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VERIFICATION INVESTIGATION WORK PLAN
FOR
THE NAVAL SCHOOL EOD SITES
AT
THE NAVAL EXPLOSIVE ORDNANCE DISPOSAL TECHNOLOGY DIVISION
NAVAL SURFACE WARFARE CENTER
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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GLOSSARY

Acid trepanning	The application of strong acids (nitric or sulfuric acid) to the protective hull of an ordnance in order to access and subsequently extract (via steaming) and detonate an explosive device.
Aluminum powder	Frequently added to explosives and propellants in order to improve their efficiency.
Ammonium nitrate	The most important raw material in the manufacture of industrial explosives.
Black powder	A mechanical mixture of potassium nitrate, sulfur, and charcoal, which is mostly pressed, granulated, and classified into definite grain fractions; is classified as a "low" explosive.
Blasting caps	Initiators of explosive charges consisting of a cylindrical copper and aluminum capsule containing a primary charge of an initiating explosive and a secondary charge of a high-brisance explosive.
Composition C	A Military explosive consisting of cyclonite (RDX) and a plasticizer, which itself may or may not be explosive.
Composition C-3	A military plastic explosive consisting of RDX (78%) and an explosive plasticizer (22%).
Composition C-4	Military plastic explosive consisting of RDX (90%) and polyisobutylene (10%).
Cyclonite (RDX; trimethylene trinitramine)	Probably the most important high brisance explosive. Its brisant power is high due to its density and high detonation velocity.
Cyclotetramethylene tetranitramine (HMX); octogen; homocyclonite	Military explosive; appears in four modifications, of which only the β modification displays a particularly high density and hence also a particularly fast detonation rate.
Detonating cord	Consists of a PETN core (about 12 g/m) with wound hemp or jute threads and a plastic coating around it.
Glycerin	Raw material for manufacture of nitroglycerine.
H-6 Shot	A mixture of RDX (45%), TNT (30%), aluminum (20%), and Wax (5%) [USA].
HBX	Pourable mixture of TNT, RDC, and aluminum containing phlegmatizing additives.
Magnesium powder	Used in pyrotechnics.
Molotov cocktails	A crude bomb made of a bottle filled with flammable liquid, such as gasoline, usually filled with a wick that is ignited just before the bottle is hurled.

M-Scope	Electric water level indicator.
Nitroglycerine	One of the most important and most frequently used components of explosive materials including gelatinous industrial explosives, powders, and solid rocket propellants.
Nitroguanidine	Can be incorporated into nitrocellulose powder, nitroglycerine powder, or diglycol dinitrate powder; these "cold" (calorie-poor) powders erode gun barrels to a much lesser extent than do conventional powders.
Nitrocellulose	Commonly employed designation for nitric acid esters of cellulose (cellulose nitrates).
Pentaerythritol tetranitrate	One of the most powerful and most brisant explosives; used in high-efficiency blasting cap fillings and detonation cords.
Potassium nitrate	Used as a component in pyrotechnical compositions, in industrial explosives, and in black powder.
Propellant	Solid or liquid material with low rate of combustion which will burn smoothly at uniform rate after ignition without depending on interaction with atmosphere. **Single Base** Consists primarily of matrix of nitrocellulose. **Double Base** Contains nitrocellulose and nitroglycerine. **Multibase** (Composite) Contains oxidizing agent in a matrix of binder.
Red phosphorus	Used for pyrotechnics and for manufacturing of incendiary shells, smoke bombs, and tracer bullets.
Sodium nitrate	Used in industrial explosives and in B-black powder as an oxidizer.
Thermite	An incendiary composition consisting of 2.75 parts of black iron oxide (ferrosoferric oxide) and 1.0 part granular aluminum.
Trinitrotoluene	The most important explosive for blasting charges of each kind of weapon; also an important component of industrial explosives.

ACRONYMNS

ARARs	Applicable and Relevant or Appropriate Requirements.
ASTM	American Society for Testing and Materials.
CAP	Corrective Action Permit.
CLEAN	Comprehensive Long-Term Environmental Action Navy.
COC	Chain of Custody.
COMPD	Ammonium picrate.
CTO	Contract Task Order.
EDM	Electronic distance meter.
EOD	Explosive Ordnance Disposal.
EODS	Explosive Ordnance Disposal School.
EPA	United States Environmental Protection Agency.
FOL	Field Operations Leader.
FSAP	Field Sampling and Analysis Plan.
ft AMSL	Feet above mean sea level.
Halliburton NUS	Halliburton NUS Corporation.
HASP	Health and Safety Plan.
HMX	Cyclotetramethylene tetranitramine; Octogen; Homocyclonite.
IDW	Investigative Derived Wastes.
IED	Improvised Explosive Devices.
IHDIVNAVSURFWARCEN	Indian Head Division, Naval Surface Warfare Center.
IOD	Inert Ordnance Disposal.
NAVEODTECHDIV	Naval Explosive Ordnance Disposal Technology Division.
NAVSCOLEOD	Naval School Explosive Ordnance Disposal.
NC	Nitrocellulose.

NEESA	Naval Energy and Environmental Support Activity.
NG	Nitroglycerine.
NQ	Nitroguanidine.
OVA	Organic vapor analyzer.
PCBs	Polychlorinated biphenyls.
PETN	Pentaerythritol tetranitrate.
PID	Photo-ionization detector.
PVC	Polyvinyl chloride.
QA/QC	Quality Assurance/Quality Control.
RBCs	Risk-Based Concentrations.
RCRA	Resource Conservation and Recovery Act.
RDX	Cyclonite; trimethylenetrinitramine.
Semi-VOCs	Semivolatile organic compounds.
SOP	Standard operating procedure.
SWMU	Solid Waste Management Unit.
TAL	Target Analyte List.
TCL	Target Compound List.
TH3	Thermite.
TKN	Total Kjeldahl nitrogen.
TNT	2,4,6-Trinitrotoluene.
TOC	Total Organic Carbon.
TOX	Total organic halides.
TPH	Total petroleum hydrocarbons.
USCS	Unified Soil Classification System.
VI/RFI	Verification Investigation/RCRA Facility Investigation.
VOCs	Volatile organic compounds.

1.0 INTRODUCTION

This Work Plan presents the investigative approach that will be used and the planning documents that will be followed to determine whether environmental contamination is present at four solid waste management units (SWMUs) within the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV), Stump Neck Annex, Indian Head, Maryland. NAVEODTECHDIV is a tenant activity at the Indian Head Division, Naval Surface Warfare Center (IHDIVNAVSURFWARCEN). The following four SWMUs within NAVEODTECHDIV are the focus of the investigation:

- Range 6 (SWMU 5)
- The Improvised Explosive Devices (IED) Site (SWMU 26)
- The Inert Ordnance Disposal (IOD) Site (SWMU 27)
- Area 8, the Underwater Ordnance Training Area (SWMU 25)

The primary goal of the verification investigation is to collect information necessary to determine if remediation may be necessary at these SWMUs and to formulate a cost estimate for remediation, if necessary. The principal mission of NAVEODTECHDIV is to provide Explosive Ordnance Disposal (EOD) technology and logistics management for the joint U. S. military services and to develop war essential elements of intelligence, equipment, and procedures to counter munitions, both domestic and foreign, as required to support the United States Department of Defense and the peacetime security needs of other agencies.

A major tenant organization of IHDIVNAVSURFWARCEN Naval School Explosive Ordnance Disposal (NAVSCOLEOD) conducted training exercises at Range 6, the IED, the IOD, and Area 8. Active military personnel were trained at these sites to perform Explosive Ordnance Disposal (EOD) operations. The NAVSCOLEOD is scheduled for relocation. IHDIVNAVSURFWARCEN is responsible for identifying and addressing any potential environmentally impacted sites caused by the NAVSCOLEOD.

Environmental investigations are being conducted at Range 6, the IOD, the IED, and Area 8 because of the planned NAVSCOLEOD relocation and because Range 6 is included in a Resource Conservation And Recovery Act (RCRA) Corrective Action Permit (CAP) for the Stump Neck Annex. (The investigation will be referred to as the Verification Investigation throughout this Work Plan.) The permit (Corrective Action Permit Number MD 417 009 0001) was issued in January, 1991, by Region III of the United States Environmental Protection Agency (EPA). In response to the Corrective Action Permit, the Navy developed and submitted

a Verification Investigation/RCRA Facility Investigation (VI/RFI) Work Plan (Ensafe, Allen, and Hoshall, July 1991). The Navy is awaiting comments on the VI/RFI Work Plan. The specifications of the VI/RFI Work Plan were considered in the preparation of this Work Plan. The IED, the IOD, and Area 8 have been identified for possible inclusion in the Corrective Action Permit.

This Work Plan includes a Quality Assurance/Quality Control (QA/QC) Plan and a Health and Safety Plan (HASP), which establish quality assurance and safety protocol for the investigative activities specified in the Work Plan and Field Sampling and Analysis Plan (FSAP). The results of the environmental investigations will be documented in a Verification Investigation Report.

Authorization for Halliburton NUS Corporation (Halliburton NUS) to preform the tasks identified in this Work Plan was provided by the Northern Division of the Naval Facilities Engineering Command via Contract Task Order (CTO) Number 222, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62472-90-D-1298.

1.1 SITE LOCATION AND DESCRIPTION

The IHDIVNAVSURFWARCEN is located near Indian Head, Maryland, in the west-central portion of Charles County, approximately 30 miles south-southwest of Washington, D.C., as illustrated in Figure 1-1. This facility occupies two peninsulas of land along the eastern shore of the Potomac River. The NAVEODTECHDIV, which operates as a tenant of the IHDIVNAVSURFWARCEN, is located on 1,100 acres situated on the southwest portion of the peninsula known as Stump Neck Annex (Stump Neck). All four sites being addressed by this Work Plan are located on Stump Neck. Stump Neck is separated from the main side (IHDIVNAVSURFWARCEN) peninsula by Mattawoman Creek. The locations of IHDIVNAVSURFWARCEN and Stump Neck are illustrated in Figure 1-2. The four sites addressed in this Work Plan (Range 6, the IED, the IOD, and Area 8) are all located on Stump Neck and are a controlled by the NAVEODTECHDIV. The sites are located as noted in Figure 1-3. The following paragraphs provide a description of each site.

1.1.1 Range 6 (SWMU 5)

As described in the July 17, 1991 VI/RFI Work Plan for the Stump Neck Annex (Ensafe, Allen, and Hoshall, July 1991), Range 6 is located at the end of Archer Avenue, on a point of land extending into the Potomac River and Chicamuxen Creek. Water surrounds the site on three sides, the Potomac River to the northeast and the Chicamuxen Creek to the southwest. Archer Avenue, an asphalt road, bisects the site terminating close to the water's edge. Access to Range 6 is controlled by fencing and a gate located on Archer Avenue. The site lies completely within the 100-year flood plain and is approximately 11 acres in size.

Range 6 is sparsely vegetated and surrounded by wetlands. The terrain is generally flat and gently sloping toward the surrounding water bodies. The location and general features of Range 6 are displayed in Figure 1-4.

1.1.2 The Improvised Explosive Devices (IED) Site (SWMU 26)

The IED is located south of Archer Avenue in the vicinity of Buildings 2119, 2118, and 2090. The site encompasses 51.42 acres; however, most training exercises occurred in an area approximately 300 feet by 300 feet. This area is often referred to as the VIP demonstration area. Important features of the IED are the incendiary demonstration area, a demonstration area located in front of a set of bleachers, Building 2118 (used for mixing chemicals), and the detonation demonstration area. Access to the site is controlled by fencing and a gate located on Archer Avenue. No wetlands exist in the immediate vicinity of the site. The location and general features of the IED are displayed in Figure 1-5.

1.1.3 The Inert Ordnance Disposal (IOD) Site (SWMU 27)

The IOD is located off a dirt road in the vicinity of the intersection of Archer Avenue and Lewis Road. The site consists of a deteriorating concrete pad measuring approximately 18 by 12 feet. Two circular manholes exist in the top of the concrete pad, which is located on the slope of a steep hill. A 4- to 5-foot depression exists immediately below the concrete pad. Discarded inert ordnance (e.g. fuses) can be seen underneath the pad directly below the circular opening on the left side of the pad (looking down the hillside). Access to the IOD is controlled by a gate located on Archer Avenue. Wetlands and Chicamuxen Creek are located downgradient of the site. The location and general features of the IOD are displayed in Figure 1-6.

1.1.4 Area 8 (SWMU 25)

Area 8, the Underwater Ordnance Training Area, is an active training area located on Roach Road. Access to the site is controlled by fencing and a gate located on Archer Avenue. Significant features of the site are Buildings 2104 and 2125, a pond (approximately 1 acre in size), and numerous water-shot and air-shot test locations. A student would be 30 feet and 75 feet from the Area 8 water-shot and air-shot locations, respectively, during a training exercise.

Area 8 is approximately 9.6 acres in size. In comparison to Range 6, the IOD, and the IED, the terrain at Area 8 is very steep and the site is heavily wooded. Two acres of wetlands have been identified on this site. The water table is very shallow as evidenced by marshy areas and groundwater springs. Chicamuxen Creek

is an important environmental receptor located downgradient of Area 8. The location and general features of Area 8 are displayed in Figure 1-7.

1.2 SITE OPERATIONS AND HISTORY

The following paragraphs provide a summary of site operations historically or currently conducted at Range 6, the IED, the IOD, and Area 8. The NAVSCOLEOD may have begun operations at these site as early as the 1950s. The NAVSCOLEOD is expected to cease operations at Stump Neck in 1997.

