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Stream Monitoring Work Plan

Unnamed Tributary to Little Neshaminy Creek

Area A Sites
Naval Air Warfare Center (NAWC)
Warminster, Pennsylvania

Naval Air Warfare Center
Warminster, Pennsylvania

Northern Division
Naval Facilities Engineering Command
Contract No. N62472-90-D-1298
Contract Task Order 0252

August 1999

TETRA TECH NUS, INC.

R-51-8-9-6

STREAM MONITORING
WORK PLAN
FOR
UNNAMED TRIBUTARY TO LITTLE NESHAMINY CREEK
AREA A SITES
NAVAL AIR WARFARE CENTER
WARMINSTER, PENNSYLVANIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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August 1999

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L/DOCUMENTS/NAVY/6883/039012

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1.0 INTRODUCTION

This Stream Monitoring Work Plan has been prepared by Tetra Tech NUS, Incorporated (TtNUS) under Contract Task Order (CTO) 252 for the Northern Division (NORTHDIV) Naval Facilities Engineering Command (NAVFAC) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62472-90-D-1298. The purpose of this plan is to describe field activities to be performed as part of the Installation Restoration Program (IRP) being implemented by the Navy at the former Naval Air Warfare Center (NAWC) Warminster, Pennsylvania. The work to be performed is also in support of actions being taken by the Navy under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

1.1 OBJECTIVES

The objective of the monitoring program is to provide a baseline and then 3 years of long-term monitoring data to determine the impact, if any, of the Navy operations on the unnamed tributary to Little Neshaminy Creek. Specifically, the Navy will evaluate the results of the monitoring program to determine the need for additional monitoring and/or the scope of additional remedial actions within the area.

The scope of the work to be conducted under this plan consists of the collection and evaluation of surface water, sediment, and biological (benthic macroinvertebrate) samples from an unnamed tributary to Little Neshaminy Creek. The study area is located within and adjacent to the northern boundary of NAWC. The stream is located near three former Navy disposal sites that have been studied through the remedial investigation (RI) process and have been the subject of removal actions overseen by the Navy.

1.2 REPORTING

The results of the monitoring program will be reported after the completion of each sampling effort. Each monitoring report will present a summary of site history, a description of the field activities performed, the analytical results, and the findings of the biological sampling. The analytical and biological monitoring results will be presented in both tabular and text form. Results from previous monitoring events will be presented in the tables and the text, as appropriate, for comparison and possible trend analysis. All reports will be prepared and submitted to the Navy in rough draft form for review and comment and to the Navy and regulators in draft and final form after receipt and consideration of comments.

In addition to the preparation of sampling-round specific monitoring reports, annual reports summarizing the results of the monitoring program will be prepared and submitted for review. The first annual report, to be prepared after completion of 4 quarterly monitoring events, will present the benthic macroinvertebrate data and characterize the benthic community through an evaluation of taxa richness and diversity. Station-specific data will be compared to determine community similarity. This will include comparisons of the potentially impacted samples with the reference sample.

Surface water and sediment chemical and physical data will be presented and evaluated with the biological data to determine the possible source or cause of any benthic community impairment identified. If the data indicate benthic community impairment from sources other than Navy disposal activities, the possible source or cause of the impairment will be identified. The report will also recommend any changes to the sampling program that should be applied to future monitoring or data evaluation efforts. In the event that no community impairment is identified and continued monitoring is recommended the report will identify the criteria and decision steps to be taken to support the termination of the program.

If impairment of the benthic community is apparent but the data do not clearly identify the source or if the source is associated with Navy disposal activities, the report will recommend changes to the long-term monitoring program necessary to further define or quantify the problem and the possible causes.

The first year's data will be combined with the second year's data to establish a baseline for chemical and biological conditions in the stream. If concentrations of chemicals do not appear to have decreased during the first two years of monitoring and the benthic community appears to be impaired, surface water and sediment data will be compared to screening guidelines presented on Tables 3-1 and 3-2 to further characterize risks. The second year's report, and subsequent annual reports (if necessary), will evaluate the data and trends over time in a similar manner and present recommendations for evaluating possible remedialalternatives.

1.3 SCHEDULE OF ACTIVITIES

The monitoring program will be implemented over a 5-year period. Stream and sediment samples will be collected quarterly for the first year, semi-annually for the second year, and annual for the third through fifth year of the program. Macroinvertebrate samples will be collected

semi-annually during the first year and annually for subsequent years of the program. A general schedule of activities is presented below:

Activity	Date
Work Plan Approval	August 1999
First-Quarter Sampling	September 1999
First-Quarter Draft Report	November 1999
Second-Quarter Sampling	November 1999
First-Quarter Final Report	January 2000
Second-Quarter Draft Report	January 2000
Third-Quarter Sampling	February 2000
Second-Quarter Final Report	March 2000
Third-Quarter Draft Report	April 2000
Fourth-Quarter Sampling	May 2000
Third-Quarter Final Report	June 2000
Fourth-Quarter Draft Report	July 2000
Fourth-Quarter Final Report	September 2000
Second-Year Fall Sampling	August 2000
Second-Year Fall Draft Report	October 2000
Second-Year Fall Final Report	August 2000
Second-Year Spring Sampling	May 2001
Second-Year Spring Draft Report	July 2001
Second-Year Spring Final Report	August 2001
Third-Year Sampling	May 2002
Third-Year Draft Report	July 2002
Third-Year Final Report	August 2002
Fourth-Year Sampling	May 2003
Fourth-Year Draft Report	July 2003
Fourth-Year Final Report	August 2003
Fifth-Year Sampling	May 2004
Fifth-Year Draft Report	July 2004
Fifth-year Final Report	August 2004

TtNUS will be responsible for conducting the first year of monitoring and preparing the first four quarterly reports only. The remainder of the schedule is presented for Navy planning purposes only.

1.4 PRINCIPLE INVESTIGATORS AND RESPONSIBILITIES

TtNUS will be responsible for the management and conduct of the field investigation activities presented in this work plan. The following key personnel will be involved with the first year of monitoring activities for this CTO:

- Navy remedial project manager (RPM)
- NAWC Caretaker Site Office (CSO) representative
- CLEAN program manager
- CLEAN program quality assurance (QA) manager
- CLEAN program health and safety (H&S) manager
- TtNUS project manager (PM)

The Navy RPM for CTO 252 is Lonnie Monaco, of NORTHDIV. Mr. Monaco can be reached at (610) 595-0567. As RPM, he is responsible for the following:

- Provide logistical assistance
- Provide management and technical guidance and oversight
- Review results and recommendations

The NAWC CSO representative is Tom Ames. Mr. Ames can be reached at (215) 441-1114. As the NAWC CSO representative, Mr. Ames is responsible for the following:

- Provide logistical assistance
- Review results and recommendations

The CLEAN program manager is John Trepanowski, of TtNUS. He can be reached at (610) 491-9688. As program manager, Mr. Trepanowski is responsible for the following:

- Ensure that contract requirements are met.
- Provide necessary resources to the project team to meet the requirements of the work plan.
- Maintain consistency of procedures and work products with other CTOs.

- Establish and maintain communications among the Navy RPM, CLEAN program contracting officer, CLEAN program QA manager, CLEAN H&S manager, and TtNUS PM.

The CLEAN program QA manager is Paul Frank, of TtNUS. He can be reached at (412) 921-8950. As QA manager, Mr. Frank is responsible for the following:

- Review laboratory QA work plans, work plans, audit reports, and site data.

- Identify nonconformance situations to management and provide guidance in the correction of nonconformances.

- Ensure deliverables meet requirements of the Navy quality assurance/quality control (QA/QC) program.

- Make recommendations to the program manager and the PM regarding corrective actions.

The CLEAN program H&S manager is Matt.Soltis, of TtNUS. Mr. Soltis can be reached at (412) 921-8912. As H&S manager, he is responsible for the following:

- Ensure that the site-specific H&S plan (HASP) is in conformance with federal and state regulations and contract specifications.

- Provide technical safety and industrial hygiene oversight for all field work performed under the CLEAN contract.

- Provide clearance for the Navy for all personnel on the site in accordance with federal and state regulations and the CLEAN contract requirements.

- Perform audits to evaluate program effectiveness.

- Provide assistance and guidance to the project H&S representative.

- Maintain communication with the program manager, PM, and the project H&S representative.

The project manager is Garth Glenn, of TtNUS. He can be reached at (610) 491-9688. As project manager, Mr. Glenn is responsible for the following:

- Complete the project in a timely manner and maintain the project scope, budget, and schedule.
- Coordinate and implement all tasks indicated in the approved site-specific work plan.
- Supervise data collection, reporting, and document control.
- Approve deliverables and associated documents before transmittal.
- Implement programs and protocols related to the project.
- Establish and maintain communication among technical staff, Navy, CLEAN program staff, and regulators.

Subcontracts for laboratory analytical and macroinvertebrate identification services will be procured to support the activities under this CTO. In addition, a survey subcontract will be issued to locate sampling stations. All subcontract services will be procured and awarded by the CLEAN subcontracting officer before commencement of field activities.

2.0 BACKGROUND

2.1 FACILITY BACKGROUND

The former NAWC Warminster is located in Warminster Township, Bucks County, Pennsylvania. The facility lies in a populated suburban area surrounded by private homes, various commercial/industrial activities, and a golf course. Figure 2-1 shows the general facility location. The facility, approximately 820 acres in size, is being parceled off and transferred to the private sector. Four areas of study (Areas A, B, C, and D) have been identified within the original facility. These areas were identified based on groupings of suspected disposal sites, contamination, geographic boundaries, common sources and receptors, and facility characteristics. Figure 2-2 presents these four major areas of concern. The focus of the biomonitoring program is an unnamed tributary to Little Neshaminy Creek located within Area A.

Area A is located in the northwestern corner of NAWC, between Jacksonville Road and the off-base railroad tracks west of the base. This area contains Sites 1, 2, and 3. Figure 2-3 depicts the approximate locations of these sites.

Site 1 is located at the northwestern border of NAWC. This site was reportedly operated as a burn pit from 1948 to 1950. Various waste materials such as paints, oils, asphalt, roofing material, solvents, scrap metal, and unspecified chemicals were reportedly burned within this pit. Historical aerial photographs indicate that this area may also have been used for the placement of fill material.

Site 2 is located southeast of and adjacent to Site 1. This site reportedly received sludge material from the industrial wastewater treatment facility from 1965 to 1970. It is reported that the sludge material was buried within this area.

Site 3 is located immediately northwest of Jacksonville Road. This site was reportedly used as a burn pit from 1955 to 1965. It has been reported that the pit was used to burn solvents, paints, roofing material, and other unspecified chemicals. Historical information suggests that the pit was backfilled and regraded with soils from the base upon closure. The area now consists of a gravel and asphalt parking lot.

Area A soils have been sampled under several RIs and numerous supplemental investigations. The most comprehensive sampling investigations conducted in the area were performed under

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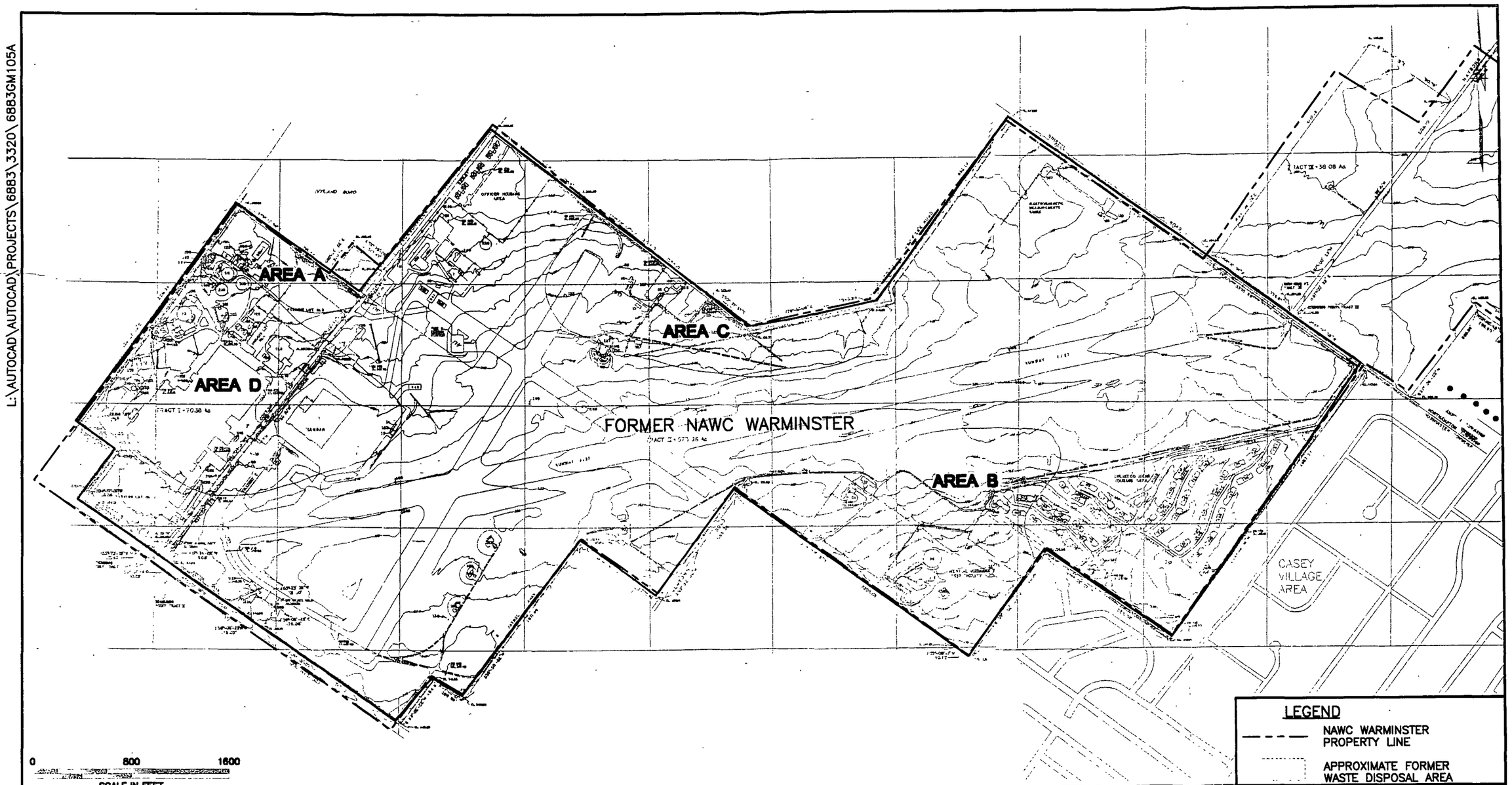
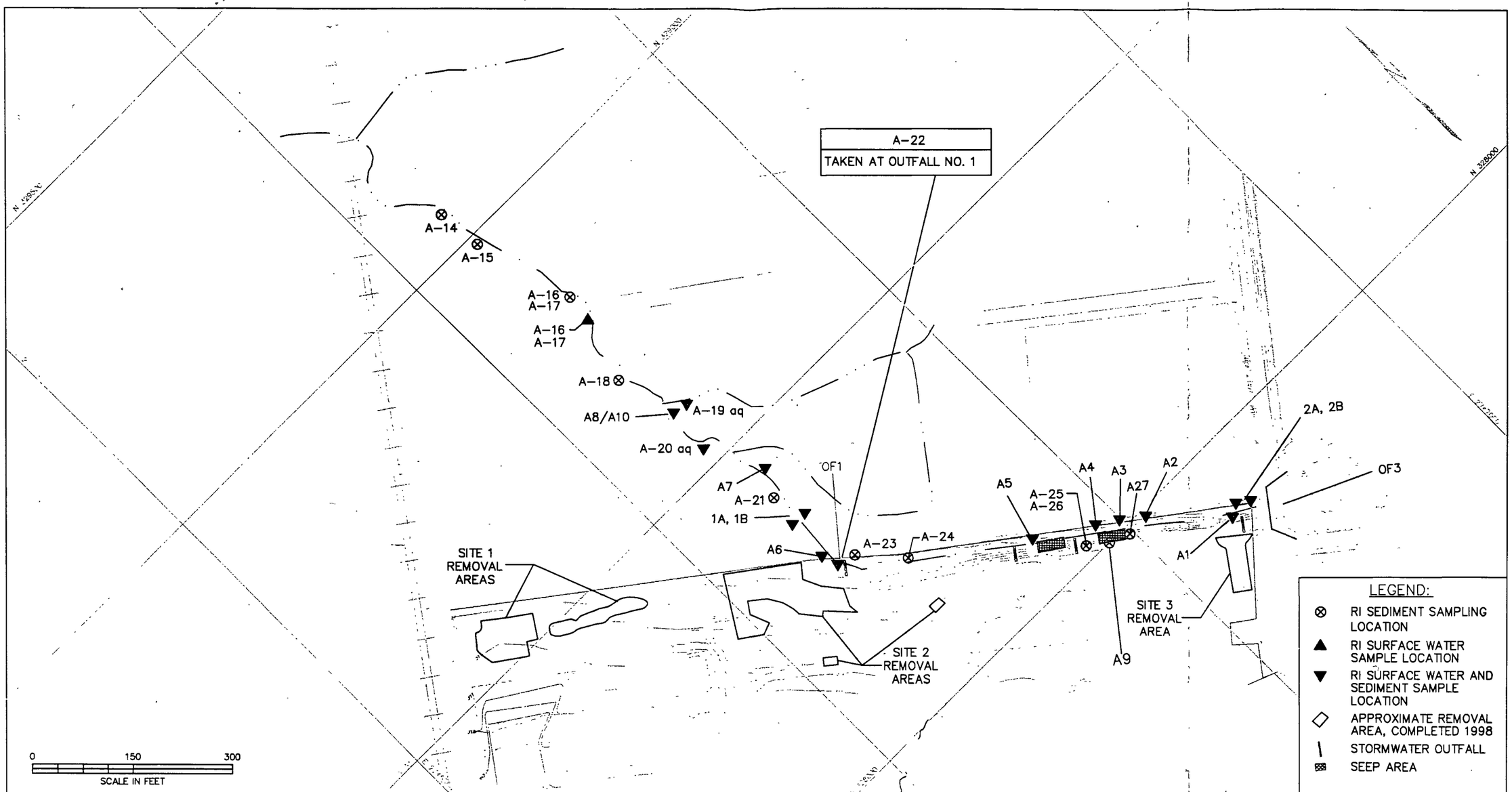


