 0.1 mg/kg (skin) (Eisler, 1988). Based on this study (and other studies of snakes, frogs, and toads in the same reference), the lead concentration in livers of painted turtles from Site 8 is unremarkable.

These limited data provide no evidence that lead contamination at Site 8 has moved into the food chain to a significant extent. In order to definitively rule out lead contamination, however, it would be necessary to capture many more fish for analyses of lead in tissues. Older fish and bottom-dwelling species would be preferred, because research has shown that older, larger fish tend to contain higher body burdens of lead than younger, smaller fish (Eisler, 1988).

4.0 SUPPLEMENTAL SEDIMENT SAMPLING AND ANALYSIS

Supplemental sediment sampling and analysis was performed by Halliburton NUS at both Site 8 and Control Site 1. This work was performed in accordance with the procedures described in the letter report work plan that was sent from Halliburton NUS to the U.S. Navy on May 17, 1994. As described in that letter samples were collected in accordance with the procedures and methods described in the Site 8 Post-Removal Verification Sampling and Analysis Plan (Halliburton NUS, April 1994c). Field sampling work was performed by Halliburton NUS on May 18, 1994. The sediment samples were subsequently analyzed by GP Environmental Services Laboratory, Inc. (GP) in Gaithersburg, Maryland.

Sediment samples collected from Site 8 were analyzed for lead. This sampling and analysis was performed to obtain more information on the extent of lead contamination at Site 8. Elevated lead levels were discovered in the NPDES samples taken at discharge point IW-31 and previous sediment/soil samples taken for the Site Characterization Report (Halliburton NUS, 1993f).

Sediment samples collected from Control Site 1 were analyzed for mercury. This sampling and analysis was performed to verify that the control site is not overly contaminated with mercury. Mercury concentrations in fish tissue at this control site and Site 8 are very similar. Supplemental sediment sampling and analysis was performed to confirm the control site does not have elevated mercury levels in the sediment/soils.

4.1 SAMPLING METHODS

Sediment samples were collected from surface sediments (and soils) from both locations.

4.1.1 Site 8 Sediment Sampling

Twelve environmental sediment samples were collected from Site 8. Six of these samples were taken from the Site 8 Pond and six were taken from the Site 8 stream. Two additional duplicate QA/QC samples were also taken, one from the Pond and one from the stream. The approximate location of the samples collected are shown in Figure 2-1.

Sediment/soil samples were collected in the open water portion of the Site 8 Pond. Sampling was performed from a boat provided by the Navy. The samples were collected along transect lines that were delineated by ropes. These transect lines were previously used to mark the location of sediment samples

collected during previous mercury sampling at the Site 8 pond. The ropes were attached to fixed points (trees, snags, etc.) on each shore. The samples collected in the Pond (at the transects) were collected using the 2-inch-diameter clear plastic tubes. The tubes were pushed by hand into the bottom sediment/ soils. They were then twisted, capped, and removed. Although "baskets" were used to retain the sample in the tube, poor sample recovery was a problem at some sampling locations; in these locations, the same location was sampled multiple times to obtain an adequate sample volume. Also, the tube sampling technique may have compacted the samples. In some areas the sample tube was pushed approximately 2 feet into the pond bottom; however only 6 inches of sample was actually retained in the tube.

The samples collected in the stream were also surface sediment samples (0 to 6 inches deep). These samples were collected with disposable trowels. Samples were collected from locations that were identified in the field as the locations of previous sediment samples (from the earlier mercury sampling). The lead sampling locations were also marked with new pin flags.

4.1.2 Control Site 1 Sediment Sampling

Three environmental sediment samples and one QA/QC duplicate sample were collected at Control Site 1 (Stump Neck Beaver Pond) for mercury analysis. The duplicate samples were collected in the stream downstream from the wooden bridge flows into the beaver pond. The other two samples were taken at the edge of the beaver pond, one where the primary stream discharges into the pond and the other near the beaver dam. The approximate location of these sampling points is shown in Figure 4-1. The samples collected consisted of near-surface sediments (0 to 6 inches deep).

4.2 SAMPLE HANDLING

Sample handling was performed in accordance with the Site 8 Post Removal Verification Sampling and Analysis Plan (Halliburton NUS, 1994c), the EPA User's Guide to the Contract Laboratory Program (EPA, December 1986), and the Federal Register (EPA, October 26, 1984). Each sample collected was assigned a unique sample tracking number. The sample tracking number consisted of a three-segment, alpha-numeric code that identifies the sample medium, location, and depth. All sediment/soil samples were designated as SO samples. Other pertinent information regarding sample identification was recorded in the field log book. Samples were packaged, placed in coolers, and packed with ice. The samples were shipped to the laboratory. Sample custody was documented on chain-of-custody forms in accordance with standard sample handling procedures.

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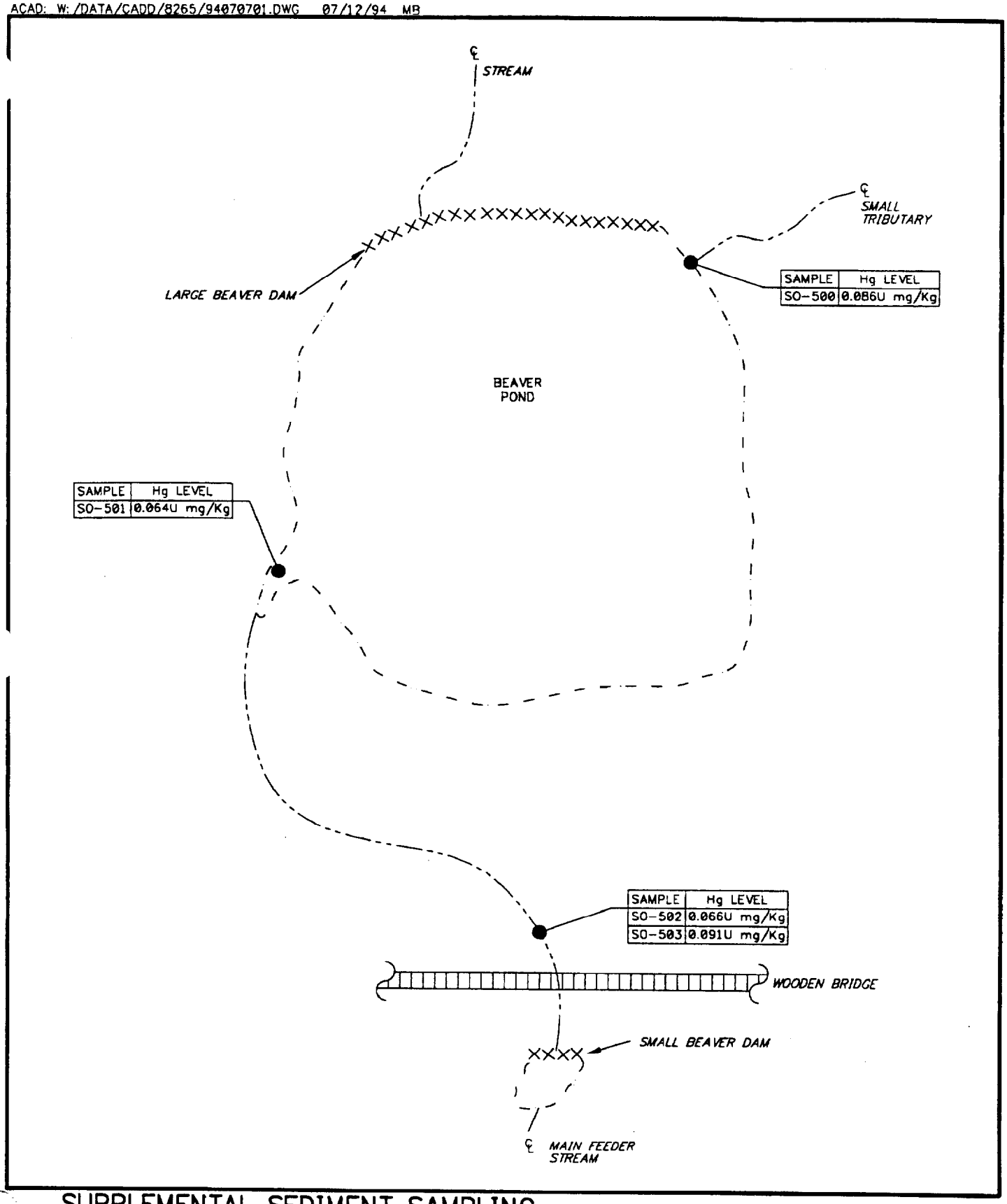

