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Engineering Evaluation/ Cost Analysis (EE/CA) Report

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 0064

January 1993

HALLIBURTON NUS
Environmental Corporation

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ENGINEERING EVALUATION/ COST ANALYSIS (EE/CA) REPORT 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	SITE DESCRIPTION	1-2
1.2	PROJECT BACKGROUND	1-6
1.3	ANALYTICAL DATA	1-7
1.3.1	Upper Section of Stream	1-9
1.3.2	TCLP Analytical Results	1-12
1.3.3	Background Mercury Concentrations in Sediment/Soil	1-12
1.3.4	Surface Water	1-17
1.4	BIOMONITORING PROGRAM AT SITE 8	1-17
2.0	**IMPACTS OF MERCURY CONTAMINATION AT SITE 8**	**2-1**
2.1	HUMAN HEALTH IMPACTS	2-1
2.1.1	Direct Human Exposure to Mercury at Site 8	2-3
2.1.2	Indirect Human Exposure to Mercury at Site 8	2-4
2.2	ECOLOGICAL IMPACT	2-5
2.2.1	Aquatic Ecosystems	2-6
2.2.2	Terrestrial Ecosystems	2-7
2.3	SUMMARY OF MERCURY IMPACTS AT SITE 8	2-7
3.0	**REMOVAL ACTION OBJECTIVE**	**3-1**
3.1	REMOVAL ACTION SCHEDULE	3-2
3.2	ARARs AND TBC CRITERIA	3-2
3.2.1	Classification of Mercury-Contaminated Soil	3-4
3.3	REMOVAL ACTION OBJECTIVE AND RATIONALE	3-10
4.0	**REMOVAL ACTION ALTERNATIVES**	**4-1**
4.1	ALTERNATIVE 1: NO ACTION	4-1
4.2	ALTERNATIVE 2: NO ACTION WITH BIOMONITORING	4-1
4.3	ALTERNATIVE 3: RIPRAP STREAM AND BIOMONITORING	4-2
4.4	ALTERNATIVE 4: EXCAVATE AND STABILIZE WITH BIOMONITORING	4-2
4.5	ALTERNATIVE 5: EXCAVATE AND DISPOSE OFFSITE WITH BIOMONITORING	4-4
5.0	**ANALYSIS OF REMOVAL ACTION ALTERNATIVES**	**5-1**
5.1	ALTERNATIVE 1: NO ACTION	5-2
5.2	ALTERNATIVE 2: NO ACTION WITH BIOMONITORING	5-2
5.3	ALTERNATIVE 3: RIPRAP STREAM AND BIOMONITORING	5-3
5.4	ALTERNATIVE 4: EXCAVATE AND STABILIZE WITH BIOMONITORING	5-4
5.5	ALTERNATIVE 5: EXCAVATE AND DISPOSE OFFSITE WITH BIOMONITORING	5-4
6.0	**SUMMARY AND RECOMMENDED ALTERNATIVES**	**6-1**
6.1	SUMMARY OF ALTERNATIVE ANALYSIS	6-1
6.2	RECOMMENDED ALTERNATIVES	6-5
REFERENCES		

TABLE OF CONTENTS (Continued)

SECTION

APPENDICES

A REPORT ON OCTOBER 1992 BIOMONITORING

B CALCULATION SHEETS

C EXHIBITS

C-1 Site 8 - Nitroglycerin Plant Office - Site Plan
C-2 Site 8 - Nitroglycerin Plant Office - Contaminant Occurrence and Distribution in Upper Section of Stream
C-3 Site 8 - Nitroglycerin Plant Office - Sediment/Soil Sampling Locations and Areas of Elevated Mercury Concentrations

TABLE OF CONTENTS (Continued)

TABLES

NUMBER		PAGE
1-1	SEDIMENTATION/SOIL ANALYTICAL SUMMARY	1-8
1-2	SEDIMENT/SOIL ANALYTICAL RESULTS, UPPER SECTION OF STREAM	1-10
1-3	SEDIMENT/SOIL ANALYTICAL RESULTS TCLP METALS	1-13
1-4	SURFACE WATER ANALYTICAL RESULTS TAL METALS	1-14
1-5	BACKGROUND SEDIMENT/SOIL ANALYTICAL RESULTS	1-16
1-6	SURFACE WATER ANALYTICAL RESULTS	1-18
3-1	CONTAMINANT-SPECIFIC ARARs AND TBCs	3-5
3-2	LOCATION-SPECIFIC ARARs AND TBCs	3-7
3-3	ACTION-SPECIFIC ARARs AND TBCs	3-8
6-1	COMPARISON OF ALTERNATIVES FOR EFFECTIVENESS	6-2
6-2	COMPARISON OF ALTERNATIVES FOR IMPLEMENTABILITY	6-3
6-3	SUMMARY OF ESTIMATED COSTS FOR ALTERNATIVES	6-4

FIGURES

NUMBER		PAGE
1-1	SITE LOCATION MAP	1-3

1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order Number 0064 (CTO 0064) to Halliburton NUS Environmental Corporation (Halliburton NUS), under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. CTO 0064 is for environmental investigative work at the Navy Installation Restoration Program Site 8 - Nitroglycerin Plant Office (Installation Restoration Site 8), at the Indian Head Division, Naval Surface Warfare Center, (IHDIVNAVSURFWARCEN or NSWC) in Indian Head, Maryland. NSWC is in the Chesapeake Division (CHESDIV) of the Naval Facilities Engineering Command. CTO 0064 consists of tasks to: (1) investigate mercury contamination in the sediment/soils and surface water in and around Installation Restoration Site 8 to define the extent of contamination; (2) perform an Engineering Evaluation/Cost Analysis (EE/CA) to support interim removal action if necessary; and (3) develop and begin implementation of a Biomonitoring Program to assess the extent of mercury contamination in the biota of the Installation Restoration Site 8 Tidal Pond/Marsh Area as well as evaluate the potential ecological impacts of any interim removal action.

An engineering evaluation/cost analysis (EE/CA) is a comparative analysis of non-time-critical removal action options. The EE/CA process is a procedure to develop, evaluate, and select a removal action. Halliburton NUS has prepared this EE/CA report to present the results of the EE/CA process that was performed by Halliburton NUS. This EE/CA report is based on the results of the sampling and analysis work that was performed by Halliburton NUS in August and September 1992. The results of that sampling and analysis are summarized in the Site Characterization Report that was issued by Halliburton NUS in October 1992. The work performed by Halliburton NUS under CTO 64 includes a Biomonitoring Program. The result of the first round of biomonitoring (October 1992) performed under that program are presented in Appendix A of this EE/CA Report.

According to a Draft EE/CA Guidance Document for the USEPA, the goals of an EE/CA are to:

- Provide a methodology for evaluating and selecting an alternative technology for waste disposition to ensure that the technology is sound and appropriate for the specific site.

- Fulfill the requirements of the National Environmental Policy Act (NEPA) for non-time-critical removal actions/expedited response actions (ERAs).

- Provide improved documentation for removal action selection.

- Provide a plan for the proposed removal action.

- Provide better documentation of the decision-making process for removal actions.

Halliburton NUS performed this EE/CA in order to meet the above listed goals. This report is organized to present the EE/CA process in a logical manner. Background information and analytical data from Installation Restoration Site 8 are presented in this section. Impacts of mercury contamination at Site 8 are presented in Section 2.0. Removal action objectives are presented in Section 3.0. Removal action alternatives are presented and analyzed in Sections 4.0 and 5.0, respectively. A comparative analysis of the alternatives and recommendations are contained in Section 6.0. A report on the October 1992 phase of biomonitoring are presented in Appendix A. Project calculations and cost estimates are presented in Appendix B. Drawings of Installation Restoration Site 8 are presented in Appendix C.

1.1 SITE DESCRIPTION

The Indian Head NSWC consists of the main area and the Stump Neck Annex. The main area of the NSWC contains approximately 2,500 acres. Slightly less than 1,000 additional acres are located across Mattawoman Creek at the Stump Neck Annex. The Indian Head NSWC is located approximately 25 miles southwest of Washington, D.C., in the northwestern section of Charles County, Maryland. The main area of the NSWC is located on a peninsula bounded by the Potomac River to the northwest, and Mattawoman Creek to the south and southeast. As shown on Figure 1-1, Installation Restoration Site 8 (Site 8) is located in the central portion of the main area of Indian Head NSWC; water from Site 8 discharges into Mattawoman Creek.

Site 8 - Nitroglycerin Plant Office consists of the following: Building 766 - Nitroglycerin Plant Office, a 3-inch drain pipe from Building 766 to a manhole (Manhole A), a concrete pipe that conveys water from Manhole A under railroad tracks to a stream (approximately 1,300 feet of stream), and a Tidal Pond/Marsh Area. The Tidal Pond/Marsh Area is approximately 700-feet long and 200-feet wide; it includes both a marsh and open water area. The tidal pond outlets through a culvert under Noble Road and into Mattawoman Creek.

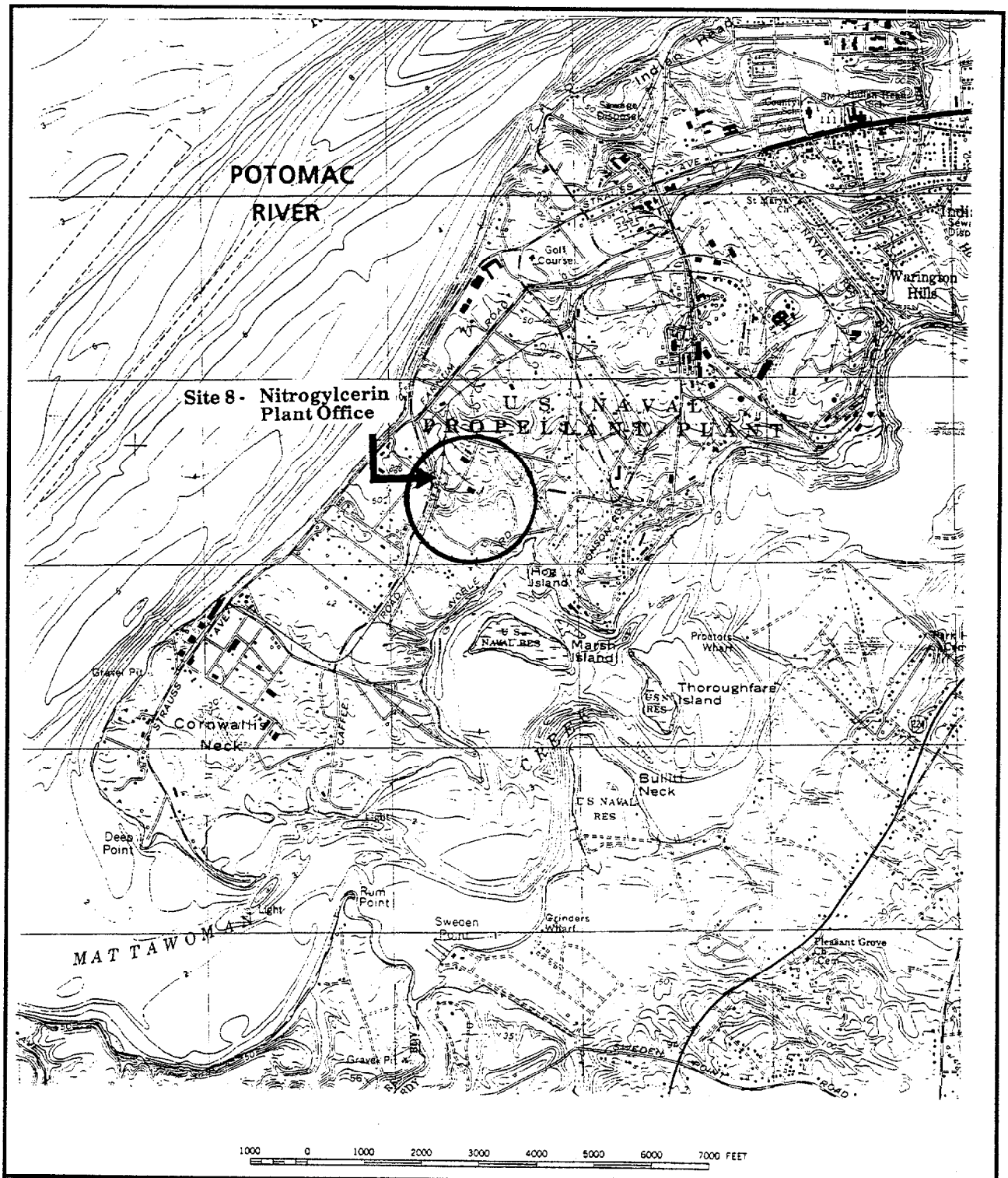

FIGURE 1-1
SITE LOCATION MAP
INSTALLATION RESTORATION PROGRAM
SITE 8 - NITROGLYCERIN PLANT OFFICE

HALLIBURTON NUS
Environmental Corporation

Source: 7.5 Minute USGS Quad Indian Head, MD-VA 1966 Photo Revised 1978

As described above, Site 8 extends from Building 766 to Mattawoman Creek and is divided into the following component areas.

- Building 766 Area
- Upper Section of Stream
- Mid-section of Stream
- Lower Section of Stream
- Marsh /Stream Transition Area
- Tidal Pond/Marsh Area
- Area Downstream of Noble Road
- Tributaries and Spring
- Town Gut Landfill Area

Each of these areas are shown on the Site Map of Installation Restoration Program Site 8 presented on Exhibit C-1 contained in Appendix C of this report and are described as follows.

Building 766 Area. The Building 766 Area is located on the western side of Site 8. Building 766, the source of mercury contamination at Site 8, is located in this area. This area extends from Caffee Road to the outlet of a 36-inch diameter pipe. The pipe extends underneath a series of railroad tracks and discharges into the Upper Section of Stream. The area immediately adjacent to Building 766 is open and grassy. Near the center of this area is Manhole A. Manhole A is approximately 30 feet east of Building 766. A 12-inch diameter concrete pipe that collects surface water runoff from the area north of Building 766 also drains into Manhole A. A 3-inch drain line also enters Manhole A from the direction of Building 766. The existing Manhole A and 3-inch drain line were installed after the source of mercury contamination was removed. Previously, a 3-inch drain line from Building 766 conveyed flow from the sink and floor drains in Building 766 to Manhole A; this 3-inch line was the source of mercury contamination at Site 8. The original 3-inch drain line and Manhole A were removed in 1984 when mercury contamination was observed in the soils during a construction project. Approximately 200 drums (55-gallon capacity) of contaminated soil were also excavated and removed from the area. The 36-inch diameter concrete pipe that conveys flow from Manhole A under the railroad tracks to the Upper Section of Stream was in place when mercury was released into Site 8. The 36-inch pipe discharges into a pool of water located approximately 3 feet below the outlet invert of the pipe. This pool then spills over into the Upper Section of Stream.

Upper Section of Stream. The Upper Section of Stream is approximately 300-feet long. It begins at the pool located at the outlet of the pipe under the railroad tracks and extends in a southern direction approximately 200 feet generally parallel to the railroad tracks and then turns to the east for approximately 100 feet. The Upper Section of Stream flows through a moderately vegetated wooded area and drops approximately 16 feet in elevation. The stream bed varies from 1 to 2 feet in width and has steep overbanks.

Mid-section of Stream. The Mid-section of Stream is located downstream of the Upper Section of Stream. It is approximately 400-feet long and generally flows in an eastern direction. This section of stream flows through a moderately vegetated wooded area and drops approximately 3 feet in elevation. The stream bed varies in width from 1 to 3 feet and has wide, shallow overbanks.

Lower Section of Stream. The Lower Section of Stream is located downstream of the Mid-section of Stream. It is approximately 400-feet long and generally flows in a northeastern direction. This section of the stream flows through a moderately vegetated wooded area. The topography in this area is flat with approximately a 1-foot drop in elevation. The stream bed varies in width from 2 to 3 feet, with extremely wide shallow overbanks. Some older abandoned stream channels connect to, and parallel, the existing stream channel in this area. Based on visual observations, the stream apparently flowed through these older channels in the past.

Marsh/Stream Transition Area. The Marsh/Stream Transition Area is located downstream of the Lower Section of Stream and is approximately 400-feet long. The stream transitions into a marsh through this area. Generally, water flows through this area in a western direction. The area is wooded and heavily vegetated. It is very flat and the stream splits into two channels through parts of the area; abandoned stream channels (some are dry and others contain stagnant water) are also located in this area. The stream varies in width from 2 to 5 feet.

Tidal Pond/Marsh Area. The Tidal Pond/Marsh Area is located north of Noble Road and west of Atkins Road Extension. This area is approximately 800-feet long and varies from 50-feet wide at the upstream end to 200 feet at the downstream end. The Site 8 stream discharges into the back of the Tidal Pond/Marsh Area from the west and a second larger tributary (North Tributary) discharges into the Tidal Pond/Marsh Area from the north. The area adjacent to the west side of the Tidal Pond/Marsh Area is steep and heavily wooded. The area adjacent to the east side of the tidal pond contains both a wooded and a grassed area. The east wooded area appears to be located along the original shoreline. The grassed area on the east side appears to be a construction demolition debris disposal area. Concrete, rebar, wooden timbers, chunks of asphalt paving, and other construction wastes were observed in the area. The Tidal Pond/Marsh Area discharges through an 84-inch diameter corrugated

metal pipe (CMP) under Noble Road and into Mattawoman Creek. For years, a beaver dam was located at the upstream end of the 84-inch pipe and maintained the water elevation of the Tidal Pond/Marsh Area at an artificial height above tidal influences. The beaver dam was removed during the summer of 1992, and the pool level was lowered by approximately 4 feet. During field sampling (August and September 1992), the water generally varied from 1- to 2-feet deep. A weir that will regulate flow from the tidal pond and restore the pond to its previous level was scheduled to be installed on the outlet pipe in the fall of 1992. However, as of January 1993, the weir has not been installed.

Area Downstream of Noble Road. The Tidal Pond/Marsh Area outlets through an 84-inch CMP and discharges downstream of Noble Road and into Mattawoman Creek. The area downstream of Noble Road is tidally influenced. During low tide, a defined stream channel can be observed. The channel varies in width from 10 feet to 40 feet. It is bound on both sides by thick patches of swamp grass.

Tributaries and Spring. Eight minor (but defined) tributaries outlet into the stream and Tidal Pond/Marsh Area throughout Site 8. Two tributaries and one spring are located on the south and east sides of the Upper Section of Stream. One tributary enters the Mid-section of Stream from the north; one tributary from the north and two from the south enter the Lower Section of Stream. One tributary enters the marsh/stream transition area from the south. One tributary from the north discharges into the back of the Tidal Pond/Marsh Area.

Town Gut Landfill Area. The Town Gut Landfill Area is located adjacent to, and northeast of the Tidal Pond/Marsh Area. The North Tributary flows from the area north/northeast of Site 8 through this area and into the Tidal Pond/Marsh. The tributary stream varies from 2- to 5-feet wide.

1.2 PROJECT BACKGROUND

Building 766 was constructed in 1953. Building 766 was originally the Nitroglycerin (NG) Plant office and Nitroglycerin (NG) Plant laboratory. It is no longer the NG Plant office, however it was recently renovated and the entire building is now a laboratory. From 1953 to 1981, mercury used in laboratory tests in Building 766 was inadvertently disposed through drains and discharged into Site 8. Since 1981, the drains have been sealed and the practice discontinued. Environmental investigative work began at Site 8 after mercury contamination was discovered in 1981. In 1984, a contractor inadvertently broke the drain pipe from Building 766 to Manhole A; mercury was observed leaking into the soil. The drain pipe, Manhole A, and approximately 200 drums (55-gallon capacity) of mercury contaminated soil were excavated and removed from the site. After the excavation was completed, the drain pipe and manhole were replaced. Uncontaminated backfill material was used to replace the

excavated area. The removal and subsequent replacement action were performed with oversight from the enforcement staff of the State of Maryland.

1.3 ANALYTICAL DATA

Environmental investigative work began at Site 8 in 1984. Both surface water and sediment/soil samples were collected and analyzed from Site 8 from 1984 through 1989 by other environmental contractors. Seventeen of the 74 surface water samples collected during that time period had mercury concentrations that ranged from 0.0002 mg/L to 0.17 mg/L (ABB, 1992). Sediment/soil samples collected and analyzed from Site 8 indicated that sediments in the stream, and Tidal Pond/Marsh Area were contaminated with mercury; however, the actual extent of mercury contamination was not defined. In August and September 1992, Halliburton NUS collected both sediment/soil and surface water samples. The purpose of the sediment/soil sampling and analysis was to determine the extent of mercury contamination.

During the August and September 1992 sampling and analysis work, Halliburton NUS collected sediment/soil samples from the nine component areas of Site 8 identified in Section 1.2. In addition, five sediment/soil samples were collected from background areas in the vicinity of Site 8. The results of that sampling analysis are present in the Site Characterization Report prepared by Halliburton NUS (January 1993). During the August/September 1992 sampling, sediment/soil samples were typically collected from 6-inch intervals at depths ranging from 0- to 24-inches deep. Each sediment/soil samples was analyzed for total mercury. The number of sediment/soil samples collected in each area and the number of samples that had mercury concentrations within discrete ranges are presented in Table 1-1.

Mercury concentrations in the 204 sediment/soil samples collected from Site 8 in 1992 varied significantly. In order to initially compare and evaluate mercury concentration levels, mercury concentrations of 10 mg/kg and 25 mg/kg were selected to segregate the data and identify the most highly contaminated areas. These levels (10 and 25 mg/kg) are used in this report to classify the data and were selected from other studies. As described later in this report, the 10 and 25 mg/kg levels were identified in previous reports on Site 8 as potential action levels; however, they are presented and utilized in this section of the report as a means to evaluate and compare mercury contamination in Site 8. As shown in Table 1-1, the Upper Section of Stream was the only area of Site 8 that contained mercury contaminant concentrations greater than 25 mg/kg. Twenty-one of the sediment/soil samples collected in the Upper Section of Stream had mercury concentrations greater than 25 mg/kg; seven samples had mercury concentrations ranging from 10 to 25 mg/kg. One sediment/soil sample collected in the Building 766 Area and three from the Tidal Pond/Marsh Area had

TABLE 1-1

SEDIMENT/SOIL ANALYTICAL SUMMARY
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Area	No. of Samples Collected(1)	No. of Samples with Mercury Concentrations		
		From Non-Detect to 10 mg/kg	From >10 mg/kg to 25 mg/kg	>25 mg/kg
Building 766 Area	12	11	1(2)	0
Upper Section of Stream	42	14	7	21
Mid-section of Stream	18	18	0	0
Lower Section of Stream	20	20	0	0
Marsh/Stream Transition Area	16	16	0	0
Tidal Pond/Marsh Area	57	54	3	0
Area Downstream of Noble Road	12	12	0	0
Tributaries and Spring	18	18	0	0
Town Gut Landfill Area	4	4	0	0
Background	5	5	0	0
Total	**204**	172	11	21

(1) Excluding duplicates.
(2) Mercury concentration of 21.7 mg/kg was detected in sand sediments at outlet of 36-inch pipe in Upper Section of Stream.

mercury concentrations in the range of 10 to 25 mg/kg. The subject Building 766 Area sample had a mercury concentration of 21.7 mg/kg; however, it was located at the pool at the outlet of the 36-inch diameter RCP in the Upper Section of Stream. The three samples with mercury concentrations ranging from 10 to 25 mg/kg in the Tidal Pond/Marsh Area were at two locations (13.2 mg/kg and 13.4 mg/kg at one location and 11.4 mg/kg in the second location).

Based on the August/September 1992 sampling, the Upper Section of Stream is the area with the highest mercury concentrations of Site 8. The other areas of Site 8 contain significantly lower mercury concentration levels. Three samples from the Tidal Pond/Marsh Area had mercury concentrations greater than 10 mg/kg. However, ongoing biomonitoring in this area will determine what impact (if any) the mercury has in the area. Therefore, this EE/CA will address mercury contamination in the Upper Section of Stream only.