Tetra Tech NUS, Inc.

APPROXIMATE LOCATION OF AREAS OF CONCERN
FORMER NAWC, WARMINSTER
WARMINSTER, PENNSYLVANIA

1 in. = 800 ft.

FIGURE 2-2



REVISIONS	BY	CHKD	APPD	INTERPRETATIONS

LDL 3/31/99

Tetra Tech NUS, Inc.

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AREA A

UNNAMED TRIBUTARY TO LITTLE NESHAMINY CREEK STUDY AREA

NAWC, WARMINSTER, PA

1" = 150'

FIGURE 2-3

REV

the Phase III RI [Draft Phase III RI, Media Other Than Groundwater, Brown & Root Environmental (B&RE), 1996]. Supplemental sampling investigations that were completed after the Phase III RI were summarized and reported in a series of letter reports (Results from Additional Site 1 Soil Investigation, July 10, 1998 B&RE; Results from Additional Site 2 Soil Investigations, July 21, 1998 TtNUS; Supplemental Subsurface Soils at Site 3, July 23, 1998 B&RE; Results from Additional Site 2 Subsurface Soil Investigation, July 28, 1998 B&RE; Preliminary Results from Verification and Supplemental Sampling Area A Site 2, October 29, 1998 TtNUS; Characterization Sampling Results Area A Site 1B, November 12, 1998 TtNUS) issued by the Navy and reviewed by the BRAC Closure Team (BCT).

The results of the RIs and supplemental investigations were evaluated by the Navy and formed the basis for removal actions completed by the Navy. Removal action alternatives were evaluated and presented in a Removal Evaluation Report (Draft Removal Site Evaluation for Area A Soils, April 1998, B&RE) and further refined in a subsequent evaluation and revised excavation letter report issued in September 1998 (Alternatives 4 and 5 Draft Removal Evaluation Report – Area A Soils, August 4, 1998 TtNUS and Area A Removal Action – Addendum to Excavation Approach, September 10, 1998 TtNUS).

The Navy completed removal actions in 1998. In general, the actions consisted of the excavation and off-site disposal of contaminated soils. Two excavations were conducted at Site 1. These excavations extended to bedrock and continued laterally until visual and analytical evidence indicated that no additional contamination existed. Site 2 removal actions consisted of three excavations. The largest was immediately adjacent to the northern property line and immediately upgradient of the unnamed tributary that flows near this boundary. Both surface and subsurface soils were removed from this area based on potential risks to human health and the environment. Excavations were extended at depth and laterally until visual and analytical evidence indicated that no contamination in excess of clean-up goals remained. Similarly, Site 3 removal actions consisted of the removal of surface soils adjacent to Jacksonville Road. This excavation was also extended until evidence confirmed that the target clean-up levels had been attained. The Site 3 excavation extended to about 30 feet from the unnamed tributary to Little Neshaminy Creek at Jacksonville Road.

2.2 SITE BACKGROUND

An unnamed tributary to Little Neshaminy Creek is located north of Area A (Figure 2-3). This stream originates from a stormwater culvert under Jacksonville Road and flows from the southeast to the northwest before turning north, away from NAWC Warminster. Between the base boundary and Bristol Road, the stream flows north under Mearns Road through pastures

and small woodlots to its confluence with Little Neshaminy Creek. Surface water drainage from portions of the airfield and hangar area discharges from a culvert where the stream originates. Surface water runoff from Area A and adjacent areas also enters this stream. A major stormwater discharge culvert (OF1 on Figure 2-3) is located at the point where the stream turns to the north and exits the NAWC property.

The stream adjacent to Area A is a small urban headwater reach that appears to be perennial. The portion of the stream within the NAWC property is channeled with a very high (10 to 12 feet) and steeply sloped (4:1 to 5:1) southern bank. Sites 2 and 3 are located immediately above this southern bank, and approximately one-third to one-half of the area is paved with asphalt paving material. The stream channel in this area averages about 4 feet in width and 1/2 foot in depth. Several small pool areas with depths up to 1 to 2 feet exist within this stretch. In general, the streambed is rocky and gravelly. The deeper, slower moving pools contain a layer of finer sediment.

In addition to the major stormwater discharge (OF1) noted at the property boundary, three other surface water stormwater discharge pipes exist in the upper reaches of the stream adjacent to Sites 2 and 3 (see Figure 2-3). Flow from these pipes is limited to the collection of stormwater. The major discharge pipe, OF1, contains flow most of the year. Historical aerial photographs indicate that another unnamed tributary existed in this area of NAWC, flowing from the south to the north, and discharged in the approximate area of OF1. It is believed, from reviewing these photographs and other historical documents, that the stream was enclosed and now discharges through OF1.

Several seep areas have been identified in addition to the stormwater discharge pipes located on the southern bank of the stream. These seep areas are noted on Figure 2-3. The upper or easternmost seep was evident but not flowing during a March 1999 field inspection. The other two seeps were notable and appeared to flow into the stream over a relatively wide sheet type of discharge rather than a well-defined discharge point. These areas were defined by the presence of wet soils, orange to rusty discoloring of the soils, and the presence of wet soil-type plant species.

Three sampling events were performed in the unnamed tributary to Little Neshaminy Creek during the completion of the RI phases. In general, the surface water and sediment sample analytical results revealed low-level contamination with metals and polycyclic aromatic hydrocarbons (PAHs). The source of the contamination, especially PAHs was not well defined.

A screening-level ecological risk assessment (ERA) was performed as part of the Phase III RI. Surface water and sediment analytical results were compared to conservative Benchmark Toxicity Values to estimate the potential ecological risks associated with the contaminant concentrations. The ERA concluded that surface water contamination presented a low to moderate potential for adverse ecological impacts. Sediment contamination was estimated to present a moderate to high potential for adverse impacts. The ERA recommended further site-specific data collection and analysis to define potential ecological impacts. The EPA Biological Technical Assistance Group (BTAG) concurred with this recommendation and suggested the implementation of a long-term chemical and benthic macroinvertebrate monitoring program at the site.

3.0 FIELD SAMPLING AND ANALYTICAL PLAN

3.1 SAMPLING OBJECTIVES

The sampling objectives of this program are as follows:

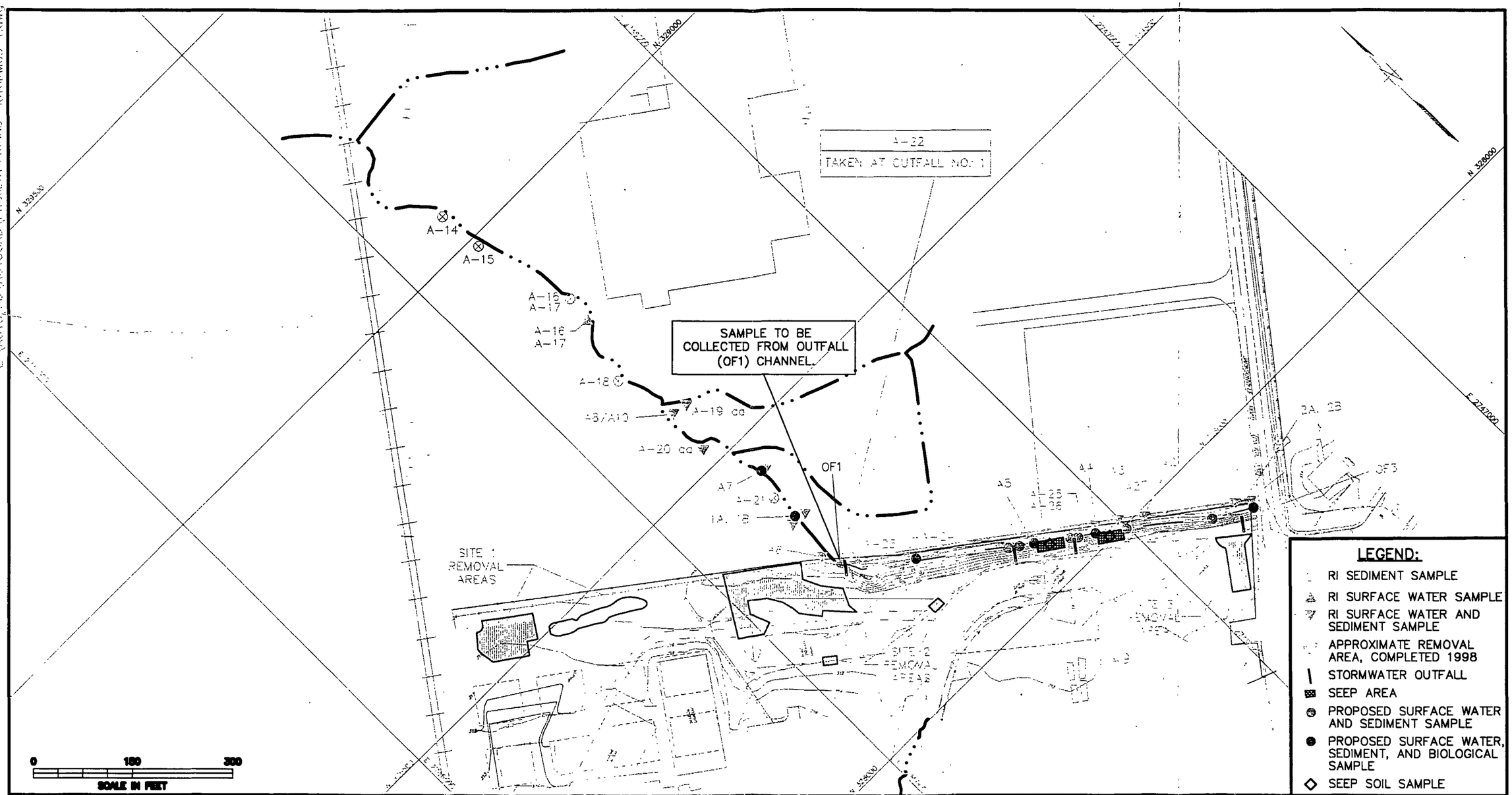
- Establish baseline chemical and benthic macroinvertebrate conditions of the unnamed tributary to Little Neshaminy Creek.
- Collect analytical and biological data over time to determine if the stream conditions vary over the established period of monitoring.
- Collect analytical and biological data to determine the cause, if present, of impacts to the stream community.
- Collect analytical and biological data to determine the source, if present, of contamination.

3.2 FIELD INVESTIGATION TASK DESCRIPTIONS

Field activities are presented by task in the following subsections. All field activities will be conducted in accordance with procedures referenced, TtNUS Standard Operating Procedures (SOPs) (see Appendix A), and the site-specific HASP.

3.2.1 Surface Water Sampling

Surface water samples will be collected at a reference station, immediately upstream and downstream of suspected areas of influence, and downstream of the study area. Figure 3-1 depicts the planned sampling locations. The reference station sample will be collected immediately downstream of Jacksonville Road upstream of surface water runoff and the stormwater discharge outfall located in this area. This station will be used as the reference station for comparing analytical data to downstream or potentially impacted sampling stations. Downstream stations will be located immediately above and below identified influences, including seeps and discharge outfalls and above and below known disposal areas. Surface water samples will be collected at all biological sampling stations. Figure 3-1 shows the total number and location of planned sampling stations.



DRAWN BY EEH	DATE 8/2/99	Tetra Tech NUS, Inc.	CONTRACT NO. 6883	OWNER NO. 5010
CHECKED BY	DATE	AREA A BIOLOGICAL/CHEMICAL MONITORING PROGRAM UNNAMED TRIBUTARY TO LITTLE NESHAMINY CREEK NAWC, WARMINSTER, PA	APPROVED BY	DATE
COST/SCHED-AREA			APPROVED BY	DATE
SCALE 1" = 150'			DRAWING NO. FIGURE 3-1	REV 1

Surface water samples will be collected using laboratory-cleaned sample containers. The samples will be obtained as specified in the SOPS contained in Appendix A. Samples requiring preservation will be collected directly into the sample container containing the sample preservative or will be collected using a laboratory-provided clean sample container rinsed with the stream water before sampling. If this method is used, the sample aliquot will then be added to the sample container containing the appropriate preservative. A separate sample container will be used for each sampling location.