SUPPLEMENTAL SEDIMENT SAMPLING LOCATIONS AND RESULTS – CONTROL SITE 1 – STUMP NECK ANNEX BEAVER POND INDIAN HEAD, MD

FIGURE 4-1

NOT TO SCALE

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4.3 ANALYTICAL METHODS

The analytical work performed on the samples collected during the field work is summarized on Table 4-1.

4.4 QUALITY ASSURANCE/QUALITY CONTROL

In addition to documentation, field Quality Assurance/Quality Control (QA/QC) samples in the form of field duplicates were collected during environmental sampling activities. The number of field QA/QC samples are shown on Table 4-1. Duplicates were obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Duplicates were analyzed for the same parameters in the laboratory.

4.5 ANALYTICAL RESULTS

A total of 15 sediment/soil samples plus 3 duplicates were collected. Fourteen of the samples which were collected at Site 8 were analyzed for total lead and the remaining four samples were collected at the Control Site 1 - Beaver Pond were analyzed for total mercury. The laboratory results are summarized on Tables 4-2 and 4-3. Additional analytical information is presented in Appendix C.

4.5.1 Analytical Results from the Site 8 Sediment Sampling

Analytical results of the lead samples are presented on Table 4-2 and seven samples of the 14 total samples collected at Site 8 were collected in the Site 8 Pond. Two sample locations were collected at Transects Number 2, 4, and 6. Sample SO-402 and Sample SO-403 are duplicates and had lead levels of 246 mg/kg and 220 mg/kg, respectively. It was observed that high levels of lead occurred on the west side of the pond and decreased slightly downgradient in the pond. The highest lead level detected in the pond sediments was in sample SO-405 of 704 mg/kg and the lowest lead in the pond sediments was 163 mg/kg at sample location SO-402 which is on the opposite side and end of the Pond from the highest reading.

The other seven samples were taken in the stream sediments which feeds into the Pond. Samples SO-407, SO-408, and SO-409 were taken in the marshy area where the ground elevation is relatively flat and stream velocity reduced. The upgradient sample, SO-409 had the lowest lead level of 491 mg/kg and the downgradient sampling SO-408 and SO-409 had lead levels of 780 mg/kg and 811 mg/kg, respectively. Sample SO-410 and SO-411 are duplicates taken in the stream channel upgradient from the marshy area and receive lead reading of 40.6 mg/kg and 73.0 mg/kg. Sample SO-412 was taken just downgradient of

TABLE 4-1

ANALYTICAL PROGRAM SUMMARY
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Parameter	Method	Sample Matrix	Environmental Samples	Duplicates	Total Samples
Mercury (dry weight basis)	SW 846/7471	Solid (Sediment soil)	3	1	4
Lead (dry weight basis)	SW 846/7421	Solid (Sediment soil)	12	2	14
Total			**15**	**3**	**18**

TABLE 4-2

SITE 8 SEDIMENT ANALYTICAL RESULTS FOR INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER INDIAN HEAD, MARYLAND

Sample Number	Location Description	Lead Results (mg/kg)
SO-400-00/01	Transect No. 2, 15 feet from west bank	236
SO-401-00/01	Transect No. 2, 100 feet from east bank	163
SO-402-00/01	Transect No. 4, 25 feet from west bank (403 Dup)	246
SO-403-00/01	Transect No. 4, 25 feet from west bank (402 Dup)	220
SO-404-00/01	Transect No. 4, 20 feet from east bank	199
SO-405-00/01	Transect No. 6, 80 feet from west bank	704
SO-406-00/01	Transect No. 6, 30 feet from east bank	196
SO-407-00/01	Transect No. 8, center of stream in swamp	811
SO-408-00/01	50 Feet north of Transect 8	780
SO-409-00/01	50 Feet downgradient of SS-35	491
SO-410-00/01	Center of stream (Dup of 411)	40.6
SO-411-00/01	Center of stream (Dup of 410)	73.0
SO-412-00/01	Immediately downstream of discharge (IW-31)	79.2
SO-413-00/01	Upgradient of discharge (IW-31)	6.73

TABLE 4-3

SEDIMENT/SOIL ANALYTICAL RESULTS BEAVER POND
CONTROL SITE 1 - STUMP NECK ANNEX BEAVER POND
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Sample Number	Location Description	Mercury Results (mg/kg)
SO-500	Edge of pond across from primary tributary of stream near the beaver dam.	0.086 U
SO-501	Where primary tributary stream feeds into the Beaver pond.	0.064 U
SO-502	In the stream which feeds the beaver pond downstream of the walking bridge. (Duplicate for SO-503)	0.066 U
SO-503	In the stream which feeds the beaver pond downstream of the walking bridge. (Duplicate for SO-502)	0.091 U

U - Value is a nondetect as reportedly by the laboratory.

the discharge point IW-31 and had a level of 79.2 mg/kg. Sample SO-413 was taken upgradient of the discharge point and had a lead level of 6.73 mg/kg.

The sampling and analysis results from the Site 8 indicate that there are significantly higher levels (two orders at magnitude) of lead downstream from NPDES Discharge Location IW-31. The highest levels were detected in the marsh at the back of the pond. As the samples progressed into the pond the levels of lead decreased indicating that the lead may have settled out prior to being conveyed through the pond.

4.5.2 Analytical Results from the Control Site 1 Sampling

Two locations in Control Site 1 (Stump Neck Beaver Pond) and one location in the main stream feeding the pond was sampled. As shown in Table 4-3 and Figure 4-1 all samples collected were below the analytical detection limit. This indicates that there is not an elevated mercury contamination associated with the Control Site 1. The similarity in the fish tissue mercury levels between Site 8 and Control Site 1 may indicate that bioaccumulation of background levels of mercury are comparable to these observed at both sites.

5.0 SUMMARY AND CONCLUSIONS

5.1 SUMMARY

Periphyton. The periphyton community of Site 8 was dominated by diatoms and green algae in October 1992 and July 1993, and by diatoms in January and April 1993. In October 1993 and January 1994, the periphyton community showed more variety, with diatoms, green algae, blue-green algae, and golden-brown algae all present in large numbers. In April 1994, the periphyton community was composed mostly of diatoms, green algae, and blue-green algae. Periphyton, which are short-lived and very prolific, often show in these kinds of pronounced seasonal shifts in community structure.

Benthic Macroinvertebrates. The Site 8 benthic macroinvertebrate community is composed largely of herbivores that feed on attached algae (e.g., chironomids) and detritivores that feed on organic detritus (e.g., oligochaetes). The simple structure and low diversity of the Site 8 benthic community are typical of tidal freshwater marshes and ponds of the east coast with their featureless sand and mud substrates.