1.2.1 Range 6

Range 6 consists of five ranges historically used for open detonation training. Range 6 was identified in the Notice of Decision for RCRA Corrective Action Permit EPA I.D. No. MD 417 009 0001 (January 24, 1991 through January 23, 2001) as Solid Waste Management Unit number five (SWMU 5).

The Range 6 training ranges operated from the early 1950s until early in 1988. The frequency of training exercises at this site depended on the number of recruits (students) requiring training at any one given time. It is estimated the training ranges were used weekly. The following list of chemicals and materials are among those used at Range 6:

- Trinitrotoluene
- HBX
- RDX
- PETN
- Composition C-4
- COMPD
- Composition C-3
- TH3 (Thermite)
- Nitric acid
- Sulfuric acid
- Nitrocellulose
- Nitroquanidine
- Blasting caps
- H6 shot
- Single base, double base, multibase propellants

Small amounts (less than two to three pounds) of explosives were used during the training exercises conducted at Range 6. Based on this estimate, approximately 100 pounds of ordnance were used each year. Most of the actual detonation work during the training exercises occurred within the sparsely vegetated lowland area to the south of Archer Avenue. However, other related training activities, such as acid trepanning, occurred to the north of Archer Avenue. Acid trepanning involved the application of strong acids (nitric or sulfuric acid) to the protective hull of an ordnance in order to access and subsequently extract (via steaming) and detonate an explosive device. Based on the personnel interviews which occurred

on June 20 and 21, 1995, a burn pit and heavy used demolition area may have existed at Range 6 as shown on Figure 1-4. Waste materials at Range 6 are also likely to include small quantities of shrapnel and castings from the detonation of explosives.

The Range 6 training ranges are currently inactive, and there is minimal visual evidence of their actual location and size. (Five small white wooden placards [numbered 1 through 5] were noted at Range 6 during the site visit conducted on July 20 and 21, 1995. These placards may indicate the approximate locations of the 5 test ranges.) It is unlikely that Range 6 will ever be used for training purposes again. The unit has been phased out since this portion of the Explosive Ordnance Disposal School (EODS) relocated to Florida in 1988.

Background documents available for the Stump Neck Annex indicate that in 1956/1957, approximately 1500 to 2000 pounds of arsenic powder contained in plastic bags were buried in a pit located within Range 6 and measuring 40 feet deep and 6 feet in diameter. It should be noted that the RCRA Corrective Action Permit for Stump Neck does not mention of the arsenic disposal pit. The Indian Head Base drawing (Dwg. No. 15455-A) indicates that SWMU 5 is only 300 feet by 300 feet and does not indicate the location of the arsenic pit. Two possible locations for the arsenic pit have been indicated on Figure 1-4. One location was noted on Figure 10 of Revision No. 0 of the Ensafe/Allen & Hoshall Work Plan dated July 17, 1991. The second location was identified during the June 20/21, 1995 interviews. The information regarding the existence and location of an arsenic pit at Range 6 is tentative and difficult to verify.

1.2.2 The Improvised Explosive Devices (IED) Site

The IED is used to test and demonstrate the explosive potential of chemical mixtures. The site was first used in November of 1957 and is still an active training/demonstration area. Activities at the site are performed year round, and it is estimated that approximately 10 pounds (net explosive weight) of ordnance is used in this area each year. The following list of chemicals/explosives are among those used at the IED training area:

- Sulfuric acid
- Potassium chloride
- Potassium permanganate
- Sodium chloride
- Gasoline
- Aluminum powder
- Nitric acid
- Black powder
- Red phosphorus
- Sodium peroxide
- Hydrogen peroxide
- Magnesium powder
- Calcium hypochlorite
- Potassium nitrate

- Glycerin
- Detonation cord
- Ammonium nitrate
- Ferrous oxide

Molotov cocktails were also used during some of the training demonstrations. This information is based on historical records maintained by the Explosive Safety Officer, which are considered accurate and complete dating back to January 1990 (Indian Head Naval Surface Warfare Center, February 1995).

1.2.3 The Inert Ordnance Disposal (IOD) Site

Minimal background information is available to date regarding historical activities at the IOD. The building originally atop the concrete pad at the IOD may have been Building 2061. At one time, an aircraft fuselage may have been situated atop the IOD and may have been used in training exercises (i.e., the training exercise would have simulated the deactivation of unexploded ordnance aboard a downed aircraft). Based on visual inspection of the site, IOD was used for the disposal of inert ordnance. Inert ordnance (e.g., pieces of fuses) can be seen underneath the concrete pad covering the disposal site. In the 1980s, concrete was poured into the hole in the concrete pad covering the IOD. It is not an active disposal site.

1.2.4 Area 8

Area 8, the Underwater Ordnance Training Area, is an active facility used to train military personnel to the defuse explosive devices. Training exercises at Area 8 are performed 10 months out of the year. It is estimated that approximately 50 to 75 pounds (net explosive weight) of ordnance are used at this training facility each year. No more than 0.5 pound of explosives is used at the air- or water-shot locations during training exercises. At the water-shot locations, the explosive is placed 2 to 5 feet below the water surface. At the air-shot locations, the explosive is suspended (on wire) approximately 2 feet above ground. The type of ordnance used includes TNT (2,4,6-trinitrotoluene) block, pentaerythritol tetranitrate (PETN), military dynamite, blasting caps, detonation cord, and similar devices.

Area 8 is defined by numerous water- and air-shot locations, a stagnant water hole, and a pond (Figure 1-7). The stagnant water hole has been inactive since 1993. The water-shot and air-shot locations have been the primary locations for training and testing activities. The water-shot locations consist of depressions measuring a few feet in diameter and 6 to 9 feet deep. Surface water 4 to 5 feet deep fills these depressions. Those shot locations appearing to the left of Archer Avenue on Figure 1-7 will be referred to as "B-side" locations, those to the right of Archer Avenue will be referred to as "A-side" locations. B-side Locations 5, 6, 7, 8, 9, and 22 are the most used water-shot locations, whereas B-side locations 24 and 38 are the most used air-shot locations. A-side water-shot location 7 is the closest location to Chicamuxen

Creek. This information is based on historical records maintained by the Explosive Safety Officer, which are considered accurate and complete dating back to January 1990 (Indian Head Naval Surface Warfare Center, February 1995).

1.3 PHYSIOGRAPHY

The Naval Surface Warfare Center is located at Indian Head, Maryland. As noted previously, the facility consists of two peninsulas, approximately 3,500 acres in area, which are both located on the eastern shore of the Potomac River. The northern and larger peninsula is designated the IHDIVNAVSURFWARCEN. The southern, and smaller peninsula, is designated as Naval Ordnance Station, Stump Neck Annex. The NAVEODTECHDIV is located on the Stump Neck peninsula and is approximately 1,100 acres in area.

The southwestern area of the Stump Neck peninsula is bounded by Chicamuxen Creek, the northern area by the Potomac River and the northeastern area by Mattawoman Creek. The Stump Neck Peninsula has a flat to slightly rolling topography. Most of the land adjacent to Chicamuxen and Mattawoman Creeks are wetlands with slopes of three percent or less. The inland portion of the peninsula has slopes of five percent or more in many places. Elevations at the Stump Neck peninsula range from mean sea level to 143 feet above mean sea level (ftAMSL). Elevations along the creek boundaries are generally 30 ftAMSL with the exception of a few bluffs along the Mattawoman Creek that are 50 to 60 ftAMSL.

1.4 CLIMATE

The climate at the facility is a temperate, continental type that is influenced by the facility's proximity to the Chesapeake Bay and the Potomac River. The region experiences well-defined seasons with warm summers and cold, wet winters. The average summer high and winter low temperatures are 89° and 21°F, respectively (Ensafe, Allen, and Hoshall, July 1991).

The mean annual precipitation for Charles County, Maryland, is 47 inches (Ensafe, Allen and Hoshall, July 1991). The mean annual frozen precipitation is 19 inches. The average wind speeds are 9 miles per hour, and the prevailing wind direction is northwest becoming more southerly during the summer months.

1.5 SURFACE DRAINAGE

Surface waters for Area 8, the IOD, and IED drain to marsh and wetland areas and then into Chicamuxen Creek or directly into the creek. Approximately half of the surface water flow at Range 6 is toward Chicamuxen Creek and remaining drainage is toward the Potomac River.

1.6 SOILS

Three different soil associations have been identified at the NAVEODTECHDIV (Ensafe, Allen, and Hoshall, 1991). These soils are the Evesboro-Keyport-Elkton Association in the western area, the Bibb-Tidal Marsh Swamp Association in the central area and the Beltsville-Exum-Wickham Association in the eastern area of the facility.

The Evesboro-Keyport-Elkton Association soils range from sandy, excessively drained soils to loamy, poorly drained soils that are underlain by clayey subsoils. These soils are level to moderately sloping.

The Bibb-Tidal Swamp Association soils are miscellaneous, poorly drained soils located in unclassified wetland and major flood-plain areas. These soils are generally wet, unstable, and subject to flooding by brackish or saline waters.

The Beltsville-Exum-Wickham Association soils are generally very silty with dense fragipan. These soils are typically moderately sloping and situated on elevated areas. These soils are highly erodible on moderate slopes and are moderately dissected by major rivers and streams in this area.

1.7 GEOLOGY

The Indian Head and Stump Neck peninsulas lie within the Atlantic Coastal plain physiographic province. The general topography of the area consists of rolling terrain, marshlands, swamps, and the shoreline of the Potomac River, Mattawoman Creek, and Chicamuxen Creek. The geology of the area consists of 500 to 600 feet of unconsolidated fluvial and marine deposits overlying much older Precambrian igneous and metamorphic bedrock. The unconsolidated sediments strike northeast and dip to the southeast at approximately 50 feet per mile.

The unconsolidated deposits underlying the site are of the Potomac Group, which consist of (in descending order) the Patapsco, Arundel, and Patuxent Formations. The Patapsco Formation is a sequence of gently dipping, unconsolidated layers of clay, silt, sand, and gravel deposits. The average thickness of the Patapsco Formation is approximately 200 to 300 feet (Tech International, 1988; Aware, 1982).

The Patapsco Formation is underlain by the Patuxent-Arundel Formations, which consist of clays and sandy to silty clays with occasional, thin sand layers. These thin sand units within the otherwise clay dominated formation are not laterally continuous, and generally pinch out within 2 miles or less (Tech

International, 1988). The average thickness of the Patuxent-Arundel Formation in the vicinity of Indian Head is approximately 300 feet.

In some areas on the Indian Head and Stump Neck peninsulas, the Upper Potomac Group sediments were eroded by the ancestral Potomac River system, which deposited paleo-channel and fluvial (river) sediments on top of the Potomac Group. Along the eastern side of the Indian Head peninsula these Quaternary age fluvial sediments extend to approximately 75 feet below sea level (Hiortdahl, 1990). In other areas, the Potomac Group is overlain by younger sedimentary layers which may include the Aquia Greensand, the Columbia Formation, and other deposits. On Stump Neck, the paleo-channel deposits average from about 80 feet to 100 feet deep.

1.8 HYDROGEOLOGY

The Potomac Group aquifer system is the major confined aquifer for the area around Indian Head and Stump Neck, Maryland. Localized shallow aquifers (e.g., water table aquifers) may exist in the Quaternary fluvial sediments which overlie the Potomac Group, but in this area these aquifers are not used for potable water (Hiortdahl, 1990). The Potomac Group aquifer is a multi-aquifer system which contains several confined aquifers within the Patapsco and Patuxent Formations (Figure 1-8). These confined aquifers consist of saturated, poorly consolidated sand and gravel deposits that generally range from 1 to 20 feet in thickness (Hiortdahl, 1990). These water-bearing units are interbedded with clay and fine-grained units that confine and isolate the sand units.

The Potomac Group produces water of good quality, and has supplied all of the ground water withdrawn from production wells in the Indian Head and Stump Neck area. The Patapsco Formation contains several water-bearing sand layers, which have been extensively tapped. Three zones within this formation have been encountered which contain significant permeable units; the Upper Sand, Middle Sand, and Lower Sand zones. In the Indian Head area, the Upper Sand zone is thin or absent and is not a significant water producer. The Middle Sand zone occurs between 50 and 200 feet below MSL and is not as productive as the Lower Sand zone. The Lower Sand zone generally yields the most water and is encountered between 200 and 300 feet below MSL (Greenhorn and O'Mara, 1990).