1.3.1 Upper Section of Stream

The Upper Section of Stream is located downstream of Building 766 Area and upstream of the Mid-section of Stream. This area consists of approximately 300 feet of stream flowing through a steep inclined wooded area. The Upper Section of Stream sampling locations and analytical results are shown on Exhibit C-2 in Appendix C. A total of 42 environmental samples (plus 5 duplicates) were collected from 24 sampling locations. Three sets of samples (at points SS-62, 66, and 67) were collected in the form of lateral cross-sections (LC). Analysis of samples collected from the lateral cross-sections was used to define the extent of mercury contamination beyond the stream channel.

The results of total mercury analysis on the samples collected in the Upper Section of Stream are shown in Table 1-2. Fifteen sediment/soil samples (plus four duplicates) were collected in the stream channel at a depth of 0 to 6 inches; the mercury concentrations ranged from nondetect (U) to 671 mg/kg. Mercury concentrations in ten of these samples ranged from 10 to 100 mg/kg and four samples ranged from 100 to 671 mg/kg. Eighteen sediment/soil samples (plus one duplicate) were collected in lateral cross-sections (LC) perpendicular to the center of the stream. The lateral cross-section samples were collected from 13 sampling locations. They were collected up to 10 feet from the centerline of the stream and exhibited varying levels of mercury concentrations. With the lateral cross-sections, 10 sediment/soil samples (plus one duplicate) were collected from a depth of 0 to 6 inches; five were collected from a depth of 6 to 12 inches and three from a depth of 10 to 24 inches. On other sections of the stream (excluding lateral cross-sections), 14 samples were collected at a depth of 6 to 12 inches and three from a depth of 18 to 24 inches. Generally, the deeper samples contained lower concentrations of mercury but there were areas that contained higher concentrations of mercury at deeper depths.

TABLE 1-2

SEDIMENT/SOIL ANALYTICAL RESULTS
UPPER SECTION OF STREAM
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Sample Number	Location Description	Mercury (mg/kg)		
		0 to 6 inches	6 to 12 inches	18 to 24 inches
SS-59	Stream Sediments	11.1	6.4	---
SS-60	Stream Sediments	15.0	1.4	---
SS-61	Stream Sediments	0.63	5.6	---
SS-62	Stream Sediments	15.0(1)	73.1	---
SS-62A	Stream Sediments	59.2	---	---
SS-62-D	Stream Sediments	199	---	---
SS-62LC1	Centerline of Stream	---	1.0	0.32
SS-62LC2	4 Feet North of 62LC1	43.4	---	---
SS-62LC3	10 Feet North of 62LC1	4.7	---	---
SS-62LC4	2.5 Feet South of 62LC1	23.1	22.2	---
SS-62LC5	5 Feet South of 62LC1	60.2	---	---
SS-63	Stream Sediments	34.6	12.4	---
SS-64	Stream Sediments	218(1)	4.5	---
SS-64A	Stream Sediments	13.2U	---	---
SS-64A-D	Stream Sediments	8.4	---	---
SS-65	Stream Sediments	66.0	47.7	---
SS-66	Stream Sediments	73.7	30.9	---
SS-66LC1	Centerline of Stream	---	0.124	0.12U
SS-66LC2	2.5 Feet North of 66LC1	42.6	---	---
SS-66LC3	2.0 Feet South of 66LC1	196	163	---
SS-66LC3-D	2.0 Feet South of 66LC1	113	---	---
SS-66LC4	6.0 Feet South of 66LC1	69.8	---	---
SS-67	Stream Sediments	671	0.37	---
SS-67-D	Stream Sediments	0.84	---	---

TABLE 1-2
SEDIMENT/SOIL ANALYTICAL RESULTS
UPPER SECTION OF STREAM
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND
PAGE TWO

Sample Number	Location Description	Mercury (mg/kg)		
		0 to 6 inches	6 to 12 inches	18 to 24 inches
SS-67A	Stream Sediments	30.7(2)	---	---
SS-67A	Stream Sediments	0.14U	---	---
SS-67A-D	Stream Sediments	0.50	---	---
SS-67B	10 Feet Upstream of SS-67	307	---	---
SS-67C	20 Feet Upstream of SS-67	43.4	---	---
SS-67LC1	Centerline of Stream	---	0.48	62.0
SS-67LC2	3 Feet North of 67LC1	136	---	---
SS-67LC3	6 Feet North of 67LC1	73.3	---	---
SS-67LC4	10 Feet North of 67LC1	4.6	---	---

(1) Sample was also analyzed for TCLP metals. Mercury TCLP concentration was nondetect, see Table 1-3.
(2) Sample taken from a depth of 0 to 4 inches.
--- No sample collected.
U Value is nondetect as reported by the laboratory.

The Upper Section of Stream is contaminated with mercury at concentrations greater than 25 mg/kg. Although contamination was detected throughout the area, the concentrations vary widely. Samples and duplicates (respectively) had the following levels (in mg/kg): 15.0 and 199; 13.2 and 8.4; 196 and 113; 671 and 0.84; and 0.14U (nondetect) and 0.50. This variation may be due to elemental mercury in the sample matrix; elemental mercury may not be evenly distributed throughout the sample.

1.3.2 TCLP and TAL Metal Results

Three sediment/soil samples were collected from Site 8 and were analyzed for TCLP (toxicity characteristic leaching procedure) and TAL (target analytic list) metals. Two of the samples were from the Upper Section of Stream; the third sample was from the Tidal Pond/Marsh Area. The results of the TCLP metals analysis are presented on Table 1-3; the results of the TAL metal analysis are presented in Table 1-4.

TCLP metal anlaysis was performed to determine if the mercury-contaminated soil would be classified as a hazardous waste if it was sent offsite for disposal. The results of the TCLP metal analysis are compared to the hazardous waste concentrations in Table 1-3. As shown in Table 1-3, the sediment/soil from the site would not be classified as hazardous based on TCLP metal analysis.

TAL metal analysis was performed to assist in potential classification of the waste and to obtain additional information about metal contamination of Site 8. TAL metal analytical results are presented in Table 1-4.

1.3.3 Background Mercury Concentrations in Sediment/Soil

Five background sediment/soil samples were collected from areas in the vicinity of, but outside the area downstream of Site 8. Two samples (SS-200 and 201) were collected in another stream on the NSWC, approximately 8,000 feet north of Site 8. The other three samples (SS-202, 203 and 204) were collected in Mattawoman Creek upstream of Site 8. The results of the analysis are shown on Table 1-5.

As shown on Table 1-5, mercury was detected in only one sample (SS-203). This sample contained a mercury concentration of 0.34 mg/kg. It was collected at a depth of 0 to 4 inches from the sediments upstream of the NSWC property line but downgradient of the Publicly Owned Treatment Plant (POTW) located in Indian Head, Maryland.

TABLE 1-3

SEDIMENT/SOIL ANALYTICAL RESULTS
TCLP METALS
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Analyte	Hazardous Waste Concentration (µg/L)	Sediment/Soil Sample		
		SS-62-0006 (µg/L)	SS-64-0006 (µg/L)	SS-113-0006 (µg/L)
Arsenic	5,000	276 U	276 U	276 U
Barium	100,000	837	26.0 U	588
Cadmium	1,000	18.0 U	18.0 U	18.0 U
Chromium	5,000	25.0 U	25.0 U	25.0 U
Lead	5,000	282 U	282 U	282 U
Mercury	200	20.0 U	20.0 U	29.6 R(q)
Selenium	1,000	167 U	167 U	167 UL(n)
Silver	5,000	45.0 U	45.0 U	45.0 U

U - Value is a nondetect as reported by the laboratory.
UL(n) - Nondetect is considered to be biased low due to poor instrument performance (i.e., negative laboratory method blank concentrations).
R(q) - Result is a rejected value. Result is considered to be a false positive based on questionable quantitation.

TABLE 1-4

SEDIMENT/SOIL ANALYTICAL RESULTS
TAL METALS
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Analyte	Sediment/Soil Sample		
	SS-62-0006 mg/kg	SS-64-0006 mg/kg	SS-113-0006 mg/kg
Aluminum	3,180	3,950	15,400
Antimony	4.1 R(m,n)	5.7 R(m,n,p)	14.6 L(m,n)
Arsenic	0.95 R(m)	1.3 R(m)	36.7 L(m)
Barium	28.8	39.4	143
Beryllium	0.69	0.99	0.92
Cadmium	0.62 U	0.86 U	1.6 U
Calcium	452	252	2,480
Chromium	11.5	11.4	41.6
Cobalt	5.9	8.2 U	22.6
Copper	4.4 UL(n)	6.2 UL(n)	70.2 L(n)
Iron	16,800	9,390	32,800
Lead	10.5	9.6	442
Magnesium	416	285	1,690
Manganese	173 L(m)	69.6 L(m)	300 L(m)
Mercury	15.0	218	13.2
Nickel	7.4 U	10.3 U	30.5
Potassium	227 L(n)	107 UL(n)	206 UL(n)
Selenium	1.1 R(m)	1.5 R(m)	3.0 R(m,p)
Silver	0.18 UL(m,n)	0.25 UL(m,n)	2.3 L(m,n)
Sodium	48.6 UL(n)	67.6 UL(n)	130 UL(n)
Thallium	0.93 U	1.3 U	2.5 U

TABLE 1-4
SEDIMENT/SOIL ANALYTICAL RESULTS
TAL METALS
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND
PAGE TWO

Analyte	Sediment/Soil Sample		
	SS-62-0006 mg/kg	SS-64-0006 mg/kg	SS-113-0006 mg/kg
Vanadium	13.8	14.2	54.5
Zinc	109	44.4	287

U - Value is a nondetect as reported by the laboratory.
UL(n) - Nondetect is considered to be biased low due to poor instrument performance (i.e., negative laboratory method blank concentrations).
UL(m,n) - Nondetect is considered to be biased low due to poor instrument performance (i.e., negative laboratory method blank concentrations) and low MS recovery.
L(n) - Positive value is considered to be biased low due to poor instrument performance (i.e., negative laboratory method blank concentrations).
L(m) - Positive value is considered to be biased low due to low matrix spike recovery.
L(m,n) - Positive value is considered to be biased low due to low matrix spike recovery and poor instrument performance (i.e., negative laboratory method blank concentrations).
R(m) - Nondetect is rejected due to extremely low MS recovery.
R(m,p) - Nondetect is rejected due to extremely low MS recovery and low graphite furnace PDS recovery.
R(m,n) - Nondetect is rejected due to extremely low MS recovery and poor instrument performance (i.e., negative laboratory method blank concentrations).
R(m,n,p) - Nondetect is rejected due to extremely low MS recovery, low graphite furnace PDS recovery, and poor instrument performance (i.e., negative laboratory method blank concentrations).

TABLE 1-5

BACKGROUND SEDIMENT/SOIL ANALYTICAL RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Sample Number	Location Description	Mercury (mg/kg)
		0 to 6 inches
SS-200	300 Feet Upstream of Jackson Road	0.12 UJ(d)
SS-201	300 Feet Upstream of Jackson Road	0.14 UJ(d)
SS-202	300 Feet Upstream of Route 225 in Mattawoman Creek	0.18 U(1)
SS-203	500 Feet Upstream of NSWC property in Mattawoman Creek and downstream of Indian Head POTW	0.34(1)
SS-204	Upstream of Indian Head POTW in Mattawoman Creek	0.17U

(1) Sample taken from a depth of 0 to 4 inches.
U Value is a nondetect as reported by the laboratory.
UJ(d) Nondetect is estimated due to laboratory duplicate imprecision. Bias cannot be determined.

1.3.4 Surface Water

Surface water samples were collected from two locations at Site 8 (SW-01 and SW-02) and analyzed for both total and dissolved mercury. Location SW-01 was the outfall of the Tidal Pond/Marsh Area into Mattawoman Creek and the second is the outfall of the 36-inch pipe from Manhole A into the Upper Section of Stream. The results of the surface water analysis are shown in Table 1-6.

As shown on Table 1-4, the only mercury contaminants detected in the surface water occurred at the outfall of the 36-inch RCP after the lining of the pipe was scraped. These analytical results indicate that there is mercury contamination in the sludge that lines the pipe; however, this sludge appears to adhere to the pipe and does not readily discharge into the stream.

1.4 BIOMONITORING PROGRAM AT SITE 8

As part of CTO 64, Halliburton NUS developed a Biomonitoring Program for Site 8. This Biomonitoring Program was presented in a Biomonitoring Plan, which proposed initial biomonitoring at the Tidal Pond/Marsh Area of Site 8 on a quarterly basis for approximately 2 years. After 2 years, additional biomonitoring may be performed based on actual results. The plan proposed the following types of sampling and analysis:

- Water quality
- Periphyton
- Macroinvertebrate
- Fish

The Biomonitoring Program will be used to determine what affect (if any) mercury contamination at Site 8 may have on the aquatic ecosystem of Site 8. Biomonitoring will also be used to determine if mercury contamination is accumulating in fish at Site 8; this information can then be used to assess if fish from the area may pose a threat to human health. Biomonitoring will also be used to assess what impact an EE/CA removal action has on the aquatic ecosystem at Site 8. The first round of biomonitoring was performed on October 1992. The results of that work are presented in Appendix A of this EE/CA Report.

TABLE 1-6

SURFACE WATER ANALYTICAL RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Sample Number	Location Description	Mercury	
		Total (µg/l)	Dissolved (µg/l)
SW-01-01	Outfall of Tidal Pond/Marsh into Mattawoman Creek.	0.20U	0.20U
SW-01-02		0.20U	0.20U
SW-01-03		0.20UJ(m)	0.20UJ(m)
SW-01-04		0.20U	0.20U
SW-01-05		0.20U	0.20U
SW-02-01	Outfall of 36 inch RCP into Upper Section of Stream	0.20U	0.20U
SW-02-02		0.20UJ(m)	---
SW-02-03(1)		10.6J(d)	3.2J(d)
SW-02-04(1)		111	1.7

(1) Sample collected after sludge was scraped from the invert of pipe and suspended in the water.

--- No sample collected.

U Value is nondetect as reported by the laboratory.

J(d) Value is estimated due to laboratory duplicate imprecision. Bias cannot be determined.

UJ(m) Nondetect is estimated due to matrix spike noncompliance. Bias cannot be determined.

2.0 IMPACTS OF MERCURY CONTAMINATION AT SITE 8

Mercury, the contaminant of concern at Site 8, is unique. It is the only metal which exists in liquid form at room temperature. In addition to this metallic or elemental form, mercury can exist in two other forms: (1) as an inorganic mercury (e.g., mercury salts); and (2) as organic mercury (e.g., methyl mercury). Mercury has no known metabolic function. All three forms of mercury are toxic.

Mercury contamination at Site 8 was investigated with regard to human and ecological impacts. Both direct and indirect human exposure pathways were assessed, and both ecological and aquatic ecosystems were investigated as part of this EE/CA. The results of that assessment and investigation are presented in this section of the EE/CA report.

2.1 HUMAN HEALTH IMPACTS

Information about the toxicity of methyl mercury is drawn largely from well documented cases involving populations that have ingested food contaminated with methyl mercury.

In 1976, the EPA canceled registration for all pesticides products containing mercury. The most direct threat to human health from environmental mercury contamination in the United States today is by ingestion of methyl mercury-contaminated fish.

Exposure to mercury can occur from inhalation, ingestion, and skin absorption. Elemental mercury volatilizes at ambient air temperatures and is readily absorbed by the lungs. It is lipid soluble and has a high affinity for the central nervous system and red blood cells. Several studies have shown that approximately 80 percent of inhaled mercury vapor is absorbed by the human lung (Tasinger and Fiserova-Bergerova, 1965; Nielsen-Kudsk, 1965; Hurch et al, 1976). Elemental mercury is only very slowly absorbed by the gastrointestinal route in a study of human volunteers (Rahola et al, 1971). Gastrointestinal absorption of methyl mercury has been reported to be to 100 percent (Aberg et al, 1969; Miettinen, 1973). Skin absorption of mercury compounds is well documented, based on the use of mercury in dermal pharmaceuticals.

Exposure to high levels of elemental mercury vapor (>1 mg Hg/m^3) can result in damage to lung tissue and acute mercurial pneumonitis (EPA, 1980). Chronic exposure to lower levels of elemental and inorganic mercury may result in the classic symptoms of muscular tremors, increased irritability or

excitability (erethism), and inflammation of the gums (gingivitis) (Classen, 1986). Additional symptoms of exposure to elemental or inorganic mercury include changes in personality and behavior, loss of memory, kidney damage (immunologic glomerular disease), enlargement of the thyroid, increased salivation (sialorrhea), and such nonspecific symptoms as fatigue, loss of appetite, and weight loss.

Following exposure to elemental or inorganic mercury, the greatest concentration of mercury is observed in the kidneys. Kidney damage seldom occurs without neurological damage also being present. Reproductive effects, including an increased incidence of miscarriages, neonatal deaths, menstrual disturbances, and breast disease have been related to exposure to mercury vapor.

For organic mercury the greatest concentration following exposure is observed in the central nervous system. Methyl mercury inhibits protein synthesis in the brain; this effect occurs before the appearance of signs of toxicity. The primary symptoms of toxicity from exposure to organic mercury, particularly alkyl mercury compounds such as methyl mercury, are neurological. Neurological symptoms of organic mercury toxicity include tremor, abnormal sensations of tingling or prickling (paresthesia), constricted visual fields, inability to coordinate muscular movements (ataxia), difficulty in articulating words (dysarthria), and hearing impairment. Methyl mercury irreversibly destroys the neurons of the central nervous system. The delayed onset of symptoms from methyl mercury toxicity has been reported in humans and similar findings have been reported in other primates.

Currently only relatively insensitive clinical methods are available to evaluate the neurological effects of chronic low-level exposure to methyl mercury. Furthermore, the data presently available are not sufficient to evaluate the carcinogenic potential of mercury.

Human receptors can be exposed to mercury contamination at Site 8 through either direct or indirect exposure pathways. Direct exposure pathways include humans coming into direct contact with mercury contamination in surface waters and/or sediment soils at Site 8; indirect exposure pathways include the consumption of fish that have been contaminated with mercury from Site 8. Public health exposure assessment/risk characterization methodology and available standards and criteria (e.g., the Ambient Water Quality Criteria) may be used to evaluate mercury concentrations detected in environmental media (surface water, sediments, and fish tissue). The following sections present a discussion of potential public health threats posed by human exposure to the mercury contamination at or migrating from Site 8.

2.1.1 Direct Human Exposure to Mercury at Site 8

Installation Restoration Site 8 is located in an area that is used to manufacture explosives; it is unlikely that this area will be used for a different purpose in the future. Access to Site 8 at Indian Head is controlled and extremely limited. Two sequential security checks are required to reach this area. Due to the isolated location, control of human access through the NSWC to Site 8 is easily maintained, and risk of public exposure to mercury contamination is extremely limited (Davis, 1987). Public exposure could occur to the Site 8 area via access from Mattawoman Creek (e.g., technically possible but has never been reported [Davis, 1987]). No fence separates Mattawoman Creek from the NSWC, but "No Trespassing" signs are posted identifying it as government property. NSWC police occasionally patrol this area in a boat. Although fisherman and boaters regularly use Mattawoman Creek, there have been no reports of individuals leaving their boats and entering NSWC property (Davis, 1987).

According to the EPA Integrated Risk Information System, mercury is not classifiable as to human carcinogenicity. Potential noncarcinogenic health risks associated with mercury are evaluated by utilizing the Reference Dose (RfD) available for inorganic and methyl mercury. An RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are developed for chronic and/or sub-chronic human exposure to hazardous chemicals and are based on the assumption that thresholds exist for certain toxic effects. The RfD is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). The RfD is derived by dividing the no-observed-adverse-effect level (NOAEL) or the lowest-observed-adverse-effect level (LOAEL) by an uncertainty factor (UF) times a modifying factor.

The mercury action levels for Site 8 presented in this EE/CA Report are for human exposure to mercury assuming an occasional trespass scenario. This occasional trespass scenario assumes that an adult receptor (military/industrial lead use scenario) is exposed to the sediments via incidental ingestion and dermal exposure. The action levels are based on the person being exposed to mercury in the sediment for 50 days per year for 30 years and that methyl mercury, a particular toxic form of mercury, is present. The levels are based on a RfD of 3×10^{-4} mg/kg/day. Given the exposure assumptions of a trespass scenario, the mercury concentrations in the soils/sediments must exceed the calculated action levels before deleterious health effects will occur. According to those calculations and assuming an occasional trespass scenario, the action levels for Site 8 are as follows:

- 3066 mg/kg of total mercury for accidental ingestion
- 4599 mg/kg of total mercury for dermal contact
- 398 mg/kg of methyl mercury for dermal contact

Total mercury concentrations in the samples collected at Site 8 do not exceed the action levels for total mercury. Only the mercury concentration in the sediment sample collected at SS-67 exceeds the action level for methyl mercury. Mercury specification analysis was performed; however, a significant portion of the mercury would have to be methel mercury before it would pose a health risk. Therefore, no action is required at Site 8 based on a direct human exposure pathway. Action level calculations are presented in Appendix B of this EE/CA Report.

It should be noted that sediment action levels as low as 10 mg/kg have been suggested by the EPA for the protection of human health; however, this level was established for areas identified as having the possibility of future residential land use and possible fish ingestion scenarios.

The current Federal Safe Drinking Water Act Maximum Contaminant Level (MCL) for mercury is 2 µg/L. (Although the surface water bodies in the immediate study area are not used as domestic water supply resources, the MCLs are useful as a point of reference.) The current Ambient Water Quality Criteria for the protection of human health is 0.14 µg/L (consumption of aquatic life and ingestion of water). The maximum mercury concentration detected at one surface water sampling location during the August/September 1992 sampling at Site 8, 111 µg/L, exceeds these criteria. However, it should be noted that mercury was detected in surface water only when the sludge lining the bottom of a pipe was scraped and the sludge collected in the surface water. These results suggest that mercury levels may only exceed available standards/criteria on an intermittent basis (i.e. when sediments are disturbed).

2.1.2 Indirect Human Exposure to Mercury at Site 8

Humans could be indirectly exposed to the mercury contamination at Site 8 through consumption of fish. The ongoing Biomonitoring Program (as described in Section 1.4 and presented in Appendix A) will be used to evaluate if mercury contamination is impacting the aquatic ecosystem at Site 8 and/or if mercury is accumulating in fish and presenting a pathway for human exposure. The FDA action level for mercury in edible fish tissue is 1 mg/kg; whole body tissue analysis indicates that mercury concentration in the fish are substantially less. This exposure pathway will be evaluated and prescribed in subsequent rounds of biomonitoring.

Human exposure could also occur if the mercury from Site 8 were transported to Mattawoman Creek in either water or suspended sediment. A marina is located at a state park approximately 3/4 to 1 mile south and west of the outlet from the Noble Road culvert to Mattawoman Creek (Davis, 1987). A duck blind is also located in the creek not far from this outlet. If sediment and water in Mattawoman Creek

were to be contaminated, mercury could be bioaccumulated by fish and human exposure could occur through consumption. Preliminary sampling and analyses of biota by the U.S. Fish and Wildlife Services have not shown significant evidence of mercury contamination of fish in Mattawoman Creek downstream of Site 8.

2.2 ECOLOGICAL IMPACT

The ultimate fate and form of mercury in the environment has been the subject of numerous scientific investigations. Elemental mercury may become methylated under certain environmental conditions, and inorganic mercury can be methylated both by sediment-dwelling microorganisms and abiotic processes (Nriagu, 1979; EPA, 1985; Phillips, et al., 1987). There is also evidence that the methylation process can occur in fish tissue as well (EPA, 1985; Sorensen, 1991). Organic forms of mercury, including monomethyl mercury and dimethyl mercury, are more toxic than inorganic forms primarily because of their enhanced bioavailability and capacity to move into the biological food chain and affect biological tissue toxicologically (Eisler, 1987).

Studies indicate that absorption of methyl mercury by aquatic organisms is enhanced by increased salinity and low pH (EPA, 1985; Phillips, et al., 1987). Based on preliminary water quality measurements, rates of conversion to methyl mercury are expected to be greatest in the tidal pond habitat at the site. However, concentrations of total mercury are generally lower in the tidal pond than in the stream and tidal marsh areas (ABB-ES, 1992b).