All samples will be collected from approximately mid-depth (0.6 depth) of the main stream channel. Samples will be collected starting at the farthest downstream location and working upstream to avoid influencing subsequent samples from disturbing the streambed during sampling activities. In-stream measurements of temperature, pH, and dissolved oxygen content will be taken at each sampling location. These measurements will be obtained according to the SOPs contained in Appendix A and in accordance with the instrument manufacturer's manual. All field data and sample information and observations will be recorded in a field logbook.

Surface water samples will be analyzed for Target Analyte (TAL) metals, PAHs, total organic carbon (TOC), and hardness. Samples will be analyzed to achieve low detection limits similar to Ambient Water Quality Criteria (AWQCs). Table 3-1 presents the analytical parameters, detection limits, and associated criteria. In cases where the criteria have been established below achievable analytical detection limits, the lowest available detection limit using an approved analytical method has been specified.

Surface water samples will be collected on a quarterly basis during the first year, on a semi-annual basis during the second year, and annually for the remaining years of the program. TtNUS will collect the samples for the first year only.

3.2.2 Sediment Sampling

Stream sediment samples will be collected at all surface water sampling stations. Sediment samples will be collected from the surface (top 2 inches) of the bottom of the stream channel. Samples will be collected using decontaminated stainless-steel trowels/sampling scoops or wide-mouthed, laboratory-cleaned and -provided sample containers. Dredges will not be used due to the shallow, rocky nature of the stream. Samples will be collected after the surface water sample has been collected from the designated sample location. Rocks, stones, gravel, and vegetative matter will be removed from the sample before submittal to the laboratory. Sampling will be conducted to avoid loss of fine sediments as much as possible.

TABLE 3-1
PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SURFACE WATER
NAWC WARMINSTER, PENNSYLVANIA

Chemical	Analytical Method (SW-846)	IDL/PQL	AWQC (1) Freshwater Chronic Screening	Does PQL Exceed? Y or N	Bottleware	Preservation	Holding Time
TAL METALS (UG/L)							
Aluminum	6010B	54	87	N	1 Liter polyethylene with plastic cap	HNO_3, pH<2	6 months, mercury 28 days
Antimony	6010B	3 4*	NA	N			
Arsenic	6010B	3*	8.1	N			
Barium	6010B	3 4	3 9 (2)	N			
Beryllium	6010B	0 67	5 1 (2)	N			
Cadmium	6010B	0 62*	2 2	N			
Calcium	6010B	150	NA	N			
Chromium (total)	6010B	3 4*	74/11	N			
Cobalt	6010B	17*	3 (2)	N			
Copper	6010B	3 1	9	N			
Iron	6010B	50	1000	N			
Lead	6010B	2.1*	2.5	N			
Magnesium	6010B	52	NA	N			
Manganese	6010B	3 1	80 (2)	N			
Mercury	1631	0.0005	0.012	N			
Nickel	6010B	15	52	N			
Potassium	6010B	120	NA	N			
Selenium	6010B	3.9*	5	N			
Silver	6010B	0 59*	NA	N			
Sodium	6010B	340	NA	N			
Thallium	6010B	9 7*	NA	N			
Vanadium	6010B	1*	19 (2)	N			
Zinc	6010B	11	120	N			
PAHs (UG/L)							
Acenaphthene	8310	1	24 (2,3)	N	2.5 Liter Amber glass with teflan lined cap	4°C	Extract 7 days, analyze 40 days.
Acenaphthylene	8310	1	24 (2,3)	N			
Anthracene	8310	2	24 (2,3)	N			
Benzo(a)anthracene	8310	0 1	0 014 (2,4)	Y			
Benzo(a)pyrene	8310	0.1	0 014 (2)	Y			
Benzo(b)fluoranthene	8310	0 1	0.014 (2,4)	Y			
Benzo(g,h,i)perylene	8310	0 1	0 014 (2,4)	Y			
Benzo(k)fluoranthene	8310	0 05	0 014 (2,4)	Y			
Carbazole	8310	1	0 014 (2,4)	Y			
Chrysene	8310	0 1	0 014 (2,4)	Y			
Dibenzo(a,h)anthracene	8310	0 1	0 014 (2,4)	Y			
Dibenzofuran	8310	1	20 (2)	N			
Fluoranthene	8310	0 1	3 9 (2,5)	N			
Fluorene	8310	1	3.9 (2)	N			
Indeno(1,2,3-cd)pyrene	8310	0 1	0 014 (2,4)	Y			
Naphthalene	8310	2	24 (2)	N			
Phenanthrene	8310	1	24 (2,3)	N			
Pyrene	8310	0 1	24 (2,3)	N			

Notes:

* denotes analysis by Trace ICP to achieve this instrument detection limit (IDL) IDLs differ from laboratory to laboratory

TAL = Target Analyte List

NA = Not available

(1) December, 10 1998 Ambient Water Quality Criteria (AWQC) Freshwater CCC

(2) January 1996 Vol 3, No 2 Eco Update Ecotox Thresholds for 67 chemicals commonly found at Superfund sites Surface water freshwater Tier II values.

(3) In the absence of a screening value for this compound benzo(a)pyrene was used as a surrogate

(4) In the absence of a screening value for this compound naphthalene was used as a surrogate

(5) In the absence of a screening value for this compound fluorene was used as a surrogate

TABLE 3-2
PROPOSED ANALYTICAL METHODS AND ECOLOGICAL SCREENING CRITERIA - SEDIMENT
NAWC WARMINSTER, PENNSYLVANIA

Chemical	Analytical Method (SW-846)	IDL/PQL	NOAA ER-L(1)	Does PQL Exceed? Y or N	Bottleware	Preservation	Holding Time
TAL METALS (MG/KG)							
Aluminum	6010B	3.12	NA	N	8 oz with teflan lined cap	4°C	6 months, mercury 28 days
Antimony	6010B	0.41	2	N			
Arsenic	6010B	0.36	8.2	N			
Barium	6010B	0.15	NA	N			
Beryllium	6010B	0.09	NA	N			
Cadmium	6010B	0.06	1.2	N			
Calcium	6010B	3.86	NA	N			
Chromium (total)	6010B	0.1	81	N			
Cobalt	6010B	0.95	NA	N			
Copper	6010B	0.42	34	N			
Iron	6010B	1.05	NA	N			
Lead	6010B	0.27	46.7	N			
Magnesium	6010B	4 64	NA	N			
Manganese	6010B	0.22	NA	N			
Mercury	7471A	0.008	0.15	N			
Nickel	6010B	1.94	20.9	N			
Potassium	6010B	120	NA	N			
Selenium	6010B	0.48	NA	N			
Silver	6010B	0.08	1	N			
Sodium	6010B	18.35	NA	N			
Thallium	6010B	0.63	NA	N			
Vanadium	6010B	1.48	NA	N			
Zinc	6010B	3.3	150	N			
PAHs (UG/KG)							
Acenaphthene	8310	33	16	Y	8 oz with teflan lined cap	4°C	Extract 14 days, analyze 40 days.
Acenaphthylene	8310	33	44	N			
Anthracene	8310	5	85.3	N			
Benzo(a)anthracene	8310	5	261	N			
Benzo(a)pyrene	8310	5	430	N			
Benzo(b)fluoranthene	8310	5	430 (2)	N			
Benzo(g,h,i)perylene	8310	5	430 (2)	N			
Benzo(k)fluoranthene	8310	5	430 (2)	N			
Carbazole	8310	33	430 (2)	N			
Chrysene	8310	5	384	N			
Dibenzo(a,h)anthracene	8310	5	63.4	N			
Dibenzofuran	8310	5	430 (2)	N			
Fluoranthene	8310	5	600	N			
Fluorene	8310	5	19	N			
Indeno(1,2,3-cd)pyrene	8310	5	430 (2)	N			
Naphthalene	8310	33	160	N			
Phenanthrene	8310	5	240	N			
Pyrene	8310	5	665	N			

Notes:

TAL = Target Analyte List

NA = Not available

(1) 1997 ES/ER/TM-95/R4 Toxicological Benchmarks for Screening COPCs for Effects on Sediment Associated Biota

(2) In the absence of a screening value for this compound benzo(a)pyrene was used as a surrogate

Sediment samples will be analyzed for TAL metals, TOC, PAHs, and grain size. Table 3-2 shows the analytical methods, parameters, and detection limits for sediment samples. As with surface water, the lowest achievable detective limits, similar to Effects Range-low (ER-L) concentrations, using approved analytical methods have been specified.

In addition to collecting stream sediment samples, soil samples will be collected from the two seep areas located on the southern bank of the unnamed Tributary to Little Neshaminy Creek (see Figure 3-1). One sample will be collected from each seep area. The samples will be collected at the base of the seep area immediately above the stream bank. The soil samples will be collected from the top 6 inches of soil and will be analyzed for the same parameters as the sediment samples using the same methods.

Seep soil samples will be collected quarterly for the first year of monitoring. A recommendation regarding the need for continued sampling will be made after the first year of data is evaluated. The first-year soil data will be compared to NAWC background soil concentrations as presented in the Phase III RI and evaluated in conjunction with surface water, sediment and biological data.

3.2.3 Macroinvertebrate Sampling

Benthic macroinvertebrate samples will be collected in May and August, beginning in August 1999, at selected locations in the stream and in a reference or upgradient area. Five samples will be collected in the stream during each sampling event and one sample will be collected in the reference/upgradient area. The sampling locations were selected during a June 1999 site visit by Navy EPA, BTAG, and TtNUS personnel and were based on sediment depositional areas, outfalls, seeps, and other areas where chemicals would tend to accumulate. The following describes the locations of the six macroinvertebrate sampling sites in the stream (see Figure 3-1):

- Approximately 30 feet downstream from the culvert under Jacksonville Road. This location will serve as the reference (upstream) location. It is slightly upstream of Site 3 and approximately 300 feet upstream of Site 2. This is the farthest upgradient area of the stream that is expected to have an assemblage of benthic macroinvertebrates. The waterbody is small and concrete or grass lined on the other side of Jacksonville Road.

- Slightly downgradient of Site 3. Seeps were noted in this area. Thus, this sample will serve as an indicator of potential impacts to the stream from Site 3.

- Adjacent to Site 2 near a large seep area. This sample will be an indicator of the influence of Site 2 and associated seeps, as well as all other upgradient influences.

- Between stormwater Outfall 2 and stormwater Outfall 1. This sample will be an indicator of the impacts from Outfall 2 and other upgradient influences.

- Approximately 100 feet downgradient of Outfall 1. This sample will serve as an indicator of potential impacts to the stream from Outfall 1 and all the other upgradient influences mentioned above.

- Approximately 200 feet downstream of Outfall 1. This sample will serve as an indicator of potential impacts from all upgradient influences.

The six sampling locations were selected in areas of the stream where the substrate and water flow under normal flow conditions were similar. An effort was made to match the water depth under normal flow conditions at each site, as well.

The benthic macroinvertebrate samples will be collected with a Surber stream bottom sampler. The Surber sampler consists of square metal frame hinged at a right angle to another square metal frame that has a mesh net attached to it. The sampling crew will enter the stream downstream of the sampling stations and walk upstream for some distance before setting the sampler to avoid disrupting sediments. The samples will be collected from the farthest downstream location, working upstream to the reference station. The metal frame will be placed into the bottom substrate (facing upstream) and the substrate will be agitated with a metal trowel to a uniform depth, which is generally 2 to 4 inches (Handbook of Common Methods in Limnology, Lind, 1979; Standard Methods for the Examination of Water and Wastewater, APHA, 1989). Benthic macroinvertebrates will be dislodged and carried with the current into the net. Larger rocks and debris will be brushed with a small fingernail-type brush to dislodge organisms. The substrate will be agitated from the outside of the frame toward the inside. For each site, samples will be collected until the substrate is thoroughly scoured. Two replicates will be collected at each sampling location and composited.

The contents of the net will be washed into a pre-labeled (see Section 3.3) wide-mouth jar after the net is turned inside out. Larger organisms that stick to the netting will be removed with forceps and placed into the jar. The jar will contain a 95 percent ethanol solution for sample preservation. The laboratory will sort and identify the benthic macroinvertebrates to the lowest taxonomic level practicable (i.e., genus, species), with the exception of juveniles and fragmented

individuals. Classification of all organisms to species level is desired but may be difficult for certain groups, such as Chironomidae and Oligochaeta. In these instances, it may only be practicable for the laboratory to identify organisms to family, sub-family, or tribe. If different groups are classified to different levels in a given sample, the levels of classification for each group will be the same among samples for consistency when calculating metrics/indices. The laboratory will use sample sorting and analysis methods as described by Standard Methods for the Examination of water and wastewater, APHA (1989) and the United States Environmental Protection Agency (EPA) (1990). The laboratory will generate the descriptive statistics and metrics/indices described in Section 4.0. It should also be noted that the field and laboratory methods used in the biomonitoring will be evaluated after the first sampling event to determine if any modifications are necessary.

3.2.4 Stream, Flow Monitoring

Stream depth and width measurements will be taken and recorded during each sampling event at each sampling station. Stream flow measurements will also be collected and recorded at all biological (macroinvertebrate) sampling locations during the biological sampling events. Stream flow measurements will be obtained using a portable in-stream flow monitoring and recording device manufactured specifically for low-flow streams. Measurements will be taken upstream of the sampler and according to manufacturer's manual and instructions. Flow, depth, and width measurements will be recorded in a field logbook and reported with the analytical results and findings.

3.3 SAMPLE DESIGNATION SYSTEM

Each sample collected for analysis will be assigned a unique sample tracking number. This number will consist of a two-segment alphanumeric code that identifies the sample type or QC sample designation and the station or QC number. The following codes will be used to designate the type of sample collected:

SW = Surface water
SD = Sediment
BI = Biological (macroinvertebrate)
DU = Duplicate
TB = Trip blank
RB = Rinsate blank

Station location numbers will be assigned to each stream location. These numbers will be assigned sequentially, starting with station 01. As indicated in previous sections, sampling will be conducted from the most downstream location, working upstream. Therefore, sample location 01 will be the farthest downstream location. All pertinent sample identification and location information will be recorded in field logbooks and on sample logsheets, where appropriate. In addition, the information necessary to track samples will be entered onto a chain-of-custody form prior to shipment.

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

This quality assurance and quality control Section identifies specific parameters and procedures that are applicable to the investigation:

- Project scope and complexity
- Project organization and responsibilities
- QA objectives for analytical data
- Field decontamination procedures
- Custody protocol
- Analytical parameters and sample frequency
- Identification of analytical methods
- Calibration procedures
- Data reduction, validation, and reporting procedures
- Data assessment procedures

4.1 PROJECT SCOPE AND COMPLEXITY

This project will include the collection of surface water, sediment, and macroinvertebrate samples from the unnamed tributary to little Neshaminy Creek. The results of the sampling effort will be used to determine the need for additional long-term monitoring and/or other remedial actions.

4.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

Overall project coordination personnel and responsibilities are discussed in Section 1.4 of this work plan.