Fish. The two most abundant fish species (mosquitofish and mummichog) in 1992 collections from the Site 8 pond are omnivores that feed on plant matter, larval and adult insects, and small fish. In 1993, no species of fish was abundant, but bluegill, brown bullhead, mosquitofish, and mummichog were all collected on two or more occasions. Thus far in 1994, very few fish have been collected, all Lepomids (sunfish) and carp. Fish species richness and abundance are low at Site 8. Concentrations of mercury in fish tissue from Site 8 over the course of this investigation have revealed no clear differences between species (between bluegill and mosquitofish, for example) or areas (between Site 8 and the two control sites). Limited investigations of lead residues in fish from Site 8 have turned up no evidence of lead contamination. Mercury levels in fish samples collected in the first five quarters of biomonitoring (October 1992 through October 1993) were generally below those suggested as a guideline for protection of sensitive piscivorous birds (0.1 mg/kg) and piscivorous mammals (1.1 mg/kg). In July 1993, a warmouth from the Site 8 pond and a redfin pickerel from Control Site 1 contained 0.23 and 0.21 mg/kg of mercury, respectively. In October 1993, one species from Site 8 (mosquitofish) and two species from Control Site 1 (creek chub and pumpkinseed) contained mercury levels >0.1 mg/kg. In April 1994, no Site 8 fish contained mercury concentrations higher than 0.09 mg/kg, but a pumpkinseed collected in Mattawoman Creek contained 0.29 mg/kg of mercury, the highest concentration measured at any location since this study began. All indications are that birds and mammals that feed on Site 8 fish and invertebrates are not at risk, and that mercury levels in biota have stabilized.

Supplemental Sediment Sampling and Analysis at Site 8. The supplemental sediment sampling and analysis at Site 8 appears to indicate that there are elevated levels of lead in the sediments downstream of NPDES discharge point IW-31. This condition is indicated by the fact the lowest lead level in the sediments at Site 8 was detected upstream of the NPDES discharge point. All downstream sampling locations contained higher levels of lead. The lead levels in the Site 8 pond are generally two orders of magnitude above the lead levels upstream of the NPDES discharge point.

Supplemental Sediment Sampling and Analysis at Control Site 1. The supplemental sediment sampling and analysis at Control Site 1 (Stump Neck Beaver Pond) indicate that the control site is not overly contaminated with mercury.

5.2 CONCLUSIONS

Mercury. Although the mercury levels in the Site 8 pond are higher than those at the control sites, there does not appear to be a corresponding increase in the mercury levels detected in the fish at Site 8. Preliminary results suggest that the Site 8 fish do not appear to have been significantly impacted by mercury contamination at Site 8.

Lead. Composite samples of fish from the Site 8 pond contained low concentrations of lead (detectable, but too low to be statistically significant), while samples of fish from the two control sites contained low, but measurable, concentrations of lead. Liver tissue from a semi-aquatic species of turtle (*Chrysemys picta*) contained concentrations of lead that appear to be within a normal range, based on limited information in the scientific literature. These preliminary findings suggest that lead contamination at Site 8, is in a form that is not readily bioavailable.

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APPENDIX A

PERIPHYTON SAMPLING RESULTS

TABLE A-1

TRANSECT 1W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Gomphonema	10022	5.2	61.28	0.2
Melosira	4176	2.2	292.88	1.0
Navicula	41758	21.6	1793.15	6.1
Stephanodiscus	835	0.4	61.21	0.2
Synedra	5011	2.6	215.18	0.7
CHLOROPHYTA				
Crucigenia	1670	0.9	14.32	0.0
Spirogyra	111910	58.0	27132.35	91.7
CYANOPHYTA				
Aphanocapsa	15033	7.8	10.45	0.0
CHRYSOPHYTA				
Botrydiopsis	1670	0.9	9.29	0.0
Epipyxis	835	0.4	7.16	0.0
TOTALS	192920	100	29597.27	100
BACILLARIOPHYTA	61802	32.0	2423.7	8.2
CHLOROPHYTA	113580	58.9	27146.67	91.7
CYANOPHYTA	15033	7.8	10.45	0.0
CHRYSOPHYTA	2505	1.3	16.45	0.1

TABLE A-2

TRANSECT 1C
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	19180	7.4	411.82	7.1
Cyclotella	2877	1.1	26.36	0.5
Cymbella	3836	1.5	296.51	5.1
Fragilaria	3426	5.2	528.81	9.1
Gomphonema	5754	2.2	35.19	0.6
Melosira	6713	2.6	470.85	8.1
Navicula	67132	26.0	2882.77	49.9
Synedra	13426	5.2	1123.73	19.4
CHLOROPHYTA				
Mougeotia	22058	8.6	0.37	0.0
Spirogyra	91107	35.3	0.37	0.0
CYANOPHYTA				
Unidentified filamentous	11508	4.5	0.37	0.0
CHRYSOPHYTA				
Chrysosphaera	959	0.4	5.33	0.1
TOTALS	257976	100.0	5782.48	100.0
BACILLARIOPHYTA	132344	51.3	5776.04	99.9
CHLOROPHYTA	113165	43.9	0.74	0.0
CYANOPHYTA	11508	4.5	0.37	0.0
CHRYSOPHYTA	959	0.4	5.33	0.1

TABLE A-3

TRANSECT 1E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	40984	5.2	879.96	2.2
Cymbella	11077	1.4	856.18	2.1
Fragilaria	98583	12.6	3882.81	9.6
Gomphonema	12184	1.6	74.51	0.2
Melosira	47630	6.1	3340.69	8.2
Navicula	167259	21.3	7182.41	17.7
Synedra	22153	2.8	1854.15	4.6
CHLOROPHYTA				
Chlamydomonas	4431	0.6	10.39	0.0
Chlorella	6646	0.8	124.7	0.3
Chlorogonium	1108	0.1	19.49	0.0
Oedogonium	77537	9.9	1454.89	3.6
Spirogyra	79752	10.2	19335.79	47.6
Ulothrix	33230	4.2	1401.14	3.4
CYANOPHYTA				
Aphanocapsa	66460	8.5	46.19	0.1
Chroococcus	2215	0.3	1.54	0.0
Gloeocapsa	27692	3.5	75.78	0.2
Oscillatoria	22153	2.8	23.06	0.1
Unidentified filamentous	55384	7.1	1.8	0.0
CHRYSOPHYTA				
Chrysosphaera	8861	1.1	49.27	0.1
TOTALS	785339	100.0	40614.75	100.0
BACILLARIOPHYTA	399870	50.9	18070.71	44.5
CHLOROPHYTA	202704	25.8	22346.4	55.0
CYANOPHYTA	173904	22.1	148.37	0.4
CHRYSOPHYTA	8861	1.1	49.27	0.1

TABLE A-4

TRANSECT 1 SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	20054.67	4.9	430.59	1.7
Cyclotella	959.00	0.2	8.79	0.0
Cymbella	4971.00	1.2	384.23	1.5
Fragilaria	37336.33	9.1	1470.54	5.8
Gomphonema	9320.00	2.3	56.99	0.2
Melosira	19506.33	4.7	1368.14	5.4
Navicula	92049.67	22.3	3952.78	15.6
Stephanodiscus	278.33	0.1	20.40	0.1
Synedra	13530.00	3.3	1064.35	4.2
CHLOROPHYTA				
Chlamydomonas	1477.00	0.4	3.46	0.0
Chlorella	2215.33	0.5	41.57	0.2
Chlorogonium	369.33	0.1	6.50	0.0
Crucigenia	556.67	0.1	4.77	0.0
Mougeotia	7352.67	1.8	0.12	0.0
Oedogonium	25845.67	6.3	484.96	1.9
Spirogyra	94256.33	22.9	15489.50	61.1
Ulothrix	11076.67	2.7	467.05	1.8
CYANOPHYTA				
Aphanocapsa	27164.33	6.6	18.88	0.1
Chroococcus	738.33	0.2	0.51	0.0
Gloeocapsa	9230.67	2.2	25.26	0.1
Oscillatoria	7384.33	1.8	7.69	0.0
Unidentified filamentous	22297.33	5.4	0.72	0.0