Because the toxicological effects of mercury exposure are highly dependent upon the particular form of mercury present in the environment (EPA, 1985), a speciation study was conducted in 1989-1990 by ABB Environmental Services (for a discussion of this study and results see ABB-ES, 1992b). This study provided additional data on the extent and magnitude of mercury contamination in sediment and soil. In addition, methyl mercury, as well as other forms of mercury which can be readily methylated (e.g., elemental, bound), was detected in sediment throughout Site 8. As a result of this study, a Biological Assessment and Monitoring Program were recommended. The Biomonitoring Program, as described in Section 1.4, was designed and the first round was implemented in October 1992 to evaluate the effects of mercury on the environment at Site 8. Results of the first round of the Biomonitoring Program are presented in Appendix A.

The U.S. Fish and Wildlife Service (USFWS) has conducted a Biomonitoring Program in Mattawoman Creek downstream of Site 8 since 1987 (USFWS, 1991). This program was designed to evaluate the uptake of mercury by recreationally and commercially important aquatic species that may have been exposed to mercury emanating from NSWC. During the most recent round of sampling, tissues of

channel catfish (*ictalurus punctatus*) collected in the vicinity of Marsh Island (near the Site 8 outlet) had significantly higher mercury concentrations than samples collected from a control site located 4.5 miles above the Site 8 outlet on Mattawoman Creek. However, this phenomenon was observed only in channel catfish during the most recent sampling; previous USFWS reports did not report a similar observation. Also, tissue concentrations of mercury from large-mouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) did not appear to be significantly different between sampling locations (USFWS, 1991). The USFWS recently questioned the placement of its original control site due to concerns about possible widespread mercury contamination in Mattawoman Creek resulting from "tidal distribution," and recommended that another control site be placed outside of the tidal influence (USFWS, 1991). Consequently, the results of the USFWS studies must be considered preliminary, and may not adequately address the movement of mercury into Mattawoman Creek from Site 8.

Ecological impacts associated with mercury contamination of aquatic habitats have been studied in considerable detail (reviews in Eisler, 1987; Sorensen, 1991). Mercury is one of the most toxic inorganic compounds in nature, with many aquatic organisms deleteriously affected at exposure concentrations in the parts per billion range. In aquatic organisms, comparatively low concentrations of mercury can adversely affect reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange (Nriagu, 1979; Eisler, 1987). Mercury, which is a mutagen, teratogen, and carcinogen, also causes embryocidal, cytochemical, and histopathological effects (Eisler, 1987; Sorensen, 1991).

Available standards and criteria as well as toxicity information provided by the scientific literature may be used to evaluate mercury concentrations detected in environmental media samples collected in the study area. The Ambient Water Quality Criteria established for mercury for the protection of aquatic life is 0.012 µg/L (freshwater, chronic value). During the August/September 1992 sampling, mercury was detected at one surface water sampling location in Site 8 at a maximum concentration of 111 µg/L. However, it should be noted that mercury was detected in surface water only when the sludge lining the bottom of a pipe was scraped and the sludge collected in the surface water.

The biomonitoring currently underway will evaluate the effect of the mercury contamination on the biota within Site 8.

2.2.1 Aquatic Ecosystems

Aquatic organisms may be exposed to contaminants in surface water and sediment through direct contact and incidental sediment ingestion. In addition, the consumption of contaminated prey items may represent a significant exposure route to higher trophic organisms such as fish. Dietary exposure

may similarly be important for wading birds such as the great blue heron (*Ardea herodias*), wh is comprised largely of aquatic organisms (Scott, 1987), and semi-aquatic mammals such raccoon (*Procyon lotor*), mink (*Mustela vison*), and river otter (*Lutra canadensis*) all of which heavily on crustaceans, molluscs, and, in the case of mink and otter, fish (Webster et al., 1985).

2.2.2 Terrestrial Ecosystems

In the forested areas surrounding the stream and Tidal Pond/Marsh, terrestrial animals such as white-tailed deer (*Odocoileus virginianus*) and a number of birds of prey [e.g., osprey (*Pandion haliaetus*) and northern harrier (*Circus cyaneus*)] may be exposed to mercury by feeding on contaminated biota or through the incidental ingestion of soil or sediment. This is not expected to be a significant route of exposure however, because these species are wide ranging and spend only a small portion of their lives feeding in this relatively small area.

2.3 SUMMARY OF MERCURY IMPACTS AT SITE 8

As previously described, the mercury contamination in the surface water and sediment/soils at Site 8 does not appear to present a problem with regard to direct exposure to humans at Site 8. In addition, the limited areal extent of mercury contamination in soil, as well as the relatively low concentrations detected, suggests that the potential risk to terrestrial wildlife is also low (Jordan, 1987). However, direct contact with sediment may pose a hazard to aquatic organisms. Subsequently, the risks to organisms that feed on aquatic organisms (e.g., fish, and some birds and mammals) are potentially high because of the tendency of mercury to accumulate in biological tissue. The area in the vicinity of and downstream of Site 8 is actively fished. Accumulated mercury contamination in the fish may pose a risk to human consumption. This issue will be investigated as part of the ongoing Biomonitoring Program for Site 8.

The Upper Section of Stream (approximately 300-feet long) is known to be contaminated with mercury; mercury was detected in sediment samples (in the Upper Section of Stream) throughout the stream and overbanks. The sediment in the Upper Section of Stream may be a continuing source of mercury contamination into downstream areas including the Tidal Pond/Marsch Area and Mattawoman Creek.

3.0 REMOVAL ACTION OBJECTIVE

Prior to implementation of a removal action, the site must be evaluated to determine if site conditions justify a removal action. Paragraph (b)(2) of Section 300.65 of the NCP lists the following factors that should be considered when determining the appropriateness of a removal action:

(1) Actual or potential exposure to hazardous substances or pollutants or contaminants of nearby populations, animals, or food chain.

(2) Actual or potential contamination of drinking water supplies or sensitive ecosystems.

(3) Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers, that may pose a threat of release.

(4) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate.

(5) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.

(6) Threat of fire or explosion.

(7) The availability of other appropriate Federal or state response mechanisms to respond to the release.

(8) Other situations or factors which may pose threats to public health or welfare or the environment.

The above factors were considered during the EE/CA process. As described in Section 2.0, the mercury contamination at Site 8 does not present a direct risk to human health. However, there has been no investigative work to assess what effect, if any, the mercury contamination has on the biota and ecosystem at Site 8 and potential human exposure through fish consumption. The recently started Biomonitoring Program will provide information to assess that effect; however, conclusions from the Biomonitoring Program will not be available until several rounds of biomonitoring are complete.

The Upper Section of Stream (approximately 300 feet long) is known to be contaminated with mercury; mercury was detected in sediment samples (in the Upper Section of Stream) throughout the stream and overbanks. The sediment in the Upper Section of Stream may be a continuing source of mercury contamination into downstream areas including the Tidal Pond/Marsh Area and Mattawoman Creek.

The objective of a EE/CA removal action is to eliminate, reduce, or control hazards posed by the site and to expedite the completion of total site cleanup. The scope of the proposed removal action selected in this EE/CA report must achieve this objective. The proposed removal action must eliminate existing and potential future sources of mercury contamination and should not interfere with any future remedial actions at the site. The Biomonitoring Program will address the Tidal Pond/Marsh Area; however, the results of biomonitoring are not yet available. Therefore, the objective of an EE/CA removal action to be performed at this time (prior to complete biomonitoring results) will address the mercury contamination in the Upper Section of Stream. An EE/CA removal action should reduce the potential migration of mercury contamination to prevent it from increasing risks associated with Site 8.

3.1 REMOVAL ACTION SCHEDULE

Removal action, if appropriate, will begin after completion of removal action design. Major factors that will influence the removal action schedule include: completion of design; procurement of a remediation contractor; approval of a treatment/disposal option; permitting requirements; and weather.

3.2 ARARs AND TBC CRITERIA

One of the primary concerns during the development of removal action alternatives for hazardous waste sites under CERCLA is the degree of human health and environmental protection afforded by a given remedy. Section 121 of CERCLA requires that primary consideration be given to alternatives that attain or exceed applicable, or relevant and appropriate requirements (ARARs). The purpose of this requirement is to make CERCLA response actions consistent with other pertinent Federal and state environmental requirements. Although Site 8 is not a CERCLA site, ARARs and TBC criteria were reviewed in order to develop and assess the removal action alternatives.

ARARs may include the following:

- Any standard, requirement, criterion, or limitation under Federal environmental law.

- Any promulgated standard, requirement, criteria, or limitation under a state environmental or a facility-siting law that is more stringent than the associated Federal standard, requirement, criterion, or limitation.

A requirement may be either "applicable" or "relevant and appropriate," but not both. Definitions of the two types of ARARs as well as other "to be considered" (TBC) criteria are given below:

- Applicable Requirements - Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, or location.

- Relevant and Appropriate Requirements - Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, or location, address problems or situations sufficiently similar (relevant) to those encountered at the site, that their use is well suited (appropriate) to the particular site. Requirements must be relevant and appropriate to be an ARAR.

- To Be Considered (TBC) Criteria - TBC Criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action, or necessary for determining what is protective to human health and/or the environment. Examples of TBC criteria include EPA Drinking Water Health Advisories, Carcinogenic Potency Factors, and Reference Doses.

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain all ARARs if any of six conditions for a waiver of ARARs exist. These conditions are as follows: (1) the remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion; (2) compliance will result in greater risk to human health and the environmental than other options; (3) compliance is technically impracticable; (4) an alternative remedial action will attain the equivalent of the ARAR; (5) for state requirements, the state has not consistently applied the requirement in similar circumstances; and (6) compliance with the ARAR will not provide a balance between protecting

public health, welfare, and the environment at the facility with the availability of Superfund money for response at other facilities (fund-balancing). Because the proposed action at Site 8 is an EE/CA action, it is considered an interim action, i.e., additional action may be performed at Site 8 as a result of biomonitoring. Therefore complete compliance with ARARs is not required, however, ARARs and TBC Criteria will be reviewed as part of the EE/CA process.

ARARs fall into three categories, based on the manner in which they are applied. The characterization is not perfect, as many requirements are combinations of the three types of ARARs. These categories are as follows:

- Contaminant-specific - Health- and/or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of contaminant-specific ARARs include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) water quality criteria. Contaminant-specific ARARs and TBSs are presented in Table 3-1.

- Location-specific - Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site. Examples of location-specific ARARs include RCRA location requirements and floodplain management requirements. Location-specific areas and TBCs are presented in Table 3-2.

- Action-specific - Technology- or activity-based controls or restrictions on activities related to management of hazardous waste. Action-specific ARARs and TBCs are presented in Table 3-3.

In general, the contaminant-specific ARARs and TBCs are considered during the assessment of risks to human health and the environment. These ARARs and TBCs are also considered in the development of remedial action objectives. The action-specific ARARs and TBCs, which affect the implementation and/or operation of the remedial alternatives, are primarily used to assess the feasibility of remedial technologies and alternatives.

3.2.1 Classification of Mercury-Contaminated Soil

ARARs for mercury contamination are presented in Table 3-1 through 3-3. As shown in these tables, there are no known ARARs that specifically address mercury contaminated sediment/soil and establish cleanup levels. However, if the sediment/soils are excavated and sent off site for disposal because of

TABLE 3-1

CONTAMINANT-SPECIFIC ARARS AND TBCS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

ARAR/TBC	Requirement	Requirement Synopsis	Comments
Federal Requirements Surface Water	Safe Drinking Water Act (SDWA) - Maximum Contaminant Levels (MCLs and non-zero MCLGs) (40 CFR 141.11-141.16)	MCLs have been promulgated for a number of common organic and inorganic contaminants. These levels regulate contaminant concentration in public drinking water supplies.	When the risks to human health due to consumption of groundwater were assessed, concentrations of concern were compared to their MCLs. The MCL for Mercury is 0.02 mg/L.
Federal Requirements Surface Water	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR 141)	MCLGs are health-based limits and do not consider cost or feasibility. As health goals, MCLGs are established at levels at which no known or anticipated adverse effects on the health of persons occur and which allow for an adequate margin of safety.	If technically feasible, these levels are to be considered when other human health threats at the site justify setting lower cleanup levels. The MCLG for Mercury is 0.003 mg/L.
Federal Requirements Surface Water	Clean Water Act (CWA) - Ambient Water Quality Criteria (AWQC) - Protection of Freshwater Aquatic Life, Human Health - Fish Consumption.	AWQC are developed under the Clean Water Act (CWA) as guidelines from which states develop water quality standards. A more stringent AWQC for aquatic life may be found relevant and appropriate rather than an MCL, when protection of aquatic organisms is being considered at a site.	The CWA will be considered when determining cleanup levels. The AWQC established for mercury for the protection of aquatic life is 0.012 µg/L (freshwater chronic value). The AWQC established for mercury for the protection of human health is 0.15 µg/L (consumption of aquatic life).
Criteria, Advisories, and Guidance to be Considered - Surface Water	EPA Risk Reference Doses (RfDs).	EPA RfDs are levels established to characterize risks due to exposure to contaminants in surface water sediment, as well as other media.	EPA RfDs were used to characterize risks due to exposure to contaminants in surface water and sediment, as well as other media.

TABLE 3-1
CONTAMINANT-SPECIFIC ARARs AND TBCs
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND
PAGE 2

ARAR/TBC	Requirement	Requirement Synopsis	Comments
Criteria, Advisories, and Guidance to be Considered - Surface Water	EPA Carcinogen Assessment Group Potency Factors.	EPA Carcinogenic Potency Factors are used to compute the individual incremental cancer risk resulting from exposure to carcinogens.	These factors were used to assess health risks from carcinogens present at the site.
Criteria, Advisories, and Guidance to be Considered - Surface Water	EPA Health Advisories and Acceptable Intake Health Assessment Documents.	Intended for use in qualitative public health evaluation of remedial alternatives.	To be used, if adequate data exist, in assessing health risks from ingesting surface water and sediment at the site.
FDA Action Limit	Concentration of Mercury allowed in edible portion is 1 ppm.	--	Edible portion only (excludes head, scales, viscera, and inedible bones)

TABLE 3-2

LOCATION-SPECIFIC ARARs AND TBCs
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

ARAR/TBC	Requirement	Requirement Synopsis	Comments
Federal Requirements Wetlands/Floodplain	Clean Water Act (CWA) 404, (33 USC 1344 40 CFR 230).	Applies to dredge and fill activities. Under this requirement, no activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available.	This requirement is applicable to any action that may affect wetlands.
Federal Requirements Wetlands/Floodplain	Fish and Wildlife Coordination Act.	This regulation requires that any Federal agency that proposes to modify a body of water must consult with the U.S. Fish and Wildlife Services. This is addressed under CWA regulations at 40 CFR 230.	If an alternative modifies a body of water, the U.S. Fish and Wildlife Services must be consulted.
Federal Requirements Wetlands/Floodplain	Endangered Species Act of 1973 (16 USC 1531 et seq.); 36 CFR 800.	This regulation requires action to conserve endangered species or threatened species, including consultation with the Department of the Interior.	This requirement is applicable to any remedial action that may involve endangered species.

TABLE 3-3

ACTION-SPECIFIC ARARS and TBCS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

ARAR/TBC	Requirement Synopsis	Comments
Federal Requirements RCRA Facility Standards and Land Disposal Restrictions (40 CFR 264)	Facility standards specify design, groundwater monitoring, and closure, and post-closure care for specific types of facilities. Land disposal restrictions exist for specified wastes without approved treatment.	Any on-site remedial alternatives must conform, to the the extent feasible to the governing technical standards.
Federal Requirements CWA - National Pollutant Discharge Elimination System (NPDES) (40 CFR 122, 125)	Any point-source discharge must meet NPDES permitting requirements, which include compliance with corresponding water quality standards; establishment of a discharge monitoring system; and completion of regular discharge monitoring records.	Process water used on site and discharged to a surface water body will need to comply with the water quality standards.
Federal Requirements Occupational Safety and Health Administration (OSHA) Regulations for Worker Safety (29 CFR 1910)	Contains safety and health standards for workers at hazardous waste sites.	The implementation of all proposed cleanup alternatives will meet OSHA standards. The requirements are applicable for all actions at the site.
Federal Requirements CWA Dredge and Fill Regulations (40 CFR 230)	This regulation outlines requirements for discharge of dredged or fill material. Under this requirement, no activity that affects a wetland shall be permitted if a practicable alternative exists; all impacts must be mitigated.	During the detailed analysis of alternatives, the effects on wetlands must be evaluated. This requirement would be applicable to any dredging or filling.
Federal Requirements Clean Air Act (CAA) National Ambient Air Quality Standards (NAAQS) for Total Suspended Particulates (40 CFR 129.105, 750)	This regulation specifies maximum primary and secondary 24-hour concentrations for particulate matter.	Fugitive dust emissions from site excavation activities will be maintained below 260μ/m^3 (primary standard) by dust suppressants, if necessary. This requirement will be applicable if any excavation occurs.

TABLE 3-3
ACTION-SPECIFIC ARARS and TBCS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND
PAGE TWO

ARAR/TBC	Requirement Synopsis	Comments
Federal Requirements Protection of Archaeological Resources (32 CFR Part 229, 229.4; 43 CFR Part 107, 171.1-171-5)	This regulation develops procedures for the protection of archaeological resources.	If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and state archaeologists. This requirement is applicable to any excavation on site.
Federal Requirements Department of Transportation (DOT) Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-171.5)	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting of hazardous materials.	Hazardous materials will be packaged, manifested, and transported to a licensed off site disposal facility in compliance with these regulations. These regulations are applicable for any action that includes off site transportation of hazardous materials.

contamination, they will be considered wastes. According to 40 CFR 261.24 wastes can be characterized as hazardous or nonhazardous based on the level of contamination found in the extract as a result of the toxicity characteristic leachate procedure (TCLP) analysis. As shown in Table 1-3, based on the three TCLP analyses performed on sediment/soil samples from Site 8, the soil is considered nonhazardous. All mercury TCLP results were nondetect.

Hazardous Waste - When levels of contamination in the TCLP extract exceed regulatory levels as specified in 40 CFR 261.24 the waste is considered hazardous and is subject to LDR standards as stated in 40 CFR 268.41. Once the waste is deemed hazardous the type of treatment must be chosen. As per 40 CFR 268.42 for mercury in nonwastewaters (which includes soils) treatment is based on the actual level of contamination which exists in the waste. The EPA's hazardous waste number for mercury contaminated waste is D009. For wastes containing mercury, a High and Low Mercury Subcategories have been defined.

Hazardous wastes with mercury concentrations exceeding 260 mg/kg total mercury are considered to be in the High Mercury Subcategory and the EPA requires treatment consistent with the Best Demonstrated Available Technology (BDAT). BDAT for mercury concentrations greater than or equal to 260 mg/kg are Thermal Recovery or Incineration.

Hazardous wastes with mercury concentrations lower than 260 mg/kg are considered to be in the Low Mercury Subcategory. The EPA is a little less stringent on the method of treatment for these wastes. The main requirement is that after treatment of the waste the concentration of mercury in the extract as a result of TCLP does not exceed 0.2 mg/l. Several treatment methods exist for contamination in the Low Mercury Subcategory. BDAT treatment for contamination in the Low Mercury Subcategory is Acid Leaching followed by chemical precipitation and dewatering. Other treatment methods include Soil Washing/Ion Exchange, Extraction, Electroreclamation, and Immobilization/Stabilization.

Nonhazardous Waste - When levels of contamination in the leachate do not exceed regulatory levels specified in 40 CFR 261.24 they may be treated as nonhazardous wastes and disposed of in a nonhazardous landfill. Once a waste is deemed nonhazardous it no longer requires treatment before disposal. Sediment/soils removed from Site 8 would be considered nonhazardous wastes.

3.3 REMOVAL ACTION OBJECTIVE AND RATIONALE

There are no identified direct human exposure pathways associated with Site 8 that pose an unacceptable risk at this time. However, the mercury-contaminated sediment in the Upper Section of Stream is a source area for mercury contamination and may contaminate other downstream areas. The

objective of the EE/CA removal action at Site 8 will be to remove a potential source of mercury contamination (mercury contaminated sediment in the Upper Section of Stream) in order to eliminate the potential for it to spread downstream and into Tidal Pond/Marsh Area and Mattawoman Creek. The removal action must provide a level of remediation which protects the public health and environment and meets applicable local, state, and Federal requirements. The EE/CA removal action will primarily address reducing risks created by potential migration. Long-term risks will be more focused upon completion of the Biomonitoring Program. The Biomonitoring Program will evaluate the impact of mercury at Site 8 and monitor the response to any EE/CA removal action.

A previous EE/CA performed for this site recommended a cleanup level of 25 mg/kg for sediment/soil at this site (ABB, 1992). However, that level was not specifically established for Site 8. The 25 mg/kg level was established at other sites which may not have similar site conditions as Site 8. Previously, sediment/soil action levels of both 10 mg/kg and 25 mg/kg were proposed for this site. Navy discussions with regulatory personnel have indicated that 10 mg/kg was an acceptable action level for an EE/CA removal action; therefore, 10 mg/kg was used as a base target action level for EE/CA removal action in the Upper Section of Stream.

The rationale for an EE/CA removal action is to prevent the spread of mercury contamination and to reduce the potential impact of mercury contamination. The removal action is <u>not</u> in response to a known unacceptable risk to either human health or the environment.

4.0 REMOVAL ACTION ALTERNATIVES

This section discusses the EE/CA removal action alternatives for Site 8. Although these removal actions vary in effectiveness, implementability, and cost; they are all viable alternatives and address mercury contamination in the Upper Section of Stream. The area to be addressed by the EE/CA removal action is shown on Exhibit C-3 in Appendix C of this report. The removal action alternatives consist of the following:

- Alternative 1: No action
- Alternative 2: No action with biomonitoring
- Alternative 3: Riprap stream and biomonitoring
- Alternative 4: Excavate and stabilize with biomonitoring
- Alternative 5: Excavate and dispose offsite with biomonitoring

Except for Alternative 1, biomonitoring is proposed for each alternative. The base biomonitoring for Alternatives 2 through 5 is on a quarterly basis for 2 years. Additional biomonitoring is anticipated for Alternative 2 (twice a year for 5 years) and Alternative 3 (twice a year for 2 years). However, the actual duration of the biomonitoring period will depend upon actual biomonitoring results. It will be discontinued when sufficient data indicates that a problem no longer exists at the site.

4.1 ALTERNATIVE 1: NO ACTION

Under the no action alternative, no removal action and no biomonitoring would be performed at Site 8.

4.2 ALTERNATIVE 2: NO ACTION WITH BIOMONITORING

This alternative includes no removal action at Site 8, but quarterly biomonitoring would be conducted for the first 2 years and then biannually for a period of 5 more years. This alternative would not eliminate any risks associated with human contact with the contaminated sediment/soils, however, potential risks for human contact are minimal. Biomonitoring sampling would be conducted to determine the need for a future removal action. Continued monitoring would be conducted to determine if mercury is being passed through the food chain, and to determine if the mercury is destructive to the existing biota at Site 8.

4.3 ALTERNATIVE 3: RIPRAP STREAM AND BIOMONITORING

This alternative includes no removal action at Site 8, but the most highly contaminated section of the stream (Upper Section of Stream) would be covered with geotextile and riprap to prevent any direct contact with the contaminated sediment/soils and to minimize sediment transport. This alternative would eliminate any direct contact with the mercury contaminated soils, but it would not completely eliminate the potential for the mercury to transport in the surface water to the Tidal Pond/Marsh Area.

Appendix B contains construction quantities and costs for this alternative. The stream would be regraded to allow for better placement of the geotextile and riprap. The covering would be placed in conjunction with the regrading process to minimize erosion due to the disturbance of the stream.

As part of this alternative, biomonitoring sampling would be performed quarterly for the first 2 years and then biannually for a period of 2 more years, to determine the need for a future removal action.