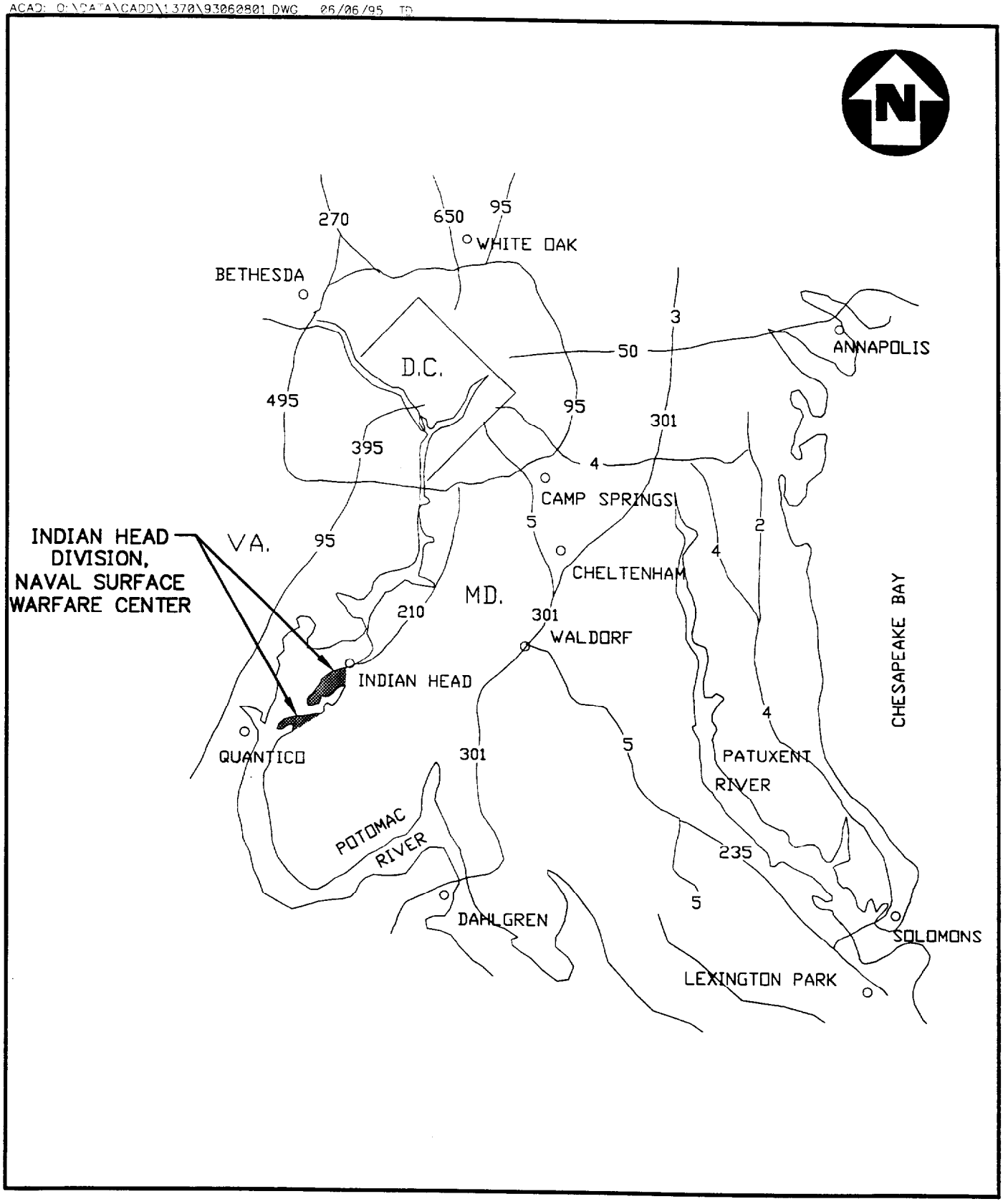
The transmissivity of the Lower Sand zone at the Indian Head area ranges from 270 ft^2/day to 535 ft^2/day, with the combined transmissivity of the entire Patapsco Formation estimated at about 1,070 ft^2/day. The clay-rich aquitards of this formation have very low vertical hydraulic conductivities, in the range of 2×10^{-8} ft/sec to 2×10^{-10} ft/sec (Tech International, 1988). Coefficients of storage for the Patapsco

Formation range from 0.0004 to 0.0002 feet per vertical foot (ft/ft). The average well yield for wells in this area is approximately 250 gallons per minute (gpm) (Greenhorn and O'Mara, 1990).

The deeper Patuxent Formation contains mostly clay-rich units, although the main base production wells tap the permeable sand layers (some of which are in the Patuxent Formation), which are interbedded with these units. The sand units are not laterally continuous, and most wells find sufficient water yields within the overlying Patapsco Formation.

The IHDIVNAVSURFWARCEN is the largest water user in the Indian Head region, with 15 production wells from the Patapsco Formation which together pump more than 1.3 million gallons per day (gpd). Thirteen of the fifteen production wells are located on the Indian Head peninsula, and the remaining two are located on the Stump Neck Peninsula. Eight of the production wells are screened exclusively in the Lower Sand zone, with seven wells screened in the Upper and Middle Sand zones as well as the Lower Sand zone. The screened interval extends into the Patuxent Formation at some locations. Extensive pumping has occurred at these wells for several decades, and potentiometric water levels around the Indian Head peninsula for the deep aquifer system have declined more than 85 feet over the last 80 to 90 years because of pumping (Tech International, 1988; Aware, 1982).