TABLE A-4 (Continued)
TRANSECT 1 SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
CHRYSOPHYTA				
Botrydiopsis	556.67	0.1	3.10	0.0
Chrysosphaera	3273.33	0.8	18.20	0.1
Epipyxis	278.33	0.1	2.39	0.0
TOTALS	412078.33	100.0	25331.50	100.0
BACILLARIOPHYTA	198005.33	48.1	8756.82	34.6
CHLOROPHYTA	143149.67	34.7	16497.94	65.1
CYANOPHYTA	66815.00	16.2	53.06	0.2
CHRYSOPHYTA	4108.33	1.0	23.68	0.1

TABLE A-5

TRANSECT 2W
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	668	2.7	14.35	1.3
Cymbella	334	1.4	25.82	2.4
Frustulia	334	1.4	22.95	2.1
Navicula	16035	64.9	688.57	63.9
Synedra	2338	9.5	195.72	18.2
CHLOROPHYTA				
Chlorella	334	1.4	6.27	0.6
Oedogonium	2004	8.1	115.98	10.8
CYANOPHYTA				
Gloeocapsa	2672	10.8	7.31	0.7
TOTALS	24719	100.0	1076.97	100.0
BACILLARIOPHYTA	19709	79.7	947.41	88.0
CHLOROPHYTA	2338	9.5	122.25	11.4
CYANOPHYTA	2672	10.8	7.31	0.7

TABLE A-6

TRANSECT 2C
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	5512	10.6	118.35	9.3
Cocconeis	580	1.1	5.32	0.4
Cymbella	870	1.7	67.27	5.3
Gomphonema	2901	5.6	17.74	1.4
Navicula	13055	25.1	560.6	43.9
Synedra	5512	10.6	461.33	36.1
CHLOROPHYTA				
Ulothrix	580	1.1	24.46	1.9
CYANOPHYTA				
Chlorogloea	12184	23.5	10.58	0.8
Synechococcus	4642	8.9	0.15	0.0
Unidentified filamentous	5512	10.6	0.18	0.0
CHRYSOPHYTA				
Chrysosphera	290	0.6	1.61	0.1
EUGLENOPHYTA				
Euglena	290	0.6	9.45	0.7
TOTALS	51928	100.0	1277.04	100.0
BACILLARIOPHYTA	28430	54.7	1230.61	96.4
CHLOROPHYTA	580	1.1	24.46	1.9
CYANOPHYTA	22338	43.0	10.91	0.9
CHRYSOPHYTA	290	0.6	1.61	0.1
EUGLENOPHYTA	290	0.6	9.45	0.7

TABLE A-7

TRANSECT 2E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	**Density (cells/cm^2)**	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	1723	10.4	37	7.3
Cymbella	287	1.7	38.05	7.5
Gomphonema	246	1.5	1.51	0.3
Navicula	430	2.6	306.53	60.2
Synedra	287	1.7	63.42	12.4
CHLOROPHYTA				
Chlorella	861	5.2	4.62	0.9
Oedogonium	2152	13.0	56.97	11.2
CYANOPHYTA				
Unidentified filamentous	5452	32.8	0.12	0.0
CHRYSOPHYTA				
Chrysosphaera	5165	31.1	1.37	0.3
TOTALS	16603	100.0	509.59	100.0
BACILLARIOPHYTA	2973	17.9	446.51	87.6
CHLOROPHYTA	3013	18.1	61.59	12.1
CYANOPHYTA	5452	32.8	0.12	0.0
CHRYSOPHYTA	5165	31.1	1.37	0.3

TABLE A-8

TRANSECT 2SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	2634.33	8.5	53.23	5.6
Cocconeis	193.33	0.6	1.77	0.2
Cymbella	497.00	1.6	43.71	4.6
Frustulia	111.33	0.4	7.65	0.8
Gomphonema	1049.00	3.4	6.42	0.7
Navicula	9840.00	31.7	518.57	54.5
Synedra	2712.33	8.7	240.16	25.2
CHLOROPHYTA				
Chlorella	398.33	1.3	3.63	0.4
Oedogonium	1385.33	4.5	57.65	6.1
Ulothrix	193.33	0.6	8.15	0.9
CYANOPHYTA				
Chlorogloea	4061.33	13.1	3.53	0.4
Gloeocapsa	890.67	2.9	2.44	0.3
Synechococcus	1547.33	5.0	0.05	0.0
Unidentified filamentous	3654.67	11.8	0.10	0.0
CHRYSOPHYTA				
Chrysosphaera	1818.33	5.8	0.99	0.1
EUGLENOPHYTA				
Euglena	96.67	0.3	3.15	0.3
TOTALS	31083.33	100.0	951.20	100.0
BACILLARIOPHYTA	17037.33	54.8	871.51	91.6
CHLOROPHYTA	1977.00	6.4	69.43	7.3
CYANOPHYTA	10154.00	32.7	6.11	0.6
CHRYSOPHYTA	1818.33	5.8	0.99	0.1
EUGLENOPHYTA	96.67	0.3	3.15	0.3

TABLE A-9

TRANSECT 3W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m$_2$)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	4343	10.0	93.24	8.4
Cyclotella	1336	3.1	12.24	1.1
Fragilaria	668	1.5	26.31	2.4
Frustulia	668	1.5	45.9	4.1
Melosira	5345	12.3	374.89	33.8
Navicula	8352	19.2	358.63	32.3
Synedra	1670	3.8	139.8	12.6
CHLOROPHYTA				
Oedogonium	1002	2.3	57.99	5.2
CYANOPHYTA				
Synechococcus	5011	11.5	0.16	0.0
Unidentified filamentous	15033	34.6	0.49	0.0
TOTALS	43428	100.0	1109.65	100.0
BACILLARIOPHYTA	22382	51.5	1051.01	94.7
CHLOROPHYTA	1002	2.3	57.99	5.2
CYANOPHYTA	20044	46.2	0.65	0.1

TABLE A-10

TRANSECT 3C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	10971	13.8	235.56	8.1
Gomphonema	4642	5.8	28.38	1.0
Melosira	844	1.1	59.19	2.0
Navicula	21942	27.5	942.25	32.3
Synedra	8439	10.6	706.34	24.2
CHLOROPHYTA				
Chlamydomonas	422	0.5	0.99	0.0
Oedogonium	16035	20.1	927.81	31.8
CYANOPHYTA				
Chlorogloea	12659	15.9	11.0	0.4
Unidentified filamentous	3376	4.2	0.11	0.0
CHRYSOPHYTA				
Epipyxis	422	0.5	3.62	0.1
TOTALS	79752	100.0	2915.25	100.0
BACILLARIOPHYTA	46838	58.7	1971.72	67.6
CHLOROPHYTA	16457	20.6	928.8	31.9
CYANOPHYTA	16035	20.1	11.11	0.4
CHRYSOPHYTA	422	0.5	3.62	0.1