4.4 ALTERNATIVE 4: EXCAVATE AND STABILIZE WITH BIOMONITORING

This alternative would include excavation of the contaminated soils in the Upper Section of Stream and Stabilization of these soils with cement, lime, or some other reagent. The stabilized soils would then be disposed of at an area designated by the Navy. After excavation, the area will be backfilled and covered with a riprap cap to reduce potential erosion.

Excavation of the soils at Site 8 will include removal of soils with contamination in excess of 10 mg/kg of mercury. The maximum volume of contaminated soils is estimated to be 433 cubic yards. Following excavation, the stream channel would be lined with a geotextile and riprap. The riprap would be placed to minimize erosion that results from the disturbance to the natural stream bed.

Excavation of the contaminated sediments/soils in the Upper Section of Stream at Site 8 would eliminate any risk associated with direct contact with the contaminated sediments/soils as well as the potential for transport of the mercury in the surface water to the Tidal Pond/Marsh Area. Once the soil is excavated, it will be stabilized with cement, lime, or some other reagent and placed on NSWC property in an area designated by the Navy. By stabilizing the soils, the mercury contamination will be "bound" to the soil and will not transport from the soil and become a risk at the designated disposal area.

Stabilization of mercury-contaminated soils is a proven technology. Mercury-contaminated soils, which have TCLP concentrations greater than those specified by the land disposal restrictions (LDRs) may be

treated through the use of chemical fixation/solidification. This technology has been chosen as the selected remedy at two superfund sites with mercury-contaminated soils or sediments. These sites are the Pepper's Steel and Alloys Site in Medley, Florida, and the Fields Brook Site in Ashtabula, Ohio. In both cases, solidification and onsite placement are specified in the Record of Decision, which has been signed by the U.S. EPA.

Work at the Pepper's Steel and Alloys Site was completed in 1989. The treatment process consisted of pozzolan solidification using flyash and Portland cement to bind up mercury and other contaminants contained in the soil. Following solidification, the treated soils were placed onsite, and groundwater monitoring has shown the process to be effective.

In the reference book Chemical Fixation and Solidification of Hazardous Wastes, by Jesse R. Conner, the stabilization of mercury-contaminated wastes is detailed and shown to be effective. After stabilization, mercury-contaminated soils have had Toxicity Characteristic Leaching Procedure (TCLP) analytical results with concentrations of less than .001 ppm. Although no results were found for treatment of elemental mercury, results for treatment of metal finishing wastes and electroplating sludges indicate that presently available commercial processes utilizing a lime/sulfide process would immobilize the contaminant.

Prior to performing design work on removal and treatment of the contaminated sediments, a treatability study performed to determine the effectiveness of the process with actual Site 8 soil/sediments.

Appendix B contains construction quantities and costs for this alternative. The excavation process would be conducted in conjunction with the backfilling process to eliminate risk of a "wash out" due to a heavy rain during construction. The material excavated will be temporarily stockpiled at the designated storage site until excavation is completed. Following the completion of the excavation, the stockpiled contaminated sediment/soils will be stabilized and placed in a fill area designated by the Navy.

Although excavation would remove contamination in the Upper Section of Stream, it would not affect the mercury contamination that already exists in the Tidal Pond/Marsh Area; therefore, it is estimated that biomonitoring would be conducted quarterly for a period of 2 years to assess the risk of mercury entering the food chain.

4.5 ALTERNATIVE 5: EXCAVATE AND DISPOSE OFFSITE WITH BIOMONITORING

This alternative would include excavation of the contaminated soils in the Upper Section of Stream and disposal of these soils in a nonhazardous waste landfill. The contaminated soils at Site 8 are considered nonhazardous due to the results of the TCLP analysis (mercury TCLP levels were nondetect). Based on RCRA TCLP criteria for a hazardous waste for mercury (hazardous waste No. D009) the soils at Site 8 are nonhazardous. After excavation, the stream would be lined with riprap to reduce potential erosion.

Excavation of the soils at Site 8 will include removal of soils with contamination in excess of 10 mg/kg of mercury. The maximum volume of contaminated soil is estimated to be 433 cubic yards. Following excavation, the area would be regraded to allow for placement of a geotextile and riprap cover. The riprap cover would be placed to minimize erosion that results from the disturbance to the natural stream bed.

Excavation of the contaminated sediments/soils in the Upper Section of Stream would eliminate any risk associated with direct contact with the contaminated sediments/soils as well as the potential for transport of the mercury in the surface water to the Tidal Pond/Marsh Area. Once the contaminated sediment/soil is excavated, it will be disposed of in a nonhazardous landfill. The sediment/soils are considered nonhazardous based on the TCLP results. Following excavation, clean fill will be used to backfill the area, and a geotextile and riprap covering will be placed to reduce erosion.

Appendix B contains construction quantities and costs for this alternative. The excavation process would be performed in conjunction with the backfilling process to eliminate risk of a "wash out" due to a heavy rain during construction. Excavated material will be continuously hauled to the nonhazardous landfill during the excavation and will not be stored on site for more than 1 day.

Although excavation would remove contamination in the Upper Section of Stream, it would not affect the mercury contamination that already exists in the Tidal Pond/Marsh Area, therefore, continued biomonitoring would be conducted quarterly for a period of 2 years to assess the risk of mercury entering the food chain.

5.0 ANALYSIS OF REMOVAL ACTION ALTERNATIVES

Analysis of the five removal action alternatives with regard to effectiveness, implementability, and cost are presented in this section of the report.

Effectiveness is the ability of the alternative to reduce the risks of the site and includes:

- Protectiveness - Protectiveness includes protecting the community and workers during the removal action, threat reduction and potential exposure to remaining risks, time until protection is achieved, compliance with ARARs and other criteria, environmental impacts (overall protection of human health and the environment), and long-term reliability for providing continued protection.

- Use of Alternatives to Land Disposal - Alternatives to land disposal shall be used where possible.

Implementability is the ability of the alternative to be carried out at the site and includes:

- Technical Feasibility - The ability to physically implement the alternative as designed and in a manner that complies with the removal action objective.

- Availability - The availability of equipment, material, personnel, and facilities to implement the alternative, and provide any necessary post-removal site control.

- Administrative Feasibility - Acceptance of the alternative by the state and community and the ability to obtain the necessary approvals.

The costs associated with these alternatives include: (1) biomonitoring (if applicable); (2) engineering (treatability studies, design, permitting, health and safety, sampling and analysis, inspection, etc.), and (3) construction costs. Construction costs are emphasized in this section of the report. The construction costs presented in this report are preliminary and will be revised based on more detailed design work. Appendix B contains quantities and costing information for the alternatives.

5.1 ALTERNATIVE 1: NO ACTION

Under the no action alternative no removal action would be taken at Site 8. This alternative would include no removal action and no biomonitoring at the site.

Effectiveness. Under this alternative no removal action or continued biomonitoring would occur at Site 8. Although there appears to be minimal human and terrestrial organism risk associated with the mercury at Site 8 (ABB Environmental Services, Inc., 1992) this alternative would not provide information pertaining to aquatic risks.

Implementability. This alternative can be readily implemented.

Cost. There would be no costs associated with this alternative.

5.2 ALTERNATIVE 2: NO ACTION WITH BIOMONITORING

Biomonitoring would be performed at Site 8 in accordance with the site-specific Biomonitoring Plan (Halliburton NUS, 1992) for an estimated period of 7 years. Biomonitoring would be performed on a quarterly for 2 years and then biannually for a period of 5 more years. Actual biomonitoring (both types of biomonitoring performed and duration of program) will be revised based on actual results of biomonitoring. If mercury-contaminated sediments remain at Site 8 (the sediments with elevated levels of mercury in Upper Section of Stream are not removed), biomonitoring may have to be performed for an extended period.

Effectiveness. Under this alternative no removal action would occur, but, continued biomonitoring would be performed. Biomonitoring will assess mercury risk to the aquatic life and its respective food chain at Site 8. Biomonitoring may also indicate the need for a future removal action.

Implementability. This alternative can be readily implemented. There is no removal action required and field work for the first quarterly phase of biomonitoring has already been performed.

Cost. There would be no initial capital costs involved with this alternative, however, biomonitoring would be performed on a quarterly basis for 2 years and then biannually for a period of 5 more years (18 sampling rounds). The estimated sampling round cost is $28,000. Therefore, if biomonitoring was performed for 18 sampling rounds, the total estimated cost would be $504,000.

5.3 ALTERNATIVE 3: RIPRAP STREAM AND BIOMONITORING

This alternative includes no removal action at Site 8, it does however include capping the contaminated soils (with mercury concentrations greater than 10 mg/kg) in the Upper Section of Stream with a layer of geotextile and riprap. A riprap cap would (1) allow natural stream drainage to occur, (2) cover the contamination and minimize human and terrestrial animal contact with the contamination, and (3) reduce the possibility of transport of contaminated sediment from the Upper Section of Stream. Along with the riprap cap continued biomonitoring would be conducted on a quarterly basis for 2 years and then biannually for an estimated period of 2 more years.

Effectiveness. Under this alternative no removal of contaminated soils would occur, but potential direct contact risks to human and terrestrial organisms would be reduced. The risk of the mercury contamination transporting to the Tidal Pond/Marsh Area and affecting the aquatic environment would be reduced but not eliminated. Continued biomonitoring sampling would assess the effects of the mercury on the aquatic life and in particular the effects of mercury on the biological food chain at Site 8.

Implementability. Alternative 3 is technically feasible and can be readily implemented. The primary consideration with Alternative 3 is that during placement of the riprap in the Upper Section of Stream the natural terrain and woodlands would be impacted to allow access to the site. These impacts would affect the natural surface drainage, erosion, and animal habitats at Site 8. Placement of geotextile riprap would occur in approximately 300 feet of stream. Riprap would be placed in a thick layer to completely cover the stream bed and surrounding sediments.

Biomonitoring is also readily implementable. For this alternative, biomonitoring is proposed to be conducted on a quarterly basis for 2 years and then biannually for a period of 2 more years or until it is determined to be no longer necessary.

Cost. The estimated construction cost for this alternative is approximately $80,000. For costing purposes, the volume of riprap required to adequately cover the stream bed and surrounding sediments in the Upper Section of Stream was estimated to be approximately 430 cubic yards. This volume is based on a minimum depth of 2 feet and an average width of 18 feet. The cost includes all labor, equipment, and materials required for placement of the riprap. Along with the initial capital costs, costs for continued biomonitoring sampling (12 sampling rounds) would be incurred. Each sampling round is estimated to cost $28,000 for a total biomonitoring cost of $336,000.

5.4 ALTERNATIVE 4: EXCAVATE AND STABILIZE WITH BIOMONITORING

This alternative includes excavating contaminated soil (with mercury concentrations greater than 10 mg/kg) from the Upper Section of Stream. This contaminated soil would then be mixed and stabilized with Portland cement and used as construction fill material on the NSWC. The purpose of the mixing with cement would be to bind the sediments and prevent potential erosion and subsequent transport of mercury. The stabilized soil will be placed in a berm on other earthen structure on NSWC away from moving water and covered with soil. The soil cover would then either be vegetated or paved. The stream channel would then be covered with geotextile and riprap. Along with the removal action, biomonitoring would be performed on a quarterly basis for a period of 2 years.

Effectiveness. This alternative would be effective in completely removing mercury-contaminated soils from the Upper Section of Stream. Once excavation is completed, risks associated with direct contact and mercury transport would be eliminated. Continued biomonitoring would provide information to assess the affect of this action on the aquatic life and food chain at Site 8.

Implementability. This alternative is implementable. It will require mobilization of mixing equipment into the NSWC, but that type of equipment is not unusual and can be obtained by local construction companies. It will require a staging area and a construction site on the NSWC where the stabilized material can be placed. Implementation of this alternative will require installation of a diversion system (to convey surface water around the area to be excavated) and construction of access roads. These access roads may affect the natural surface drainage, erosion, and animal habitats at Site 8. After sediments are excavated, the stream channel will be covered with a geotextile and riprapped to minimize erosion. Biomonitoring would continue at the site on a quarterly basis for 2 years or until it is determined to be no longer necessary.

Cost. The estimated construction cost for this alternative is $155,000. The estimated quantity of contaminated soil was 430 cubic yards, and the estimated amount of Portland cement used to stabilize the sediment/soil was 2,810 cubic feet. Actual construction costs of this alternative would be based on final design. Biomonitoring costs would be for 2 years (8 sampling rounds). Each sampling round is estimated to cost $28,000 for a total biomonitoring cost of $224,000.

5.5 ALTERNATIVE 5: EXCAVATE AND DISPOSE OFFSITE WITH BIOMONITORING

Alternative 5 includes removal of sediment in the Upper Section of Stream with mercury concentrations greater than 10 mg/kg. Approximately 430 cubic yards of contaminated sediments would be removed, disposed in a nonhazardous landfill, and replaced with riprap. Contaminated sediments will be limited

to soils with mercury concentrations exceeding 10 mg/kg. Along with the removal action continued biomonitoring would be conducted quarterly for a period of 2 years.

Effectiveness. This alternative would be effective in completely removing the mercury contaminated soils in the Upper Section of Stream. Once excavation is complete, risks associated with direct contact and mercury transport would be eliminated. Continued biomonitoring would provide an assessment of the effect of mercury contamination on the aquatic life and the biological food chain at Site 8.

Implementability. This alternative is readily implementable. The wastes generated from the excavation of soils at Site 8 could be disposed of in a nonhazardous landfill and therefore require no special permits. The excavation can be performed with relative ease. Diversion of the surface water flow through the Upper Section of Stream and access roads to Site 8 would need to be constructed prior to excavation of sediments. These access roads may affect the natural surface drainage, erosion, and animal habitats at Site 8. Once sediments are excavated, the stream channel would be covered with a geotextile and riprap cap to minimize erosion.

Continued biomonitoring is also readily implementable. Continued monitoring would include quarterly sampling for 2 years or until it is determined to be no longer necessary.

Cost. The estimated construction cost for this alternative is $190,000. This cost includes all initial capital costs (excavation, backfill, and disposal of contaminated soils in a nonhazardous landfill). For costing purposes a volume of excavation, backfill, and disposal of 430 cubic yards was used. Actual construction costs for this alternative would be based on the final design, the disposal site selected and a more detailed cost itemization. Biomonitoring costs would be the same as those presented in Alternative 4.

6.0 SUMMARY AND RECOMMENDED ALTERNATIVES

6.1 SUMMARY OF ALTERNATIVE ANALYSIS

Tables summarizing the effectiveness, implementability, and cost of the five alternatives are presented on Tables 6-1, 6-2, and 6-3, respectively.

As shown in Table 6-1, Alternative 4: Excavate and Stabilize with Biomonitoring is rated as the most effective alternative and Alternative 3: Riprap Stream with Biomonitoring as the second most effective. Under Alternative 4, mercury contaminated soil (with concentrations greater than 10 mg/kg) would be removed from Site 8, stabilized, and incorporated into an earthen fill at NSWC. It is effective because mercury contaminated soil would be removed from the Upper Section of Stream, and could therefore no longer have the potential to migrate into the Tidal Pond/Marsh Area and downstream areas. Stabilization on site would also prevent creating an offsite disposal issue. With Alternative 3, potential protectiveness was based as medium because mercury contamination would still remain at Site 8; however, use of land disposal alternatives was rated high for Alternative 3 because it would also not include offsite disposal. The other three alternatives were rated as medium in overall effectiveness.

As shown in Table 6-2, Alternative 4: Excavate and Stabilize with Biomonitoring is rated as the most implementable alternative because it is both technically and administratively feasible; it will comply with the removal action objective and will eliminate potential administrative concerns. Alternative 3 and Alternative 5 are both rated as medium/high because they were both rated as medium for administrative feasibility.

Table 6-3 presents estimated costs to implement the five alternatives. Estimated costs are presented for biomonitoring, engineering and construction. As shown in Table 6-3, because Alternatives 1 and 2 do not include construction activities, they do not contain engineering or construction costs and are therefore the lowest cost alternatives. Alternative 3 is the lowest cost alternative that contains construction activities. The Biomonitoring Program costs presented on the table are identical for each alternative. These costs may vary because biomonitoring may be extended for a longer period of time for alternatives where contaminated soil is left in place (Alternatives 2 and 3) and may be shortened for those alternatives which include removal of contaminated soil (Alternatives 4 and 5). Actual engineering and construction costs could also vary depending upon final design.

TABLE 6-1

COMPARISON OF ALTERNATIVES FOR EFFECTIVENESS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Alternative	Protectiveness	Use of Alternatives to Land Disposal	Overall Effectiveness
Alternative 1: No Action	Low	High	Medium
Alternative 2: No Action with Biomonitoring	Low	High	Medium
Alternative 3: Riprap Stream and Biomonitoring	Medium	High	Medium/High
Alternative 4: Excavate and Stabilize with Biomonitoring	High	High	High
Alternative 5: Excavate and Dispose Off Site with Biomonitoring	High	Low	Medium

TABLE 6-2

COMPARISON OF ALTERNATIVES FOR IMPLEMENTABILITY
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Alternative	Technical Feasibility	Availability	Administrative Feasibility	Overall Implementability
Alternative 1: No Action	Low	Low	Low	Low
Alternative 2: No Action with Biomonitoring	Low	High	Low	Medium
Alternative 3: Riprap Stream and Biomonitoring	High	High	Medium	Medium/High
Alternative 4: Excavate and Stabilize with Biomonitoring	High	High	High	High
Alternative 5: Excavate and Dispose Off Site with Biomonitoring	High	High	Medium	Medium/High

TABLE 6-3

SUMMARY OF ESTIMATED COSTS FOR ALTERNATIVES
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Removal Action Alternative	Biomonitoring Program(1) ($28,000/round)	Engineering, Treatability Study, Design, Permitting, HASP, Sampling and Analysis, Report Preparation, Etc.	Estimated Construction Cost	Total Present Worth Cost for Alternative
Alternative 1: No Action	0	0	0	0
Alternative 2: No Action with Biomonitoring	$504,000	0	0	$428,000
Alternative 3: Riprap Stream and Biomonitoring	$336,000	$175,000	$80,000	$556,000
Alternative 4: Excavate and Stabilize with Biomonitoring	$224,000	$200,000	$155,000	$563,000
Alternative 5: Excavate and Dispose Off Site with Biomonitoring	$224,000	$200,000	$190,000	$597,000

(1) The period of biomonitoring and corresponding costs will be revised based on actual results of biomonitoring. Costs presented in this table are based on the estimated durations presented in this report.

6.2 RECOMMENDED ALTERNATIVES

Based on the EE/CA, the recommended alternative is Alternative 4: Excavate and Stabilize with Biomonitoring. Under this alternative contaminated sediment would be removed from Site 8 and stabilized on site; the effectiveness of the action will be monitored through continued biomonitoring.

The second recommended alternative is Alternative 3: Riprap Stream and Biomonitoring. It has a slightly lower cost alternative and will be less disruptive (compared to Alternative 4) to the environment at Site 8. However, under this alternative contamination will remain in place and may not be as administratively acceptable to regulatory agencies and the community.

REFERENCES

ABB Environmental Services (ABB-ES), 1992a. Biomonitoring Work Plan: Site 8 - Nitroglycerin Plant Office (Final Document).

ABB Environmental Services (ABB-ES), 1992b. Engineering Evaluation and Cost Analysis Report: Site 8 - Nitroglycerin Plant Office.

HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS), August 1992. Abbreviated Field Sampling Plan: Site 8 - Nitroglycerin Plant Office, Indian Head, Maryland.

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HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS), October 1992. Biomonitoring Plan for Site 8 - Nitroglycerin Plant Office.

Jordan, E. C., 1987. NIRP Feasibility Study and Remedial Design. Task 2 - Supplemental Site Characterization Report, Naval Ordnance Station, Indian Head, Maryland.

APPENDIX A

REPORT ON
OCTOBER 1992 BIOMONITORING

R-49-10-92-10

REPORT ON
OCTOBER 1992 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

Submitted to:
Chesapeake Division
Environmental Branch, Code 18
Naval Facilities Engineering Command
Building 212, Washington Navy Yard
Washington, D.C. 20374-2121

Submitted by:
HALLIBURTON NUS Environmental Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

Contract Number N62472-90-D-1298
Contract Task Order 0064

JANUARY 1993

TABLE OF CONTENTS

SECTION		PAGE
1.0	**INTRODUCTION**	**A-1**
1.1	BACKGROUND	A-1
1.2	SITE DESCRIPTION	A-2
1.3	OBJECTIVE	A-4
2.0	**SAMPLING LOCATIONS AND METHODS**	**A-5**
2.1	WATER QUALITY MEASUREMENTS	A-5
2.2	PERIPHYTON SAMPLING	A-6
2.3	BENTHIC MACROINVERTEBRATE SAMPLING	A-6
2.4	FISH SAMPLING	A-6
2.4.	Fish Survey	A-6
2.4.2	Fish Sampling for Mercury Residues	A-9
3.0	**RESULTS AND DISCUSSION**	**A-10**
3.1	WATER QUALITY	A-10
3.2	PERIPHYTON	A-10
3.3	BENTHIC MACROINVERTEBRATES	A-11
3.4	DIVERSITY	A-15
3.5	ANALYSIS OF MERCURY IN FISH TISSUE	A-16
4.0	**CONCLUSTIONS AND RECOMMENDATIONS**	**A-18**
4.1	CONCLUSIONS	A-18
4.2	RECOMMENDATIONS	A-18
ATTACHMENT A	Periphyton Sampling Results	A-1

TABLE OF CONTENTS (Continued)

TABLES

NUMBER		PAGE
3-1	(OCTOBER 29, 1992) WATER QUALITY DATA	A-10
3-2	BENTHIC MACROINVERTEBRATES SAMPLING	A-13
3-3	MERCURY FISH TISSUE ANALYTICAL RESULTS	A-16

TABLE OF CONTENTS (Continued)

FIGURES

NUMBER		PAGE
1-1	STUDY AND CONTROL LOCATION MAP BIOMONITORING PROGRAM INSTALLATION RESTORATION PROGRAM SITE 8-NITROGLYCERIN PLANT OFFICE	A-3
2-1	INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER SITE 8 - NITROGLYCERIN PLANT OFFICE OCTOBER 1992 BIOMONITORING SAMPLING LOCATIONS	A-7

1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order Number 0064 (CTO 64) to Halliburton NUS Corporation (Halliburton NUS), under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. CTO 64 is for environmental investigative work at the Navy Installation Restoration Program Site 8 - Nitroglycerin Plant Office (Installation Restoration Site 8), at the Indian Head Division, Naval Surface Warfare Center (IHDIVNAVSURFWARCEN or NSWC) in Indian Head, Maryland. NSWC is in the Chesapeake Division (CHESDIV) of the Naval Facilities Engineering Command. CTO 64 consists of tasks to (1) investigate mercury contamination in the sediment/soils and surface water in and around Installation Restoration Site 8 to define the extent of contamination and support interim removal action if necessary, and (2) develop and begin implementation of a Biomonitoring Program to assess the extent of mercury contamination in the biota of the Installation Restoration Site 8 marsh and tidal pond as well as evaluate the potential ecological impacts of any interim removal action.

Halliburton NUS developed a site specific Biomonitoring Program for Site 8. This program was presented in a Biomonitoring Plan (Halliburton NUS, 1992b) for the site. The plan outlined procedures to perform biomonitoring at Site 8 on a quarterly basis through two distinct phases - Phase I and Phase II. The plan was developed so that it could be modified (particularly during Phase I) in order to achieve the overall objective of the Biomonitoring Program. During Phase I, sample collection and analytical techniques would be refined based on actual site conditions. After the techniques are refined in Phase I, Phase II would begin. Phase I was to be performed through three months - (October 1992, January 1993 and April 1993) of biomonitoring. Phase II would begin in July 1993 and would continue until it was determined to be no longer necessary.

This report presents the results of the October 1992 round of biomonitoring; the biomonitoring was implemented in accordance with the approved Biomonitoring Plan (Halliburton NUS, 1992b). Because this first round of biomonitoring was part of Phase I, information obtained will be used both to assess Site 8 and to refine the Biomonitoring Program in subsequent Phase I and II rounds.