ACAD: Q:\DATA\CADD\1370\93060801.DWG 06/06/95 TD

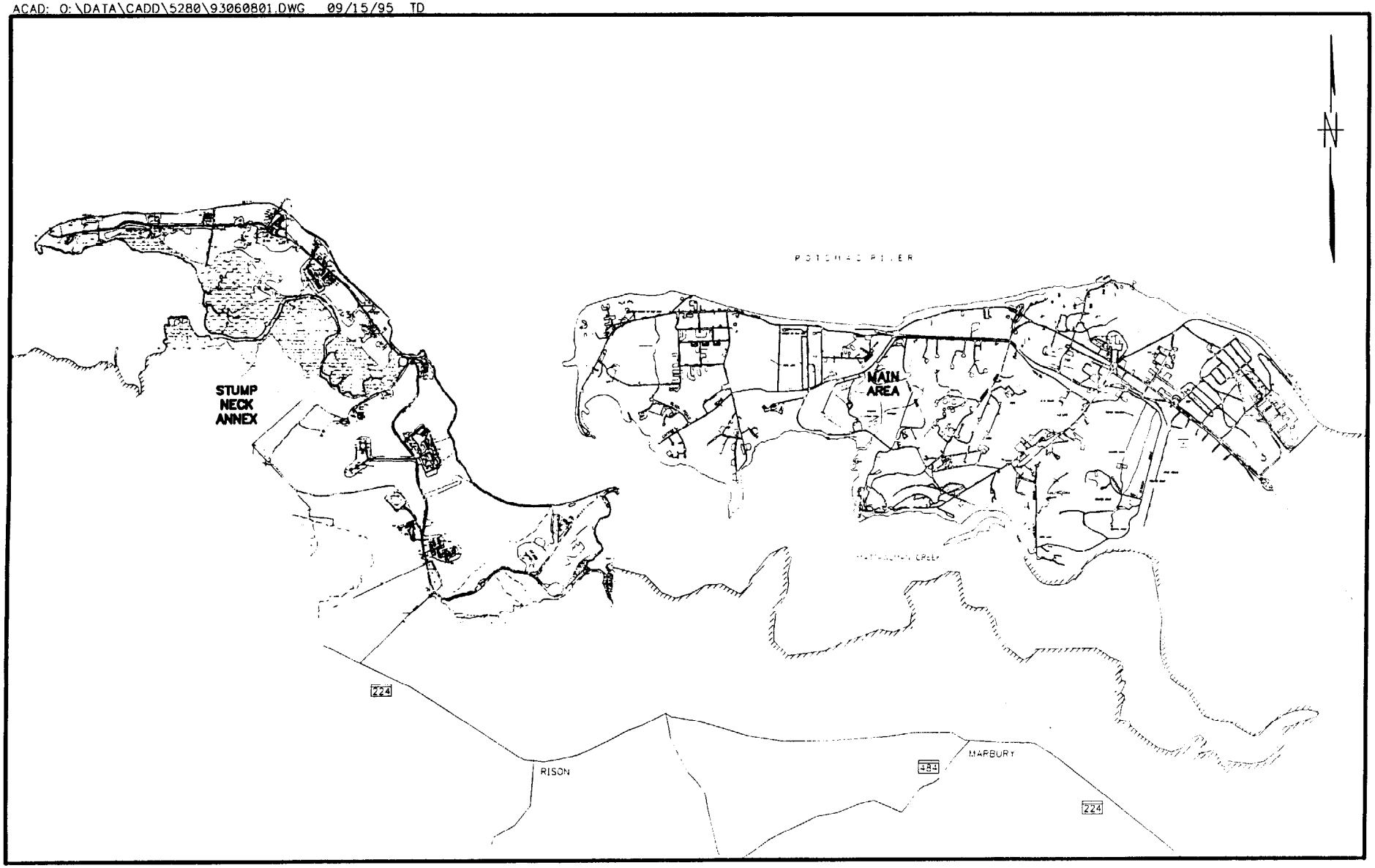


VICINITY MAP
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 1-1

Halliburton NUS CORPORATION

ACAD: Q:\DATA\CADD\5280\93060801.DWG 09/15/95 TD



LOCATION MAP
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

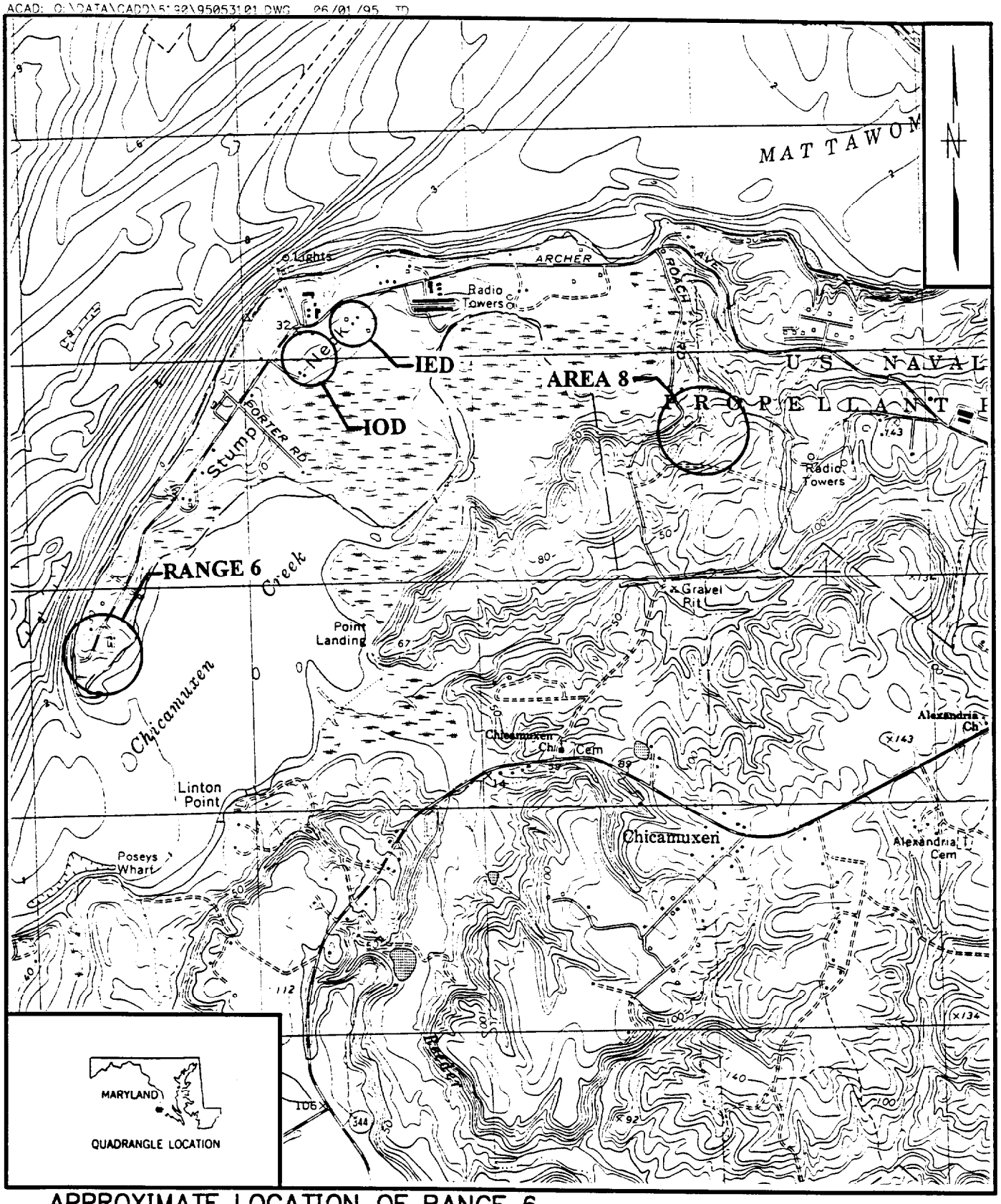
0 4000 8000
SCALE IN FEET

FIGURE 1-2

Halliburton NUS CORPORATION

FINAL

ACAD: O:\DATA\CADD\5132\95053101.DWG 06/01/95 TD

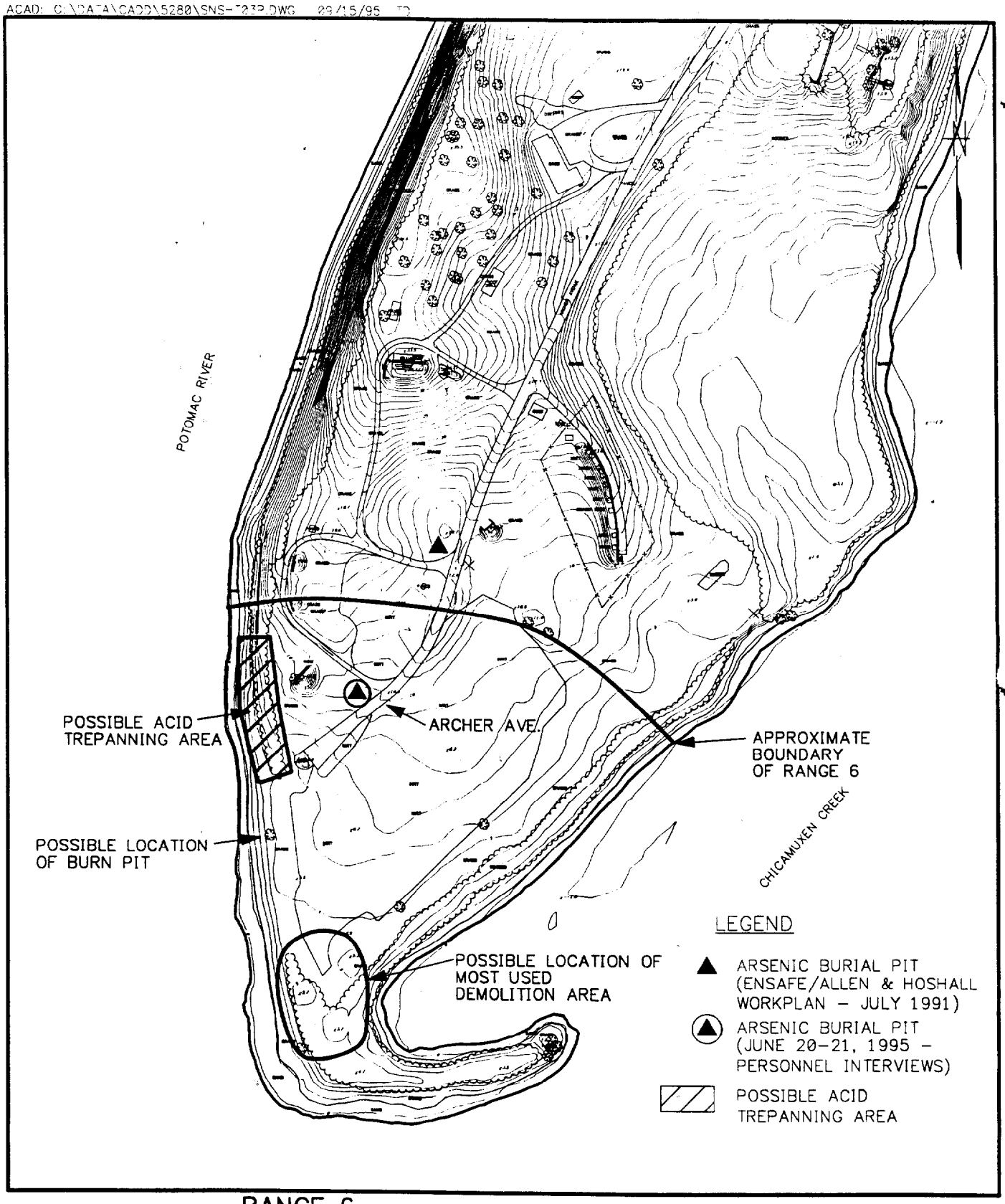


APPROXIMATE LOCATION OF RANGE 6, THE IED, THE IOD, AND AREA 8
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER

FIGURE 1-3

0 2000 4000
SCALE IN FEET

Halliburton NUS CORPORATION

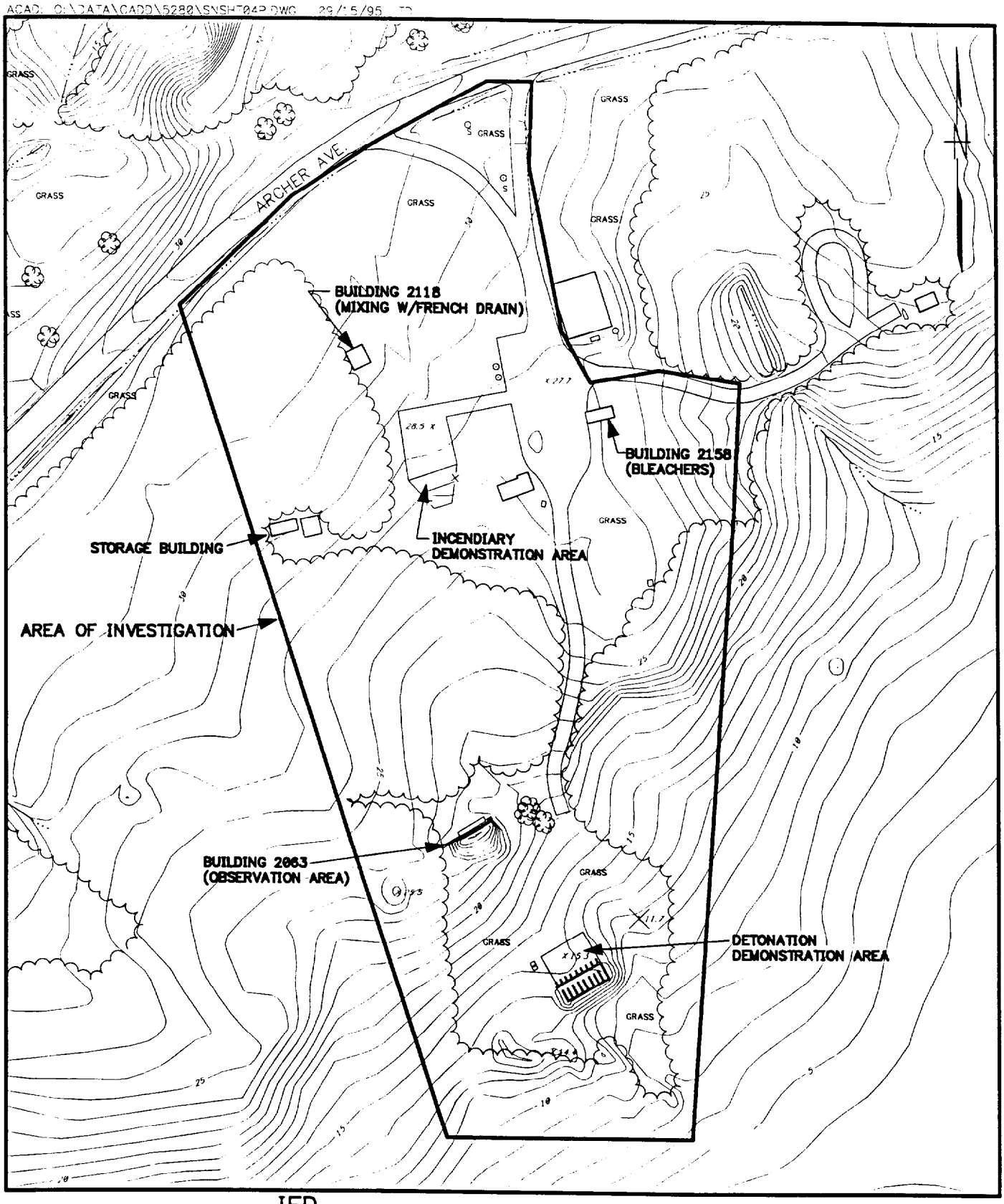


RANGE 6
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

0 200 400

FIGURE 1-4

Halliburton NUS CORPORATION

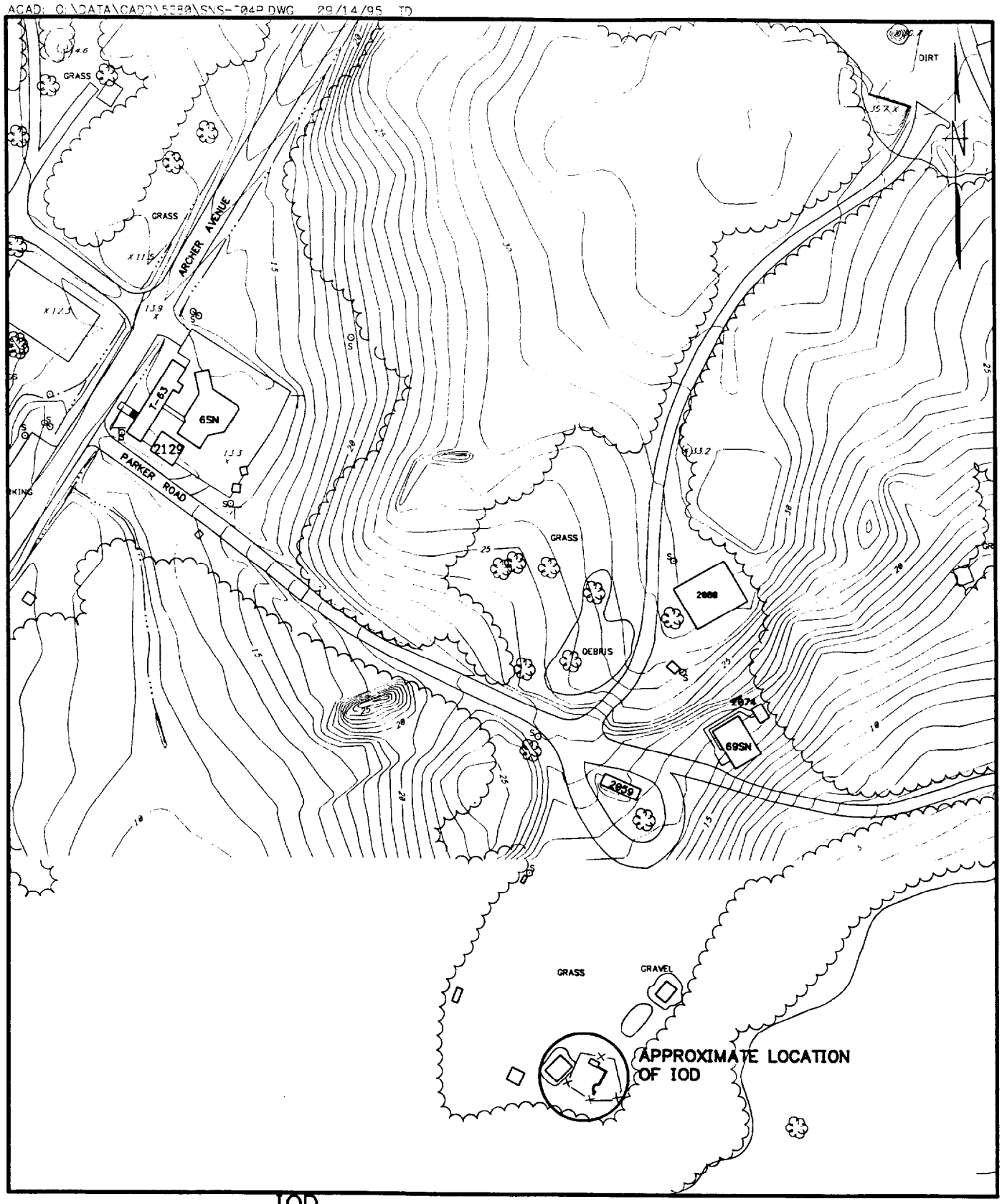


IED
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

0 100 200

FIGURE 1-5

Halliburton NUS CORPORATION

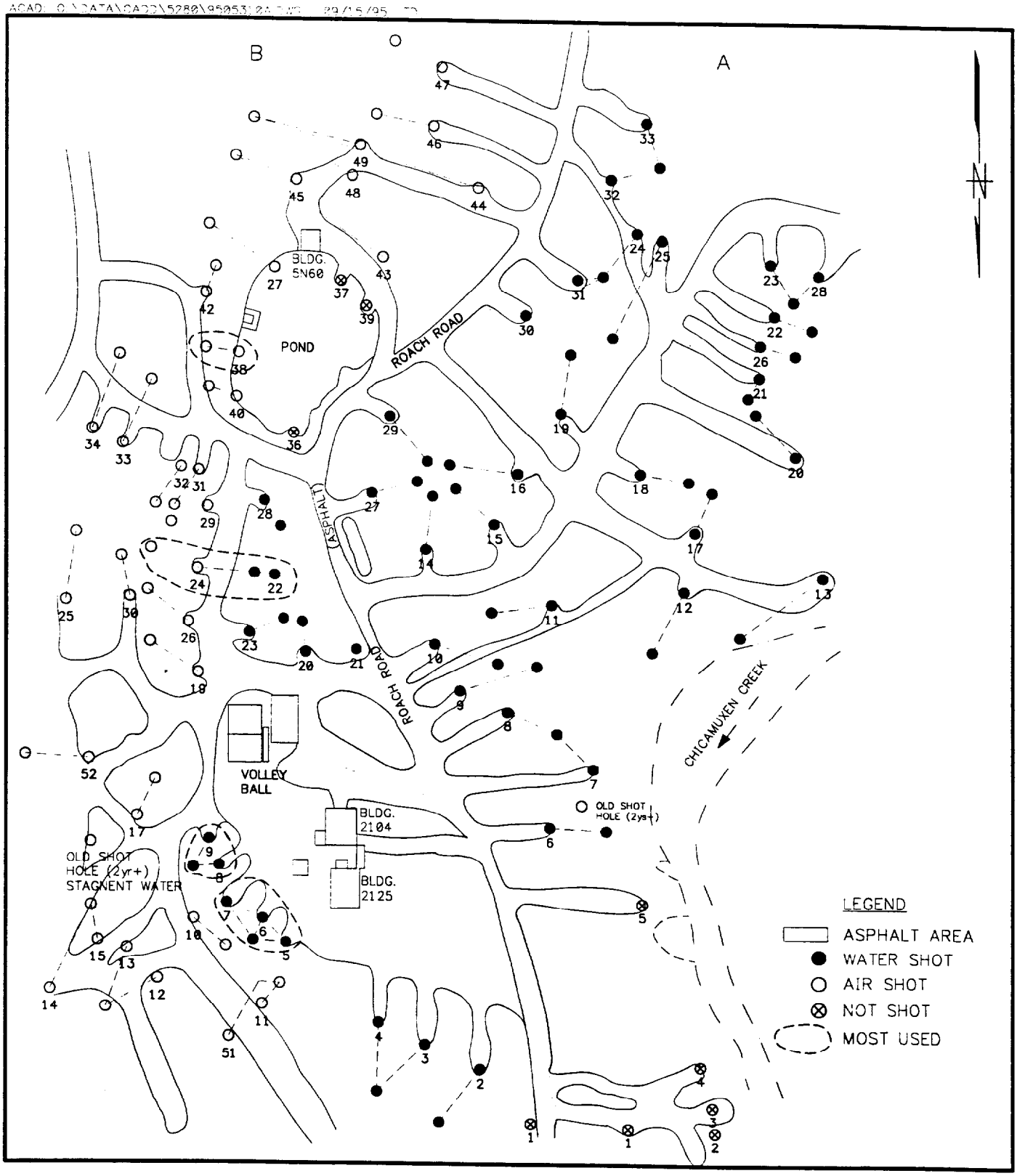


IOD
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

0 100 200
SCALE IN FEET

FIGURE 1-6

Halliburton NUS CORPORATION

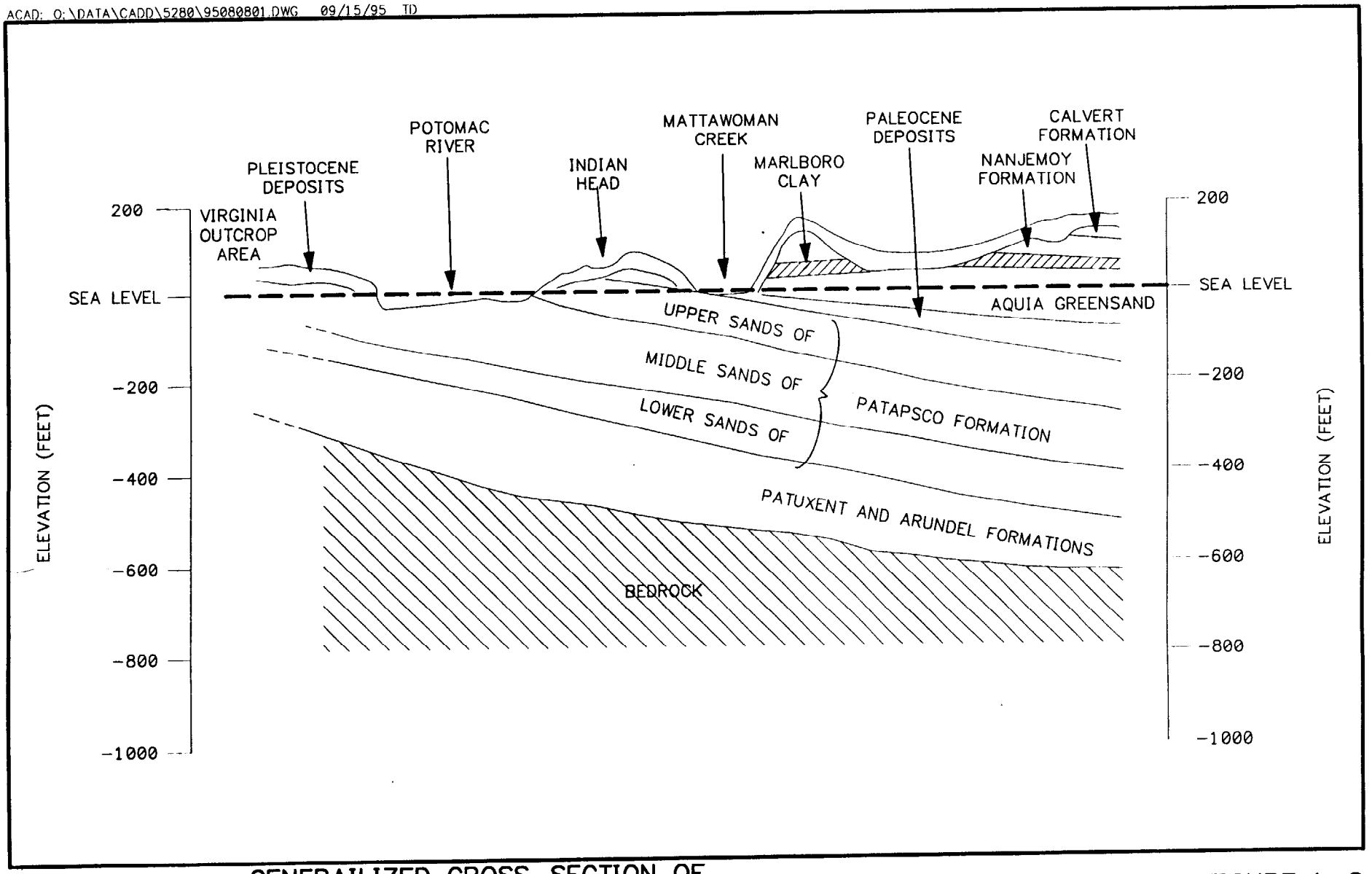


AREA 8
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 1-7

Halliburton NUS CORPORATION

ACAD: O:\DATA\CADD\5280\95080801.DWG 09/15/95 TD



GENERAILIZED CROSS-SECTION OF
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

0 5,000 10,000
SCALE IN FEET

FIGURE 1-8

Halliburton NUS CORPORATION

FINAL

2.0 OBJECTIVES OF THE INVESTIGATION/INVESTIGATIVE APPROACH

The objectives of the Verification Investigation planned for Range 6, the IOD, the IED, and Area 8 are twofold:

- Determine if environmental contaminants are present at Range 6, the IOD, the IED, and Area 8 at concentrations exceeding chemical specific Applicable and Relevant or Appropriate Requirements (ARARs) or at concentrations of public or environmental health concern.
- Collect analytical data of a quality that will meet requirements established in the RCRA Corrective Action Permit for Stump Neck.

In overview, these objectives will be achieved by:

- An environmental sampling program that targets areas that, based on historical information regarding each site of concern, are most likely to demonstrate environmental contamination, if it exists.
- Collection, analysis, and validation of analytical data per protocol acceptable to the Navy and Region III of the Environmental Protection Agency (i.e., acquisition of data in accordance with the specifications of the RCRA Corrective Action Permit for Stump Neck).

This section identifies data needs for the Verification Investigation and presents the investigative approach to accomplish the objectives of the Verification Investigation. Work tasks for the investigative approach were developed following a site visit and several discussions with the Navy, and after a review of currently available background documentation. Table 2-1 summarizes work task activities proposed for the environmental investigation. The primary goal of the environmental investigation is to collect the information necessary to determine if remediation may be necessary and to formulate a cost estimate for remediation, if necessary.

2.1 INVESTIGATIVE APPROACH FOR RANGE 6 (SWMU 5)

As detailed in Section 1.0, Range 6 is an inactive training area located at the end of Archer Avenue on the western edge of the Stump Neck Annex. The unit, which operated as early as 1953, was phased out in 1988 when the demolition range of the Explosive Ordnance Disposal School (EODS) moved to Florida. The location and general features of Range 6 were presented in Figure 1-4. The unit (approximately 11 acres

in size) consisted of five training ranges. The exact locations of the training ranges are not known at this time. However, large placards numbered 1 through 5 do exist in the lowland area to the south of Archer Avenue.

Explosive charges of less than 2 to 3 pounds were used during training exercises conducted within Range 6. Unexploded ordnance was open-detonated in place. Composition C-3, Composition C-4, COMPD (ammonium picrate), nitric acid, and sulfuric acid were among the chemicals used at the training ranges. COMPD (ammonium picrate) has been used as an explosive in military charges.

2,4,6-Trinitrotoluene (TNT), cyclotetramethylene tetranitramine (HMX), and cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX) are target analytes specifically identified in the Corrective Action Permit for Range 6 at Stump Neck. TNT is an important military and industrial explosive. HMX and RDX are also military explosives.

The environmental investigation proposed for Range 6 is described in the following paragraphs.

2.1.1 Site Background Information Research

The site background information presented in this workplan was gathered as a result of the review of available background documents and through interviews with military/civilian personnel familiar with operations conducted at Range 6. This work task was necessary because there was (and still is) limited documented information available regarding the operations conducted at Range 6. For example, although the approximate site location is known, the exact location and dimensions of the five training ranges within Range 6 have not been identified in any of the documents reviewed by Halliburton NUS Corporation to date. Interviews of military/civilian personnel took place during a site visit which occurred on June 20 and 21, 1995. The questionnaire used in the interviews is provided in Exhibit 2-1. This work task is likely to continue until the field investigation work for the project has begun.

2.1.2 Soil Sampling and Analysis