4.3 QUALITY ASSURANCE OBJECTIVES

The QA objective is to ensure that the data generated as part of this investigation are of known and acceptable quality and are suitable for the intended use. The data quality objectives (DQOs) are established by identifying the end use of the data and the degree of certainty necessary to satisfy that end use. Data will be used to determine if the unnamed tributary to little Neshaminy Creek is being impacted by previous Navy activities at Sites 1, 2, and 3.

The overall QA objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results that are legally defensible in a court of law. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control, audits, preventive maintenance of field and laboratory

equipment, and corrective action are described in other sections of this Quality Assurance Program Plan. The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and, ultimately, environmental decisions. These parameters are discussed in the remainder of this section.

4.3.1 Precision

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for samples under similar conditions. The equation for determining precision for this project is described in detail in Section 4.10.2.

4.3.1.1 Field Precision Objectives

Field duplicate precision monitors the consistency with which environmental samples were obtained and analyzed. Field duplicate results for solid matrix samples are considered to be precise if the relative percent difference (RPD) is less than or equal to 50 percent. Field duplicate results for aqueous matrix samples are considered to be precise if the RPD is less than or equal to 30 percent. Field precision is assessed through the collection and measurement of field duplicates at a rate of one duplicate per 10 analytical samples.

4.3.1.2 Laboratory Precision Objectives

Laboratory precision quality control samples will be analyzed with a frequency of five percent (i.e., one quality control sample per 20 environmental samples) for organic analyses and a frequency of 10 percent (i.e., one quality control sample per 10 environmental sample) for inorganic analyses. Laboratory precision is measured via comparison of calculated Relative Percent Difference (RPD) values and Precision Control Limits specified in the analytical method or by the laboratory's QA/QC program.

Precision for organic analysis will be measured via the RPDs for matrix spike/matrix spike duplicate samples. Precision for the remaining parameters will be measured via the RPD results for laboratory duplicate samples.

4.3.2 Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. The equation for determining accuracy for this project is described in detail in Section 4.10.1.

4.3.2.1 Field Accuracy Objectives

Accuracy in the field is assessed through the use of trip blanks and is ensured through the adherence to all sample handling, preservation, and holding times. Accuracy and precision requirements for field measurements (e.g., pH) are ensured through calibration, as discussed in Section 4.8.1.

4.3.2.2 Laboratory Accuracy Objectives

Accuracy in the laboratory is measured through the comparison of a spiked sample result against a known or calculated value expressed as a percent recovery (%R). Percent recoveries are derived from the analysis of known amounts of compounds spiked into deionized water (i.e., laboratory control sample analysis) or into actual samples (i.e., surrogate or matrix spike analysis). These analyses measure the accuracy of laboratory operations as affected by matrix. Laboratory control sample analyses are performed with a frequency of one per 20 associated samples of like matrix. Matrix spike analyses will be performed with a frequency of one per 20 associated samples of like matrix for organic analyses and with a frequency of one per 10 associated samples of like matrix for inorganic analyses. Surrogate spike analysis is performed for all organic analyses. Laboratory accuracy is assessed via comparison of calculated percent recovery (%R) values with accuracy control limits specified in the analytical method or by the laboratory's QA/QC program.

Accuracy for organic analysis will be measured via the percent recoveries for surrogate spikes and matrix spike/matrix spike duplicates.

4.3.3 Completeness

Completeness is a measure of the amount of usable, valid, analytical data obtained compared to the amount expected to be obtained. Completeness is typically expressed as a percentage. The equation for completeness is presented in Section 4.10.3.

The ideal objective for completeness is 100 percent (i.e., every sample planned to be collected is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed); errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination); or strong matrix effects can become apparent (e.g., extremely low matrix spike recovery). These instances result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. Completeness will be calculated per sampling event. If critical data points are lost, resampling and/or re-analysis may be required.

One hundred percent of the data will be validated in accordance with EPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review (EPA, February 1994a; EPA, February 1994b), as modified for EPA Region III specific requirements. Data rejected as a result of the validation process will be treated as incomplete data.

4.3.3.1 Field Completeness Objectives

Field completeness is a measure of the amount of valid field measurements obtained from all the field measurements taken in the project. Field completeness for this project is expected to be greater than 90 percent.

4.3.3.2 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the laboratory measurements taken in the project. Laboratory completeness for this project is expected to be greater than 95 percent.

4.3.4 Representativeness

Representativeness is an expression of the degree to which the data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point. Use of standardized sampling, handling, analytical, and reporting procedures ensures that the final data accurately represent actual site conditions.

4.3.4.1 Measures to Ensure Representativeness of Field Data

Representativeness is dependent upon the proper design of the sampling program and will be satisfied by ensuring that this work plan is followed and that proper sampling techniques are used.

4.3.4.2 Measures to Ensure Representativeness of Lab Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples. The sampling network for this project has been designed to provide data representative of site conditions. During development of this network, consideration was given to existing analytical data, physical setting, and field observations. The rationale for the sampling network is discussed in Section 3.0 of this plan.

4.3.5 Comparability

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized

sampling and analysis methods and data reporting formats (including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis). Additionally, consideration is given to seasonal conditions and other environmental variations that could exist to influence data results.

4.3.5.1 Measures to Ensure Comparability of Field Data

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the work plan is followed and that proper sampling techniques are used. It is also dependent on recording field measurements using the correct units. Field measurements for this project include pH, temperature, dissolved oxygen, and flow. The units used for the field measurements for this project are as follows:

- pH is measured to the nearest 0.1 standard pH units.
- Temperature is measured in degrees Celsius.
- Dissolved oxygen is measured to the nearest 0.1 mg/l.
- Flow measurements are measured in cm/second.

4.3.5.2 Measures to Ensure Comparability of Lab Data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current state and federal standards and guidelines. Organic chemicals will be reported in µg/kg for solid samples and µg/L for aqueous samples. Metals data will be reported in mg/kg for solid samples and ug/L for aqueous samples.

4.4 QUALITY ASSURANCE PROCEDURES

QA/QC samples are intended to provide control over the collection of environmental data and subsequent validation, review, and interpretation of the analytical results. Various types of blank samples and other related QA/QC concerns such as packaging, handling, and shipping of samples from the site are discussed in this section.

External QC measures (i.e., field quality control samples) consist of field duplicates, trip blanks, and field blanks. Information gained from these analyses further characterizes the level of data quality obtained to support project goals. Each of these types of field quality control samples undergo the same preservation, analysis, and reporting procedures as the related environmental samples. Each type of field quality control sample is discussed below.

4.4.1 Trip Blank

The trip blank is used exclusively for the monitoring of aqueous volatile organic analyses. The purpose of the trip blank is to measure cross contamination of the samples during shipment to and from the site. The trip blanks must travel to the site with the empty bottleware and from the site with the collected samples. At no time should the trip blank be opened in the field. The rate at which this sample is taken is one per cooler containing volatile organic samples. No volatile organic analyses are being conducted for this project.

4.4.2 Field Blank

The field blank is prepared in the field from analyte-free water used during equipment decontamination activities. The field blanks will be preserved in the same manner as the aqueous field samples and will be analyzed for the same parameters as the field samples collected that day. Field blanks will be prepared at the rate of one per sampling event.

4.4.3 Rinsate Blank

The rinsate blank is prepared in the field from analyte-free water supplied by the laboratory by pouring the water over dedicated or decontaminated sampling devices into clean sample bottles. The rinsate blanks will be preserved in the same manner as the aqueous field samples and will be analyzed for the same parameters as the field samples collected that day. Rinsate blanks will be prepared at the rate of one per day per 20 samples per matrix if sampling devices other than sample collection containers are used.

4.4.4 Field Duplicate Samples

The field duplicate is collected to monitor the precision and reproducibility of the sampling and analytical activities. The sample is prepared by collecting two samples from the same location. These samples are collected at a rate of one for every 10 samples (10 percent) per matrix for the event. These samples are submitted as blind samples to the laboratory.

4.4.5 Matrix Spike/Matrix Spike Duplicate

The matrix spike (MS) samples are collected as monitoring controls for the laboratory and are addressed under the analytical protocols. These samples are collected at a rate of five percent of the total number of organic analyses and Target Analyte List (TAL) analyses to be conducted for the event. MS/matrix spike duplicate (MSD) analyses are performed for organic fraction analysis, and MS/laboratory duplicate analyses are performed for metals fraction analysis. The preparation of the organic fraction laboratory QC samples requires supplying triple volume of the designated sample. Laboratory QC samples for

inorganic analysis are prepared by the laboratory by splitting the designated MS sample at the laboratory to accommodate the laboratory duplicate analysis. No additional volume is required.

4.4.6 Method Blanks

Method blank samples are generated within the laboratory and are used to assess contamination resulting from laboratory procedures. Laboratory duplicate samples are analyzed for inorganic parameters to check for sampling and analytical reproducibility. Matrix spikes provide information about the effect of the sample matrix on the digestion and measurement methodology. Laboratory duplicates and matrix spikes for inorganic analyses will be analyzed with a frequency of 10 percent [one per every 10 or fewer investigative samples per matrix (i.e., surface water, sediment)]. All matrix spikes for organic analyses are performed in duplicate and are hereinafter referred to as MS/MSD samples.

4.4.7 Other Laboratory QC Analyses

The level of QC effort for testing of each parameter will conform to the analytical method specified for that type of analysis. Table 4-1 present the analytical methods, by medium, to be used for this project.

4.5 FIELD DECONTAMINATION PROCEDURES

An important aspect of quality control is the decontamination of field sampling equipment. Improperly cleaned and prepared equipment can lead to misinterpretation of environmental data due to interference from cross contamination.

All non-disposable sampling equipment that comes in contact with sample medium will be decontaminated using methods in accordance with TtNUS SOPs. Specifically, the following decontamination requirements will be met:

- Potable water and detergent rinse (Alconox/Liquinox)
- Tap water rinse
- Distilled/deionized water rinse
- Methanol rinse
- Distilled/ deionized water rinse
- Air dry

TABLE 4-1
Proposed Analytical Methods and Sample Numbers
NAWC WARMINSTER, PENNSYLVANIA

Media	Parameter	Analytical Method	Field Samples (per event)	Field Blank	Rinsate Blank	Duplicate Sample	Total
Surface Water	TAL Metals	SW-846 6010B	13	1	1	1	16
	Mercury	1631	13	1	1	1	15
	PAHs	SW-846 8310	13	1	1	1	16
	TOC	EPA 415.1	13			1	14
	Hardness	EPA 130.2	13				13
Sediment	TAL Metals	SW-846 6010B	13	1	1	1	16
	Mercury	SW-846 7471A	13	1	1	1	16
	PAHs	SW-846 8310	13	1	1	1	16
	TOC	Lloyd-Kahn	13			1	14
	Grain Size	ASTM D421/D422	12				13
Soil	TAL Metals	SW-846 6010B	2				2
	Mercury	SW-846 7471A	2				2
	PAHs	SW-846 8310	2				2
	TOC	Lloyd-Kahn	2				2
	Grain Size	ASTM D421/D422	2				2

4.6 SAMPLE CUSTODY

Chain-of-custody (COC) procedures in accordance with TtNUS SOPs will be followed.

As explained in the procedure, a sample is under custody if it is in

- The possession of the sampler/analyst
- View after being in the possession of the sampler/analyst
- The possession of the sampler/analyst and then placed in a secured location
- A designated secure area

4.6.1 Sample Collection Custody Procedures

The person doing the actual field sampling is responsible for the care and custody of the samples collected until the samples are properly transferred or dispatched.

Sample labels shall be completed for each sample container, using waterproof ink. Appropriate sample description and other pertinent information must be recorded in the field logbook.

4.6.2 Field Documentation/Logbooks

A summary of all field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel but will be stored in a secured area when not in use. Each logbook will be identified by a unique number.

At a minimum, the following information will be recorded in the site logbook:

- The name of the person to whom the logbook is assigned.
- The logbook number.
- The project name.
- The project start date.
- The names and responsibilities of on-site project personnel.
- The arrival/departure of site visitors.
- Sampling activities and sample logsheet references.
- Sample shipping information including COC numbers, air-bill numbers, carrier, time, and date.

- Health and safety issues.
- A description of photographs including the date, time, photographer, roll and picture number, location, and direction of the photograph.

All entries will be written in black ink and no erasures will be made. If an incorrect entry is made, the correction will be made by striking a single line through the incorrect information; the person making the correction will initial and date the change.

Samples will be collected following procedures outlined in Section 3. The equipment used to collect the sample will be noted in the logbook or sample logsheet along with time of sampling, sampler's name, sample description, depth at which the sample was collected, and the volume and number of containers collected. QC sample information will be appropriately recorded.

Sample Documentation

A sample logsheet will be filled out for each sample collected. A sample logsheet is used to record specific types of data pertaining to the samples. Sample-specific data include such information as the sample identification number, container type and lot number, sample volume, preservative information, medium, sample description, any problems encountered during sampling, shipping information (airbill), date and time of sample, and sampler's signature. Sample logsheets are sequentially numbered and stored in a notebook. The notebook is included in the project file at the completion of field activities. Copies of these pages will be included as an appendix to rough draft, draft, and final project deliverables.

Equipment Calibration Log Form

Each TtNUS instrument requiring calibration will have a separate equipment calibration log form that documents that the manufacturer's instructions and the SOPs were followed for calibration of the equipment. This information should include the frequency and type of standard or calibration device. This record documents the accuracy, precision, or sensitivity of the measurement. If necessary, it will be used to determine if corrections should be applied to the readings. A separate form will be established and maintained for each field instrument.

These forms will be maintained in a binder and, at the completion of the field activities, will be stored in the project file.

4.6.3 Custody Transfer and Shipment Procedures

Samples will be accompanied by a properly completed chain-of-custody (COC) form. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of transfer on the record. The original form and one copy will be sealed inside the cooler for shipment; another carbon copy will be retained by the sampler.

Samples will be properly packaged for shipment and secured with strapping tape and custody seals.

If the samples are sent by common carrier, a bill of lading will be used. A receipt or a bill of lading will be retained as permanent project documentation. Commercial carriers are not required to sign the custody form as long as the forms are sealed inside the shipping container and the custody forms remain intact. If the samples are sent by mail, the package will be registered with a return receipt requested.

4.6.4 Laboratory Custody Procedures

Proper custody procedures as required by NFESC will be followed by the laboratory. When the samples are received by the laboratory, the bill of lading or shipping manifest will be signed and dated to document sample receipt. The laboratory will keep a copy of the manifest that will be included in the data package. The sample custodian will verify the integrity of the custody seals and the condition of the shipping containers. When the containers are opened, the temperature of the cooler will be measured and documented and the enclosed sample paperwork will be removed.

The samples will be removed from the coolers, and the condition of the bottles will be noted. All pertinent sample paperwork and labels will be inspected for discrepancies. TtNUS breakage or discrepancies will be resolved through the project manager. Sample preservation will be noted and any improper preservation will be documented on an Out-Of-Control Form. Holding times will be observed as specified in the VSAP and laboratory specifications. Laboratory tracking procedures will be followed as discussed in the laboratory QA plan provided by the contracted laboratory.

4.7 CALIBRATION PROCEDURES

All instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments as to fixed laboratory instruments.

4.7.1 Field Calibration And Preventative Maintenance Procedures

It is the field operation leader's responsibility to ensure that field team members are trained in the calibration, use, and maintenance of all applicable field instruments and equipment.