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 discharged into a storm drain system that discharged into a small stream that flows south and east for

approximately 1/4 mile, enters a cattail marsh and tidally-influenced pond (tidal pond), then empties into Mattawoman Creek. Previous investigations have determined that sediment and surface water of the stream, marsh, and pond contain elevated concentrations of mercury (ABB-ES, 1992a; ABB-ES, 1992b). The actual quantity of mercury that was released is unknown; however, it was previously estimated that between 200 and 500 pounds of mercury were released to the environment from Site 8 (ABB-ES, 1992a).

In August 1992, Halliburton NUS Corporation began sampling and analysis work to investigate 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, 1992a). The results of that sampling and analysis indicate that sediments in the Upper Section of Stream (near Building 766) are contaminated with mercury concentrations greater than 25 mg/kg. Mercury concentrations ranged from non-detect to 671 mg/kg. Sediments in the tidal pond/marsh area had mercury concentrations ranging from non-detect to 13.8 mg/kg. Mercury was not detected in sediments from other areas at the site or detected at substantially lower concentrations and/or not widely distributed.

The Biomonitoring Program developed by Halliburton NUS was designed to be implemented in the tidal pond/marsh area of Site 8 only. The tidal pond/marsh area is the most downstream area of Site 8, sediments from the more contaminated areas of the site (stream) accumulate in the tidal pond/marsh, and the biota in the tidal pond/marsh area are more conducive for biomonitoring.

1.2 SITE DESCRIPTION

The study site (Site 8 tidal pond/marsh) is on the main area of the NSWC. Site 8 discharges into Mattawoman Creek via a 6-foot-diameter culvert running under Noble Road. A beaver pond on the Stump Neck Annex of NSWC, approximately 3 miles southeast of the study site and 1/2 mile northwest of Alexandria Church, was chosen as the control site. The location of Site 8 and the control site are shown on Figure 1-1. The beaver pond control site is located on an unnamed tributary of the Chicamuxen Creek, with drainage to the south of Mattawoman Creek. Both streams are tributaries of the Potomac River. 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 study site in terms of water chemistry, water level, topography, and resident plants and animals. Because the beaver pond control site is approximately 2 miles upstream from Chicamuxen Creek and approximately 3 miles upstream from the Potomac River, it has not been impacted by mercury contamination 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 the Site 8 source.

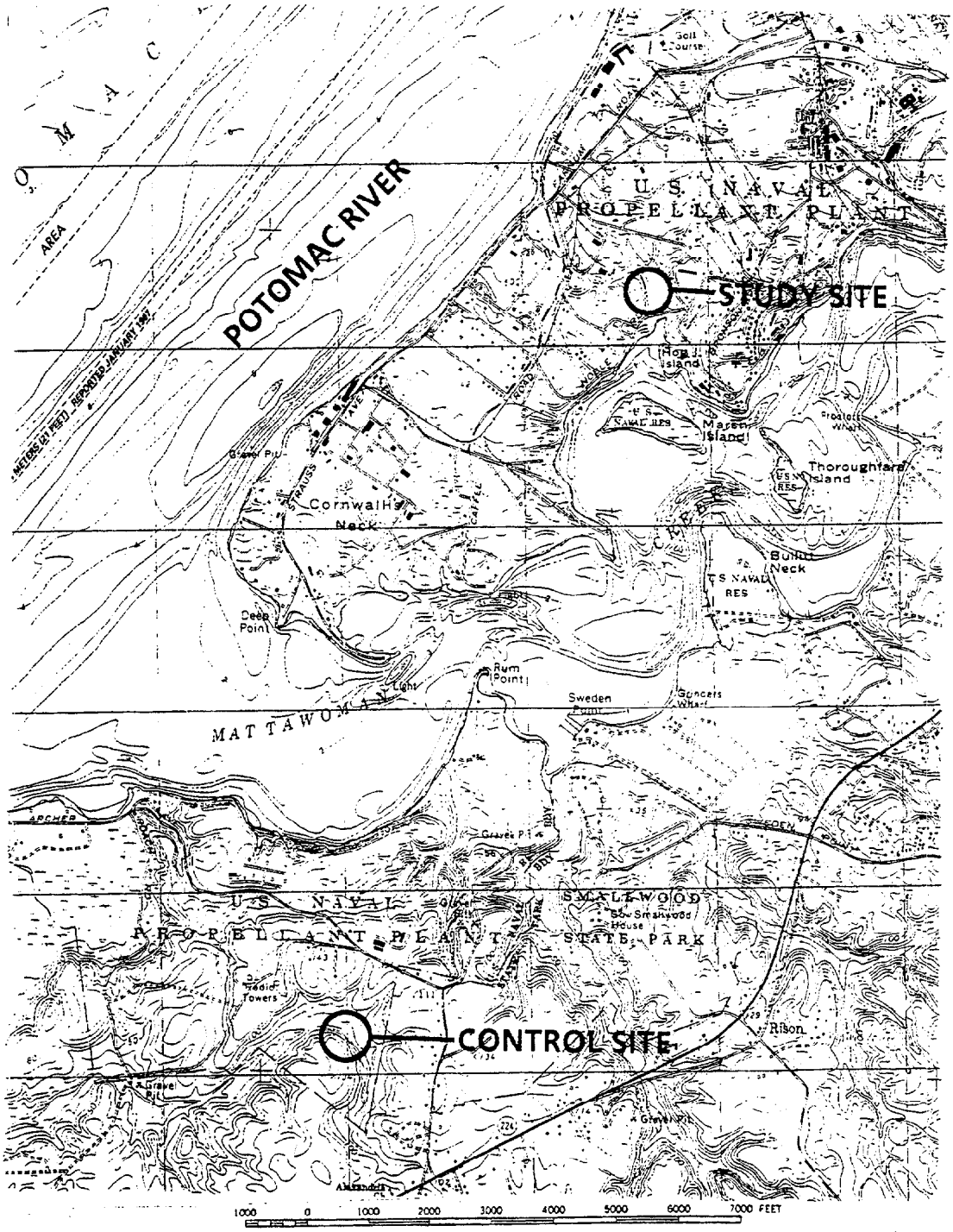

FIGURE 1-1
STUDY AND CONTROL LOCATION MAP
BIOMONITORING PROGRAM
INSTALLATION RESTORATION PROGRAM
SITE 8 - NITROGLYCERIN PLANT OFFICE

HALLIBURTON NUS
Environmental Corporation

Source: 7.5 Minute USGS Quad Indian Head, MD-VA 1966 Photo Revised 1978

Until recently (summer of 1992) the normal depth of the tidal pond/marsh was approximately 4 to 5 feet deep and was maintained by a beaver dam near the upstream end of the pipe, which outlets from the tidal pond/marsh. The beaver dam was removed in the summer of 1992 and normal pool was lowered approximately 4 feet. During the October 1992 phase of biomonitoring the water level in the study site was generally one to two feet deep. A weir to regulate flow from the study site and restore normal pool to its previous level is proposed to be installed on the upstream end of the culvert.

1.3 OBJECTIVE

The overall objective of the Biomonitoring Program is to assess the impact that mercury contamination at Site 8 has affected the biota at the Site 8 tidal pond/marsh and to evaluate potential environmental impacts of any interim removal action. The objective of the October 1992 round of biomonitoring was to collect initial biota data on Site 8, begin establishment of baseline conditions, and provide information to refine and improve subsequent phases of biomonitoring.

2.0 SAMPLING LOCATIONS AND METHODS

Field sampling for the October 1992 round of biomonitoring was conducted on October 29 and 30, 1992. Actual field sampling was performed by Coastal Environmental, Inc., a subcontractor to Halliburton NUS.

As previously described, because the weir (to replace the beaver dam) was not installed, the actual depth of the study site was approximately 1 to 2 feet deep. Field sampling was performed at seven transects through the main area of the tidal pond/marsh (Transect 1 through 7) and at a location on the north side of Atkins Road Extension (Transect 10). The sampling locations are shown on Figure 2-1. During the October 1992 phase of biomonitoring, Transects 1 through 5 were located on an open water (pool) area of the tidal pond/marsh. Transects 6 and 7 were located in the upgradient stream. Transect 10, which under normal circumstances is a marsh with standing water just upstream of the tidal pond, was, at the time of the October sampling, a small stream flowing into the tidal pond.

As part of the October 1992 round of biomonitoring the following sampling and analytical procedures were performed and/or sampled.

- Water Quality
- Periphyton
- Benthic Macroinvertebrate
- Fish

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 mid-depth only because water was <1.0 meter deep at all transects. Conductivity, rather than salinity, was monitored because preliminary field measurements indicated that the tidal pond was freshwater, with salinities <1.0 part per thousand (ppt) at all transects. Grab samples of water for hardness and total organic carbon (TOC) were taken at the surface and shipped to Halliburton NUS' Pittsburgh laboratory for analysis.

2.2 PERIPHYTON SAMPLING

Periphyton was sampled with an artificial substrate device similar to that described in Standard Methods for Analysis of Water and Wastewater (APHA, 1985). This device employs glass slides in a frame supported by styrofoam floats. Two sets of periphyton samplers, each containing 8 slides (a total of 16 slides), were placed at each sampling location. After 14 days the samplers were retrieved and transported to the laboratory for analysis.

Three randomly-selected slides from each array were analyzed for ash-free dry weight, three were analyzed for chlorophyll-a, 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. 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 and counting benthic macroinvertebrates were employed.

2.4 FISH SAMPLING

2.4.1 Fish Survey

A fish survey was conducted at the study site with a backpack electrofishing unit. The total time that current was actually applied to the water was recorded at each station. Because the fish community of the tidal pond was dominated numerically by fish from two species--*Gambusia affinis* and *Fundulus heteroclitus*--representative specimens from these two groups were measured and weighed. All fish were identified in the field and returned to the water unharmed, except for specimens retained for mercury residue analysis.

Unsuccessful attempts were made to collect fish at the control site with a backpack electrofisher and a bag seine. The lack of successful electrofishing may have been due to the water's low conductivity (approximately 75 micromhos/cm) or to the inability of the sampling crew to approach fish in this small body of water without being detected. The effectiveness of the bag seine was limited by the soft bottom and the abundance of aquatic vegetation.

2.4.2 Fish Sampling for Mercury Residues

Additional fish sampling for analysis of mercury in tissues was conducted using a combination of electrofishing, seining, and minnow traps. Minnow traps were set at the study site and control site, left overnight, and retrieved the next day. Target species were largemouth bass (*Micropterus salmoides*), brown bullhead (*Ameiurus nebulosus*), and the mosquitofish (*Gambusia affinis*), which were selected because they represent three distinct trophic (feeding) levels: top-of-the-food-chain predator, bottom-feeding omnivore, and surface-feeding insectivore (Halliburton NUS, 1992b). Because sampling efforts produced no largemouth bass, bluegill (*Lepomis macrochirus*) were collected from the study site and analyzed as a surrogate.

As noted previously, no fish were captured at the control site. In an effort to collect some additional data for purposes of comparison, fish were collected from Transect 10, a tributary stream upstream of the tidal pond. Only two species, *Gambusia* and bluegill, were collected in sufficient quantities from Transect 10 to permit tissue analysis for mercury. Fish were placed on ice and shipped to Gascoyne Laboratories, Incorporated, for analysis of mercury residues in tissues.

3.0 BIOMONITORING RESULTS AND DISCUSSION

3.1 WATER QUALITY

Water quality data are presented in Table 3-1. As shown in Table 3-1 water temperatures in the study site area ranged from 12.4 to 14.7°C. Temperatures increased with decreasing depth, with Transect 1 (deeper water at the foot of the dam) showing the lowest temperature and Transects 7 and 10, both located upstream in shallow, slow-flowing water, having the highest temperatures, 14.3 and 14.7°C. Water temperatures were lower at the control site. Dissolved oxygen (DO) levels ranged from 10.4 mg/L at Transect 10 to 5.3 mg/L at Transect 1, and were adequate to support a variety of aquatic life at all transects. DO levels were consistently lower at the two control stations, however, measuring 4.0 mg/L at both control stations. Measurements of pH ranged from 6.6 to 7.1 at the study site (Transects 1, 2, 4, and 7), and were slightly lower (5.7 to 5.9) at the control site.

TABLE 3-1

(OCTOBER 29, 1992)
WATER QUALITY DATA

Station	Time (approximate)	DO (mg/L)	Temperature (°C)	pH	Conductivity (µmhos)
T-1	10:00-11:00	5.3	12.4	6.6	372.0
T-2	10:00-11:00	5.4	12.6	6.6	398.0
T-4	10:00-11:00	9.4	13.2	6.7	344.0
T-7	12:00-13:00	7.0	14.3	6.9	406.0
T-10	12:00-13:00	10.4	14.7	7.1	304.0
Control A	17:00	4.0	11.7	5.9	74.0
Control B	17:00	4.0	11.7	5.7	73.0

3.2 PERIPHYTON

The periphyton (attached algae) of the control site were dominated by two phyla, the Baccillariophyta (diatoms) and the Chlorophyta (green algae) (see Tables in Attachment A). These two groups made up more than 95 percent by number and weight of the attached algae collected. Diatoms are ubiquitous in a wide variety of freshwater and marine habitats, and are often associated

with the littoral zones of lakes and ponds as well as the bottoms of streams (Whitford and Schumacher, 1973).

Within this diverse diatom group, the control site contained diatom genera associated with clean waters (e.g., *Cocconeis* and *Navicula*) as well as diatoms often used as bioindicators of stress or pollution in aquatic ecosystems (e.g., *Gomphonema* and *Nitzschia*) (APHA, 1985). *Eunotia*, the genus of diatom most common in control site samples, is abundant in stained, acidic waters, such as those of the control site. The pH of the beaver pond control site, which was approximately 5.8 during the October monitoring, was the most acidic of all transects tested.

Of the three green algae genera present in control site samples, *Chlorococcum* was most abundant, while *Ulothrix*, a colonial form, made up most of the biomass. Small numbers of the golden-brown algae *Ophiocytium* were also collected at the control site. This small-celled form, which is generally associated with the phytoplankton rather than periphyton (Wetzel, 1975), made up less than 5 percent of the periphyton collected from the control site and only 2 percent of the total biomass.

Green algae, numerically dominant (53.5% of total collected) in samples from Transect 1, made up approximately 84% of samples by weight. Diatoms were next in abundance and biomass. A small number of *Ophiocytium* were also present in samples from Transect 1.

Transect 3 collections were also dominated by diatoms and green algae, both in density and weight. Diatoms evidenced highest densities, while green algae made up more than 70% of the periphyton samples by weight. Densities and biomass measures of diatoms and green algae from Transect 3 were markedly higher (10 to 15 times) than those of the control site or Transect 1. Samples from Transect 3 also contained small numbers of two phyla, *Euglenophyta* and *Cyanophyta*, not seen at the control site or Transect 1. *Cyanophyta*, or blue-green "algae," are generally regarded as indicators of eutrophication or pollution. Density, biomass, and types of periphyton at Transect 3 are indicative of a much more productive body of water than the control site.

Transect 4, like Transect 3, was characterized by high densities and high measures of biomass. Diatoms were the most abundant group (66 percent), while green algae comprised the bulk of the biomass (72 percent). Transect 4 also contained small numbers of *Euglenophyta* and *Cyanophyta*.

3.3 BENTHIC MACROINVERTEBRATES

The Site 8 tidal pond is typical of tidally-influenced freshwater ponds in the Potomac River estuary, with rooted aquatic vegetation and a soft bottom containing large amounts of organic detritus

(Maryland DNR, 1981). Table 3-2 lists densities of benthic macroinvertebrates collected at the various transects.

A total of 16 macroinvertebrate taxa was collected from the pond proper (Transects 1-3), with *oligochaetes* most abundant (36.5% to 80.0% of total). A total of 10 taxa was collected from the pond-cattail marsh transition zone (Transects 4 and 5), again with *Oligochaeta* most prevalent. A total of 3 taxa was collected from Transects 6 and 7, which represent the stream-cattail marsh transition zone.

Highest densities of macrobenthos were found in the transition zone between the pond proper and the cattail marsh (Transects 4 and 5), which had 3,102 and 5,129 organisms per square meter, respectively. The highest densities of macrobenthos were at Transect 5, a relatively shallow, narrow area at the head of the pond, just below the confluence of the two tributary streams.

Diversity, on the other hand, was highest at Transects 2, 3, and 4, which contained 9, 13, and 10 taxa, respectively. Transect 1, in the deeper water at the base of the dam, contained only five taxa, the bulk of which were *Oligochaeta* and the amphipod *Gammarus*. Transects 6 and 7 (in a stream-like environment) also were low in diversity, containing a total of three macroinvertebrate taxa, the majority of which were *Oligochaetes* and the pulmonate snail *Physella*. Perhaps more significantly, Transects 2, 3, and 4 contained relatively few pollution-tolerant forms (e.g., *Oligochaeta*), and more groups that are indicative of good water quality, such as the odonates (dragonfly larvae) *Gomphus* and *Calopteryx* and an unspecified trichopteran (caddisfly).

Pennak (1978) notes that dragonfly larvae are "rare" in polluted waters. Similarly, caddisflies are associated with shallow (generally lotic) freshwater habitats where there is an adequate supply of oxygen. This dependence on relatively high oxygen levels stems from the fact that respiration in caddisfly larvae is "independent of the (water) surface and atmospheric oxygen" (Wiggins, 1984).

The megalopteran (alderfly larvae) *Sialis*, a sediment-dwelling predator that feeds on insect larvae, annelids, and crustaceans, was collected at Transect 3 only. Roback (1974) identifies *Sialis* as one of the few pollution-tolerant genera of *Megaloptera*. However, this is based on the genus' ability to withstand extremes of pH and high concentrations of several ions (e.g., sulfate and chloride), not a tolerance of low oxygen levels. According to the same reference, *Sialis* requires DO concentrations of at least 5 mg/L.

The beaver pond control site showed a depauperate macroinvertebrate community, low in density and diversity. The amphipod *Gammarus* was the dominant organism, making up 85% of the

TABLE 3-2

BENTHIC MACROINVERTEBRATE SAMPLING
DENSITY (NUMBER/M2) AND RELATIVE ABUNDANCE (%) OF ORGANISMS COLLECTED FROM TRANSECTS
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
Hymanella sp.	32 (1.5%)	--	--	211 (6.8%)	--	--
Nematoda	--	--	51 (6.1%)	306 (9.9%)	--	38 (4.3%)
Oligochaeta	1097 (50.4%)	472 (80.0%)	306 (36.5%)	1053 (34.0%)	4860 (94.8%)	804 (91.4%)
Polychaeta	--	19 (3.2%)	6 (0.8%)	230 (7.4%)	--	--
Asellus sp.	--	6 (1.1%)	--	--	--	--
Gammarus sp.	791 (36.4)	13 (2.1%)	70 (8.4%)	134 (4.3%)	--	--
Gomphus	--	6 (1.1%)	9 (1.1%)	58 (1.9%)	--	--
Calopeteryx sp.	128 (5.9%)	6 (1.1%)	140 (16.7%)	19 (0.6%)	--	--
Sialis sp.	--	--	6(0.8%)	--	--	--
Trichoptera	--	--	6 (0.8%)	--	--	--
Hemiptera	--	--	--	--	--	--
Diptera (adult)	--	6 (1.1%)	--	--	--	--
Diptera (larvae)	--	--	6 (0.8%)	--	--	--
Culex sp.	--	13 (2.1%)	--	--	--	--
Chironomidae	128 (5.9%)	48 (8.2%)	128 (15.2%)	880 (28.4%)	115 (2.2%)	--
Pysella sp.	--	--	38 (4.5%)	77 (2.5%)	115 (2.2%)	38 (4.3%)
Unionidae	--	--	6 (0.8%)	--	--	--
Sphaerium sp.	--	--	64 (7.6%)	134 (4.3%)	39 (0.8%)	--
TOTALS	**2176**	**589**	**836**	**3102**	**5129**	**880**

TABLE 3-2
BENTHIC MACROINVERTEBRATE SAMPLING
DENSITY (NUMBER/M2) AND RELATIVE ABUNDANCE (%) OF ORGANISMS COLLECTED FROM TRANSECTS
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND
PAGE TWO

	Transect 7	Transect 10	Transect 11	Control A	Control B
Hymanella sp.	--	76 (1.8%)	--	--	--
Nematoda	--	--	--	76 (9.9%)	--
Oligochaeta	172 (37.5%)	4132 (98.2%)	76 (100.0%)	--	--
Polychaeta	--	--	--	--	--
Asellus sp.	--	--	--	--	--
Gammarus sp.	--	--	--	536 (70.2%)	38 (100.0%)
Gomphus	--	--	--	--	--
Calopeteryx sp.	--	--	--	--	--
Sialis sp.	--	--	--	--	--
Trichoptera	--	--	--	--	--
Hemiptera	--	--	--	76 (9.9%)	--
Diptera (adult)	--	--	--	--	--
Diptera (larvae	--	--		76 (9.9%)	--
Culex sp.	--	--	--	--	--
Chironomidae	--	--	--	--	--
Pysella sp.	287 (62.5%)	--	-	--	--
Unionidae	--	--	--	--	--
Sphaerium sp.	--	--	--	--	--
TOTALS	**459**	**4208**	**76**	**764**	**38**

macroinvertebrates collected. Small numbers of nematodes, dipteran larvae, and hemipterans were also present. The presence of hemipterans, or "true bugs" in the control site samples is not surprising because this narrow beaver pond is surrounded by shrubby vegetation and trees. Most hemipterans are terrestrial, and those collected presumably fell from nearby vegetation or were washed into the pond by rains.

3.4 FISH DIVERSITY

Low water levels at the Site 8 study site and low conductivity at the control site hindered fish collecting in October 1992. Four fish species were captured during the population surveys at the Site 8 pond: *Lepomis gibbosus* (pumpkinseed), *Ameiurus nebulosus* (brown bullhead), *Fundulus heteroclitus* (mummichog), and *Gambusia affinis* (mosquitofish). No fish were collected from the control site. At least two more species--largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis machrochirus*)--have been collected in the past at Site 8 (letter from Robert E. Foley, U.S. Fish and Wildlife Service to Philip Moore, Halliburton NUS Corporation, dated August 11, 1992). Even if these two additional species had been collected during the October biomonitoring effort, the fish community could only be described as low in species diversity.

The water level of the tidal pond was lowered in 1992 when a beaver dam in its lower end was breached. A weir was to have been installed just upstream of the Noble Road dam prior to the October biomonitoring, but circumstances prevented its installation. As a result, water levels were lower than anticipated at the study site, making sampling of fish and invertebrates extremely difficult. The surface area of the pond was reduced by approximately one-half, and areas previously accessible by boat were no longer accessible. Once the weir has been installed, in the Spring of 1993, the water level in the pond is expected to rise approximately 3 feet, which will inundate much of the exposed pond bed.

Installation of the weir will prevent fish (and invertebrates) from moving into the Site 8 pond from Mattawoman Creek. All recruitment of biota will be from upstream, or from the pond itself. It is unclear whether this will result in marked changes in invertebrate communities, but it appears likely that the fish community will change over time, with a fishery developing that is more typical of a freshwater stream/pond than an estuary.

In the absence of recruitment from downstream, at least one species--the mummichog, *Fundulus heteroclitus*--is expected to decrease in relative abundance. A review of published life history accounts of this species suggests that 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). It is unknown what effect the installation of the weir and the isolation of the pond will have on Gambusia, bluegill, and brown bullhead. Bluegill and brown bullhead are freshwater species. *Gambusia affinis* is an adaptable euryhaline species that fares equally well in fresh or brackish water, lakes, ponds, backwaters of rivers, and drainage ditches (Lee et al., 1980).

3.5 ANALYSIS OF MERCURY IN FISH TISSUE

As previously noted, fish samples were shipped on ice to Gascoyne Laboratories, Inc. EPA Method 7471 (detection limit = 0.01 mg/kg) was used to determine the concentration of total inorganic mercury present in each sample. Analyses were performed on homogenized whole body samples, rather than on fillets. The number and total weight of fish comprising each sample and the concentration of total mercury present in each sample are summarized in Table 3-3.