Soil sampling and analysis will be conducted to determine whether there is any evidence of soil contamination at Range 6 and to optimize the placement of a groundwater monitoring well. In overview, surface soil samples will be collected and analyzed using a field screening test kit that targets explosive residues (TNT, RDX, HMX). Additionally, monitoring-well soil samples will be collected and sent to a fixed base laboratory for an extensive list of analyses. It should be noted that the Range 6 soil sampling program is designed to determine whether there is evidence of soil contamination. (Specifically, is there evidence of

explosive residues in the surface soils at Range 6.) The program is not designed to identify all potential hazardous waste source areas within Range 6, to completely characterize the vertical and horizontal extent of contamination, or to provide all the information necessary to evaluate all possible remedial alternatives, if contamination is present. The program is also not designed to investigate the arsenic disposal pit alleged to exist at Range 6.

Field screening test kits procured from D-Tech Corporation will be used to screen approximately 25 surface soil samples collected within Range 6 (Figure 2-1). (For purposes of this Work Plan, a surface soil sample is defined as a sample collected at the soil interval 0 to 2 feet below ground surface.) Literature on the use and limitations of the proposed field screening test kits is provided in Appendix C. Unless information gathered during the interviews described in Section 2.1.1 identifies the location of one or more of the training areas within Range 6, the surface soil samples will be collected at locations established by a grid (approximately 100 foot-centers). (Based on visual observation of the study area and interviews conducted to date with military/civilian personnel, it appears that the Range 6 testing ranges were located on the Chicamuxen Creek side of the Stump Neck Annex. Thus, the grid will be located in the Range 6 area between Archer Avenue and Chicamuxen Creek.) Surface soil samples collected at three background sampling locations will also be analyzed using the field screening test kits. The field screening test kits target the following analytes:

- 2,4,6-Trinitrotoluene (TNT)
- Cyclotetramethylene tetranitramine (HMX)
- Cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX)

TNT, HMX, and RDX are among the explosives potentially used during the training exercises conducted at Range 6 and Area 8. They are the only explosives specifically identified in the Corrective Action Permit for Range 6 at Stump Neck. Risk based concentrations (RBCs) established by Region III of the Environmental Protection Agency (EPA) are available for these explosives. These RBCs are available for water, assuming domestic consumption of a water resource, and for soils, assuming industrial or residential land use scenarios. (A copy of the March 7, 1995 version of the EPA Region III Risk Based Concentration Table is provided in Appendix E.) Table 2-2 compares the available RBCs to detection limits achievable using the D-Tech Corporation field screening test kits. The comparison indicates that the detection limits achievable by the field test kits are lower than or within the same order of magnitude as the RBCs.

Two soil samples will be collected during the drilling of a Range 6 monitoring well described in the following paragraph. One of the monitoring well samples will be collected from the 0- to 2-foot depth interval. This sample and the field test kit screening samples will be used to determine whether surface soil contamination

is present. The second monitoring well soil sample will be collected at the soil interval 2 to 5 feet below ground surface or the soil interval just above the water table if the water table is very shallow (i.e., less than 15 feet below ground surface). This sample will be collected to determine whether site related contaminants are migrating or are present at the soil-groundwater interface.

The monitoring well soil samples will be analyzed at a fixed-based laboratory for the following parameters:

- Method 8330 Explosives (Table 2-3)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin
- Cyanide
- Appendix IX volatile organic chemicals (VOCs)
- Appendix IX semi-volatile organic chemicals (Semi-VOCs)
- Total organic carbon (TOC)
- Nitrate-nitrite
- Ammonia-nitrogen

The analyses for explosives and propellants, metals, and the full complement of Appendix IX VOCs and semi-VOCs is necessary to determine whether contamination of public or environmental health significance is present in the soils. The Method 8330 Explosives, NC, NQ, NG, and PETN are propellants and explosives potentially used in training exercises conducted at Range 6 and/or Area 8. TNT, HMX, RDX, the metals, the Appendix IX VOCs, and the Appendix IX semi-VOCs are target analytes listed for soils in the Final Corrective Action Permit for the U.S. Naval Explosive Ordnance Disposal Technology Center, Stump Neck Annex, Indian Head, Maryland (EPA I.D. No. MD 417 009 0001). Nitrates/nitrites and NG are among the list of target analytes specified in the Statement of Work (SOW) for Navy Contract Task Order (CTO) No. 222. Parameters such as TOC are selected analytes because they are often indicators of gross levels of contamination and are often used in contaminant fate- and transport-analysis and in the evaluation of remedial alternatives.

2.1.3 Hydrogeological Investigation/Groundwater Sampling

One monitoring well will be installed at Range 6 to determine whether there is evidence of groundwater contamination in the shallow water table aquifer. Given the topography and location of Range 6,

groundwater may be encountered as shallow as 15 to 20 feet below ground surface. The monitoring well will be located based on the results of field test-kit screening of soils and any historical information developed for the site as a result of the implementation of this Work Plan. The well location will be checked for the presence of underground utilities prior to beginning drilling operations, and the locations modified as necessary to avoid any utilities present. The shallow monitoring well will be installed in accordance with the specifications described in Section 3.0 of this Work Plan.