TABLE A-11

TRANSECT 3E
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	601	0.8	46.48	1.3
Diatomella	601	0.8	94.12	2.5
Gomphonema	10824	14.5	66.19	1.8
Melosira	17438	23.4	1223.07	33.1
Navicula	25856	34.7	1110.32	30.0
Nitzschia	601	0.8	53.02	1.4
Stephanodiscus	601	0.8	44.07	1.2
Surirella	601	0.8	12.91	0.3
Synedra	11425	15.3	956.21	25.9
CHLOROPHYTA				
Chlorella	4209	5.6	78.98	2.1
CHRYSOPHYTA				
Chrysosphaera	1203	1.6	6.69	0.2
Epipyxis	601	0.8	5.16	0.1
TOTALS	74561	100.0	3697.22	100.0
BACILLARIOPHYTA	68548	91.9	3606.39	97.5
CHLOROPHYTA	4209	5.6	78.98	2.1
CHRYSOPHYTA	1804	2.4	11.85	0.3

TABLE A-12

TRANSECT 3SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	5104.67	7.7	109.60	4.3
Cyclotella	445.33	0.7	4.08	0.2
Cymbella	200.33	0.3	15.49	0.6
Diatomella	200.33	0.3	31.37	1.2
Fragilaria	222.67	0.3	8.77	0.3
Frustulia	222.67	0.3	15.30	0.6
Gomphonema	5155.33	7.8	31.52	1.2
Melosira	7875.67	11.9	552.38	21.5
Navicula	18716.67	28.4	803.73	31.2
Nitzschia	200.33	0.3	17.67	0.7
Stephanodiscus	200.33	0.3	14.69	0.6
Surirella	200.33	0.3	4.30	0.2
Synedra	7178.00	10.9	600.78	23.3
CHLOROPHYTA				
Chlamydomonas	140.67	0.2	0.33	0.0
Chlorella	1403.00	2.1	26.33	1.0
Oedogonium	5679.00	8.6	328.60	12.8
CYANOPHYTA				
Chlorogloea	4219.67	6.4	3.67	0.1
Synechococcus	1670.33	2.5	0.05	0.0
Unidentified filamentous	6136.33	9.3	0.20	0.0

TABLE A-12 (Continued)
TRANSECT 3SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
CHRYSOPHYTA				
Chrysosphaera	401.00	0.6	2.23	0.1
Epipyxis	341.00	0.5	2.93	0.1
TOTALS	65913.67	100.0	2574.04	100.0
BACILLARIOPHYTA	45922.67	69.7	2209.71	85.8
CHLOROPHYTA	7222.67	11.0	355.26	13.8
CYANOPHYTA	12026.33	18.2	3.92	0.2
CHRYSOPHYTA	742.00	1.1	5.16	0.2

TABLE A-13

TRANSECT 4W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	369	5.1	7.93	7.8
Melosira	554	7.7	38.85	38.1
Navicula	923	12.8	39.64	38.8
Synedra	185	2.6	15.45	15.1
CYANOPHYTA				
Unidentified filamentous	5169	71.8	0.17	0.2
TOTALS	7200	100.0	102.04	100.0
BACILLARIOPHYTA	2031	28.2	101.87	99.8
CYANOPHYTA	5169	71.8	0.17	0.2

TABLE A-14

TRANSECT 4C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	277	9.1	5.95	4.4
Cymbella	277	9.1	21.4	15.8
Navicula	1385	45.5	59.46	43.9
Synedra	554	18.2	46.35	34.2
CHLOROPHYTA				
Chlamydomonas	277	9.1	0.65	0.5
CHRYSOPHYTA				
Chrysosphaera	277	9.1	1.54	1.1
TOTALS	3047	100.0	135.35	100.0
BACILLARIOPHYTA	2493	81.8	133.16	98.4
CHLOROPHYTA	277	9.1	0.65	0.5
CHRYSOPHYTA	277	9.1	1.54	1.1

TABLE A-15

TRANSECT 4E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	1055	17.9	22.65	7.9
Cymbella	211	3.6	16.31	5.7
Diatomella	211	3.6	33.02	11.5
Frustulia	633	10.7	43.49	15.1
Melosira	844	14.3	59.19	20.6
Navicula	1055	17.9	45.3	15.7
CHLOROPHYTA				
Chlorella	633	10.7	11.88	4.1
CHRYSOPHYTA				
Chrysosphaera	1055	17.9	5.87	2.0
PYRROPHYTA				
Peridinium	211	3.6	50.29	17.5
TOTALS	5908	100.0	288	100.0
BACILLARIOPHYTA	4009	67.9	219.96	76.4
CHLOROPHYTA	633	10.7	11.88	4.1
CHRYSOPHYTA	1055	17.9	5.87	2.0
PYRROPHYTA	211	3.6	50.29	17.5

TABLE A-16

TRANSECT 4 SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Mean Density (cells/cm^2)	Relative Abundance (%)	Mean Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	567.00	10.5	12.18	7.0
Cymbella	162.67	3.0	12.57	7.2
Diatomella	70.33	1.3	11.01	6.3
Frustulia	211.00	3.9	14.50	8.3
Melosira	466.00	8.7	32.68	18.7
Navicula	1121.00	20.8	48.13	27.5
Synedra	246.33	4.6	20.60	11.8
CHLOROPHYTA				
Chlamydomonas	92.33	1.7	0.22	0.1
Chlorella	211.00	3.9	3.96	2.3
CYANOPHYTA				
Unidentified filamentous	1723.00	32.0	0.06	0.0
CHRYSOPHYTA				
Chrysosphaera	444.00	8.2	2.47	1.4
PYRROPHYTA				
Peridinium	70.33	1.3	16.76	9.6
TOTALS	5385.00	100.0	175.13	100.0
BACILLARIOPHYTA	2844.33	52.8	151.66	86.6
CHLOROPHYTA	303.33	5.6	4.18	2.4
CYANOPHYTA	1723.00	32.0	0.06	0.0
CHRYSOPHYTA	444.00	8.2	2.47	1.4
PYRROPHYTA	70.33	1.3	16.76	9.6

TABLE A-17

CONTROL SITE 1(BEAVER POND TRANSECT W)
PERIPHYTON SAMPLING RESULTS
SITE 8- NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	1013	3.9	21.74	1.3
Melosira	1013	3.9	71.03	4.1
Navicula	2363	9.2	101.47	5.9
Pinnularia	338	1.3	86.25	5.0
Synedra	2363	9.2	94.71	5.5
CHLOROPHYTA				
Chlamydomonas	2701	10.5	6.33	0.4
Chlorella	2363	9.2	44.34	2.6
Chlorogonium	675	2.6	11.88	0.7
Gloeocystis	3038	11.8	57.01	3.3
Mougeotia	3038	11.8	1028	59.6
Scenedesmus	1350	5.3	2.93	0.2
CHRYSOPHYTA				
Epipyxis	2025	7.9	17.37	1.0
Ochromonas	338	1.3	1.88	0.1
Ophiocytium	2701	10.5	60.06	3.5
EUGLENOPHYTA				
Trachelomonas	338	1.3	120.12	7.0
TOTALS	25657	100.0	1725.12	100.0
BACILLARIOPHYTA	7090	27.6	375.2	21.7
CHLOROPHYTA	13165	51.3	1150.49	66.7
CHRYSOPHYTA	5064	19.7	79.31	4.6
EUGLENOPHYTA	338	1.3	120.12	7.0