TABLE 3-3

MERCURY FISH TISSUE ANALYTICAL RESULTS

Fish Species	Site 8			T-10		
	No. Fish Analyzed	Total Weight (grams)	Total Hg (mg/kg)	No. Fish Analyzed	Total Weight (grams)	Total Hg (mg/kg)
Brown Bullhead	3	14.6	0.04	0	0.0	0.00
Gambusia	16	14.2	0.06	20	17.7	0.04
Bluegill	11	53.6	0.02	3	14.6	0.02

No particular trends were evident from these limited data. No significant difference was demonstrated when tissue concentrations of mercury measured in a given species were compared between sites (e.g., mercury present in bluegill samples collected from Transect 10 vs. Site 8). The data also failed to demonstrate a marked difference in the concentration of mercury measured in different fish species collected at a particular sampling station (i.e., Site 8). Because mercury exhibits a tendency to biomagnify (increases in concentration at higher levels of a food chain), detection of higher concentrations of mercury in bluegill (a mid-food-chain organism) than in bullheads or *Gambusia* would have been anticipated. This type of a pattern was not observed.

The tissue concentrations of mercury measured in the samples of bluegill collected in October 1992 are similar to concentrations reported by the USFWS for this area between 1987 and 1991 (USFWS, 1991). As noted in these reports, the levels of mercury reported for bluegill collected from Indian Head are similar to those reported for bluegill collected from other locations in Maryland and throughout the United States; comparable data were not available for bullheads or *Gambusia*. The bluegill data (1987-1992) suggest that the levels of mercury available to these organisms have remained static over the last 6 years and that mercury tissue levels in bluegill have remained within the range reported for this species from other locations throughout the state.

Eisler (1987) suggested that fish tissue levels of 0.1 mg/kg mercury (wet weight) be used as a guideline for the protection of sensitive piscivorous birds and recommended that 1.1 mg Hg/kg serve as a guidance level for the dietary intake of piscivorous mammals. The concentration of mercury present in samples of fish collected from both Site 8 and Transect 10 were well below these suggested guidance levels, indicating that piscivorous terrestrial species that feed on these fish are not at risk.

4.0 CONCLUSTIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

These preliminary findings suggest that the Site 8 marsh-tidal pond system has relatively-simple community structure. The periphyton community was dominated by diatoms and green algae in October 1992; however, the periphyton community is expected to show marked seasonal changes. The benthic macroinvertebrate community is composed largely of herbivores that feed on attached algae and detritivores (such as oligochaetes) that feed on organic detritus. The two most abundant fish species (*Fundulus heteroclitus* and *Gambusia affinis*) in the Site 8 tidal pond are omnivores that feed on plant matter, larval and adult insects, and small fish. Fish species diversity is low, as is typical of tidal streams and ponds in the mid-Atlantic.

Concentrations of mercury in fish tissue from Site 8 (0.02 to 0.06 mg/kg) revealed no clear differences between species or areas. Mercury levels in fish samples were below those suggested as a guideline for protection of sensitive piscivorous birds (0.1 mg/kg) and piscivorous mammals (1.1 mg/kg), indicating that fish-eating terrestrial species that feed on Site 8 fish are not at risk.

None of these data should be regarded as conclusive. Future biomonitoring will reveal more about community structure and will yield more definitive information about levels of mercury in Site 8 biota.

4.2 RECOMMENDATIONS

Despite a number of practical and logistical problems caused by low water levels, the October 1992 round of biomonitoring was useful in that it provided data to begin establishment of baseline conditions at the study site. In addition, based on the results of the October 1992 biomonitoring, a number of refinements will be implemented in subsequent rounds of biomonitoring. These refinements include, but are not limited to: (1) reducing the number of replicate benthos samples taken at the study site, (2) increasing the level of resolution to which certain benthic macroinvertebrate groups are identified, (3) re-evaluating fish sampling methods employed in order to capture a wider variety of fish species, (4) omitting quantitative studies of fish abundance (catch-per-unit-effort) and diversity, and (5) identifying deficiencies with the control site.

Numerous researchers have commented on the tendency of benthic macroinvertebrates to be patchily, rather than uniformly distributed (Cummins, 1975; Wetzel, 1975). Given this patchiness and the large number of samples that would be required to discern statistically significant differences between sampling events (based on the variability observed in this preliminary study), in future rounds of biomonitoring the number of benthos samples will be reduced, and that these data will be assessed qualitatively and graphically rather than quantitatively.

The number of replicate benthic macroinvertebrate samples (3 per transect--results reported here are combined) may be revised. In the future it may be wise to reduce the number of samples and increase the resolution. It is recommended that duplicate, rather than triplicate samples, be taken at each transect. It is also recommended that taxa such as *Trichoptera* and *Unionidae* be classified at least to the genus level, and, when practicable, to species. This should provide more information about the true diversity of the systems and, more importantly, allow a more detailed examination of pollution-tolerant and pollution-intolerant genera and species. As is, it is difficult to draw any conclusions about the relative pollution tolerance of the groups that are represented. Identification to the species level is essential for evaluations of the pollution sensitivity of many benthic organisms.

Given the ecology of the species present and the size and configuration of the two bodies of water, monitoring abundance of fish populations in the Site 8 pond and the control pond is not recommended. The fish communities are dominated by two species, *Gambusia affinis* and *Fundulus heteroclitus*, both of which are small, schooling species. As a result, fish sampling may produce several hundred fish in a very short time (if a large school is encountered) or no fish over a longer time period. Moreover, factors totally unrelated to NSWC operations, such as rainfall, may well determine electrofishing success. For these reasons it is suggested that fish be collected for mercury analyses only, and that additional effort go into collecting adequate numbers of fish from the three targeted groups (i.e., largemouth bass, brown bullhead, and *Gambusia*). If field teams are unable to capture several largemouth bass in the January 1993 and April 1993 sampling rounds, it may be necessary to replace this test species with bluegill, a species that is apparently more abundant than largemouth bass in the Site 8 pond.

The fish and invertebrate communities in the control site are markedly less diverse than the study site, containing only three groups of aquatic macroinvertebrates (i.e., amphipods, nematodes, and dipterans) and small numbers of fish. This probably stems from the fact that the Stump Neck Annex beaver pond is in transition from a stream ecosystem to a pond ecosystem, is in large measure a closed system, and has not been colonized by organisms from upstream and downstream to the degree that the study site has. If another site within the Indian Head complex has more diverse invertebrate and fish communities, it should be considered as the control site. However, if a more appropriate control

site is not available within the Indian Head complex, the Stump Neck Annex control site used in the preliminary round will be used and its limitations duly noted.

The first round of sampling suggests that at least one water quality parameter, salinity, may be omitted in future quarterly biomonitoring. Despite the fact that several sources (e.g., ABB-ES, 1992a) reported that the Site 8 tidal pond was oligohaline (approximately 1 ppt salinity), all indications are that this system is a tidally-influenced freshwater system. This was suggested by a definitive reference (Maryland DNR, 1981) and was confirmed by field measurements of salinity during the October 1992 biomonitoring. It is conceivable that under extraordinary circumstances (e.g., extreme drought coupled with extreme high tides, hurricanes) the Indian Head tidal pond might show low levels of salinity. In future sampling it should only be necessary to measure salinity at a representative location at each site before each day's sampling and to note these data in the field logs. Once confirmed, there should be no reason to measure salinity at every station.

Similarly, Total Organic Carbon (TOC) and hardness, measured at Transects 1, 2, 4, 7, and 10 as well as the control site during the October round of sampling, need not be as intensively investigated. TOC ranged from 3.0 mg/L to 4.0 mg/L at the four transects in the Site 8 pond and marsh. Hardness (as $CaCO_3$) ranged from 44 mg/L to 65 mg/L at these same four transects. There was very little variation in the samples, except for Transect 10, located upstream of the tidal pond, which had a higher TOC value (16.0 mg/L) than the four transects in the marsh and pond proper. It should be sufficient to take duplicate water samples for TOC and hardness from uplake and downlake locations in the tidal pond and from the control site. All of the measured values were unremarkable, indicative of soft water with low to intermediate TOC levels (Lind, 1979; Drever, 1982).

It is anticipated that the water level in the Site 8 tidal pond will still be low during the January 1993 biomonitoring. Despite the difficulty of working in very shallow water, an effort will be made to collect all the biological samples called for in the Biomonitoring Plan. Although the Biomonitoring Plan does not call for fish collecting in January, an effort will also be made to collect fish in the Site 8 pond and control site. It is hoped that normal water levels will be restored by April 1993 (the next sampling period), that the entire pond can be sampled effectively, and that a more complete and representative picture of the tidal pond ecosystem and its plant and animal communities will emerge.

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ATTACHMENT A

PERIPHYTON SAMPLING RESULTS

TABLE A-1

CONTROL SITE A
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cocconeis	14		0.14	
Cymbella	14		0.21	
Eunotia	224		5.60	
Frustulia	28		0.84	
Gomphonema	56		0.86	
Navicula	56		0.56	
Nitzschia	98		0.78	
Pinnularia	42		4.20	
Synedra	56		0.44	
CHLOROPHYTA				
Chlorococcum	28		0.02	
Oocystis	28		4.70	
Ulothrix	140		5.60	
CHRYSOPHYTA				
Ophiocytium	70		0.84	
TOTALS				
TOTALS	**854**		**24.82**	
BACILLARIOPHYTA	**588**	**68.8**	**13.65**	**55.0**
CHLOROPHYTA	**196**	**23.0**	**10.33**	**41.6**
CHRYSOPHYTA	**70**	**8.2**	**0.84**	**3.4**

TABLE A-2

CONTROL SITE B
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Eunotia	180		2.16	
Frustulia	24		0.72	
Gomphonema	84		1.10	
Navicula	108		1.08	
Nitzschia	96		0.76	
Pinnularia	12		1.20	
Synedra	24		1.92	
CHLOROPHYTA				
Chlorococcum	180		0.18	
Oedogonium	168		1.68	
Oocystis	48		8.06	
Stigeoclonium	156		0.78	
Ulothrix	264		10.56	
CHRYSOPHYTA				
Ophiocytium	36		0.43	
TOTALS				
TOTALS	**1,380**		**30.64**	
BACILLARIOPHYTA	**528**	**38.3**	**8.95**	**29.2**
CHLOROPHYTA	**816**	**59.1**	**21.26**	**69.4**
CHRYSOPHYTA	**36**	**2.6**	**0.43**	**1.4**

TABLE A-3

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Eunotia	144		1.92	
Frustulia	16		0.48	
Gomphonema	64		0.64	
Navicula	48		0.48	
Nitzschia	240		2.35	
Pinnularia	48		4.80	
Synedra	16		0.12	
CHLOROPHYTA				
Chlorococcum	416		0.41	
Oedogonium	96		0.96	
Oocystis	16		2.68	
Ulothrix	176		7.04	
CHRYSOPHYTA				
Ophiocytium	32		0.38	
TOTALS				
TOTALS	**1,312**		**22.28**	
BACILLARIOPHYTA	**576**	**43.9**	**10.80**	**48.5**
CHLOROPHYTA	**704**	**53.7**	**11.10**	**49.8**
CHRYSOPHYTA	**32**	**2.4**	**0.38**	**1.7**

TABLE A-4

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	20		0.08	
Eunotia	600		6.00	
Frustulia	20		0.60	
Gomphonema	160		1.60	
Navicula	200		2.00	
Nitzschia	580		4.64	
Synedra	60		4.80	
Other Diatoms	20		10.00	
CHLOROPHYTA				
Chlorococcum	360		0.36	
Cladophora	160		32.00	
Oedogonium	2,680		260.00	
CHRYSOPHYTA				
Ophiocytium	20		0.24	
TOTALS				
TOTALS	**4,880**		**322.32**	
BACILLARIOPHYTA	**1,660**	**34.0**	**29.72**	**9.2**
CHLOROPHYTA	**3,200**	**65.6**	**292.36**	**90.7**
CHRYSOPHYTA	**20**	**<1.0**	**0.24**	**<1.0**

TABLE A-5

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cocconeis	24		0.24	
Cyclotella	24		0.09	
Eunotia	456		4.56	
Frustulia	24		0.72	
Gomphonema	408		4.08	
Melosira	96		0.28	
Navicula	552		7.44	
Nitzschia	912		7.29	
Pinnularia	24		2.40	
Synedra	72		5.76	
Other Diatoms	48		24.00	
CHLOROPHYTA				
Cladophora	216		43.20	
Oedogonium	1,272		128.88	
Ulothrix	288		11.52	
CHRYSOPHYTA				
Ophiocytium	24		0.28	
TOTALS				
TOTALS	**4,440**		**240.76**	
BACILLARIOPHYTA	**2,640**	**59.5**	**56.88**	**23.6**
CHLOROPHYTA	**1,776**	**40.0**	**183.60**	**76.3**
CHRYSOPHYTA	**24**	**<1.0**	**0.28**	**<1.0**

TABLE A-6

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cocconeis	32		0.32	
Gomphonema	160		2.30	
Navicula	192		1.92	
Nitzschia	608		4.86	
Synedra	80		6.40	
Other Diatoms	16		8.00	
CHLOROPHYTA				
Cladophora	96		19.20	
Oedogonium	1,264		114.72	
CYANOPHYTA				
Chroococcus	32		0.12	
TOTALS				
TOTALS	**2,480**		**157.85**	
BACILLARIOPHYTA	**1,088**	**43.9**	**23.80**	**15.1**
CHLOROPHYTA	**1,360**	**54.8**	**133.92**	**84.8**
CYANOPHYTA	**32**	**<1.0**	**0.12**	**<1.0**

TABLE A-7

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cocconeis	320		3.20	
Cyclotella	320		1.28	
Cymbella	160		2.40	
Eunotia	1,920		19.20	
Frustulia	320		9.60	
Gomphonema	10,000		101.76	
Gyrosigma	160		11.20	
Melosira	880		6.00	
Navicula	8,880		104.80	
Nitzschia	14,880		149.28	
Pinnularia	960		96.00	
Synedra	960		76.80	
CHLOROPHYTA				
Closterium	40		40.00	
Oedogonium	15,680		1,221.60	
CHRYSOPHYTA				
Ophiocytium	720		8.64	
EUGLENOPHYTA				
Trachelomonas	160		8.48	
TOTALS				
TOTALS	**56,360**		**1,860.24**	
BACILLARIOPHYTA	**39,760**	**70.5**	**581.52**	**31.3**
CHLOROPHYTA	**15,720**	**27.9**	**1,261.60**	**67.8**
CHRYSOPHYTA	**720**	**1.3**	**8.64**	**<1.0**
EUGLENOPHYTA	**160**	**<1.0**	**8.48**	**<1.0**

TABLE A-8

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	160		4.00	
Cymbella	80		1.20	
Eunotia	2,560		25.60	
Frustulia	320		9.60	
Gomphonema	9,760		101.12	
Melosira	160		3.84	
Navicula	10,080		107.20	
Nitzschia	16,960		161.80	
Pinnularia	960		96.00	
Surirella	160		6.40	
Synedra	960		76.80	
Other Diatoms	320		160.00	
CHLOROPHYTA				
Oedogonium	26,240		2,409.60	
Scenedesmus	320		4.80	
CHRYSOPHYTA				
Ophiocytium	160		1.92	
TOTALS				
TOTALS	**69,200**		**3,169.68**	
BACILLARIOPHYTA	**42,480**	**61.4**	**753.36**	**23.8**
CHLOROPHYTA	**26,560**	**38.4**	**2,414.40**	**76.1**
CHRYSOPHYTA	**160**	**<1.0**	**1.92**	**<1.0**

TABLE A-9

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	120		3.00	
Cymbella	60		0.90	
Eunotia	2,280		22.80	
Frustulia	240		7.20	
Gomphonema	10,800		108.00	
Gyrosigma	60		4.20	
Melosira	120		2.88	
Navicula	12,840		128.40	
Nitzschia	15,240		144.60	
Pinnularia	960		96.00	
Synedra	480		38.40	
Other Diatoms	120		60.00	
CHLOROPHYTA				
Oedogonium	17,400		1,507.20	
CHRYSOPHYTA				
Ophiocytium	240		2.88	
CYANOPHYTA				
Chroococcus	360		1.44	
TOTALS				
TOTALS	**61,320**		**2,127.90**	
BACILLARIOPHYTA	**43,320**	**70.6**	**616.38**	**29.0**
CHLOROPHYTA	**17,400**	**28.4**	**1,507.20**	**70.8**
CHRYSOPHYTA	**240**	**<1.0**	**2.88**	**<1.0**
CYANOPHYTA	**360**	**<1.0**	**1.44**	**<1.0**

TABLE A-10

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	60		3.00	
Eunotia	2,160		21.60	
Frustulia	120		3.60	
Gomphonema	8,880		88.80	
Melosira	120		2.88	
Navicula	13,320		138.00	
Nitzschia	11,760		100.56	
Pinnularia	240		24.00	
Surirella	60		2.40	
Synedra	840		67.20	
Other Diatoms	120		60.00	
CHLOROPHYTA				
Oedogonium	17,520		1,495.20	
Scenedesmus	480		0.48	
CHRYSOPHYTA				
Ophiocytium	120		0.36	
EUGLENOPHYTA				
Trachelomonas	120		6.36	
TOTALS				
TOTALS	**55,920**		**2,014.44**	
BACILLARIOPHYTA	**37,680**	**67.4**	**512.04**	**25.4**
CHLOROPHYTA	**18,000**	**32.2**	**1,495.68**	**74.2**
CHRYSOPHYTA	**120**	**<1.0**	**0.36**	**<1.0**
EUGLENOPHYTA	**120**	**<1.0**	**6.36**	**<1.0**

TABLE A-11

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	60		0.90	
Eunotia	1,440		14.40	
Frustulia	120		3.60	
Gomphonema	6,120		61.20	
Melosira	60		1.44	
Navicula	9,600		124.80	
Nitzschia	12,120		116.40	
Pinnularia	360		96.00	
Synedra	480		38.40	
CHLOROPHYTA				
Closterium	60		60.00	
Oedogonium	21,000		1,464.00	
Oocystis	240		40.32	
TOTALS				
TOTALS	51,660		2,021.46	
BACILLARIOPHYTA	30,360	58.8	457.14	22.6
CHLOROPHYTA	21,300	41.2	1,564.32	77.4

TABLE A-12

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

Taxon	Density (No./cm^2)	Relative Abundance (%)	mg/m^2	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	240		6.00	
Cymbella	240		3.60	
Eunotia	1,920		19.20	
Frustulia	120		3.60	
Gomphonema	5,280		52.80	
Melosira	120		2.88	
Navicula	5,160		61.20	
Nitzschia	16,440		160.68	
Pinnularia	360		36.00	
Synedra	960		76.80	
Other Diatoms	120		60.00	
CHLOROPHYTA				
Chlorococcum	1,080		1.08	
Closterium	60		60.00	
Oedogonium	9,960		812.40	
Oocystis	120		20.16	
CHRYSOPHYTA				
Ophiocytium	120		0.36	
CYANOPHYTA				
Chroococcus	720		2.88	
EUGLENOPHYTA				
Trachelomonas	60		0.60	
TOTALS				
TOTALS	**43,080**		**1,380.24**	
BACILLARIOPHYTA	**30,960**	**71.9**	**482.76**	**35.0**
CHLOROPHYTA	**11,220**	**26.0**	**893.64**	**64.7**
CHRYSOPHYTA	**120**	**<1.0**	**0.36**	**<1.0**
CYANOPHYTA	**720**	**1.7**	**2.88**	**<1.0**
EUGLENOPHYTA	**60**	**<1.0**	**0.60**	**<1.0**

APPENDIX B

CALCULATION SHEETS

RISK ASSESSMENT CALCULATIONS

HALLIBURTON NUS Environmental Corporation and Subsidiaries — **STANDARD CALCULATION SHEET**

CLIENT: NAVY CLEAN	FILE NO.:	BY: I. A. SINAGOGA	PAGE 1 OF 1
SUBJECT: Derivation of Action Level for Industrial Use/ Trespass Scenario		CHECKED BY: JNS	DATE: 10/27/92

Objective: Calculate Action Level for Hg assuming occasional contact w/ sediments by Base personnel or individual trespassing across the site... the accidental ingestion and dermal contact routes of exposure are evaluated.
RfD_o for Hg and Methyl Hg is 3×10^{-4}

Action Level for Accidental Ingestion:

$$C(mg/kg) = \frac{RfD_o(mg/kg/d) \times BW \times ED \times 365\,days/yr}{IR \times EF \times ED \times 10^{-6}\,kg/mg}$$

where:

BW = Body weight = 70Kg
ED = Duration = 30yrs
IR = Ingestion rate = 50mg/d
EF = Exposure frequency = 50day/yr

$$\text{Action Level}(mg/kg) = \frac{3 \times 10^{-4}(mg/kg/d) \times 70kg \times 30yrs \times 365\,day/yr}{50mg/day \times 50d/yr \times 30yrs \times 10^{-6}\,kg/mg}$$

$= \underline{3066\,mg/kg}$ ✓

Action Level for Dermal Contact:

$$C_{mg/kg} = \frac{3 \times 10^{-4}(mg/kg/d) \times BW \times ED \times 365\,d/yr}{SCR \times EF \times ED \times ABS \times 10^{-6}\,kg/mg}$$

where: BW, ED, EF – previously defined
SCR = Soil Contact rate = 500mg/d (Region I value)
ABS = Absorption Factor
Mercury – 1%
Methylmercury 77%
} Region I values.

$$\text{Action level}(Hg) = \frac{3 \times 10^{-4}(mg/kg/d) \times 70kg \times 30yrs \times 365d/yr \times 0.15}{500mg/d \times 50d/yr \times 30yrs \times 10^{-6}\,kg/mg \times 0.01}$$

← RfD adjustment for gastro-intestinal absorption

$= \underline{4599}$ ✓

$$\text{Action Level}(\text{Methyl Hg}) = \frac{3 \times 10^{-4}(mg/kg/d) \times 70kg \times 30yrs \times 365d/yr}{500mg/d \times 50d/yr \times 30yrs \times 10^{-6} \times 0.77}$$

$= \underline{398\,mg/kg}$ ✓

QUANTITY CALCULATIONS

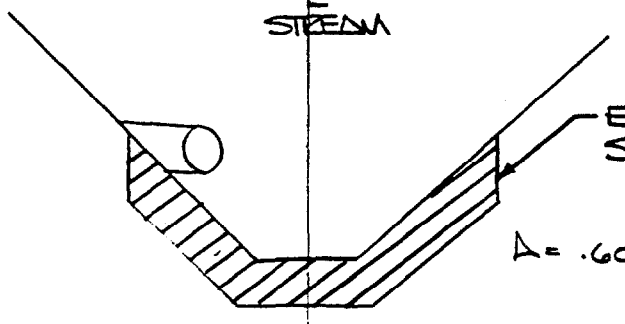
HALLIBURTON NUS Environmental Corporation and Subsidiaries — **STANDARD CALCULATION SHEET**

CLIENT:	FILE NO.:	BY:	PAGE 1 OF 7
NAVY CLEAN	5508	S. RUFFING	
SUBJECT: EXCAVATION QTY'S / ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92

X-SECTIONS OF STREAM:

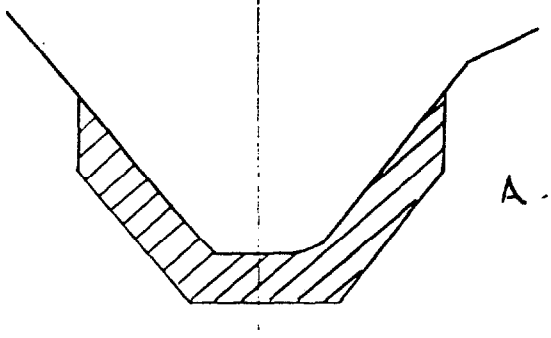
- USE AVERAGE END AREA METHOD TO CALCULATE VOLUME

1" : 8'