Equipment used during field activities and sample collection will be calibrated in accordance with TtNUS SOPs and manufacturers' instructions.

Equipment will be inspected at the beginning of each day to ensure that it is in operable condition and calibrated. All calibration activities will be documented on equipment calibration log sheets. Instruments in need of repair will be removed from service and clearly marked to ensure against further use.

The field logbook will clearly identify the specific instruments used for each task.

4.7.2 Laboratory Instrument Calibration

The laboratory is responsible for properly calibrating and maintaining analytical instrumentation. The laboratory's approved QA plan and method-specific QC activities must be in compliance with method and NFESC requirements. Sufficient documentation of compliance will be provided by the laboratory and will be included as part of the data package. Method- and instrument-specific calibration and tuning criteria for particular analyses are described briefly below. The frequency of calibration will be performed according to the requirements of the specific methods.

4.7.2.1 Polycyclic Aromatic Hydrocarbon

Calibration for high performance liquid chromatography analysis for PAHs will be performed in accordance with the applicable analytical methods. A five-point initial calibration is required before any samples are analyzed. A mid-point continuing calibration is required, at a minimum, at the beginning of the day, at the midpoint of the run, and after the last sample of the day (assuming a sample group of ten samples or less).

4.7.2.2 Inductively Coupled Argon Plasma (ICP) Analyses

Inductively coupled plasma spectrometry (ICP) systems will be calibrated in accordance with the specified analytical method. Initial calibration is required each day before any samples are analyzed. The method specifies that the instrument be calibrated according to the instrument manufacturer's recommended procedures but should consist of a calibration blank and one standard. The standard must be within the

demonstrated liner range of the instrument. The linear range is verified quarterly. Following initial calibration, an initial calibration sample (obtained from a different source than the solutions used for calibration), an initial calibration blank, and interference check samples are analyzed. A continuing calibration verification sample and a continuing calibration blank are run every 10 samples. A continuing calibration verification sample, a continuing calibration blank, and interference check samples are also run after analysis of the last sample.

4.7.2.3 Atomic Absorption Analyses

Cold vapor atomic absorption (CVAA) analyses will be calibrated in accordance with the applicable analytical method. Initial calibration is required each day before any samples are analyzed and consists of a calibration blank and at five calibration standards covering the range of concentrations of interest. Immediately following initial calibration, an initial calibration verification sample (obtained from a different source than the solutions used for calibration) and an initial calibration blank are analyzed. A continuing calibration verification samples and a continuing calibration blank are run every ten samples. A continuing calibration verification sample and a continuing calibration blank are also run after analysis of the last sample.

4.7.2.4 Miscellaneous Parameters

Calibration and standardization requirements for the analysis of TOC and hardness will be performed as specified in the applicable analytical methods.

4.8 ANALYTICAL PROCEDURES

All sampling and monitoring activities conducted in the field will be documented including calibration and use records for field instrumentation. All data generated will be reviewed by the field operation leader and approved before accepted.

Off-site analytical support will be provided by a Navy-approved analytical laboratory. This laboratory is responsible for compliance to all applicable PADEP and NFESC requirements. The analytical data package(s) is required to meet deliverable requirements to include documentation of QC results for calibration and method QC compliance as listed on laboratory QC summary sheets and raw analytical data (chromatograms, quantitation lists, and spectra) for field samples and laboratory and field blanks. Non-target compound reporting (tentatively identified compounds) will not be required, nor will raw data for calibration standards, matrix spikes, or instrument tuning. These requirements are further addressed in Section 4.8.2. All method-specific QA/QC requirements will be met. Upon approval of the work plan a Navy-approved laboratory will be procured.

4.8.1 Lab ratory Sample Storage Procedures

The laboratory is required to follow the sample storage procedures outlined in the laboratory's approved QA plan. Specifically, the samples will be maintained under custody and will be stored in compliance with all applicable method-specific and program QA/QC requirements.

4.8.2 Laboratory Data Deliverable Format

All samples that are submitted to the laboratory for analyses will require laboratory data deliverables for submission by the laboratory to include the raw data and QC forms described above. Submission of electronic data records pertaining to analyses will also be required. The format of the electronic data records will meet TtNUS requirements.

4.9 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction will be performed by the laboratory in accordance with the laboratory's approved QA plan, laboratory SOPs, analytical method, and program requirements. Documentation to support the data review will be included in the data package. The content and format of the analytical data packages are discussed in the preceding section.

Additionally, 100 percent of the standard-turnaround analytical data generated will be formally validated by qualified TtNUS personnel to ensure the integrity and accuracy of the data, as reported by the laboratory. In general, the analytical data packages will be validated using method-specific criteria and Laboratory Data Validation Functional Guidelines for Evaluating Organic and Inorganic Analyses, EPA (February 1994), as modified for Region III to the extent practicable.

As per the EPA national protocols, the organic and inorganic data will be evaluated with regard to the following general parameters:

- Data completeness
- Holding times (until preparation/analysis)
- Initial and continuing calibration
- Laboratory and field quality control blank analyses
- Laboratory and field duplicate analyses (as applicable)
- Matrix spike analyses
- Detection limits
- Analyte quantitation

As shown below, parameters specific to the nature of the analyses conducted will also be evaluated:

- Surrogate spike recoveries (organics only)
- Internal standards performance (organics only)

The validation described above is documented in memoranda to the file (complete with support documentation) for each data package evaluated. Data validation memoranda are QA checked by the data validation quality assurance officer before submittal to the project manager.

4.10 DATA ASSESSMENT PROCEDURES

Precision and accuracy will be assessed through data validation in accordance with the National Functional Guidelines (to the extent practicable for non-CLP analyses). Compliance with the completeness objectives for field and laboratory data/measurement will be calculated by hand (field measurements) and electronically via a database subroutine (laboratory data). Information necessary to complete the precision and accuracy calculations will be provided in electronic and hard-copy form by the subcontract laboratory. Equations to be used for the precision, accuracy, and completeness assessment are outlined in the remainder of this section.

4.10.1 Accuracy Assessment

To assure the accuracy of the analytical procedures, a minimum of 1 of every 20 samples for organic analysis and every 10 samples for inorganic analyses are spiked with a known amount of the analyte or analytes to be evaluated. The spiked sample is then analyzed. The increase in concentration of the analyte observed in the spiked sample, because of the addition of a known quantity of the analyte, compared to the reported value of the same analyte in the unspiked sample determines the percent recovery. Daily control charts are plotted for each commonly analyzed compound and kept on matrix-specific and analyte-specific bases. The percent recovery for a spiked sample is calculated according to the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \times 100$$

4.10.2 Precision Assessment

Duplicate samples are prepared by dividing an environmental sample into equal aliquots. Matrix spike/matrix spike duplicate (MS/MSD) samples (for organic analyses) are prepared and analyzed at a minimum frequency of 1 per every 20 environmental samples. MS/MSD samples are prepared by dividing an environmental sample into equal aliquots and then spiking each of the aliquots with a known amount of analyte. The duplicate samples are then included in the analytical sample set. The splitting of the sample allows the analyst to determine the precision of the preparation and analytical techniques associated with the duplicate samples. The relative percent difference (RPD) between the sample (or spike) and duplicate (or duplicate spike) is calculated and plotted. The RPD is calculated according to the following formula:

$$\text{RPD} = \frac{\text{Amount in Sample} - \text{Amount in Duplicate}}{0.5\ (\text{Amount in Sample} + \text{Amount in Duplicate})} \times 100$$

4.10.3 Completeness Assessment

Completeness is the ratio of the number of valid sample results to the total number of samples analyzed with a specific matrix and/or analysis. Following the completion of the analytical testing, the percent completeness will be calculated by the following equation:

$$\text{Completeness} = \frac{(\text{number of valid measurements})}{(\text{number of measurements planned})} \times 100$$

The results of the data validation process and the completeness assessment will be summarized in the sampling event report. Field and laboratory completeness objectives for this project are 90 percent and 95 percent, respectively.

4.10.4 Biological Identification and Data Assessment

Biological macroinvertebrate samples will be submitted to a laboratory for identification and enumeration of the organisms. The types and relative abundances of certain macroinvertebrates will be used to determine if the community is impaired. The laboratory will calculate descriptive statistics and specific metrics/indices that can be used to assess the condition of the benthic macroinvertebrate community.

The total number of taxa (number of species, genera, or families, as appropriate) and individuals per unit area sampled at each station will be generated, as well as percentages of dominant taxa. The total number of taxa is an indicator of species richness. Species richness is an indicator of the condition of the

benthic community as reflected in the variety of taxa. In general, species richness is expected to be higher in unpolluted systems and lower in polluted systems, assuming that all other factors (i.e., habitat, temperature) are similar. A community dominated by relatively few taxa may indicate a stressed environment. Therefore, the percent dominant taxa will consist of the highest percentage of specimens in any one taxon.

The Shannon-Weiner diversity index, macroinvertebrate biotic index (MBI), and Index of Community Similarity will be calculated by the laboratory for each sample. The Shannon-Weiner diversity index will be used to characterize species diversity, which is a function of the number of species per sample and the evenness with which individuals are distributed among species (Lind, 1979). It is calculated as follows:

$$H = -\sum (pi)(Lnpi)$$

Where:

H = Shannon-Weiner Index

p = proportion of individuals belonging to the ith taxon, equal to ni/N, which is the number of individuals of each species divided by the total number of species

i = individual taxon

In general, the higher the value of H, the more diverse the community.

The macroinvertebrate biotic index uses pollution tolerance scores for a given taxon that are then weighted by the number of individuals assigned to each tolerance value (Lenat, 1993). This index is intended for the examination of the general level of pollution regardless of the source, and is calculated as follows:

$$MBI = \frac{\Sigma(n_i * BI)}{N}$$

Where:

MBI = Macroinvertebrate Biotic Index

n_i = Number of individuals occurring in the ith taxon

BI = Biotic Index assigned to the ith taxon (from Lenat, 1993)

N = Total number of individuals in the sample

The sampled benthic macroinvertebrate populations will be assigned a general stream quality condition based on the MBI value. The five classes and their corresponding MBI values are presented below (Lenat, 1993):

- Excellent Quality: < 5.24
- Good Quality: 5.25-5.95
- Good-Fair Quality: 5.96-6.67
- Fair Quality: 6.68-7.70
- Poor Quality: > 7.71

If a BI for a specific species is not listed, the overall biotic index will be calculated using an average of the BIs for a different species within that genus.

The Index of Community Similarity measures the amount of similarity between the benthic communities at each sampling station and the reference station. This type of index is commonly applied in situations when it is desirable to determine if community assemblages have shifted along a stream gradient or above and below a source of contamination (EPA, 1990). This index (SI) is calculated using the following formula:

$$SI = \frac{2C}{A+B}$$

Where:

A = the number of species at Site 1

B = the number of species at Site 2

C = the number of species common to both sites

The SI will be a value between 0.0 and 1.0. The higher the number, the greater the similarity.

The types and abundances of organisms and metrics/indices for the upgradient samples will be compared to those in the stream samples. Values in the literature (if available) for similar types of water bodies will also be used for comparative purposes. These comparisons will help in determining if community impairment is due to natural or anthropogenic causes.

Sediment chemistry and physical data (e.g., grain size, total organic carbon) and surface water chemistry and physical data (e.g., dissolved oxygen, water flow) will be used to determine the reason(s) for impairment, if present, of the benthic macroinvertebrate community. The first-year data will combined with the second year's data to develop a baseline. Monitoring will continue for an additional 3 years (5 years total). If concentrations of chemicals in sediments do not appear to be decreasing and the benthic community may be impaired due to the presence of chemicals in sediments that could have been introduced from Navy sources (based on a qualitative evaluation), the sediment (and surface water)

chemistry data will be compared to effects-based ecological screening levels. Proposed screening levels include AWQCs (Federal Register, 1998) and Effects Range-Low (ER-Ls) and Effects Range-Median (ER-Ms) from Long et al. (1995). These screening levels are presented on Tables 3-1 and 3-2. The results and effectiveness of the monitoring will be evaluated after 5 years.

5.0 HEALTH AND SAFETY

5.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Navy CLEAN program H&S manager is responsible for ensuring that the site-specific HASP is in accordance with federal and state regulations and contract specifications. The H&S manager also provides technical safety and industrial hygiene oversight for all field work performed for all projects and provides assistance and guidance to the project H&S officer. The project H&S officer is responsible for preparing the site-specific HASP and for verifying that site personnel adhere to the site safety requirements. The project H&S officer also provides guidance about appropriate corrective action procedures and maintains communication among the project staff, project manager, and office H&S manager.

5.2 HEALTH AND SAFETY OBJECTIVES

TtNUS has established a comprehensive health, safety, and training program for all field activities, particularly those that have the potential for chemical exposures. The program is intended to provide adequate procedures, protective gear, monitoring, and follow-up to protect the health of TtNUS, subcontractor, and client personnel, as well as the public near the work sites.

This program is driven by the requirement to comply with federal and state Occupational Safety and Health Administrative (OSHA) regulations, the need to minimize the risk of adverse health effects from exposure to work hazards, and the savings inherent in safe work activities. In this regard, our objective is to comply with all standards, training requirements, medical monitoring, and employee protection requirements for workers engaged in hazardous waste operations, as required by 29 CFR 1910.120, March 6, 1989.

5.3 HEALTH AND SAFETY PLAN

The work to be performed under this project is follow-on monitoring to work conducted under the Phase III RI for NAWC Warminster. All work to be performed under this project will be performed in accordance with the approved HASP for the Phase III RI.

REFERENCES

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APPENDIX A

TtNUS STANDARD OPERATING PROCEDURES

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1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements on a global basis.
- Accommodation of laboratory sample number length constraints (10 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data handling managed by personnel located in the Northeast Region of Brown & Root Environmental (Pittsburgh, Wayne, Holt, and Wilmington) and for any large contracts managed by the Northeast Region (e.g., NORTHDIV CLEAN, SOUTHDIV CLEAN, ARCS I, ARCS III, etc.). Smaller projects (as determined by Project Manager) are outside the scope of this SOP.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Pr gram Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample numbering system consists of 12 distinct alpha-numeric characters, only 10 of which will be provided to the laboratory on the sample labels and chain-of-custody forms. The sample number provided to the lab shall be as follows where "A" indicates "alpha," "N" indicates "numeric," and "E" indicates "either"):

$$\overline{E}\ \overline{E}\ \overline{E}\ \overline{A}\ \overline{A}\ \overline{E}\ \overline{E}\ \overline{E}\ \overline{N}\ \overline{N}$$

Once the analytical results are received from the laboratory the sample number will be revised by a subroutine such that the sample number is more user friendly (i.e., dashes will be inserted). The sample number will then appear as follows:

$$\overline{E}\ \overline{E}\ \overline{E}\ -\ \overline{A}\ \overline{A}\ -\ \overline{E}\ \overline{E}\ \overline{E}\ -\ \overline{N}\ \overline{N}$$

If multiple sampling events occur (or are planned) for a given matrix, a subroutine within the database will be used to append two additional characters such that the sample number will appear as follows:

$$\overline{E}\ \overline{E}\ \overline{E}\ -\ \overline{A}\ \overline{A}\ -\ \overline{E}\ \overline{E}\ \overline{E}\ -\ \overline{N}\ \overline{N}\ -\ \overline{N}\ \overline{N}$$

Site Type Location Depth Round

5.2 Sample Number Field Requirements

The various fields in the sample number will include the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth Indicator
- Sampling Round

The site identifier must be a three-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc.