TABLE A-18

CONTROL SITE 1 (1 BEAVER POND TRANSECT C)
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Melosira	554	0.9	38.85	2.8
Navicula	2215	3.5	95.13	6.8
Synedra	1662	2.6	139.06	9.9
CHLOROPHYTA				
Chlorella	2769	4.4	51.96	3.7
Chlorogonium	554	0.9	9.74	0.7
Ulothrix	17169	27.2	723.92	51.6
CYANOPHYTA				
Unidentified filamentous	17169	27.2	0.56	0.0
CHRYSOPHYTA				
Chrysosphaera	4431	7.0	24.63	1.8
Epipyxis	3877	6.1	33.25	2.4
Gloeobotrys	8861	14.0	49.27	3.5
Ophiocytium	3323	5.3	73.9	5.3
PYRROPHYTA				
Hemidinium	554	0.9	162.38	11.6
TOTALS	63138	100.0	1402.65	100.0
BACILLARIOPHYTA	4431	7.0	273.04	19.5
CHLOROPHYTA	20492	32.5	785.62	56.0
CYANOPHYTA	17169	27.2	0.56	0.0
CHRYSOPHYTA	20492	32.5	181.05	12.9
PYRROPHYTA	554	0.9	162.38	11.6

TABLE A-19

CONTROL SITE 1 (BEAVER POND TRANSECT E)
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

APRIL 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Frustulia	501	1.3	34.43	0.2
Navicula	2505	6.6	107.59	0.5
Pinnularia	1002	2.6	256.06	1.2
Surirella	1002	2.6	43.04	0.2
Synedra	2505	6.6	209.7	1.0
CHLOROPHYTA				
Chlorella	2004	5.3	37.61	0.2
Gloeocystis	5011	13.2	11.75	0.1
Ulothrix	12026	31.6	507.08	2.4
CYANOPHYTA				
Unidentified filamentous	4009	10.5	0.13	0.0
CHRYSOPHYTA				
Chrysosphaera	501	1.3	2.79	0.0
Diceras	501	1.3	19751.46	92.6
Epipyxis	3007	7.9	25.78	0.1
Ophiocytium	2505	6.6	55.72	0.3
PYRROPHYTA				
Cystodinium	1002	2.6	293.82	1.4
TOTALS	38081	100.0	21336.96	100.0
BACILLARIOPHYTA	7515	19.7	650.82	3.1
CHLOROPHYTA	19041	50.0	556.44	2.6
CYANOPHYTA	4009	10.5	0.13	0.0
CHRYSOPHYTA	6514	17.1	19835.75	93.0
PYRROPHYTA	1002	2.6	293.82	1.4

TABLE A-20

CONTROL SITE 1 (BEAVER POND TRANSECT) SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

April 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Achnanthes	337.67	0.8	7.25	0.1
Frustulia	167.00	0.4	11.48	0.1
Melosira	522.33	1.2	36.63	0.4
Navicula	2361.00	5.6	101.40	1.2
Pinnularia	446.67	1.1	114.10	1.4
Surirella	334.00	0.8	14.35	0.2
Synedra	2176.67	5.1	147.82	1.8
CHLOROPHYTA				
Chlamydomonas	900.33	2.1	2.11	0.0
Chlorella	2378.67	5.6	44.64	0.5
Chlorogonium	409.67	1.0	7.21	0.1
Gloeocystis	2683.00	6.3	22.92	0.3
Mougeotia	1012.67	2.4	342.67	4.2
Scenedesmus	450.00	1.1	0.98	0.0
Ulothrix	9731.67	23.0	410.33	5.0
CYANOPHYTA				
Unidentified filamentous	7059.33	16.7	0.23	0.0
CHRYSOPHYTA				
Chrysosphaera	1644.00	3.9	9.14	0.1
Diceras	167.00	0.4	6583.82	80.7
Epipyxis	2969.67	7.0	25.47	0.3
Gloeobotrys	2953.67	7.0	16.42	0.2
Ochromonas	112.67	0.3	0.63	0.0
Ophiocytium	2843.00	6.7	63.23	0.8

TABLE A-20 (Continued)
CONTROL SITE 1 (BEAVER POND TRANSECT) SUMMARY
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

April 1994				
Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
EUGLENOPHYTA				
Trachelomonas	112.67	0.3	40.04	0.5
PYRROPHYTA				
Cystodinium	334.00	0.8	97.94	1.2
Hemidinium	184.67	0.4	54.13	0.7
TOTALS	42292.00	100.08	154.91	100.0
BACILLARIOPHYTA	6345.33	15.0	433.02	5.3
CHLOROPHYTA	17566.00	41.5	830.85	10.2
CYANOPHYTA	7059.33	16.7	0.23	0.0
CHRYSOPHYTA	10690.00	25.3	6698.70	82.1
EUGLENOPHYTA	112.67	0.3	40.04	0.5
PYRROPHYTA	518.67	1.2	152.07	1.9

APPENDIX B

BENTHIC MACROINVERTEBRATE SAMPLING RESULTS

TABLE B-1

BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 1					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta	878 (48.2)	95 (68.3)	38 (100)	19 (65.5)	197 (68.1)	278 (89.1)
Branchiura sp.		13 (9.4)			63 (21.8)	5 (1.6)
Polychaeta	19 (1.0)					
Hirudinea						
Asellus sp.	98 (5.4)					
Gammarus sp.	493 (27.1)					
Ephemerella sp.	26 (1.4)					
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.	42 (2.3)					
Calopteryx sp.	6 (0.3)					
Hemiptera						
Notonecta undulata	3 (0.2)					
Sialis sp.						
Trichoptera						
Dysticidae	6 (0.3)					
Diptera (adult)						
Diptera (larvae)		6 (4.3)				
Culex sp.						
Chironomidae	228 (12.5)	25 (18.0)		10 (34.5)	29 (10.0)	29 (9.3)
Helisoma sp.	6 (0.3)					
Gyraulus sp.	3 (0.2)					
Ferrissia sp.						
Lymnaea sp.						
Physa sp.						
Physella sp.	6 (0.3)					
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.	6.0 (0.3)					
Totals	1820	139	38	29	289	312

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 2					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta	615 (77.8)	273 (86.4)	48 (76.2)	342 (79.9)	29 (54.7)	352 (89.1)
Branchiura sp.		38 (12.0)	5 (7.9)	38 (8.9)		24 (6.1)
Polychaeta	24 (3.0)					
Hirudinea						
Asellus sp.	15 (1.9)					
Gammarus sp.	10 (1.3)					
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.	5 (0.6)					
Calopteryx sp.						
Hemiptera						
Notonecta undulata	10 (1.3)					
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)	5 (0.6)				5 (9.4)	
Culex sp.						
Chironomidae	101 (12.8)	5 (1.6)	10 (15.9)	48 (11.2)	19 (35.8)	19 (4.8)
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.						
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.	5 (0.6)					
Totals	790	316	63	428	53	395

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 3					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta	962 (93.4)	57 (50.0)	306 (96.8)	95 (62.1)	38 (65.5)	295 (88.6)
Branchiura sp.		38 (33.3)	10 (3.2)	10 (6.5)	10 (17.2)	38 (11.4)
Polychaeta						
Hirudinea	10 (1.0)					
Asellus sp.						
Gammarus sp.						
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.	10 (1.0)					
Calopteryx sp.						
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)		19 (16.7)				
Culex sp.						
Chironomidae	48 (4.7)			48 (31.4)	10 (17.2)	
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.						
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.						
Totals	1030	114	316	153	58	333

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 4					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta	1000 (86.0)	345 (85.8)	278 (100)	95 (90.5)	77 (100)	532 (94.8)
Branchiura sp.						
Polychaeta						
Hirudinea						
Asellus sp.						
Gammarus sp.	29 (2.5)					
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						10 (1.8)
Sympetrum sp.						
Gomphus sp.	19 (1.6)					
Calopteryx sp.						
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)						
Culex sp.						
Chironomidae	96 (8.3)	57 (14.2)		10 (9.5)		19 (3.4)
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.						
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.	19 (1.6)					
Totals	1163	402	278	105	77	561