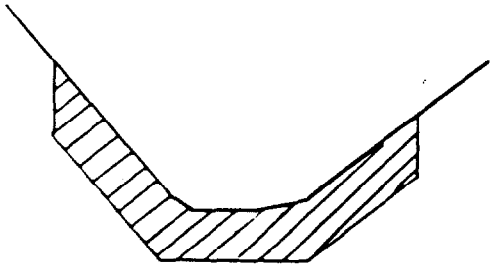
A = .60 in² x 64 = 38.4 SF

OUTLET OF 36" PIPE
(BEGINNING OF UPPER SECTION OF STREAM)



A = .70 in² x 64 = 44.8 SF

50' DOWNSTREAM

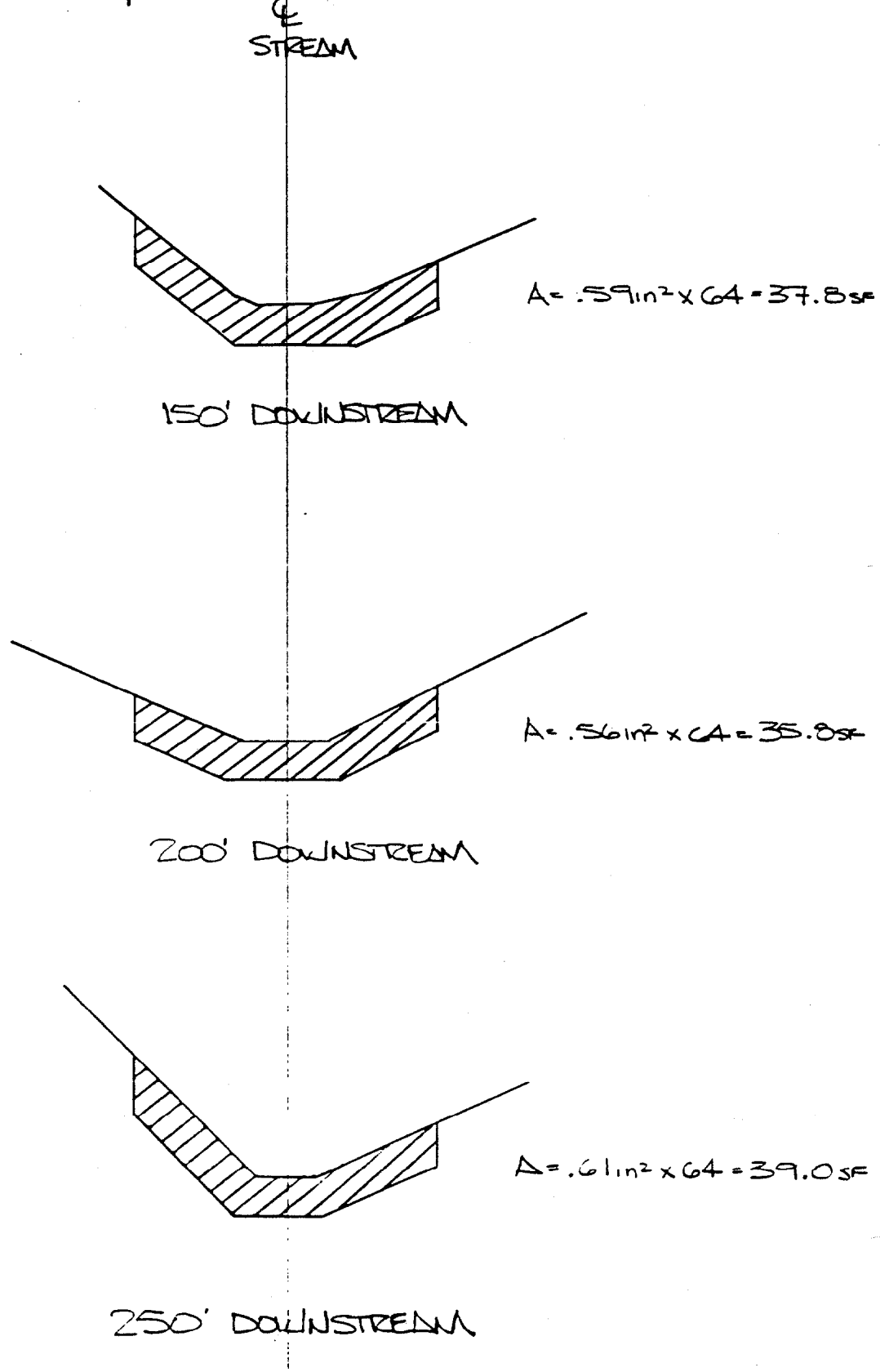


A = .62 in² x 64 = 39.7 SF

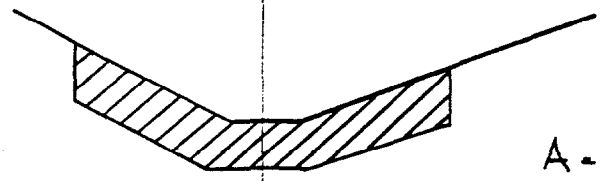
100' DOWNSTREAM

HALLIBURTON NUS Environmental Corporation and Subsidiaries	STANDARD CALCULATION SHEET

CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RUFFING	PAGE 2 OF 7
SUBJECT: EXCAVATION QTYS | ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92



CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RUFFING	PAGE 3 OF 7
SUBJECT: EXCAVATION QTYS / ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92



A = .56 in² × 64 = 35.8 SF

300' DOWNSTREAM
(END OF UPPER SECTION OF STREAM)

ASSUMPTIONS:

1. REMOVAL OF SEDIMENTS/SOILS WITH MERCURY CONCENTRATIONS EXCEEDING 10 mg/kg.
2. BASED ON MERCURY CONCENTRATIONS FOUND AT LATERAL X-SECTIONS A WIDTH OF EXCAVATION OF 15 FEET (7.5' NORTH AND 7.5' SOUTH OF STREAM CENTERLINE) WILL BE USED.
3. DEPTH OF EXCAVATION IS 2 FEET.
4. LENGTH OF EXCAVATION IS 300 FEET.
5. AFTER EXCAVATION
   - MATERIAL REMOVED SHALL BE STABILIZED WITH CEMENT AND PLACED IN AN AREA DESIGNATED BY THE NAVY.
   - AFTER EXCAVATION A LAYER OF GEOTEXTILE AND RIPRAP (2 FEET THICK) SHALL BE PLACED TO MINIMIZE EROSION.

HALLIBURTON NUS Environmental Corporation and Subsidiaries	STANDARD CALCULATION SHEET

CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RURSING	PAGE 4 OF 7
SUBJECT: EXCAVATION QTYS / ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92

USE AVG END METHOD TO CALCULATE VOLUME:

STATION	AREA	AVG AREA	DIST	CF	CY
① OUTLET OF PIPE	38.4 sf				
		41.6 sf	50 lf	2080 cf	77 cy
② 50' DOWNSTREAM	44.8 sf				
		42.25 sf	50 lf	2112.5 cf	78 cy
③ 100' DOWNSTREAM	39.7 sf				
		38.75 sf	50 lf	1937.5 cf	72 cy
④ 150' DOWNSTREAM	37.8 sf				
		36.8 sf	50 lf	1840.0 cf	68 cy
⑤ 200' DOWNSTREAM	35.8 sf				
		37.4 sf	50 lf	1870 cf	69 cy
⑥ 250' DOWNSTREAM	39.0 sf				
		37.4 sf	50 lf	1870 cf	69 cy
⑦ 300' DOWNSTREAM	35.8 sf				

TOTAL VOL: 11710 cf 433 cy

VOLUME OF EXCAVATION = 433 cy

HALLIBURTON NUS Environmental Corporation and Subsidiaries — **STANDARD CALCULATION SHEET**

CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RUFFING	PAGE 5 OF 7
SUBJECT: EXCAVATION QTYS / ASSUMPTIONS		CHECKED BY: T. J. Riley	DATE: 11/4/92

QTY OF RIPRAP & GEOTEXTILE FABRIC

SURFACE AREA TO COVER

STATION	LF @ X-SECTION	AVG LF	DIST	SF	SY
OUTLET OF 36" PIPE	19 LF				
		20 LF	50 LF	1000 SF	111 SY
50' DOWNSTREAM	21 LF				
		20.25 LF	50 LF	1012.5 SF	113 SY
100' DOWNSTREAM	19.5 LF				
		18 LF	50 LF	900 SF	100 SY
150' DOWNSTREAM	16.5 LF				
		16.25 LF	50 LF	812.5 SF	90 SY
200' DOWNSTREAM	16 LF				
		17.5 LF	50 LF	875 SF	97 SY
250' DOWNSTREAM	19 LF				
		17.75 LF	50 LF	887.5 SF	99 SY
300' DOWNSTREAM	16.5 LF				

TOTAL SURFACE AREA: 5487.5 SF 610 SY

VOLUME OF RIPRAP @ 2' THICK COVERING 610 SY = 407 CY

GEOTEXTILE FABRIC UNDER RIPRAP LAYER = 610 SY

CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RUFFING	PAGE 6 OF 7
SUBJECT: EXCAVATION QTYS / ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92

QUANTITY OF CEMENT REQUIRED FOR STABILIZATION:

ASSUMPTIONS:

① AVERAGE WATER CONTENT OF SEDIMENTS IS 30%.

② WATER / CEMENT RATIO IS 1.25.

QTY OF SEDIMENTS IS 433 cy

QTY OF WATER IN SEDIMENTS = 433 × .30 = 129.9 cy

BASED ON WATER/CEMENT RATIO OF 1.25

THE QTY OF CEMENT = $129.9 \times \frac{1}{1.25} = 103.92$ cy

THEREFORE USE 104 cy OF CEMENT TO STABILIZE 433 cy OF SEDIMENT.

POUNDS OF CEMENT:

104 cy × 27 = 2808 cf

CEMENT DENSITY : 94 lb/cf

2808 cf × 94 = 263952 lb. OF CEMENT

HALLIBURTON NUS Environmental Corporation and Subsidiaries	STANDARD CALCULATION SHEET

CLIENT: NAVY CLEAN	FILE NO.: 5508	BY: S. RUFFING	PAGE 7 OF 7
SUBJECT: EXCAVATION QTYS / ASSUMPTIONS		CHECKED BY: T.J. Riley	DATE: 11/4/92

QUANTITY OF STONE FOR ACCESS ROAD

4" THICK x 12' WIDE x 150' LONG
LAYER OF GRAVEL

.33 x 12 x 150 = 594 CF

594 CF / 27 = 22 CY

SURFACE AREA = 12 x 150 = 1800 SF
1800/9 = 200 SY @ 4" THICK

COST ESTIMATES

HALLIBURTON NUS Environmental Corporation and Subsidiaries	STANDARD CALCULATION SHEET

CLIENT:	FILE NO.:	BY:	PAGE 1 OF 1
NAVY CLEAN	5508	S. RUFFING	
SUBJECT: ALTERNATIVE 1		CHECKED BY: T. Jorsky	DATE: 11/4/92

NO FURTHER ACTION:

THIS ALTERNATIVE INCLUDES NO ADDITIONAL WORK, THEREFORE, COST IS $0.00

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
No Action
Alternate No. 2
Post Remedial Monitoring
(O&MNSWC2)

Annual Costs

ITEM	ITEM $ QUARTERLY BIOMONITORING	ITEM $ SEMI-ANNUAL BIOMONITORING	NOTES
1. Biomonitoring	112000.00		Biomonitoring Consisting of Sampling, Analysis and Reporting Years 1 and 2
2. Biomonitoring		56000.00	Biomonitoring Consisting of Sampling, Analysis and Reporting Years 3 thru 7
TOTAL ANNUAL COST	112000.00		Post Remedial monitoring will be performed quarterly for years 1 and 2
TOTAL ANNUAL COST		56000.00	Post Remedial monitoring will be performed quarterly for years 3 thru 7

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
No Action
Alternate No. 2
(PWANSWC2)
428

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	0											
2. O & M COSTS		112										
3. ANNUAL COSTS	0	112	112	56	56	56	56	56	0	0	0	0
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	0	107	102	48	46	44	42	40	0	0	0	0

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	0	0	0	0	0	0	0	0	0	0	0	0

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	0	0	0	0	0	0	0	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	0	0	0	0	0	0	0	428

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Riprap Stream
Alternate No. 3
Post Remedial Monitoring
(O&MNSWC3)

Annual Costs

ITEM	ITEM $ QUARTERLY BIOMONITORING	ITEM $ SEMI-ANNUAL BIOMONITORING	NOTES
1. Biomonitoring	112000.00		Biomonitoring Consisting of Sampling, Analysis and Reporting Years 1 and 2
2. Biomonitoring		56000.00	Biomonitoring Consisting of Sampling, Analysis and Reporting Years 3 and 4
TOTAL ANNUAL COST	112000.00		Post Remedial monitoring will be performed quarterly for years 1 and 2
TOTAL ANNUAL COST		56000.00	Post Remedial monitoring will be performed quarterly for years 3 and 4

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Riprap Stream
Alternate No. 3
(PWANSWC3)
556

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	253.7											
2. O & M COSTS		112										
3. ANNUAL COSTS	253.7	112	112	56	56	0	0	0	0	0	0	0
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	254	107	102	48	46	0	0	0	0	0	0	0

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	0	0	0	0	0	0	0	0	0	0	0	0

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	0	0	0	0	0	0	0	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	0	0	0	0	0	0	0	556

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Riprap Stream
Alternate No. 3
(NSWC3)
1/20/93

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Cost Sub.	Total Cost Mat.	Total Cost Labor	Total Cost Equip.	Total Direct Cost	Comments
MOBILIZATION/DEMOBILIZATION												
1) Office Trailer (1)	1	MO	500.00				500				500	
2) Equipment Mobilization		LS	10000.00				10000				10000	
3) Equipment Demobilization		LS	7500.00				7500				7500	
DECONTAMINATION FACILITIES												
1) Decontamination Services	1	MO	1000.00				1000				1000	
2) Decon Water	500	GAL	.20				100				100	
3) Personnel Decon Pad												
a) Concrete Pad - 4"	2	CY		70.00	125.00	5.00		140	250	10	400	
b) Curb	40	LF		3.07	1.99	.05		123	80	2	204	
4) Clean Water Storage Tank	1			1000.00	200.00			1000	200		1200	1000 Gallon
ACCESS ROAD												
1) Access Road	200	SY		6.00	.90	.90		1200	180	180	1560	
STREAM DIVERSION												
1) Stream Diversion	400	LF		1.00	2.00	3.00		400	800	1200	2400	
PIPE CLEANING												
1) Pipe Cleaning		LS		100.00	300.00	100.00		100	300	100	500	
STREAM REMEDIATION												
1) Regrade Stream		LS			600.00	1000.00			600	1000	1600	
2) Geotextile	610	SY		1.50	.50			915	305		1220	
3) Riprap	410	SY		11.00	6.00	8.00		4510	2460	3280	10250	
4) Site Restoration	150	SY		1.50	1.50	1.70		225	225	255	705	
							19100	8613	5400	6027	39139	
Burden @ 30% of Labor Cost									1620		1620	
Labor @ 15% of Labor Cost									810		810	
Material @ 10% of Material Cost								861			861	
SubContract @ 10% of Sub. Cost							1910				1910	
Total Direct Cost							21010	9474	7829	6027	44341	
Indirects @ 75% of Total Direct Labor Cost									5872		5872	
Profit @ 10% of Total Direct Cost											4434	
											54647	
Health & Safety Monitoring @ 20%											10929	
Total Field Cost											65576	
Contingency @ 20% of Total Field Cost											13115	
TOTAL CONSTRUCTION COST											78691	USE $80,000
Engineering Costs Consisting Of Permitting, Design Engineering, Health and Safety Plan, Sampling And Analysis, Report Preparation											175000	
											253691	

SAY 255.000

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Stabilization
Alternate No. 4
Post Remedial Monitoring
(O&MNSWC4)

Annual Costs

ITEM	ITEM $ QUARTERLY BIOMONITORING	NOTES
1. Biomonitoring	112000.00	Biomonitoring Consisting of Sampling, Analysis and Reporting Years 1 and 2
TOTAL ANNUAL COST	112000.00	Post Remedial monitoring will be performed quarterly for years 1 and 2

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Stabilization
Alternate No. 4
(PWANSWC4)
563

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	355.2											
2. O & M COSTS		112										
3. ANNUAL COSTS	355.2	112	112	0	0	0	0	0	0	0	0	0
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	355	107	102	0	0	0	0	0	0	0	0	0

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	0	0	0	0	0	0	0	0	0	0	0	0

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	0	0	0	0	0	0	0	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	0	0	0	0	0	0	0	563

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Stabilization
Alternate No. 4
(NSWC4)
1/20/93

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Cost Sub.	Total Cost Mat.	Total Cost Labor	Total Cost Equip.	Total Direct Cost	Comments
MOBILIZATION/DEMOBILIZATION												
1) Office Trailer (1)	2	MO	500.00				1000				1000	
2) Equipment Mobilization		LS	12500.00				12500				12500	
3) Equipment Demobilization		LS	9000.00				9000				9000	
DECONTAMINATION FACILITIES												
1) Decontamination Services	2	MO	1000.00				2000				2000	
2) Decon Water	500	GAL	.20				100				100	
3) Personnel Decon Pad												
a) Concrete Pad - 4"	2	CY		70.00	125.00	5.00		140	250	10	400	
b) Curb	40	LF		3.07	1.99	.05		123	80	2	204	
4) Clean Water Storage Tank	1			1000.00	200.00			1000	200		1200	1000 Gallon
ACCESS ROAD												
1) Access Road	200	SY		6.00	.90	.90		1200	180	180	1560	
CLEARING												
1) Clear And Grub	.5	AC			920.00	1100.00			460	550	1010	
STREAM DIVERSION												
1) Stream Diversion	400	LF		1.00	2.00	3.00		400	800	1200	2400	
PIPE CLEANING												
1) Pipe Cleaning		LS		100.00	300.00	100.00		100	300	100	500	
STREAM REMEDIATION												
1) Excavation	433	CY			8.00	11.00			3464	4763	8227	
2) Stabilization	433	CY	60.00				25980				25980	
3) Hauling Stabilized Soil	433	CY			.59	1.46			255	632	888	
4) Geotextile	610	SY		1.50	.50			915	305		1220	
5) Riprap	410	SY		11.00	6.00	8.00		4510	2460	3280	10250	
6) Site Restoration	150	SY		1.50	1.50	1.70		225	225	255	705	
							50580	8613	8979	10972	79144	
Burden @ 30% of Labor Cost									2694		2694	
Labor @ 15% of Labor Cost									1347		1347	
Material @ 10% of Material Cost								861			861	
SubContract @ 10% of Sub. Cost							5058				5058	
Total Direct Cost							55638	9474	13020	10972	89104	
Indirects @ 75% of Total Direct Labor Cost									9765		9765	
Profit @ 10% of Total Direct Cost											8910	
											107779	
Health & Safety Monitoring @ 20%											21556	
Total Field Cost											129335	
Contingency @ 20% of Total Field Cost											25867	
TOTAL CONSTRUCTION COST											155202	SAY $155,000
Engineering Costs Consisting Of Permitting, Design Engineering, Health and Safety Plan, Sampling And Analysis, Report Preparation											200000	

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Offsite Disposal
Alternate No. 5
Post Remedial Monitoring
(O&MNSWC5)

Annual Costs

ITEM	ITEM $ QUARTERLY BIOMONITORING	NOTES
1. Biomonitoring	112000.00	Biomonitoring Consisting of Sampling, Analysis and Reporting Years 1 and 2
TOTAL ANNUAL COST	112000.00	Post Remedial monitoring will be performed quarterly for years 1 and 2

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Offsite Disposal
Alternate No. 5
(PWANSWC5)
597

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	388.3											
2. O & M COSTS		112										
3. ANNUAL COSTS	388.3	112	112	0	0	0	0	0	0	0	0	0
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	388	107	102	0	0	0	0	0	0	0	0	0

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	0	0	0	0	0	0	0	0	0	0	0	0
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	0	0	0	0	0	0	0	0	0	0	0	0

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	0	0	0	0	0	0	0	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	0	0	0	0	0	0	0	597

NAVAL SURFACE WARFARE CENTER
Indian Head, Maryland
Excavation And Offsite Disposal
Alternate No. 5
(NSWC5)
1/20/93

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Cost Sub.	Total Cost Mat.	Total Cost Labor	Total Cost Equip.	Total Direct Cost	Comments
MOBILIZATION/DEMOBILIZATION												
1) Office Trailer (1)	2	MO	500.00				1000				1000	
2) Equipment Mobilization		LS	12500.00				12500				12500	
3) Equipment Demobilization		LS	9000.00				9000				9000	
DECONTAMINATION FACILITIES												
1) Decontamination Services	2	MO	1000.00				2000				2000	
2) Decon Water	500	GAL	.20				100				100	
3) Personnel Decon Pad												
a) Concrete Pad - 4"	2	CY		70.00	125.00	5.00		140	250	10	400	
b) Curb	40	LF		3.07	1.99	.05		123	80	2	204	
4) Clean Water Storage Tank	1			1000.00	200.00			1000	200		1200	1000 Gallon
ACCESS ROAD												
1) Access Road	200	SY		6.00	.90	.90		1200	180	180	1560	
STREAM DIVERSION												
1) Stream Diversion	400	LF		1.00	2.00	3.00		400	800	1200	2400	
PIPE CLEANING												
1) Pipe Cleaning		LS		100.00	300.00	100.00		100	300	100	500	
STREAM REMEDIATION												
1) Excavation	433	CY			8.00	11.00			3464	4763	8227	
2) Hauling And Disposal	433	CY	110.00				47630				47630	
3) Geotextile	610	SY		1.50	.50			915	305		1220	
4) Riprap	410	SY		11.00	6.00	8.00		4510	2460	3280	10250	
5) Site Restoration	150	SY		1.50	1.50	1.70		225	225	255	705	
							72230	8613	8264	9790	98896	
Burden @ 30% of Labor Cost									2479		2479	
Labor @ 15% of Labor Cost									1240		1240	
Material @ 10% of Material Cost								861			861	
SubContract @ 10% of Sub. Cost							7223				7223	
Total Direct Cost							79453	9474	11982	9790	110699	
Indirects @ 75% of Total Direct Labor Cost									8987		8987	
Profit @ 10% of Total Direct Cost											11070	
											130756	
Health & Safety Monitoring @ 20%											26151	
[illegible] Field Cost											156907	
[illegible] @ 20% of Total Field Cost											31381	
[illegible] COST											188288	SAY $190,000
Engineering [illegible] of [illegible]mitting, Design [illegible]ngineering [illegible]afety Plan, Sampling [illegible]ration											200000	
											388288	USE $390,000

APPENDIX C

EXHIBITS

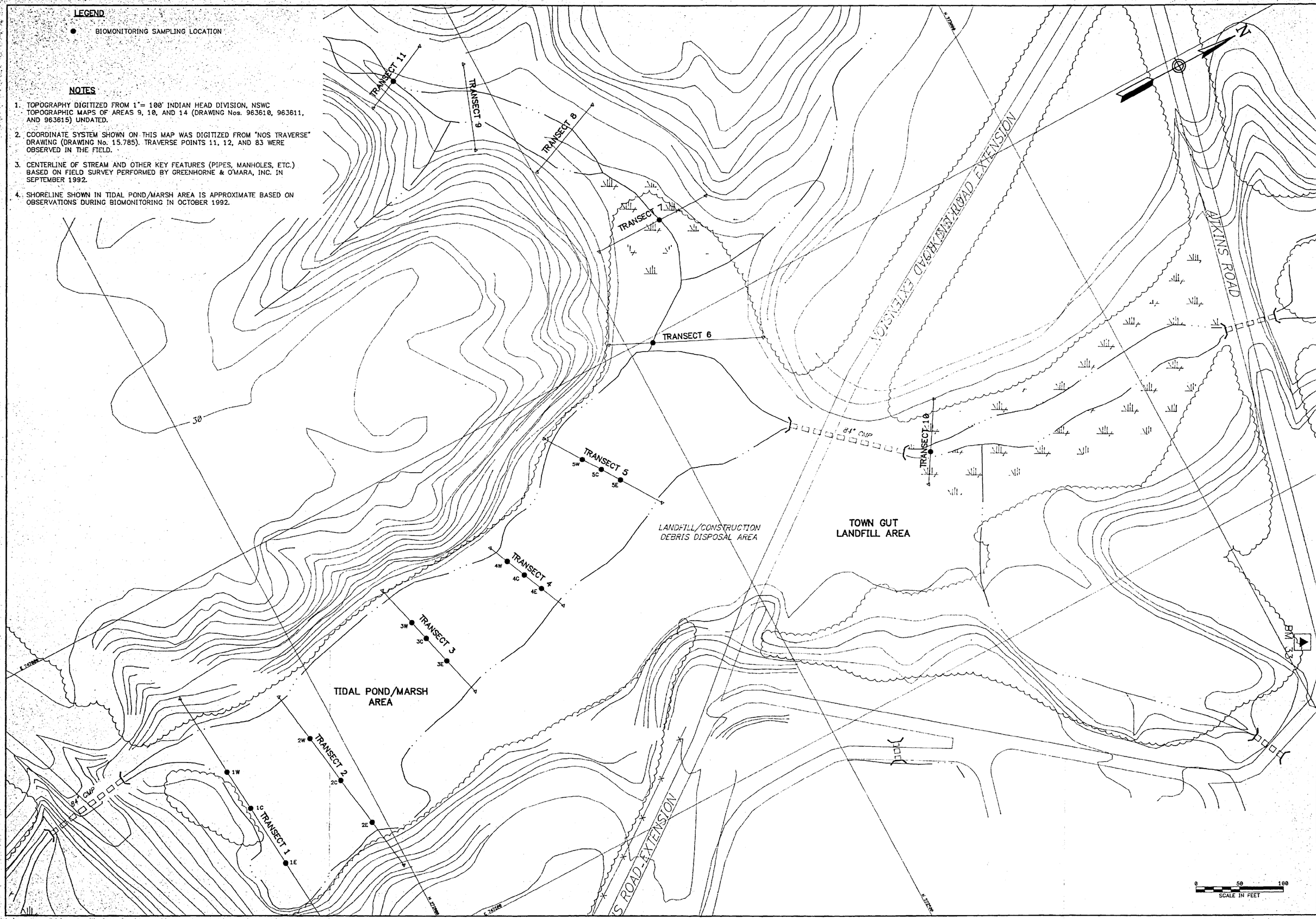
Exhibit C-1	Site 8 - Nitroglycerin Plant Office - Site Plan
Exhibit C-2	Site 8 - Nitroglycerin Plant Office - Contaminant Occurrence and Distribution in Upper Section of Stream
Exhibit C-3	Site 8 - Nitroglycerin Plant Office - Sediment/Soil Sampling Locations and Areas of Elevated Mercury Concentrations

LEGEND

● BIOMONITORING SAMPLING LOCATION

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 1992.