One groundwater sample will be collected from the Range 6 monitoring well and analyzed at a fixed-based laboratory for the following parameters:

- Method 8330 explosives (Table 2-3)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin (filtered, unfiltered)
- Cyanide
- Appendix IX VOCs
- Appendix IX Semi-VOCs
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Nitrate-nitrite
- Ammonia-nitrogen
- Total Kjeldahl nitrogen (TKN)
- Total phosphate
- Sulfate

The analyses for explosives and propellants, metals (unfiltered and filtered samples), and the full complement of Appendix IX VOCs and semi-VOCs is necessary to determine if contamination of public or environmental health significance is present in the groundwater. TNT, HMX, RDX, the metals, the Appendix IX VOCs, and the Appendix IX semi-VOCs are target analytes listed for groundwater in the Final Corrective Action Permit for the U.S. Naval Explosive Ordnance Disposal Technology Center, Stump Neck Annex, Indian Head, Maryland (EPA I.D. No. MD 417 009 0001). Nitrates/nitrites and NG are among the target analytes specified in the Statement of Work (SOW) for Navy Contract Task Order (CTO) No. 222. Parameters such as TOC and TOX are selected as target analytes because they are gross indicators of contamination and are often used in contaminant fate- and transport-analysis. Parameters such as sulfate, total phosphate, nitrate-nitrite,

ammonia-nitrogen, and total kjeldahl nitrogen are general indicators of water quality and are often used in contaminant fate-and-transport analysis and in the evaluation of remedial alternatives for groundwater.

A slug test will be performed on the Range 6 monitoring well to determine permeability characteristics of the aquifer. Synoptic water-level measurements will also be collected.

It should be noted that the groundwater investigation for Range 6 is not designed to completely characterize the vertical and horizontal extent of groundwater contamination at Range 6, to profile all aquifer characteristics, or to provide all the information necessary to evaluate possible remedial alternatives, if contamination exists. The objective of the investigation is determine whether shallow groundwater contamination exists at a location of known soils contamination based on the results of the field screening of soil samples.

2.2 INVESTIGATIVE APPROACH FOR THE IED (SWMU 26)

Summarizing from Section 1.0, the Improvised Explosive Devices (IED) site is located off Archer Avenue in the vicinity of Buildings 2119, 2118, and 2090. The site was used to test the explosive potential of chemical mixtures. Although test areas may exist throughout the IED site, the most likely test areas include, the incendiary demonstration area, the detonation demonstration area, Building 2118 (used for mixing chemicals), and the area in front of the bleachers.

2.2.1 Site Background Information Research

The site background information presented in this workplan was gathered as a result of the review of available background documents and through interviews with military/civilian personnel familiar with operations conducted at the IED. This work task was necessary because limited documented information was (and still is) available regarding the operations conducted at IED. For example, although the principal demonstration/test areas have been identified, the exact number of areas and their locations are still unknown. Interviews with military/civilian personnel took place during a site visit which occurred on June 20 and 21, 1995. The questionnaire used in the interviews is provided in Exhibit 2-1. This work task is likely to continue until the field investigation work for the project has begun.

2.2.2 Soil Sampling

The proposed soil sampling program for the IED site is limited to the sampling and analysis of surface and subsurface soil samples collected from four soil borings and three monitoring well installations. The objective

of the investigation is to determine if contaminated soils are present at suspected demonstration/ test areas. The program is not designed to identify all potential hazardous waste source areas, to completely characterize the vertical and horizontal extent of contamination, or to provide all the information necessary to evaluate possible remedial alternatives, if contamination is present.

Two soil samples will be collected from each of the three soil borings installed at the IED. One of the soil samples will be collected at the 0- to 2- foot depth interval. The second soil sample will be collected from the soil interval 2- to 5-feet below ground surface or the soil interval just above the water table if the water table is very shallow (i.e., less than 15 feet below ground surface). This sample will be collected to determine whether site-related contaminants are migrating or are present at the soil-groundwater interface. Boring locations (See Figure 2-2) are based on background information gathered for the site from the following locations:

- The center of the incendiary demonstration area,
- The center of the suspected drainage area serving the chemical mixing building (Building 2118),
- The area in front of the bleachers, and
- The center of the detonation/demonstration area.

Surface and subsurface soil samples will also be collected during the drilling of the three monitoring wells described in the following paragraph. One of the monitoring well soil samples will be collected from the 0- to 2- foot depth interval. The second monitoring well soil sample will be collected from the soil interval 2- to 5-foot below ground surface or the soil interval just above the water table if the water table is very shallow (i.e., less than 10 to 15 feet below ground surface). The monitoring well soil samples and soil boring samples will be analyzed at a fixed-based laboratory for the following parameters:

- Method 8330 explosives (Table 2-3)
- Nitrocellulose (NC)
- Nitroguanidine (NG)
- Nitroglycerine
- Target Analyte List (TAL) metals
- Cyanide
- Appendix IX VOCs
- Appendix IX Semi-VOCs
- Total organic carbon (TOC)
- Nitrate-nitrite
- Total petroleum hydrocarbons (TPH)

- Target Compound List Polychlorinated biphenyl compounds (PCBs)
- Ammonia-nitrogen

The rationale for these target analytes is similar to that presented for the analytes proposed for Range 6 except that, given the activities conducted at the IED, a limited number of samples, only, will be analyzed for the energetics because they are not anticipated to be significant contaminants of concern. As noted in Section 1, a variety of inorganic and organic compounds were included in the tests and demonstrations conducted at the IED. Thus, the analyses for the full complement of Appendix IX VOCs and semi-VOCs, metals, polychlorinated biphenyls (PCBs) is necessary to determine if contamination of public or environmental significance is present in soils at the IED. Appendix IX VOCs and semi-VOCs, and metals are also target analytes listed in the RCRA Corrective Action Permit for the Stump Neck Annex. TPH is included as target analytes because fuels could have been used at the IED.

2.2.3 Hydrogeological Investigation/Groundwater Sampling

Three monitoring wells will be installed at the IED to determine whether there is evidence of groundwater contamination in the shallow water table aquifer. One monitoring well will be installed upgradient of the IED. Background soil and groundwater samples will be collected from this monitoring well. The locations of the other monitoring wells are based on background information gathered for the site: 1) immediately downgradient of the incendiary demonstration area, and 2) immediately downgradient of the detonation demonstration area (Figure 2-2). Monitoring well locations will be checked for the presence of underground utilities prior to beginning drilling operations, and the locations modified as necessary to avoid any utilities present. The shallow monitoring wells will be installed in accordance with the specifications described in Section 3.0 of this Work Plan.

One groundwater sample will be collected from each of the IED monitoring wells and analyzed at a fixed-based lab for the following parameters:

- Method 8330 explosives (Table 2-3)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Target Analyte List (TAL) metals and tin (filtered, unfiltered)
- Cyanide
- Appendix IX VOCs
- Appendix IX Semi-VOCs

- Total organic carbon (TOC)
- Total organic halides (TOX)
- Nitrate-nitrite
- Ammonium-nitrogen
- Total Kjeldahl nitrogen (TKN)
- Total phosphate
- Sulfate
- Target Compound List PCBs
- TPH
- Ammonia-nitrogen

The rationale for these analytes is similar to that presented for the analytes proposed for Range 6 except that given the activities conducted at the IED, a limited number of samples, only, will be analyzed for energetics because they are not anticipated to be significant contaminants of concern. TPH is included as target analytes because fuels could have been used at the IED.

A slug test will be performed at each of the IED monitoring wells to determine permeability characteristics of the aquifer. Synoptic water-level measurements will also be collected.

It should be noted that the groundwater investigation for IED is not designed to completely characterize the vertical and horizontal extent of groundwater contamination at the IED, to profile all aquifer characteristics, or to provide the information necessary to evaluate all possible remedial alternatives, if contamination exists. The objective of the investigation is to determined whether site-related groundwater contamination is present based on the analysis of groundwater quality in the vicinity of known or suspected test locations.

2.3 INVESTIGATIVE APPROACH FOR THE IOD (SWMU 27)

The IOD is located off a dirt road in the vicinity of the intersection of Archer Avenue and Lewis Road. Summarizing from Section 1.0, the IOD is a pit (approximately 4 to 5 feet deep) underlying a circular opening (approximately the size of a manhole) in a concrete pad (approximately 18 feet by 12 feet). Inert ordnance (e.g., fuses) were discarded into the pit over a period of many years. The environmental investigation proposed for the IOD is described in the following paragraphs.

2.3.1 Site Background Information Research

The site background information presented in this workplan was gathered as a result of the review of available background documents and through interviews with military/civilian personnel familiar with operations conducted at the IOD. This work task was necessary because there was (and still is) limited documented information available regarding the operations conducted at IOD. For example, although discarded fuses can be seen in the disposal area, very limited information is available regarding other materials that may have been discarded into the pit. Interviews with military/civilian personnel took place during a site visit which occurred on June 20 and 21, 1995. The questionnaire used in the interviews is provided in Exhibit 2-1. This work task is likely to continue until the field investigation work for the project has begun.

2.3.2 Soil Sampling

Soil sampling will be conducted at the IOD to determine whether there is evidence of soil contamination in the vicinity of the IOD. Soil samples will be collected from two locations in the depression immediately downgradient of the disposal area. The soil samples will be collected at 0 to 2 feet below ground surface interval. The soil boring samples will be analyzed at a fixed-based laboratory for the following parameters:

- Method 8330 explosives (including TNT, HMX, and RDX)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) Metals
- Cyanide
- Appendix IX VOCs
- Appendix IX Semi-VOCs
- Total organic carbon (TOC)
- Nitrate-nitrite

The rationale for these analytes is the same as that presented for the Range 6 target analytes.

2.4 INVESTIGATIVE APPROACH FOR AREA 8 (SWMU 8)

Area 8, the Underwater Ordnance Training Area, is located along Roach Road in the vicinity of Buildings 2104 and 2125. As described in Section 1, this training area is defined by numerous water-shot and air-shot location, and by a pond (approximately one acre in size) used over the years to train military personnel to defuse bombs. Approximately 12 classes use the training course each year. Approximately 50 to 75 pounds of explosives are consumed per year. Explosive materials used at Area 8 include 2,4,6-trinitrotoluene (TNT), military dynamite, and PETN. B-side locations 24 and 38 are the most used air-shot locations, whereas B-side locations 5, 6, 7, 8, 9, and 22 are the most used water-shot locations. A-Side location 7 is the water-shot location closest to Chicamuxen Creek, an important environmental receptor adjoining and downgradient of Area 8. The environmental investigation suggested for Area 8 is described in the following paragraphs.

2.4.1 Site Background Information Research

The site background information presented in this workplan was gathered as a result of the review of available background documents and through interviews with military/civilian personnel familiar with operations conducted at Area 8. This work task was necessary because there was (and still is) limited documented information available regarding the operations conducted at Area 8. For example, while all water-shot and air-shot locations are known (see Figure 1-7), there is minimal information about the training frequency of each shot location. Interviews with military/civilian personnel took place during a site visit which occurred on June 20 and 21, 1995. The questionnaire which was used in the interviews is provided in Exhibit 2-1. This work task is likely to continue until the field work investigation work for the project has begun.

2.4.2 Soil Sampling

Soil sampling will be conducted at Area 8 to determine whether there is any evidence of soil contamination at the site and to optimize the placement of groundwater monitoring wells. The Area 8 soil sampling program is limited and is not designed to identify all potential hazardous waste source areas, to completely characterize the vertical and horizontal extent of contamination, or to provide all the information necessary to evaluate possible remedial alternatives. The proposed soil sampling program for Area 8 involves soil sampling and analysis using field screening test kits and sampling and analysis of surface and subsurface soil samples collected from soil boring and monitoring well installations.

Soils (or sediments) from a maximum of 25 water- or air-shot locations will be collected and analyzed for TNT, HMX, and RDX using field screening test kits purchased from D-Tech Corporation. Three surface soil samples will be collected at background locations. Shot locations for screening were selected based on the information gathered as a result of interviews with military/civilian personnel familiar with historical and current operations at Area 8. At a minimum soils or sediments from the following shot locations will be screened using the field screening test kits:

- B-side air-shot locations 24 and 38
- B-side water-shot locations 5, 6, 7, 8, 9, and 22
- A-side water-shot location 7
- The pond

Two soil samples will be collected from each of three soil borings installed at Area 8. One of the soil samples will be collected at the 0- to 2-foot depth interval. The second soil sample will be collected from the soil interval 2- to 5-feet below ground surface or the soil interval just above the water table if the water table is very shallow (i.e., less than 15 feet below ground surface). One boring will be installed in the vicinity of air-shot locations 24 or 38, the most used air-shot locations. The locations of the remaining two borings will be determined based on the results of the field screening for explosive residues.

Surface and subsurface soil samples will also be collected during the drilling of the three Area 8 monitoring wells described in the following paragraph. One of the monitoring well soil samples will be collected from the 0- to 2-foot depth interval. The second monitoring well soil sample will be collected from the soil interval 2- to 5-feet below ground surface or the soil interval just above the water table if the water table is very shallow (i.e., less than 15 feet below ground surface). The monitoring well soil samples and soil boring samples will be analyzed at a fixed-based laboratory for the following parameters:

- Method 8330 explosives (including TNT, HMX, and RDX)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin
- Cyanide
- Appendix IX VOCs (selected samples only)
- Appendix IX semi-VOCs (selected samples only)

- Total organic carbon (TOC)
- Nitrate-nitrite
- Ammonia-nitrogen

The rationale for these analytes is the same as that presented for the Range 6 target analytes.