The sample type must be a two-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be a three-character field (alpha, numeric, or a mixture).

The depth field must be provided for all samples, regardless if it is strictly applicable (as discussed in Section 5.3).

The sampling round is optional, but, if provided, must be two numeric characters.

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Number - Examples of site numbers/designations are as follows:

A01 - Area of Concern Number 1
125 - Solid Waste Management Unit Number 125
000 - Base or Facility Wide Sample (e.g., upgradient well)
BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

AS - Air Sample
BS - Biota Sample (See Note)
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
ID - Investigation Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample
SG - Soil Gas Sample
SP - Seep Sample
SS - Surface Soil Sample
SU - Subsurface Soil Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WI - Wipe Sample
WP - Well Point Sample
WS - Waste/Sludge Sample

Note: The biota sample designation may be contingent upon the type of biota sampled (e.g., BL - Lobster; BF - Finfish; BC - Clam; BO - Oyster). Numerous other examples can be cited but will be site-specific.

This field will also be used to designate field Quality Control Samples, as follows:

TB - Trip Blank
FB - Field Blank
RB - Rinsate Blank (Equipment Blank)
BB - Bottle Blank
AB - Ambient Condition Blank

Field quality control samples should be numbered sequentially (e.g., RB-001; FB-010, etc.).

Filtered/unfiltered surface water or groundwater samples shall be handled in an separate manner, as subsequently discussed.

Location - Examples of the location field are as follows:

A01 - Grid node A1
001 - Monitoring Well 1

It is important that consistency be maintained with respect to the use of the characters "0" and O. Data base subroutines will not sort correctly if a mixture are used (e.g, AO1 and A02).

Depth - Formerly, depth specifications were indicated with a four digit field (e.g., 0002 - 0 to 2 feet). While this is effective for depth sorting, it is difficult to include this level of detail in a 10-character lab number (FormMaster limitations). In addition, this approach will not accommodate non-integer depths (e.g., 2.5 feet to 4.5 feet).

Based on such potential problems, the following approach shall be used: Sample depths will simply represent the horizon from which the sample was obtained: For example, if ten split-spoon samples are collected from a boring, they will be numbered 01 through 10. The sample log sheet will be used to record the specific depth of the sample, and this information will be entered in a separator field in the data base.

Similar nomenclature will be used for depth-specific surface water and sediment samples, etc. If no depth information is required (e.g., groundwater samples), the field must still be filled (e.g., Ø, Ø).

This field will also be used for the designation of filtered and unfiltered samples. An unfiltered groundwater sample shall be designated as U0, if and only if, a corresponding filtered sample is collected. Such as sample shall be designated as F0.

Sampling Round - The sampling round field is straightforward. It can range from 01 to 99.

5.4 Example Sample Numbers

Examples of complete sample numbers (field/data base versus laboratory) are as follows:

Field/Data Base ID	Lab ID	Description
101-SB-A01-01	101SBA0101	The first sample (e.g., 0 to 2 feet) from soil boring A01 (grid) at Site 101.
101-SB-A01-02	101SBA0102	The second sample from boring A01 (could be the next depth interval or a duplicate of 101-SB-A01-01).
125-MW-001-01-01	125MW00101	A groundwater sample from monitoring well MW001 (first sampling round)
125-MW-001-02-01	125MW00102	A duplicate groundwater sample from monitoring well MW001 (first sampling round)
130-MW-003-U1-01	130MW003U1	An unfiltered groundwater sample from monitoring well MW003 (first sampling round)
130-MW-003-F1-01	130MW003F1	A filtered groundwater sample from monitoring well MW003 (first sampling round)
137-RB-001-00-01	137RB00100	The first rinsate blank collected at site 137.
137-TB-004-00-02	137TB00400	The fourth trip blank collected during the second sampling event at Site 137.
155-SW-003-01-01	155SW00301	A surface water sample collected from the surface of a pond at Site 155.
155-SW-003-02-01	155SW00302	A surface water sample collected from the bottom of the water column in a pond at Site 155.

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide general guidance on field methods and equipment used to measure stream cross sections, flow rates, and flow volumes.

2.0 SCOPE

This SOP describes several methods for determining cross-sectional area and flow. Since the physical characteristics that a stream exhibit could vary widely, several methods and techniques are presented which can be used in the field.

3.0 GLOSSARY

Flow (or volumetric flow rate) - the volume of water which passes through a cross-sectional plane in some unit of time. (Syn. - DISCHARGE)

Flume - an artificial channel used for constricting the flow of wastewater or water, in order to promote laminar flow and provide a flow channel of known configuration for the purpose of measuring flow volume.

Stage - the height of a water surface above an arbitrarily established datum plane.

Weir - a levee or dam-type structure containing a notch through which the flow of water can be measured.

4.0 RESPONSIBILITIES

Project Manager. In consultation with the project hydrologist, responsible for determining the optimum location for performing flow determinations within an open channel, including the selection of the appropriate methodology, technique and field procedure for conducting the field test.

Field Operations Leader (FOL). FOL is responsible for direct supervision of the installation and execution of the field tests used to determine flow in an open channel. FOL is responsible for inspection of the equipment, to ensure its adequacy for performance of the test.

5.0 PROCEDURES

5.1 General

The discussion below addresses the various methods and techniques used to measure cross-section and stream velocities with respect to the velocity-area open channel technique of stream flow measurement. These techniques should be applied whenever stream gaging information is not available. When possible, stream gaging station information shall be utilized since, not only can real-time flow information be obtained, but historical flow information can be readily obtained from the authority responsible for the station.

The most common method of open channel flow determination is the velocity-area method. In this method, a flow or discharge measurement is computed as the summation of the products of partial areas of the flow cross-section and their respective average velocities. This is represented by the formula:

$$Q = \sum (av)$$

where: Q = total discharge,
a = individual partial cross-sectional area,
v = corresponding mean velocity normal to the partial area.

5.2 Cross Sectional Area Determination

5.2.1 Width Determination

Width determination for shallow streams and brooks can usually be accomplished by a simple tape measurement. However, when streams or rivers are wide (greater than 100 feet), deep (greater than 5 feet), or exhibit a high flow velocity, width determination can be a problem. As a general rule, width determinations under these conditions need only be accurate to the nearest foot for 100-foot streams. Tape measurement of streams or rivers is usually accurate enough for streams up to 500 feet in width; however, for large streams, alternatives may be required. Bridges are convenient avenues across which measurements can be made. An equally acceptable method of determining width is by transit and stadia survey techniques.

5.2.2 Depth Determinations

Most often depth measurements are taken directly with a measured rod or sounding weight. The mass of the weight suspended at the end of the tape must be sufficient to keep the tape essentially vertical. For high velocity streams or excessively deep channels, a sonic sounder may be appropriate, since some can be adapted to produce a continuous strip chart profile of the channel depth.

5.2.3 Stormwater Containment Capacity

In some cases it may be useful to measure the cross sectional area of a stream or drainage ditch channel up to the top of the channel (including both the submerged portion of the channel and the portion above the water surface). Knowledge of the volume capacity of the stream channel at various points can be used to determine the capability of the channel to contain increased water flows from storm events of various magnitudes, and predict when and where overflows may occur.

5.3 Velocity/Flow Determinations

As a general procedure, the actual measurement of depth, width and velocity would normally occur concurrently. In any case, in many parts of the country and along many sections of streams, the actual measurement of the above parameters are not required because this information has already been determined at gaging stations.

5.3.1 Stream Gaging Stations

A network of stream gaging stations has been in place for several decades. The authorities responsible for their placement are the US Army COE, USGS, and other federal or state agencies. In general, they have been placed in sensitive watersheds and along major tributaries and rivers throughout the United States.

These stations have established water stage-discharge relationships ("rating curves") which allow flow to be determined from water stage measurements. By measuring the water level directly from the staff gage and applying it to the rating curve for that station, flow can be easily determined. The rating curve is maintained by the operator of the gaging station. If a new gaging station is to be established, the techniques outlined in the USGS publication "Discharge Measurements at Gaging Stations," Hydraulic Measurement and Computation, Book I, Chapter II, United States Department of the Interior, Geological Survey, 1965 shall be used.

5.3.2 Alternative Velocity/Flow Determination Methods

In general, the methods specified below refer to open channel stream flow where continuous long-term measurements are not required. Zero flow or non-channel flow conditions (overland flow) are not discussed within this text and require special procedures for flow determination. The main parameters to be collected for open channel flow determinations are cross-sectional area and stream velocity.

5.3.2.1 Current Meters

Current meters provide a rather quick and relatively accurate method of determining flow under existing site conditions. They are generally not used for long-term determinations. There are many types of current meters. Some are mechanical, others are electrical; some have vertical shafts, and others have horizontal shafts. The type preferred for open channel stream measurement are those which have a vertical shaft. The basic concept behind a current meter is that a rotating element at the end of the vertical shaft (or, in some cases, stationary electrodes) is submerged beneath the stream's surface where the flow of water rotates the element (or passes between the electrodes). The speed of rotation of the element (or flow between the electrodes) is measured directly by the current meter, which is then correlated to stream flow velocity through the meter's own electronic circuitry or by graphs or charts which accompany the instrument. Speed is normally measured in meters/sec or feet/sec.

Current meters can generally measure flow down to 0.03 meters/sec (0.1 ft/sec). Current meters which use electrodes are good for measuring streams that have weedy growths emanating from the stream bottom which would affect the rotating element. The depth to which current meters can be used is only limited by the ability to hold the element rigid at depth. Once a current meter measurement is taken, the measurement is averaged with other measurements taken along a vertical transect of the stream at that point to determine the mean velocity along that vertical transect. In a wide stream, several vertical transects are constructed such that less than 10 percent of the volume of the stream is represented by each transect. The mean stream velocity is calculated as the average of the individual average vertical velocities of each transect, with each average velocity weighted by the cross-sectional area of the stream that it represents. Some of the methods by which a current meter can be used are as follows:

- Six-Tenths Method. This method is best utilized when flow information must be gained quickly and/or the depth of the stream is less than 0.8 meters (2.6 feet) but greater than 0.1 meters (0.3 feet). In general, current meters cannot be used when depth of streams are less than 0.1 meters (0.3 feet). In this method, one measurement is taken at a depth 0.6 of the total depth below the surface along each of the vertical transects mentioned above. To gain a little more accuracy, each measurement within each transect may be taken three times and the result averaged to determine the mean velocity along that transect. This method reduces the effects of aberrant measurements.

  Two-Point Method. This method can only be used for streams exhibiting a depth greater than 0.8 meters (2.6 feet). This restriction is due to the effects that the surface of the stream and stream bed would have on the rotating element. In this method, measurements

are taken at 0.2 and 0.8 of the total depth below the surface. The two measurements are then averaged to obtain the mean velocity along the vertical transect. Then all the transects are averaged to determine the stream flow.

Three-Point Method. This method is also restricted to those streams exhibit a depth greater than 0.8 meters (2.6 feet). In this method, velocities are determined with a current meter at 0.2, 0.6, and 0.8 of the total depth below the surface. The 0.2 and 0.8 readings are averaged. The result is then averaged with the 0.6 reading. This method is very effective in those streams in which the vertical velocities are not normally distributed.

Vertical-Velocity Method. This method is primarily used for deep channels. In this method, readings are taken at 0.1 depth increments starting at 0.1 and ending at 0.9. These values are then averaged together to determine the mean velocity of the vertical. Due to the numerous readings required, this method is not often used.

5.3.2.2 Deflection or Drag-body Methods

This method utilizes the relationship that drag is proportional to the square of the velocity. This method tends to be insensitive to very low velocities and is also affected by aquatic growth or debris which can affect the drag coefficient of the body utilized. This method is, however, relatively inexpensive and, under certain conditions, will yield as accurate a result as any device.

5.3.2.3 Floats

Floats use the principle that velocity of the stream can be determined by measuring the velocity of a float carried on the surface of the stream. If the stream is wide enough to require several velocity measurements, several floats should be used, with the resulting velocity multiplied by the fraction of the cross-sectional area of each represented measurement. The sum of the products equates to the flow or total discharge of the stream. There are many types of floats and each has its own coefficient to obtain mean velocity from a surface velocity measurement.

5.3.2.4 Pressure Methods

Pressure methods use a device called an impact tube to measure stream velocity. The impact tube comes in several different varieties, e.g., the Pitot tube, Barcy tube, Prandtl tube, or Brabbe tube. Impact tubes work under the principle that velocity is proportional to the square root of the dynamic pressure head, which is either measured directly or as a difference between the total and static pressure head in these impact tubes.

5.3.2.5 Tracer Methods

Several types of tracers, including salt, dye, or radioisotopes, are used in this method. The major drawback to this type of velocity measurement is that pools and eddies tend to trap the tracer. Therefore, a uniform cross-sectional portion of the stream channel must be used. The tracer must be introduced as a slug into the stream channel. This may be at one point or simultaneously at many points across the stream. The tracer concentration is measured at one or more points at known distances downstream of the injection point. At each of the downstream points, concentration/time curves are created by continuous measurement. The most precise determination of average velocity is made by using the centroid of the concentration/time curve to measure the travel time; however, the measurement of time at the concentration peaks is nearly as accurate.

5.3.2.6 Weirs and Flumes

A considerably more sophisticated method of determining stream flow is through the installation of artificial pre-calibrated control structures such as weirs and flumes. A weir is a dam-like structure behind which the water is ponded. The top of the weir contains a calibrated notch through which the ponded water eventually flows. Stream flow is determined by measuring the height of flow through the weir, which is a function of potential energy behind the overfall. A flume is basically a constricted flow structure which provides a uniform cross-section for measurement of flow. Flow is determined within the supercritical section within the throat of the constriction. For a detailed discussion of weirs and flumes, see U.S. Geological Survey (1977), Volume 1, Chapter 1, p. 1-65 to 1-77.

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7.0 ATTACHMENTS

None.

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1.0 PURPOSE

This procedure describes methods and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing, or for subsequent laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - a sample containing (or suspected to contain) low-level concentrations of contaminants, which does not require special handling or transport considerations as detailed in SOP SA-6.1.

Hazardous Waste Sample - a sample containing (or suspected to contain) higher concentrations of contaminants thus requiring special handling and/or transport considerations per SOP SA-6.1.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel.

Field Operations Leader - The Field Operations Leader (FOL) is responsible for the in-field supervision of the conduct of onsite water quality analyses, ensuring the completion and accuracy of all field documentation, and making sure that custody of all samples obtained is maintained according to proper procedures.

5.0 PROCEDURES

5.1 Introduction

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives, accessibility, site topography, physical characteristics of the water body (such as flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the waterbody, direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the project plan documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples shall be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly, and during droughts and floods). Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water-quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 Surface Water Sample Collection

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode, shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project plan documents.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations. Each type of estuarine area is described below:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. The most frequently used samplers are:

- Open tube.
- Dip sampler.
- Weighted bottle.
- Hand pump.
- Kemmerer.
- Depth-Integrating Sampler.