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 5					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta	3058 (85.5)	1235 (96.3)	316 (100)	191 (86.8)	135 (93.1)	171 (100)
Branchiura sp.		10 (<1.0)			10 (6.9)	
Polychaeta						
Hirudinea	77 (2.2)					
Asellus sp.						
Gammarus sp.						
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.						
Calopteryx sp.						
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)	19 (0.4)	19 (1.5)				
Culex sp.						
Chironomidae	77 (2.2)			29 (13.2)		
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.		19 (1.5)				
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.	347 (9.7)					
Totals	3578	1283	316	220	145	171

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 7					
	Jan 93*	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta		96 (83.5)	134 (100)	86 (69.4)	625 (95.6)	656 (87.4)
Branchiura sp.						
Polychaeta						
Hirudinea						
Asellus sp.						
Gammarus sp.						
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.						
Calopteryx sp.						
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)						
Culex sp.						
Chironomidae				38 (30.6)	29 (4.4)	95 (12.6)
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.		19 (16.5)				
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.						
Totals	0	115	134	124	654	751

* This location was not sampled in January 1993.

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 10					
	Jan 93	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planarlidae						
Nematoda						
Oligochaeta	3178 (84.0)	431 (91.9)	468 (97.9)	48 (36.1)	371 (97.4)	855 (97.7)
Branchiura sp.					10 (2.6)	10 (1.1)
Polychaeta						
Hirudinea						
Asellus sp.						
Gammarus sp.						
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						10 (1.1)
Sympetrum sp.						
Gomphus sp.						
Calopteryx sp.						
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)						
Culex sp.						
Chironomidae				85 (63.9)		
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.		38 (38.1)				
Physella sp.	39 (1.0)					
Unionidae						
Corbicula sp.	19 (0.5)					
Pisidium sp.	506 (13.4)					
Sphaerium sp.	41 (1.0)		10 (2.1)			
Totals	3783	469	478	133	381	875

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	CONTROL SITE 1 (STUMP NECK BEAVER POND)					
	Jan 93*	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae			19 (1.9)			
Nematoda						
Oligochaeta		326 (84.9)	832 (82.0)	67 (69.1)	1049 (90.7)	1178 (81.0)
Branchiura sp.						
Polychaeta						
Hirudinea						
Asellus sp.						
Gammarus sp.				10 (10.3)	19 (1.6)	10 (0.7)
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						10 (0.7)
Sympetrum sp.						10 (0.7)
Gomphus sp.				10 (10.3)		
Calopteryx sp.				10 (10.3)		
Hemiptera						
Notonecta undulata						
Sialis sp.						
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)		10 (2.6)			10 (<1.0)	
Culex sp.						
Chironomidae		19 (4.9)	163 (16.1)		39 (3.4)	228 (15.7)
Helisoma sp.		29 (7.6)				
Gyraulus sp.						
Ferrissia sp.						
Lymnaea sp.						
Physa sp.						
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.					29 (2.5)	19 (1.3)
Totals	0	384	1014	97	1156	1455

* This station was not sampled in January 1993.

TABLE B-1 (Continued)
BENTHIC MACROINVERTEBRATES
DENSITY (NO./m^2) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	CONTROL SITE 2 (MATTAWOMAN CREEK)					
	Jan 93*	Apr 93	Jul 93	Oct 93	Jan 94	Apr 94
Hymanella sp.						
Planariidae						
Nematoda						
Oligochaeta		10 (3.0)	192 (50.0)	10 (5.5)	981 (60.7)	257 (74.9)
Branchiura sp.						
Polychaeta						
Hirudinea						
Asellus sp.						
Gammarus sp.			10 (2.6)	10 (5.5)	10 (<1.0)	57 (16.6)
Ephemerella sp.						
Helocordulia sp.						
Plathemis sp.						
Sympetrum sp.						
Gomphus sp.						
Calopteryx sp.				10 (5.5)	10 (<1.0)	
Hemiptera						
Notonecta undulata						
Sialis sp.			10 (2.6)	10 (5.5)	10 (<1.0)	
Trichoptera						
Dysticidae						
Diptera (adult)						
Diptera (larvae)						
Culex sp.						
Chironomidae		326 (97.0)	172 (44.8)	143 (78.1)	576 (35.6)	29 (8.5)
Helisoma sp.						
Gyraulus sp.						
Ferrissia sp.					10 (<1.0)	
Lymnaea sp.					10 (<1.0)	
Physa sp.						
Physella sp.						
Unionidae						
Corbicula sp.						
Pisidium sp.						
Sphaerium sp.					10 (<1.0)	
Totals	0	336	384	183	1617	343

*This station was not sampled in January 1993.

APPENDIX C

ANALYTICAL RESULTS OF SUPPLEMENTAL SEDIMENT SAMPLING

GP Work Order # 9405173

SAMPLE ANALYSIS REPORT

Prepared For:

Halliburton NUS
661 Andersen Drive
Pittsburgh, PA 15220

CTO-117 INDIAN HEAD-NSWC

Prepared By:

GP Environmental Services, Inc.
202 Perry Parkway
Gaithersburg, Maryland 20877

June 14, 1994

for Albert Ellis, Laboratory Director

GP ENVIRONMENTAL SERVICES
ANALYTICAL RESULTS

roject: CTO-117 INDIAN HEAD-NSWC

Halliburton NUS
61 Andersen Drive
Pittsburgh, PA 15220
Atten: J.D. Chu

GP ENVIRONMENTAL SERVICES
202 Perry Parkway
Gaithersburg, MD 20877

Atten: Client Services
Phone: (301) 926-6802

Certified by:

SAMPLE IDENTIFICATION

GP ID	Client ID
9405173-01A	SO-400-00/01
9405173-02A	SO-401-00/01
9405173-03A	SO-402-00/01
9405173-04A	SO-403-00/01
9405173-05A	SO-404-00/01
9405173-06A	SO-405-00/01
9405173-07A	SO-406-00/01
9405173-08A	SO-407-00/01
9405173-09A	SO-408-00/01
9405173-10A	SO-409-00/01
9405173-11A	SO-410-00/01
9405173-12A	SO-411-00/01
9405173-13A	SO-412-00/01
9405173-14A	SO-413-00/01
9405173-15A	SO-500
9405173-16A	SO-501
9405173-17A	SO-502
9405173-18A	SO-503

GP ENVIRONMENTAL SERVICES
METALS ANALYSIS RESULTS

GP ID: 9405173-01
Client ID: SO-400-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	236.0	13.9	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-02
Client ID: SO-401-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	163.0	11.3	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-03
Client ID: SO-402-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	246.0	11.5	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-04
Client ID: SO-403-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	220.0	14.5	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-05
Client ID: SO-404-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	199.0	9.59	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-06
Client ID: SO-405-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	704.0	30.7	mg/Kg	50	06/08/94	06/09/94 FU

GP ENVIRONMENTAL SERVICES
METALS ANALYSIS RESULTS

GP ID: 9405173-07 Matrix: SOIL
Client ID: SO-406-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	196.0	16.1	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-08 Matrix: SOIL
Client ID: SO-407-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	811.0	31.2	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-09 Matrix: SOIL
Client ID: SO-408-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	780.0	20.9	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-10 Matrix: SOIL
Client ID: SO-409-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	491.0	22.6	mg/Kg	50	06/08/94	06/09/94 FU