2.4.3 Hydrogeological Investigation/Groundwater Sampling

Three monitoring wells will be installed at Area 8 to determine whether there is evidence of groundwater contamination in the shallow water table aquifer (See Figure 2-3). Given the of existence of wetlands and Chicamuxin Creek in the immediate vicinity of Area 8, groundwater may be encountered as shallow as 15 to 20 feet below ground surface in many portions of Area 8. Monitoring wells will be installed (1) upgradient of Area 8, (2) in the vicinity of B-side water-shot locations 5, 6, 7, 8, and 9, and (3) in the vicinity of Chicamuxen Creek (A-side location 7). Background soil and groundwater samples will be collected from the upgradient monitoring well. Analytical results for groundwater samples collected from the monitoring wells will characterize groundwater quality in the vicinity of the most used water-shot location and at an important receptor location (i.e., Chicamuxen Creek). Monitoring well locations will be checked for the presence of underground utilities prior to beginning drilling operations, and the locations modified as necessary to avoid any utilities present. The shallow monitoring well will be installed in accordance with the specifications described in Section 3.0 of this Work Plan.

One groundwater sample will be collected from each of the Area 8 monitoring wells and analyzed at a fixed-based lab for the following parameters:

- Method 8330 explosives (including TNT, HMX, and RDX)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin (filtered, unfiltered)
- Cyanide
- Appendix IX VOCs
- Appendix IX semi-VOCs
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Nitrate-nitrite

- Ammonia-nitrogen
- Total Kjeldahl nitrogen (TKN)
- Total phosphate
- Sulfate

The rationale for these analytes is the same as that presented for the Range 6 target analytes.

A slug test will be performed at each of the Area 8 monitoring wells to determine permeability characteristics of the aquifer. Synoptic water level measurements will also be collected.

It should be noted that the groundwater investigation for Area 8 is not designed to completely characterize the vertical and horizontal extent of groundwater contamination at Area 8, to profile all aquifer characteristics, or to provide all the information necessary to evaluate possible remedial alternatives, if contamination exists. The objective of the investigation is to characterize background groundwater quality and to determined whether site-related groundwater contamination is present based on the analysis of groundwater quality in the vicinity of the most used water-shot locations and in the vicinity of an important environmental receptor (Chicamuxen Creek).

2.4.4 Surface Water/Sediment Sampling

Surface water and/or sediment samples from a maximum of 25 water-shot locations will be collected and analyzed for TNT, HMX, and RDX using field screening test kits purchased from D-Tech Corporation. The analytical results will be used to characterize Area 8 surface water and sediment quality and to target sampling locations for fixed based laboratory analysis.

Surface water and sediment samples will be collected from the following Area 8 sampling locations and sent to a fixed based laboratory for analysis:

- The most used water-shot location (5, 6, 7, 8, 9, or 22)
- A water-shot location to be determined based on the results of the field screening
- An upstream location on Chicamuxen Creek
- Chicamuxen Creek immediately adjoining Area 8 (in the vicinity of A-side location 7)

Samples from the water-shot locations will be used to characterize Area 8 surface water/sediment quality at the most used test locations and to confirm the field screening results. Because surface water and sediment contamination is most likely present at the most used water-shot locations, this approach should

indicate the maximum contaminant concentrations for Area 8. Surface water samples sent to the fixed-based laboratory will be analyzed for the following parameters:

- Method 8330 explosives (including TNT, HMX, and RDX)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin (filtered, unfiltered)
- Cyanide
- Appendix IX VOCs
- Appendix IX semi-VOCs
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Nitrate-nitrite
- Ammonia-nitrogen
- Total Kjeldahl nitrogen (TKN)
- Total phosphate
- Sulfate

The rationale for these analytes is the same as that presented for the Range 6 target analytes.

Sediment samples sent to the fixed-based laboratory will be analyzed for the following parameters:

- Method 8330 explosives (including TNT, HMX, and RDX)
- Nitrocellulose (NC)
- Nitroguanidine (NQ)
- Nitroglycerine (NG)
- Pentaerythritol tetranitrate (PETN)
- Target Analyte List (TAL) metals and tin
- Cyanide
- Appendix IX VOCs
- Appendix IX semi-VOCs
- Total organic carbon (TOC)

- Nitrate-nitrite
- Ammonia-nitrogen

The rationale for these analytes is the same as that presented for the Range 6 target analytes.

TABLE 2-1

INVESTIGATION MATRIX
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Data Needs	Investigative Technique	Location	Number of Samples	Analytes
RANGE 6				
• Information on site and source areas of contamination.	• Review records/interview military/civilian personnel regarding operations conducted at Range 6 (June/July 1995).	NA	NA	NA
• Soil concentrations	• Establish soil grid at Range 6. Collect a maximum of 25 soil samples (maximum depth interval 0 to 2 feet below ground surface) and analyze using field test-kits.	Grid points at Range 6 (See Figure 2-1)	25	2,4,6-Trinitrotoluene (TNT) Cyclotetramethylene tetranitramine (HMX) Cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX)
	• Collect monitoring-well soil samples during the drilling of the Range 6 monitoring well.	Range 6 monitoring well (Location based on results of field test kits)	2	Explosives, Method 8330 Nitrocellulose (NC) Nitroguanidine (NQ) Nitroglycerine (NG) Pentaerythritol tetranitrate (PETN) Target Analyte List (TAL) metals and tin Cyanide Appendix IX volatiles (VOCs) Appendix IX semivolatiles (Semi-VOCs) Total organic carbon (TOC) Nitrate-nitrate Ammonia-nitrogen
• Groundwater concentrations	• Install one monitoring well. The location of the monitoring well will be based on the results of the analysis of soil samples using field screening test kits. Collect groundwater sample. The monitoring well location will be surveyed.	Based on field test kit results.	1	Explosives, Method 8330 — NG TAL metals/tin (Unfiltered) — NQ TAL metals/tin (Filtered) — PETN Appendix IX VOCs — Cyanide Appendix IX Semi-VOCs — TOC Ammonia-nitrogen — TOX Nitrate-nitrite — Sulfate Total Kjeldahl nitrogen (TKN) Total Phosphate
• Physical and hydro-geological characteristics of the aquifer (PRELIMINARY INVESTIGATION)	• Collect synoptic water level upon the completion of the Range 6 monitoring well. • Perform slug test at the Range 6 monitoring well. (Results of slug tests will be used to establish groundwater hydraulic conductivity.)	Range 6 monitoring well	NA	NA

TABLE 2-1 (Continued)
INVESTIGATION MATRIX
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Data Needs	Investigative Technique	Location	Number of Samples	Analytes
THE INERT ORDNANCE DISPOSAL (IOD) SITE				
• Information on site and source areas of contamination.	• Review records/interview military/civilian personnel regarding operations conducted at IOD (June/July 1995)	NA	NA	NA
• Surface/subsurface soils concentrations	• Collect two soil/sediment samples in the depression immediately downgradient of IOD. Samples will be collected at 0 to 2 feet below ground surface.	Immediately downgradient of the IOD.	2	Explosives, Method 8330 TAL metals and tin Appendix IX VOCs Appendix IX Semi-VOCs Nitrate-nitrite Ammonia-nitrogen NC NG NQ PETN Cyanide TOC
THE IMPROVISED EXPLOSIVES DEVICES (IED) SITE				
• Information on site and source areas of contamination	• Review records/interview military/civilian personnel regarding operations conducted at IED (June/July 1995)	NA	NA	NA
• Surface/subsurface soil concentrations.	• Install 4 soil borings at suspected source-area locations. The target areas were selected based on site background information and additional information gathered June/July 1995. Collect 2 samples per boring: 1) 0 to 2 feet below ground surface 2) The 2- to 5-foot interval (or top of water table)	• The incendiary demonstration area. • The French Drain Area at Building 2118. • The detonation demonstration area. • The area in front of the bleachers. (See Figure 2-2)	6	Explosives, Method 8330 NC NG NQ TAL metals and tin Cyanide Appendix IX VOCs Appendix IX Semi-VOCs Total petroleum hydrocarbons (TPH) Polychlorinated biphenyl compounds (PCBs) TOC Nitrate-nitrite Ammonia-nitrogen
	• Collect soil samples during the drilling of 3 monitoring wells. Collect 2 soil samples per monitoring well: 1) 0 to 2 feet below ground surface 2) The 2- to 5-foot interval (or top of water table)	As noted in groundwater investigation	6	

TABLE 2-1 (Continued)
INVESTIGATION MATRIX
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Data Needs	Investigative Technique	Location	Number of Samples	Analytes
• Groundwater concentrations • Background groundwater concentrations	• Install 3 monitoring wells. Collect groundwater samples from each monitoring well.	• Upgradient of IED. • Downgradient of incendiary demonstration area. • Downgradient of detonation demonstration area (See Figure 2-2).	3	TAL metals and tin (Filtered, Unfiltered) Appendix IX VOCs Appendix IX Semi-VOCs Total phosphate Nitrate-nitrite Ammonia-nitrogen Cyanide Explosives Method 8330 TPH PCBs Sulfate TOX TOC TKN NC NG NQ
• Physical and hydrogeological characteristics of the aquifer	• Collect synoptic water levels upon completion of the 3 monitoring wells. • Perform slug test at each IED monitoring well. (Results of slug tests are used to establish groundwater hydraulic conductivity.)	As noted for groundwater investigation	NA	NA
AREA 8 - THE UNDERWATER ORDNANCE TRAINING AREA				
• Information on site and source areas of contamination	• Review records/interview military/civilian personnel regarding operations conducted at Area 8 (June/July 1995).	NA	NA	NA
• Surface/subsurface soil concentrations • Background soil concentrations	• Collect soils samples from a maximum of 25 water/air -shot locations. Samples will be analyzed using field screening test kits for explosives (TNT, HMX, RDX).	To be determined. Locations already selected include: (1) Water-shot location 5, 6, 7, 8, 9, and 22 (2) Air-shot location 24 and 38 (3) Water-shot location 7 (Figure 2-3)	25	TNT HMX RDX
	• Install 3 soil borings; collect 2 samples from each boring: 1) 0 to 2 feet below ground surface 2) The 2- to 5-foot interval (or top of water table)	Locations selected based on the results of the field screening test kits. (One location will be the most used air shot location No. 24.)	6	Explosives, Method 8330 TAL metals and tin Appendix IX VOCs Appendix IX Semi-VOCs Nitrate-nitrite Ammonia-nitrogen NC NG NQ PETN Cyanide TOC
	• Collect soil samples during the drilling of 3 monitoring wells. Collect 2 samples per monitoring well: 1) 0 to 2 feet below ground surface 2) The 2- to 5-foot below ground surface interval (or top of water table)	As noted in groundwater investigation	6	

TABLE 2-1 (Continued)
INVESTIGATION MATRIX
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Data Needs	Investigative Technique	Location	Number of Samples	Analytes
• Groundwater concentrations • Background groundwater concentrations	• Install 3 monitoring wells. Collect groundwater samples.	- Upgradient of Area 8 - Vicinity of water-shot locations 5, 6, 7, 8, 9 - Adjoining Chicamuxen Creek (See Figure 2-3)	3	Explosives, Method 8330 TAL metals and tin (Unfiltered) TAL metals and tin (Filtered) Appendix IX VOCs Appendix IX Semi-VOCs Ammonia-nitrogen Nitrate-nitrite Total Kjeldahl nitrogen (TKN) Total phosphate NG NC NQ PETN Cyanide TOC TOX Sulfate
• Physical and hydrogeological characteristics of the aquifer.	• Collect synoptic water levels upon the completion of the 3 monitoring wells. • Perform slug test at each Area 8 well. (Results of slug tests will be used to establish groundwater hydraulic conductivity.)	As noted for groundwater investigation As noted for groundwater investigation	NA	NA
• Surface water/sediment concentrations. • Background surface water concentrations for Chicamuxen Creek.	• Surface water/sediment samples from a maximum of 25 water-/air-shot locations will be analyzed using field screening test kits for explosives (TNT, HMX, RDX). • Collect 4 surface water/sediment samples. Two locations along Chicamuxen Creek will also be sampled.	To be determined. Locations already selected include water-shot locations 5, 6, 7, 8, 9, and 22, the pond. • 2 water-shot locations (based on results of field test kit screening) • Upstream location on Chicamuxen Creek. • Chicamuxen Creek location immediately adjoining Area 8.	25 4	TNT HMX RDX Surface Waters: Explosives, Method 8330 TAL metals and tin (Unfiltered) TAL metals and tin (Filtered) Appendix IX VOCs Appendix IX Semi-VOCs Ammonia-nitrogen Nitrate-nitrite Total Kjeldahl nitrogen (TKN) NG NC NQ PETN Cyanide TOC TOX Sulfate Total phosphate Sediments: Explosives, Method 8330 TAL metals and tin Appendix IX VOCs Appendix IX Semi-VOCs Nitrate-nitrite Ammonia-nitrogen NG NC NQ PETN Cyanide TOC

NA - Not Applicable.

TABLE 2-2

COMPARISON OF RISK BASED CONCENTRATIONS (RBCs) AND FIELD SCREENING DETECTION LIMITS VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Compound	RBC[1] Groundwater (ug/L)	Groundwater Detection Limit (ug/L)	RBC[1] Soil (mg/Kg)	Soil Detection Limit (mg/Kg)
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	1800	150	3900	0.5
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	0.61	5	5.8	0.5
2,4,6-Trinitrololuene	2.2	5	21	0.5

1 Risk-Based Concentration Table. January - June 1995. EPA Region III, March 17, 1995.

Values calculated assuming long term exposure to compounds in soil or groundwater. Exposure assumptions reflective of a residential land use scenario were used to calculate the RBCs presented.