REV.	DESCRIPTION	PREP BY	DATE	APPRVD

HALLIBURTON NUS Environmental Operations
DESIGN: DRAWN: DR: CH. ENG.
SUBMITTED BY: (FIRM MEMBER) (TITLE) (DATE)
CHKD BY: DR: FPG: HD: HD: DIR:
OFFICER IN CHARGE APPROVED DATE

NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, DC

DEPARTMENT OF THE NAVY
WASHINGTON NAVY YARD

CHESAPEAKE DIVISION

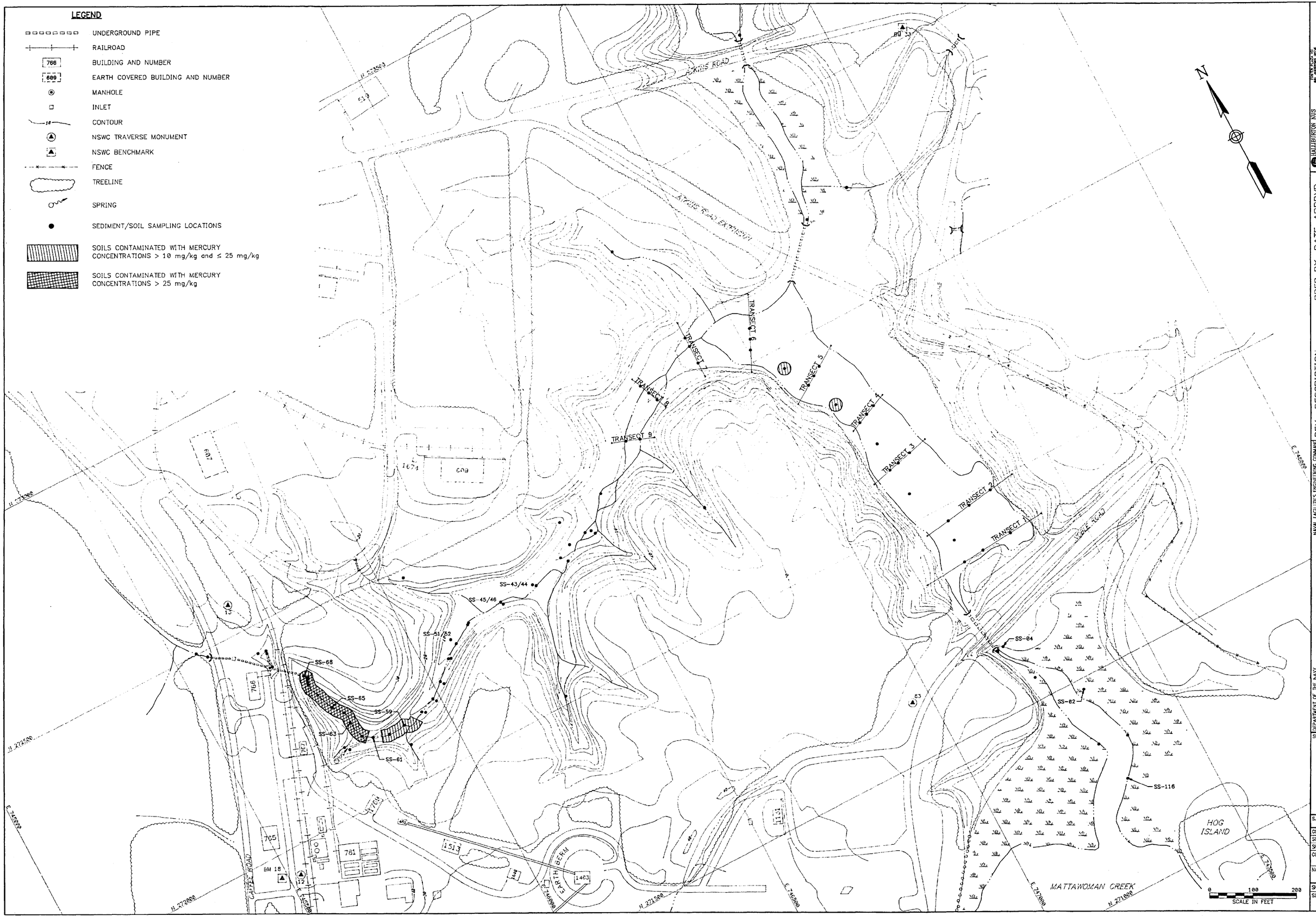
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
SITE 8 – NITROGLYCERIN PLANT OFFICE
OCTOBER 1992 – BIOMONITORING SAMPLING LOCATIONS

ISSUED: JANUARY 22, 1993

NORTHDIV FOR COMMANDER, NAVFAC

SEAL AREA

SAT TO:	DATE
CODE I.D. NO.	80091
SCALE :	AS SHOWN
SPEC. NO. 04 –	NA
CONSTRN. CONTR. NO.	NA
NAVFAC DRAWING NO.	NA
SHEET 1 OF 1	
SIZE: D	DIS. SH. NO. FIGURE 2–1



HALLIBURTON NUS Environmental Corporation
401 Wood Street
Pittsburgh, PA 15222

DSGN: DR: CHK:
SUPV: CH ENG:
SUBMITTED BY: (FIRM NUMBER) (TITLE) (DATE)
CHCSDIV MD: DNC: MD: PFC: DIR:
OFFICER IN CHARGE DATE
APPROVED

REV.	DESCRIPTION	PREP BY	DATE	APPRVD
1	REVISED TITLE	M. Jonnet	JANUARY 1993	APK

NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, DC

DEPARTMENT OF THE NAVY
CHESAPEAKE DIVISION
WASHINGTON NAVY YARD

INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

SITE 8 – NITROGLYCERIN PLANT OFFICE SEDIMENT/SOIL SAMPLING LOCATIONS AND AREAS OF ELEVATED MERCURY CONCENTRATIONS

NORTHDIV FOR COMMANDER, NAVFAC

ISSUED: JANUARY 22, 1993

SEAL AREA

SAT TO DATE

CODE I.D. NO. 80091

SCALE : AS SHOWN

SPEC. NO. 84 – NA

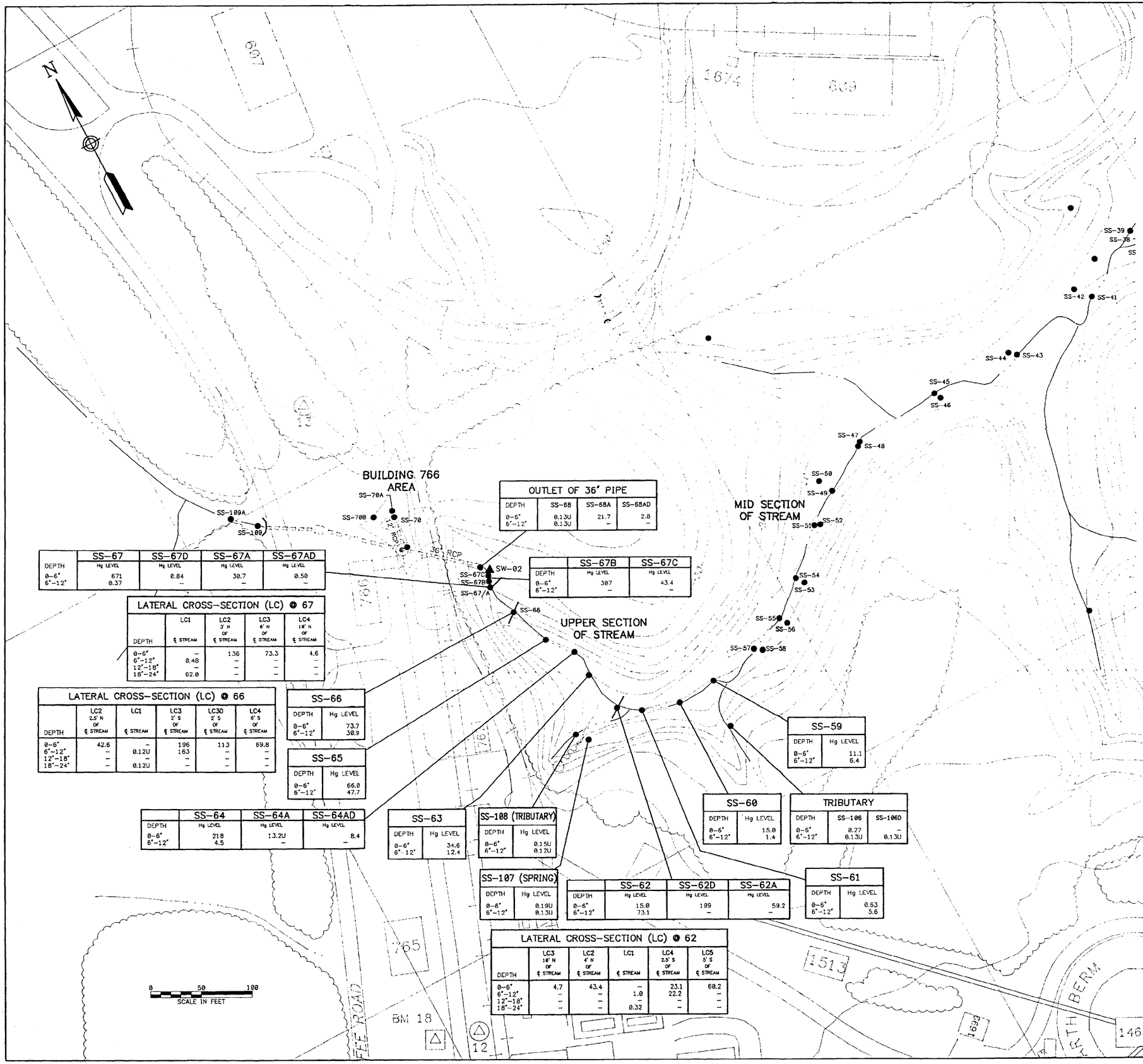
CONSTRN. CONTR. NO. NA

NAVFAC DRAWING NO. NA

SHEET 1 OF 1

SIZE: D

DIS. SH. NO. EXHIBIT C-3



OUTLET OF 36" PIPE			
DEPTH	SS-68	SS-68A	SS-68AD
0-6"	0.13U	21.7	2.8
6"-12"	0.13U	–	–

	SS-67	SS-67D	SS-67A	SS-67AD
DEPTH	Hg LEVEL	Hg LEVEL	Hg LEVEL	Hg LEVEL
0-6"	671	0.84	30.7	0.50
6"-12"	0.37	–	–	–

	SS-67B	SS-67C
DEPTH	Hg LEVEL	Hg LEVEL
0-6"	307	43.4
6"-12"	–	–

LATERAL CROSS-SECTION (LC) @ 67				
DEPTH	LC1 ℄ STREAM	LC2 3' N OF ℄ STREAM	LC3 6' N OF ℄ STREAM	LC4 18' N OF ℄ STREAM
0-6"	–	1.36	73.3	4.6
6"-12"	0.48	–	–	–
12"-18"	–	–	–	–
18"-24"	62.0	–	–	–

LATERAL CROSS-SECTION (LC) @ 66					
DEPTH	LC2 2.5' N OF ℄ STREAM	LC1 ℄ STREAM	LC3 2' S OF ℄ STREAM	LC30 2' S OF ℄ STREAM	LC4 6' S OF ℄ STREAM
0-6"	42.6	–	196	113	69.8
6"-12"	–	0.12U	163	–	–
12"-18"	–	–	–	–	–
18"-24"	–	0.12U	–	–	–

SS-66	
DEPTH	Hg LEVEL
0-6"	73.7
6"-12"	30.9

SS-65	
DEPTH	Hg LEVEL
0-6"	66.0
6"-12"	47.7

	SS-64	SS-64A	SS-64AD
DEPTH	Hg LEVEL	Hg LEVEL	Hg LEVEL
0-6"	218	13.2U	8.4
6"-12"	4.5	–	–

SS-63	
DEPTH	Hg LEVEL
0-6"	34.6
6"-12"	12.4

SS-108 (TRIBUTARY)	
DEPTH	Hg LEVEL
0-6"	0.15U
6"-12"	0.12U

SS-107 (SPRING)	
DEPTH	Hg LEVEL
0-6"	0.19U
6"-12"	0.13U

	SS-62	SS-62D	SS-62A
DEPTH	Hg LEVEL	Hg LEVEL	Hg LEVEL
0-6"	15.0	1.99	59.2
6"-12"	73.1	–	–

LATERAL CROSS-SECTION (LC) @ 62					
DEPTH	LC3 18' N OF ℄ STREAM	LC2 4' N OF ℄ STREAM	LC1 ℄ STREAM	LC4 2.5' S OF ℄ STREAM	LC5 5' S OF ℄ STREAM
0-6"	4.7	43.4	–	23.1	68.2
6"-12"	–	–	1.0	22.2	–
12"-18"	–	–	–	–	–
18"-24"	–	–	0.32	–	–

SS-59	
DEPTH	Hg LEVEL
0-6"	11.1
6"-12"	6.4

SS-60	
DEPTH	Hg LEVEL
0-6"	15.0
6"-12"	1.4

TRIBUTARY		
DEPTH	SS-106	SS-106D
0-6"	0.27	–
6"-12"	0.13U	0.13U

SS-61	
DEPTH	Hg LEVEL
0-6"	0.63
6"-12"	5.6

LEGEND

- UNDERGROUND PIPE
- RAILROAD
- BUILDING AND NUMBER
- EARTH COVERED BUILDING AND NUMBER
- MANHOLE
- INLET
- CONTOUR
- NSWC TRAVERSE MONUMENT
- NSWC BENCHMARK
- FENCE
- TREELINE
- SEDIMENT/SOIL SAMPLING LOCATION
- SURFACE WATER SAMPLING LOCATION
- SPRING

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. FIVE BACKGROUND SEDIMENT/SOIL SAMPLES WERE COLLECTED AT SITE 8. THREE SAMPLES WERE COLLECTED UPSTREAM OF SITE 8 IN MATTAWOMAN CREEK. THE REMAINING TWO SAMPLES WERE COLLECTED FROM A STREAM CHANNEL LOCATED AT THE NORTHWESTERN CORNER OF THE BASE, APPROXIMATELY ONE MILE FROM SITE 8.
5. ALL MERCURY CONCENTRATIONS ARE SHOWN IN mg/kg. DUPLICATE SAMPLES ARE IDENTIFIED WITH A "D" SUFFIX.
6. DATA VALIDATION QUALIFIERS ARE AS FOLLOWS:

   – – NO SAMPLE TAKEN

   U – VALUE IS NONDETECT AS REPORTED BY THE LABORATORY.

   K(m) – POSITIVE RESULTS ARE ESTIMATED AND BIASED HIGH DUE TO HIGH MATRIX SPIKE RECOVERY.

   J(m) – VALUE IS ESTIMATED DUE TO MATRIX SPIKE NONCOMPLIANCES. BIAS CANNOT BE DETERMINED.

   UJ(m) – NONDETECT IS ESTIMATED DUE TO MATRIX SPIKE NONCOMPLIANCE. BIAS CANNOT BE DETERMINED.

   UJ(d) – NONDETECTED IS ESTIMATED DUE TO LABORATORY DUPLICATE IMPRECISION. BIAS CANNOT BE DETERMINED.

   J(d) – VALUE IS ESTIMATED DUE TO LABORATORY DUPLICATE IMPRECISION. BIAS CANNOT BE DETERMINED.

HALLIBURTON NUS Environmental Engineers
DSGN: DR: CH ENG:
SUPV: CHK:
SUBMITTED BY: (FIRM NUMBER) (TITLE)
CHECKED BY: DAC: PROJ. ENGR: NO: NO: DATE: (DATE)
OFFICER IN CHARGE APPROVED DATE

REV. DESCRIPTION PREP BY DATE APPRVD

NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, DC
DEPARTMENT OF THE NAVY
CHESAPEAKE DIVISION
WASHINGTON NAVY YARD

INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
SITE 8 – NITROGLYCERIN PLANT OFFICE CONTAMINANT OCCURRENCE AND DISTRIBUTION IN UPPER SECTION OF STREAM

NORTHDIV FOR COMMANDER, NAVFAC
ISSUED: JANUARY 22, 1993

SEAL AREA

SAT TO DATE

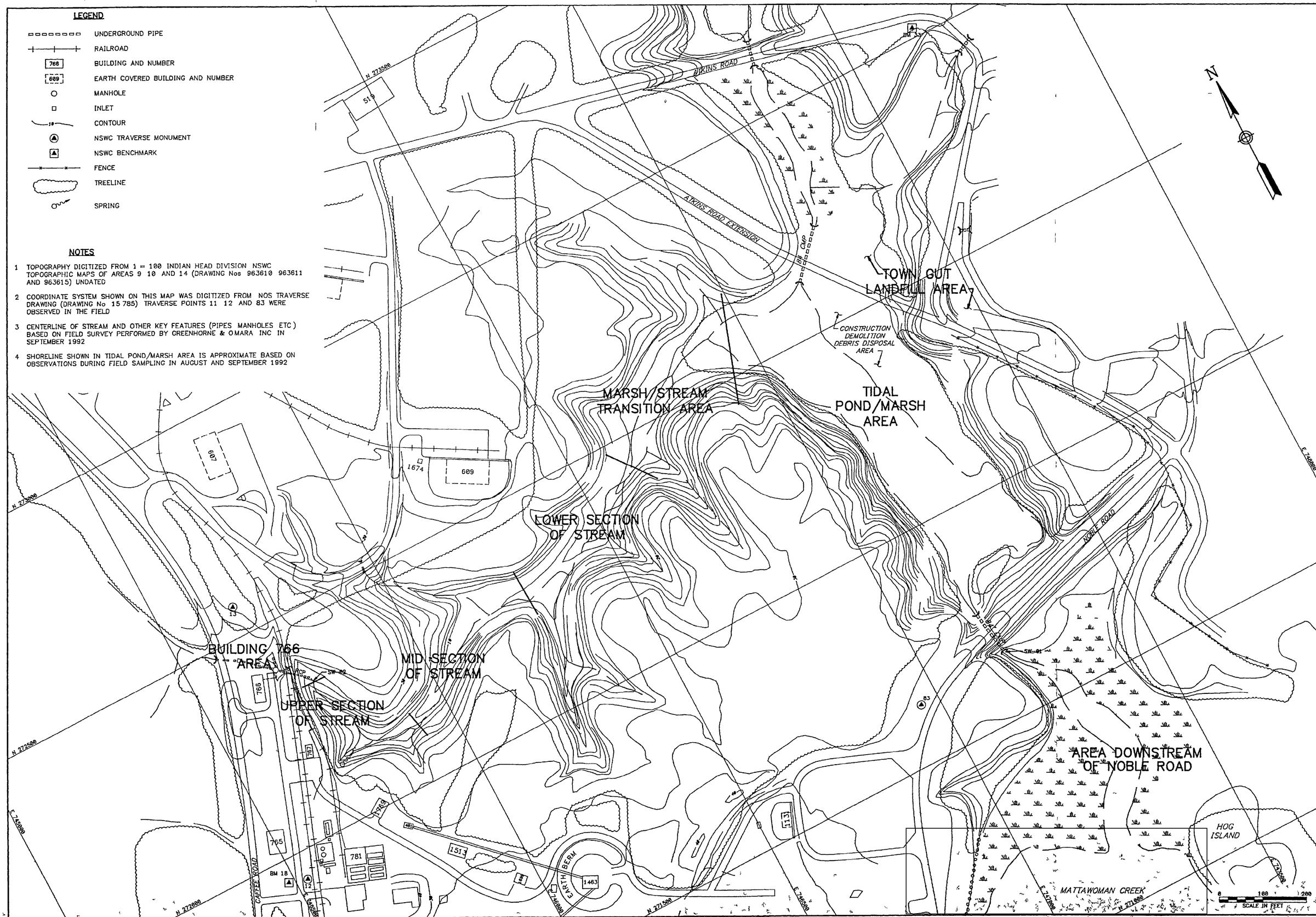
CODE I.D. NO. 80091
SCALE : AS SHOWN
SPEC. NO. 04 – NA
CONSTRN. CONTR. NO. NA
NAVFAC DRAWING NO. NA
SHEET 1 OF 1
SIZE: D
DIS. SH. NO. EXHIBIT C-2

LEGEND

- UNDERGROUND PIPE
- RAILROAD
- 766 — BUILDING AND NUMBER
- 609 — EARTH COVERED BUILDING AND NUMBER
- MANHOLE
- INLET
- CONTOUR
- NSWC TRAVERSE MONUMENT
- NSWC BENCHMARK
- FENCE
- TREELINE
- SPRING

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 FIELD SAMPLING IN AUGUST AND SEPTEMBER 1992



REV	DESCRIPTION	PREP BY	DATE	APPRVD

NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON DC

DEPARTMENT OF THE NAVY
WASHINGTON NAVY YARD

CHESAPEAKE DIVISION

INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
SITE 8 – NITROGLYCERIN PLANT OFFICE
SITE PLAN

ISSUED JANUARY 22 1993

NORTHDIV FOR COMMANDER NAVFAC

HALLIBURTON NUS Environmental Operations
DSGN DR
SUPV
SUBMITTED BY (FIRM NAME)
CHK
CH ENG
(TITLE)
(DATE)
DESIGN
CM
PMC
KD
DR
OFFICER IN CHARGE
APPROVED
DATE

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. EXHIBIT C-1