GP ID: 9405173-11 Matrix: SOIL
Client ID: SO-410-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	40.6	2.71	mg/Kg	10	06/08/94	06/09/94 FU

GP ID: 9405173-12 Matrix: SOIL
Client ID: SO-411-00/01 Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	73.0	5.02	mg/Kg	20	06/08/94	06/09/94 FU

GP ENVIRONMENTAL SERVICES
METALS ANALYSIS RESULTS

GP ID: 9405173-13
Client ID: SO-412-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	79.2	5.38	mg/Kg	20	06/08/94	06/09/94 FU

GP ID: 9405173-14
Client ID: SO-413-00/01

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Lead	SW846 7421	6.73	0.162	mg/Kg	1	06/08/94	06/24/94 RA

GP ID: 9405173-15
Client ID: SO-500

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Mercury	SW846 7471	BQL	0.086	mg/Kg	1	06/13/94	06/13/94 DH

GP ID: 9405173-16
Client ID: SO-501

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Mercury	SW846 7471	BQL	0.064	mg/Kg	1	06/13/94	06/13/94 DH

GP ID: 9405173-17
Client ID: SO-502

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Mercury	SW846 7471	BQL	0.066	mg/Kg	1	06/13/94	06/13/94 DH

GP ID: 9405173-18
Client ID: SO-503

Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Mercury	SW846 7471	BQL	0.091	mg/Kg	1	06/13/94	06/13/94 DH

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9405173-01
Client ID: SO-400-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	28.8		%			06/12/94 MG

GP ID: 9405173-02
Client ID: SO-401-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	35.3		%			06/12/94 MG

GP ID: 9405173-03
Client ID: SO-402-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	34.8		%			06/12/94 MG

GP ID: 9405173-04
Client ID: SO-403-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	27.6		%			06/12/94 MG

GP ID: 9405173-05
Client ID: SO-404-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	41.7		%			06/12/94 MG

GP ID: 9405173-06
Client ID: SO-405-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	32.6		%			06/12/94 MG

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9405173-07
Client ID: SO-406-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	24.8		%			06/12/94 MG

GP ID: 9405173-08
Client ID: SO-407-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	12.8		%			06/12/94 MG

GP ID: 9405173-09
Client ID: SO-408-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	19.1		%			06/12/94 MG

GP ID: 9405173-10
Client ID: SO-409-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	44.2		%			06/12/94 MG

GP ID: 9405173-11
Client ID: SO-410-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	73.9		%			06/12/94 MG

GP ID: 9405173-12
Client ID: SO-411-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	79.6		%			06/12/94 MG

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9405173-13
Client ID: SO-412-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	74.3		%			06/12/94 MG

GP ID: 9405173-14
Client ID: SO-413-00/01
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	74.1		%			06/12/94 MG

GP ID: 9405173-15
Client ID: SO-500
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	57.8		%			06/12/94 MG

GP ID: 9405173-16
Client ID: SO-501
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	78.2		%			06/12/94 MG

GP ID: 9405173-17
Client ID: SO-502
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	75.4		%			06/12/94 MG

GP ID: 9405173-18
Client ID: SO-503
Matrix: SOIL
Collected: 05/18/94

Parameter	Method	Result	Det.Lim.	Units	Dil.	Prepared	Analyzed By
Percent Solids	MCAWW 160.3	54.9		%			06/12/94 MG

GP ENVIRONMENTAL SERVICES

Possible notes and definitions for this report:

BQL = Below Quantitation Limit

J = An estimated value, below method detection limit

B = Indicates that the compound was found in the associated blank

E = Indicates that the concentration exceeded the calibration range of the instrument

U = Indicates that the compound was analyzed for but not detected, number indicates the detection limit

D = Indicates that the compound was found in a analysis at a secondary dilution factor

* = Value obtained from a 1:5 dilution

+ = Value obtained from a 1:10 dilution

= = Value obtained from a 1:20 dilution

^ = Value obtained from a 1:50 dilution

– = Value obtained from a 1:100 dilution

! = Value obtained from a 1:250 dilution

G = Value obtained from a 1:125 dilution (Medium Level)

S = Value obtained from a 1:4000 dilution

& = Value obtained from a 1:10000 dilution

N = Flashpoint not observed; heated to specified limit

R = Flammable at room temperature

TNTC = Too numerous to count

B.P. = Detection limit taken from boiling point

F.F. = Sample gave off flammable fumes

05-173

P ENV. NMENTAL SERVICES, INC.

202 Perry Parkway
Gaithersburg, Maryland 20877
(301) 926-6802

Contract #/Billing Reference: _____

1 of _____ Pgs.

Project: CTO-117 supplemental sample
Client: INDIAN HEAD - NSWC
Send Results To: TONY Klimek (HNUS)
Address: 661 ANDERSEN Drive
Pittsburgh, PA 15220
Phone: (412) 921-7090

Turnaround Time: 28 day
# of Container: 1
Container Type: 4oz Glass
Preservative Used: —
Type of Analysis: Lead

Sample ID#	Date	Time	Sample Matrix	Sampler's Initials	Lead	CLIENT COMMENTS
SO-400-00/01	5/18	12:15	Soil	RB	✓	
SO-401-00/01	5/18	12:20	Soil	RB	✓	
SO-402-00/01	5/18	12:00	Soil	RB	✓	
SO-403-00/01	5/18	12:00	Soil	RB	✓	
SO-404-00/01	5/18	12:00	Soil	RB	✓	
SO-405-00/01	5/18	11:45	Soil	RB	✓	
SO-406-00/01	5/18	11:30	Soil	RB	✓	
SO-407-00/01	5/18	12:50	Soil	RB	✓	
SO-408-00/01	5/18	12:55	Soil	RB	✓	
SO-409-00/01	5/18	1:30	Soil	RB	✓	
SO-410-00/01	5/18	1:25	Soil	RB	✓	
SO-411-00/01	5/18	1:25	Soil	RB	✓	

Relinquished By:	Date/Time	Received By:	Relinquished By:	Received for Laboratory By:	Date/Time
[signature]	5/18 5:20			[signature]	5/20/94 1:30

Relinquished By:	Date/Time	Received By:	Date/Time	Shipper:	Airbill No.:

Relinquished By:	Date/Time	Received By:	Lab Comments:	Temp:
				19 °C

;P ENVIRONMENTAL SERVICES, INC.

202 Perry Parkway
Gaithersburg, Maryland 20877
(301) 926-6802

Contract #/Billing Reference

Project: CTO-117
Client: Indian Head
Send Results To: HNUS
Address: C/o Tony Klimek
Phone:

Sample ID#	Date	Time	Sample Matrix	Sampler's Initials	Lead	Mercury	CLIENT COMMENTS
Turnaround Time					28 day		
# of Container					1		
Container Type					4oz glass		
Preservative Used							
Type of Analysis							
SO-412-0/1	5/18	1:15	Soil	RS	✓		
SO-413-0/1	5/18	1:10	Soil	RS	✓		
SO-500	5/18	4:30	Soil	RS		✓	
SO-501	5/18	4:50	Soil	RS		✓	
SO-502	5/18	5:05	Soil	RS		✓	
SO-503	5/18	5:05	Soil	RS		✓	

Relinquished By:	Date/Time	Received By:	Relinquished By:	Received for Laboratory By:	Date/Time
[signature]	5/18 5:20			[signature]	5/6/94 1:30

Relinquished By:	Date/Time	Received By:	Date/Time	Shipper:	Airbill No.:

Relinquished By:	Date/Time	Received By:	Lab Comments:	Temp:
				19°c