The dip sampler and the weighted bottle sampler are used most often, and detailed discussions for these devices only (and the Kemmerer sampler) are addressed subsequently in this section.

The criteria for selecting a sampler include:

- Disposability and/or easy decontamination.
- Inexpensive cost (if the item is to be disposed).
- Ease of operation.
- Nonreactive/noncontaminating properties - Teflon-coated, glass, stainless-steel or PVC sample chambers are preferred (in that order).

As specified in the project plan document plan documents, each sample (grab or each aliquot collected for compositing) shall be measured for:

- Specific conductance.
- Temperature.
- pH.
- Dissolved oxygen (optional).

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample logsheets (see SOP SA-6.3). These analyses will provide information on water mixing/stratification and potential contamination.

Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible, it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling with this device is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampling line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.

- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. This bottle can be used as the sample container as long as the bottle is an approved container type.

Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless-steel or acrylic cylinder, with rubber stoppers that leave the ends open while being lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at a 0.6 foot stream depth in a well-mixed stream.
- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken. This is not applicable when sample containers are provided "pre-preserved."
- For sampling running water, it is suggested that the farthest downstream sample be obtained first, and that subsequent samples be taken as one works upstream. In general, work from zones suspected of low contamination to zones of high contamination.
- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid node is combined into one sample, or several grid nodes are selected at random.
- Care should be taken to avoid excessive agitation of the water, as loss of volatile constituents could result.
- When obtaining samples in 40 mL septum vials for volatile organics analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. The vial can be turned upside down to check for air bubbles.
- Do not sample at the surface, unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing upstream. When sample containers are provided "pre-preserved," use a dedicated, clean, un-preserved bottle for sampling and transfer to an appropriately-preserved container.

5.4 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

5.5 Sediment Sampling

5.5.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body.

Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center of a water body will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathometry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials, shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3.

5.5.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain onshore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler.
- Dredge samplers.

Each type of sampler is discussed subsequently.

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and best way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping the sampler along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger". Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Brown & Root Environmental field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Brown & Root Environmental field activities, as applicable. Other or additional documents may be required by specific client contracts.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all forms used in site activities (i.e., records, field reports, and upon the completion of field work, the site logbook) in the project's central file.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Brown & Root Environmental or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Brown & Root Environmental project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the site notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts must be compiled to account for routine film processing. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Site Notebooks

Key field team personnel may maintain a separate dedicated notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate site notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a site notebook.

5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Tabl of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment and Request for Analysis

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. A l g sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B-5. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One part of the completed COC form is retained by the field crew while the other two or three portions are sent to the laboratory. The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. A supply of these forms are purchased and stocked by the field department of the various Brown & Root Environmental offices. Alternately, COC forms supplied by the laboratory may be used. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Brown & Root Environmental Project Manager). The COC form is signed and one of the remaining two parts are retained by the laboratory while the last part becomes part of the samples' corresponding analytical data package. Internal laboratory chain-of-custody procedures are documented in the Laboratory Quality Assurance Plan (LQAP).

5.3.1.4 Chain-of-Custody Seal

Attachment B-7 is an example of a custody seal. The Custody seal is also an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The COC seals are signed and dated by the samplers and affixed across the opening edges of each cooler containing environmental samples. COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.2 Geohydrological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A packer test report form shown in Attachment C-3 must be completed for each well upon which a packer test is conducted following well installation.

5.3.2.4 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-4) is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), these results must be entered on the boring log (under the "Remarks" column) at the appropriate depth. The "Remarks" column can also be used to subsequently enter the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well piezometer or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions. The Monitoring Well Construction Details Form is not a controlled document.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log (Attachment C-10) must be filled out by the responsible field geologist or sampling technician.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of

equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Weekly Status Reports

To facilitate timely review by project management, Xeroxed copies of logbook/notebook entries may be made for internal use. To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required.

5.4.2 Daily Activities Report

5.4.2.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors (Attachment E is an example of a Daily Activities Report).

5.4.2.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.2.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-8A	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-9	EXAMPLE TEST PIT LOG
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

BROWN & ROOT ENV.	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B-1
EXAMPLE GROUNDWATER SAMPLE LOG SHEET

GROUNDWATER
SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: _____

Project No.: _____

☐ Domestic Well Data
☐ Monitoring Well Data
☐ Other Well Type: _____
☐ QA Sample Type: _____

Sample ID No.: _____

Sample Location: _____

Sampled By: _____

C.O.C. No.: _____

Sampling Data

Date: / Time: / Method:	pH	S.C.	Temp. (°C)	Turbidity	Color	TBD	TBD	TBD

Purge Data

Date: / Method:	Volume	pH	S.C.	Temp.(°C)	Turbidity	Color	TBD	TBD
	Initial							
Monitor Reading (ppm):	1							
Well Casing Dia. & Material Type:	2							
	3							
Total Well Depth (TD):	4							
Static Water Level (WL):	5							
TD-WL (ft.) =								
One Casing Volume: (gal/L)								
Start Purge (hrs.):								
End Purge (hrs.):								
Total Purge Time (min):								
Total Amount Purged (gal/L):								

Analysis	Preservative	Container Requirements	Collected (✓)

Observations/Notes:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No:	

TBD: To Be Determined

ATTACHMENT B-2
EXAMPLE SURFACE WATER SAMPLING LOG SHEET

SURFACE WATER SAMPLING LOG SHEET

Page ____ of ____

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

☐ Spring ☐ Pond
☐ Stream ☐ Lake
☐ Other _____
☐ QA Sample Type: _____

Sampled By: _____

C.O.C. No.: _____

Sample Data		
Date and Time	Method	Depth

pH	S.C.	Temp. (°C)	Turbidity	Color	TBD	TBD	TBD

Analysis	Preservative	Container Requirements	Collected (✓)

Observations/Notes:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

TBD: To Be Determined

ATTACHMENT B-3
EXAMPLE SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET

SOIL/SEDIMENT
SINGLE SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: _____

Project No.: _____

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Other _____
- ☐ QA Sample Type: _____

Sample ID No.: _____

Sample Location: _____

Sampled By: _____

C.O.C. No.: _____

Sample Method:	Composite Sample Data		
	Sample	Time	Color/Description
Depth Sampled:			
Sample Date and Time:			
Type of Sample			
☐ Grab			
☐ Composite			
☐ Grab-Composite	Grab Sample Data		
☐ High Concentration	Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)	
☐ Low Concentration			

Analysis	Container Requirements	Collected (✓)	Map:

Observations/Notes:

Circle If Applicable:		Signature(s):
MS/MSD	Duplicate ID No:	

ATTACHMENT B-4
CONTAINER SAMPLE LOG SHEET FORM

Brown & Root Environmental

Page ___ of _

☐ Container Data

Case #: _____

By: _____

Project Site Name: _____ Project Site No. _____

Brown & Root Env. Source No. _____ Source Location: _____

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other _____ ☐ Bag/Sack ☐ Tank ☐ Other _____	Color: _____ Condition: _____ Markings: _____ Vol. of Contents: _____ Other: _____

Disposition of Sample	Sample Description			
☐ Container Sampled ☐ Container opened but not sampled. Reason: _____ ☐ Container not opened. Reason: _____		Layer 1	Layer 2	Layer 3
	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	_____	_____	_____
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
	% of Total Volume	_____	_____	_____
	Other	_____	_____	_____

Monitor Reading:	Type of Sample ☐ Grab ☐ Low Concentration ☐ Composite ☐ High Concentration ☐ Grab-composite
Sample Method:	

Sample Date & Time:	Sample Identification	Organic	Inorganic
Sampled by:			
Signature(s):			
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-5

SAMPLE LABEL

Brown & Root Environmental PROJECT: _____

STATION LOCATION: _____

DATE: ____/____/____ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MEDIUM ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNAs ☐	Cool to 4°C ☐
PCBs ☐ PESTICIDES ☐	HNO_3 to pH < 2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NaOH to pH > 12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Remarks:

ATTACHMENT B-6

CHAIN-OF-CUSTODY RECORD FORM
(Original is 8.5 x 11")

PROJECT NO	PROJECT NAME	NO. OF CONTAINERS	REMARKS
SAMPLERS: *(Signature)*			

STA NO.	DATE	TIME			STATION LOCATION							

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks:	

ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

GROUNDWATER LEVEL MEASUREMENT SHEET

Page ___ of ___

PROJECT NAME: _____ LOCATION: _____
PROJECT NUMBER: _____ MEASURING DEVICE: _____
PERSONNEL: _____ ADJUSTMENT FACTOR: _____
DATE: _____ REMARKS: _____
WEATHER CONDITIONS: _____

Well or Piezometer Number	Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Groundwater Elevation (Feet)*	Comments

*Measurements to nearest 0.01 foot.

Signature(s): _____

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

PUMPING TEST DATA SHEET

Page ___ of ___

PROJECT NAME: _____
PROJECT NUMBER: _____
PUMPING TEST: [ ]
TEST NUMBER: _____
METHOD OF MEASUREMENT: _____
DATE(s): _____
STATIC H_2O LEVEL (ft) (SO) _____

PUMPING WELL NUMBER: _____
MEASURED WELL NUMBER: _____
STEP DRAW DOWN TEST [ ]
MONITORING POINT: _____
DEPTH CORRECTION (ft) _____
PUMP SETTING (Ft. below monitoring point): _____
DISTANCE FROM PUMPING WELL (ft) (r): _____

PUMPING TEST PERFORMED BY: _____
REMARKS: _____

MILITARY TIME	ELAPSED TIME SINCE PUMP START OR STOP (Min.)	WATER LEVEL (Ft.)	CORRECTION (Ft.)	DRAW DOWN OR RECOVERY (Ft.)	FLOW METER READING (Gals.)	PUMPING RATE (GPM)	REMARKS

SIGNATURE(s): _____

ATTACHMENT C-3

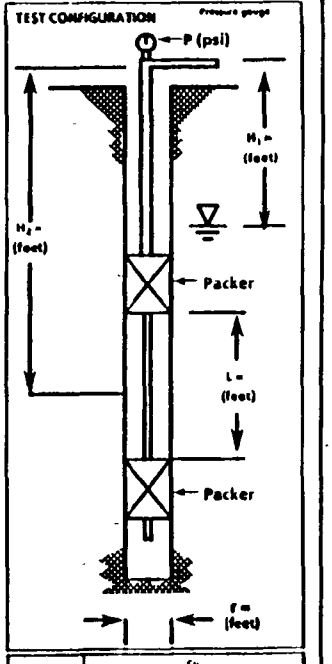
PACKER TEST REPORT FORM

PROJECT: _____ PROJECT NO.: _____ TEST NO: _____ PAGE ____ OF ____

BORING NO.: _____ CASING DEPTH: _____ CONTRACTOR: _____ STATIC WATER LEVEL _____

TEST INTERVAL: _____ BY: _____ CHECKED: _____ PACKER PRESSURE _____

Flow Test					Calculated Results							
Pressure, p (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(ft) = 2.31 (psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp Q/H	K (cm/sec) = K (ft/yr) / 9.67 x 10⁶



Length of Test Section in feet	Cp			
	Drilling Bit Size			
	EX (1.5")	AX (1.875")	BX (2.31")	NX (3")
1	31,000	28,500	25,000	21,000
2	19,000	18,100	16,000	15,500
5	9,000	9,100	8,000	8,000
8	6,000	6,500	6,100	5,800
10	5,700	5,400	5,000	4,900
15	4,100	3,800	3,700	3,600
20	3,200	3,100	3,000	2,800

CP = (1/(2 π L)) ln(L/r) (70.315 5)
7.48 Gallons = 1 Ft³
1 psi = 2.31 ft head

* H_1 is used when the test length is below the water table
H_2 is used when the test length is above the water table

Remarks _____

ATTACHMENT C-4
EXAMPLE BORING LOG

BORING LOG Page___ of___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE : _____
DRILLING COMPANY: _____ GEOLOGIST: _____
WATER LEVEL DATA: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No	Blows/ 6" or RQD (%)	Sample Recovery/ Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: *Material Classification	USCS	Remarks	PID or FID Reading (ppm)

*When rock coring enter rock brokeness.

CONVERTED TO WELL : ___ Yes ___ No; WELL I.D.#: _____
REMARKS: _____

Signature(s): _____

LEGEND

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS — More Than Half of Material is LARGER Than No 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50%(+)>1/4"Ø	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<1/4"Ø	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see MCL)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS — More Than Half of Material is SMALLER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)	Identification Procedures on Fraction Smaller than No. 40 Sieve Size				GROUP SYMBOL	TYPICAL NAMES
		DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS AND CLAYS Liquid Limit <50		None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50		Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
		Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily pentrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects
Soft	Easily Gouged	Crushes when pressed with hammer
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges
Medium Hard	Can be scratched	Breaks (one blow); sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges

ROCK BROKENESS

Descriptive Terms	Abbreviation	Spacing
Very Broken	(V. Br.)	0-2"
Broken	(Br.)	2"-1'
Blocky	(Bl.)	1'-3"
Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

S-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample

O - Other Samples, Specify in Remarks

ROCK SAMPLES TYPES

X-NX (Conventional) Core (-2-1/8" O.D.)

Q-NQ (Wireline) Core (-1-7/8" O.D.)

Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/10 ▼ 12.6' Initial Level w/Date & Depth

12/10 ▼ 12.6' Stabilized Level w/Date & Depth

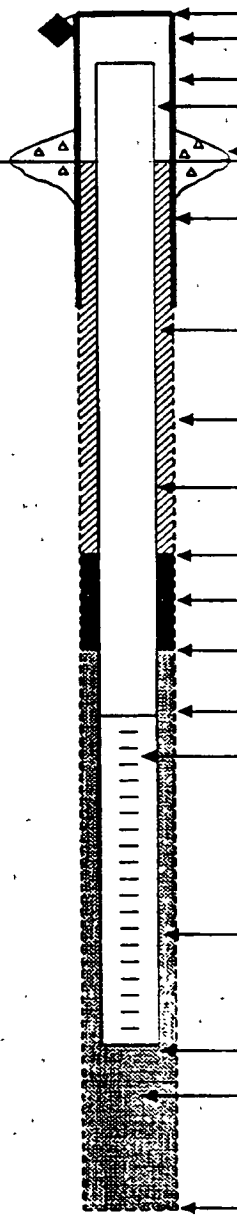
ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

OVERBURDEN
MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING _____
STICK - UP RISER PIPE . _____

TYPE OF SURFACE SEAL: _____

I. D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: ____/____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: ____/____

ELEVATION / DEPTH BOTTOM OF SAND PACK: ____/____

TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: ____/____

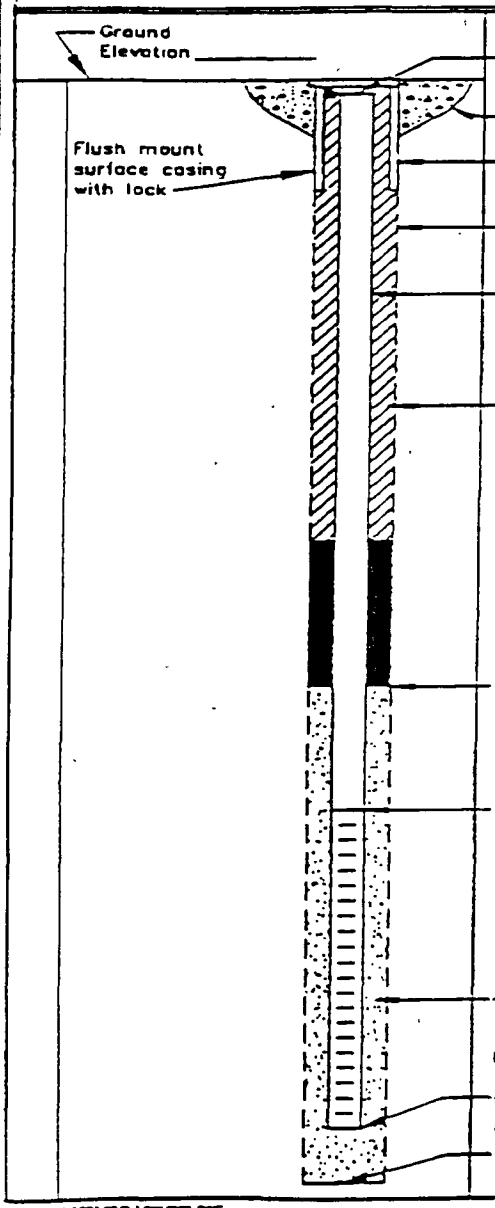
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: _____

MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

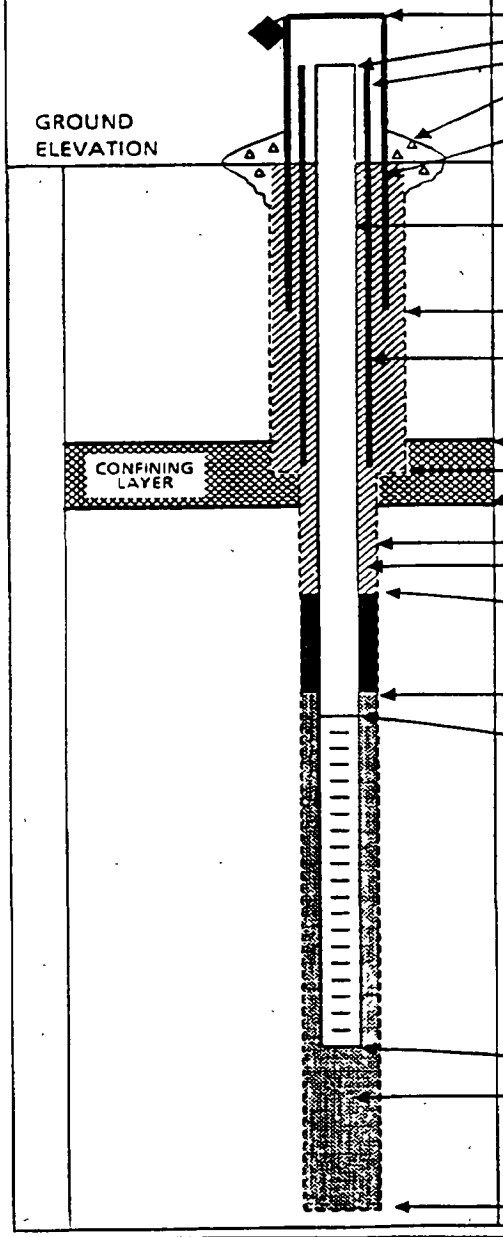
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____
ELEVATION TOP OF PERM. CASING: _____
TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE _____

BOREHOLE DIAMETER: _____

PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____

ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT. CONFINING LAYER: _____

BOREHOLE DIA. BELOW CASING: _____
TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____

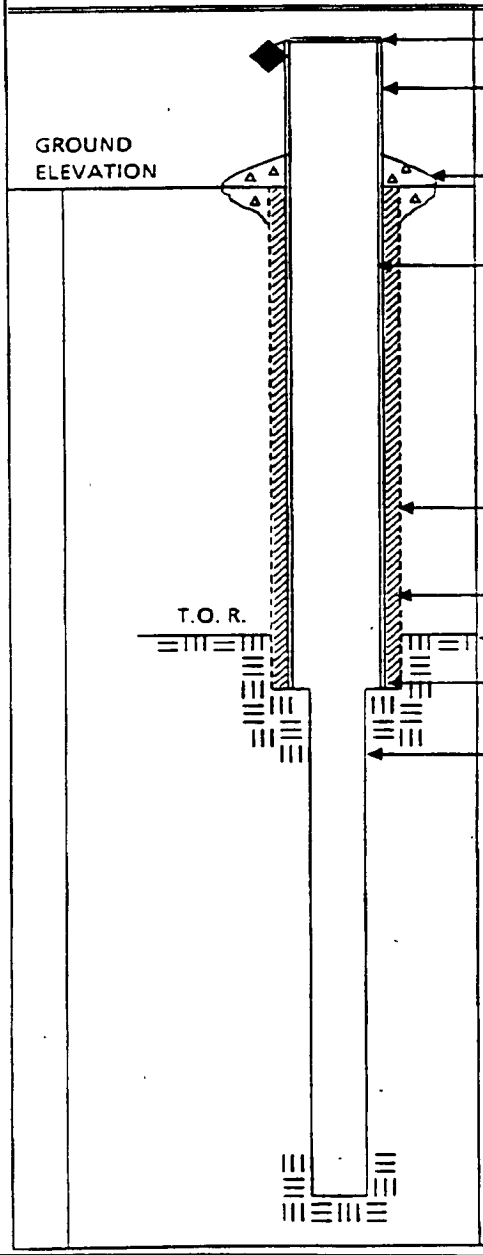
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO.: _____

BEDROCK MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____
TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

ELEVATION / DEPTH OF HOLE: _____ / _____

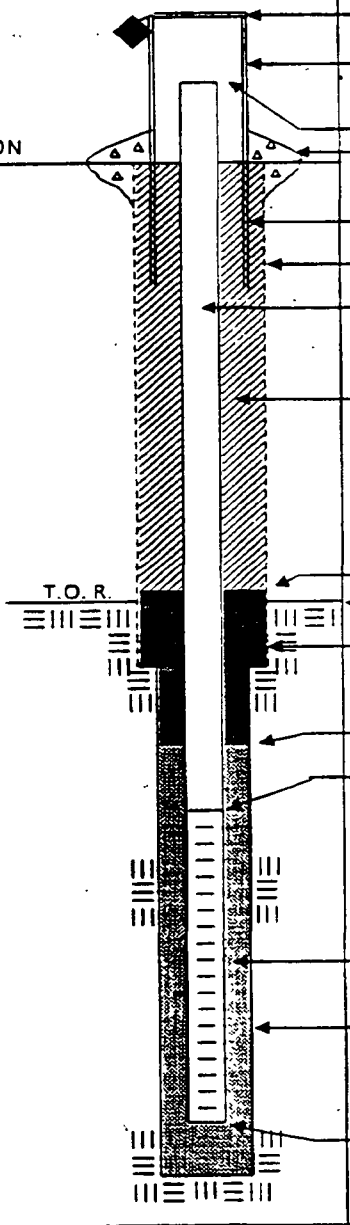
ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: ____/____

ELEVATION / DEPTH TOP OF BEDROCK: ____/____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: ____/____

ELEVATION / DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: ____/____

ELEVATION / DEPTH BOTTOM OF HOLE: ____/____

ATTACHMENT C-8A
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: _____

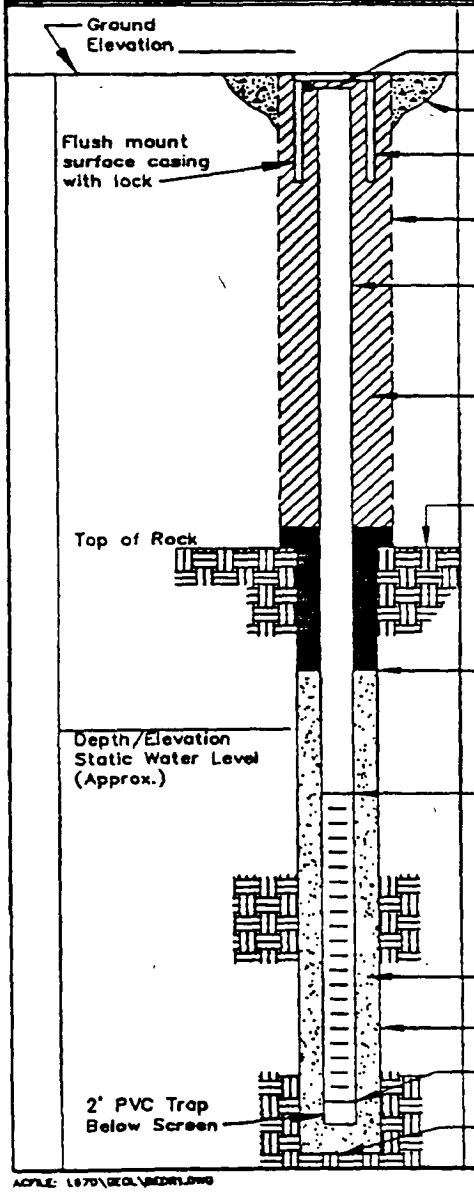
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: _____ LOCATION: _____ DRILLER: _____

PROJECT NO.: _____ BORING: _____ DRILLING METHOD: _____

ELEVATION: _____ DATE: _____ DEVELOPMENT METHOD: _____

FIELD GEOLOGIST: _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF BEDROCK: _____ / _____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

ACFILE: L870\GEOL\BEDRL.DWG

ATTACHMENT C-9
EXAMPLE TEST PIT LOG

TEST PIT LOG

Brown & Root Environmental

PROJECT: _____ TEST PIT NO.:

PROJECT NO _____ DATE: _____

LOCATION: _____

FIELD GEOLOGIST _____

DEPTH (ft.)	LITHOLOGY CHANGE (Depth/ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS _____

PHOTO LOG _____ TEST PIT _____

PAGE ____ OF ____

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Brown & Root Environmental

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME / MODEL : _____

JOB NAME : _____

MANUFACTURER : _____

JOB NUMBER : _____

CALIBRATION DATE	INITIAL SETTINGS	STANDARDS USED	PROCEDURE	ADJUSTMENTS MADE	FINAL SETTINGS	SIGNATURE	COMMENTS

ATTACHMENT E
EXAMPLE DAILY ACTIVITIES RECORD

DAILY ACTIVITIES RECORD — **Brown & Root Environmental**

PROJECT _____ LOCATION _____
CLIENT _____ ARRIVAL TIME _____ JOB NO. _____
DATE _____ DEPARTURE TIME _____
CONTRACTOR _____ DRILLER _____
BORING NO. _____ HNUS REPRESENTATIVE _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY:

_____ HNUS FIELD REPRESENTATIVE

_____ DRILLER OR REPRESENTATIVE

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

MONDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

TUESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

WEDNESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

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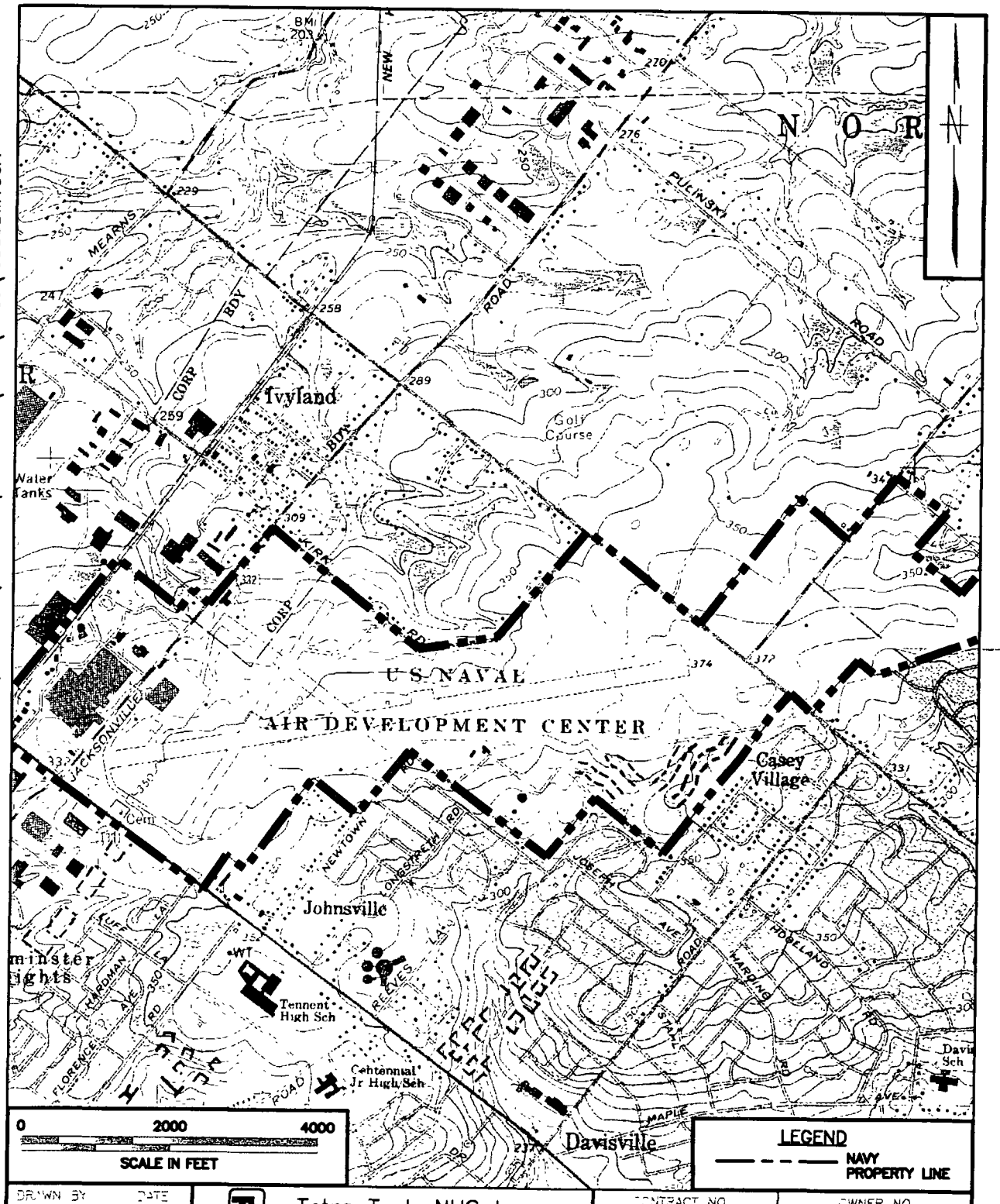

DRAWN BY EEH	DATE 4/5/99	Tetra Tech NUS Inc.	CONTRACT NO. N62472-90-D-1298 / OWNER NO CTO 0252
CHECKED BY	DATE	SITE LOCATION MAP FORMER NAWC WARMINSTER WARMINSTER, PENNSYLVANIA	APPROVED BY / DATE
DIST/SCHED-AREA			APPROVED BY / DATE
SCALE 1 in.=2000 ft.			DRAWING NO FIGURE 2-1 / REV 0

FORM L:\AUTOCAD\BLOCKS\BORDERS\TETRA TECH\ TTNUS_AV3.DWG – REV 0 – 11/18/1998