TABLE 2-3

SW-846 METHOD 8330 TARGET ANALYTES
NITROAROMATICS AND NITRAMINES BY HIGH PERFORMANCE
LIQUID CHROMATOGRAPHY (HPLC)
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Compound	Abbreviation	CAS No[a]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-3
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

[a] Chemical Abstracts Service Registry number

EXHIBIT 2-1

SITE BACKGROUND INFORMATION RESEARCH QUESTIONNAIRE
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

1) Describe site operations to the best of your recollection.

2) List chemicals used or disposed of at the site. If possible, please do not use code names or abbreviations - use actual chemical names, if known.

3) Did any chemical/waste releases occur at the site? Quantity? When?

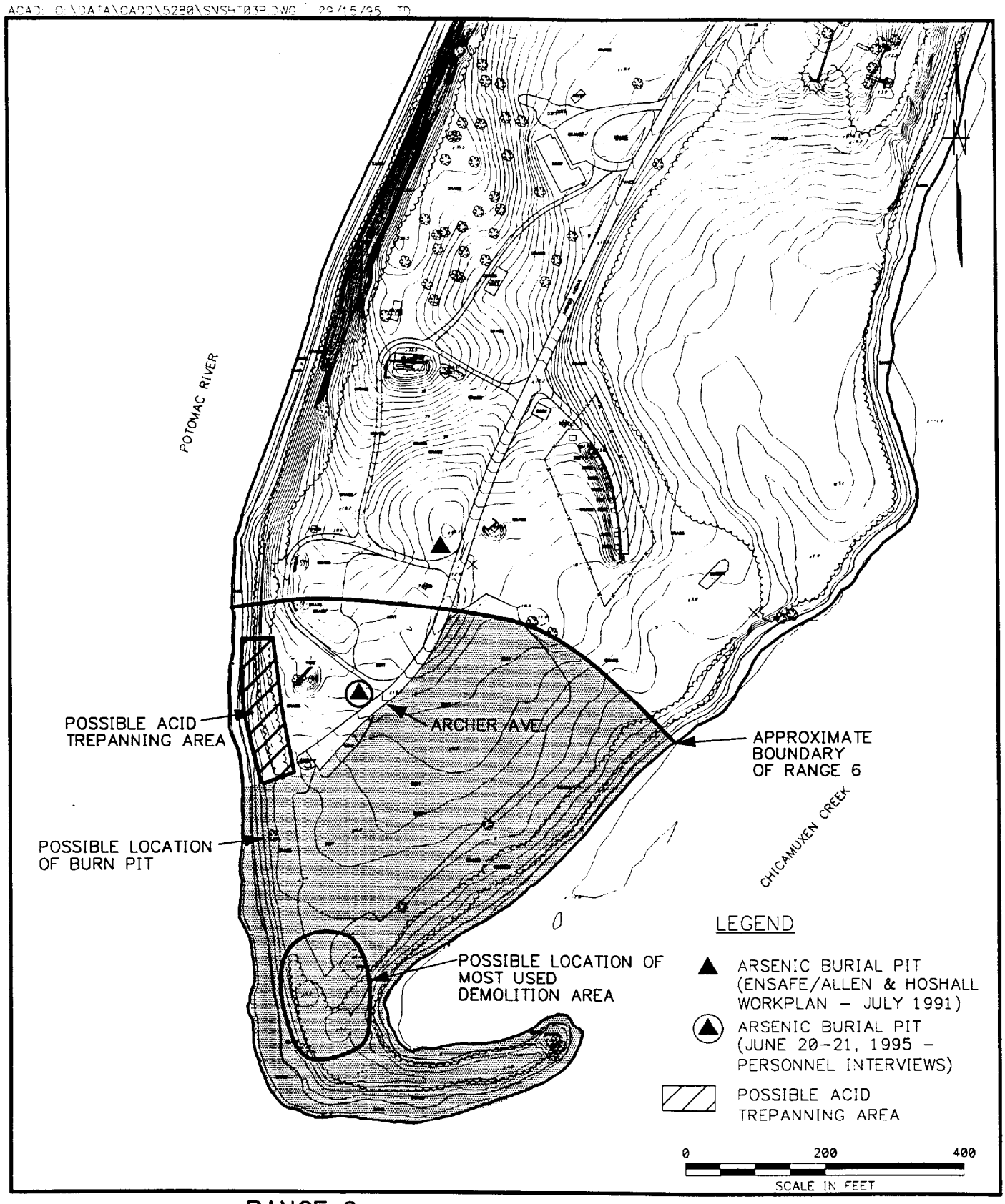
4) Can you provide a start and/or end data for site operations? Within that time period, how often was the site used?

5) Can you provide accurate site dimensions/boundaries?

6) To your knowledge, has any environmental testing occurred at the site?

7) Can you provide any maps/reports which depict/describe past or current site operations or environmental conditions?

8) Who on-base or off-base is most knowledgeable about historical activities/environmental conditions at the site?

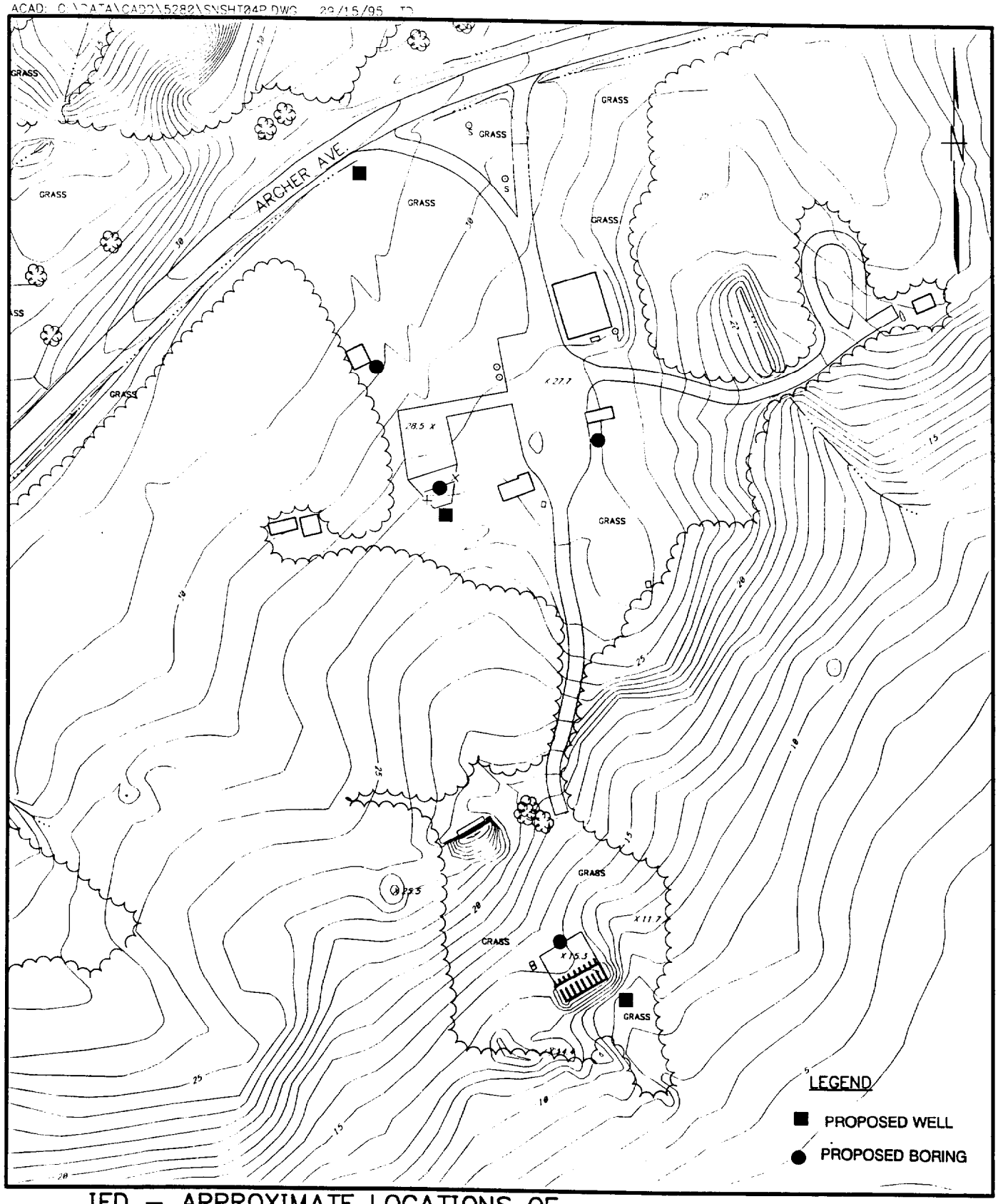


RANGE 6
APPROXIMATE FIELD TEST KIT SCREENING AREA
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 2-1

Halliburton NUS CORPORATION

ACAD: C:\DATA\CADD\5282\SNSHT04P.DWG 09/15/95 TD

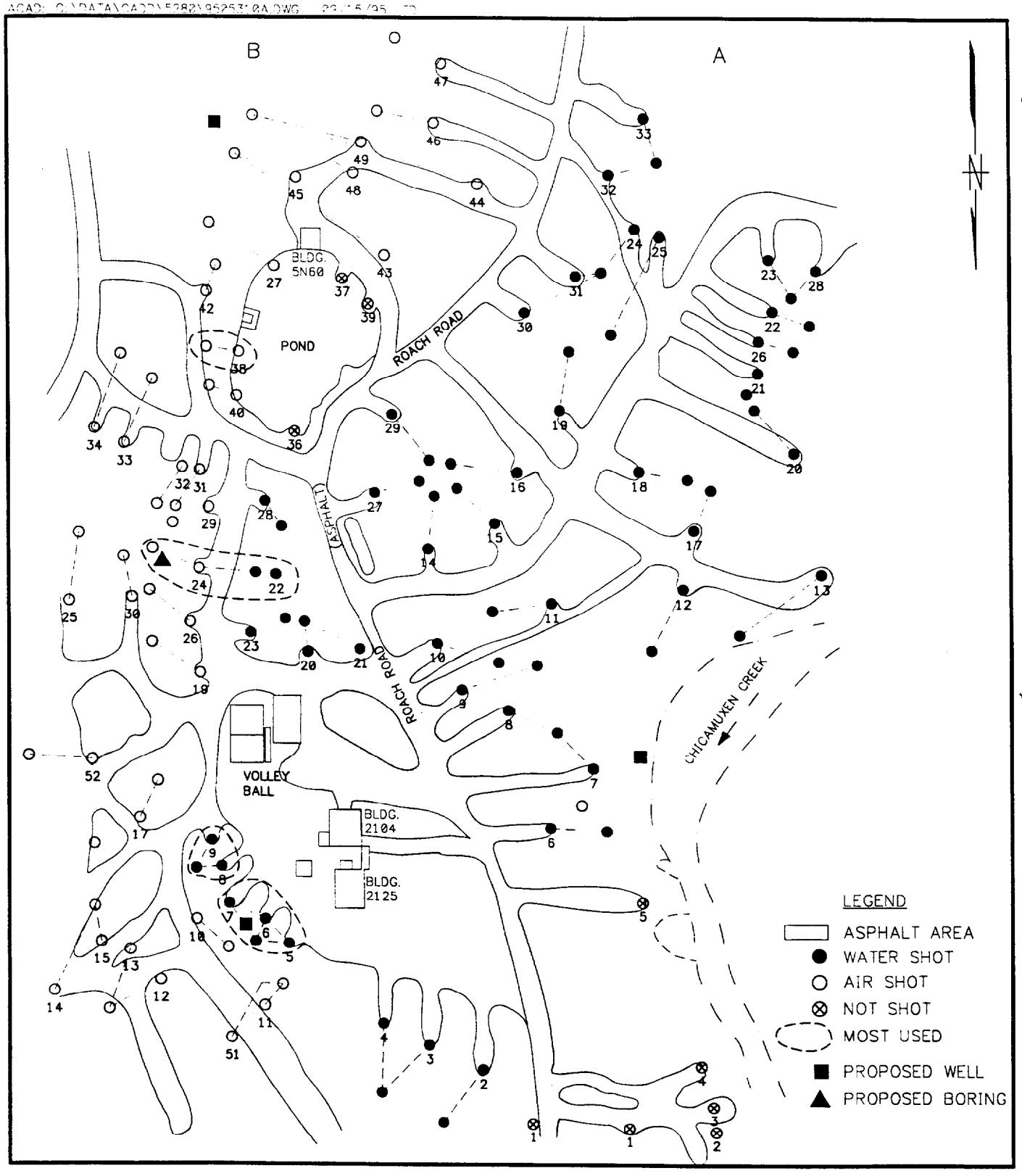


IED – APPROXIMATE LOCATIONS OF PROPOSED WELLS/BORINGS–STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 2–2

0 100 200
SCALE IN FEET

Halliburton NUS CORPORATION



AREA 8 – APPROXIMATE LOCATION OF PROPOSED WELLS/BORINGS
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 2-3

Halliburton NUS CORPORATION

3.0 FIELD SAMPLING AND ANALYSIS PLAN

3.1 FIELD OPERATIONS

3.1.1 Field Operations Summary

The field investigation to be performed at the Stump Neck Annex will consist of multimedia environmental sampling at Area 8, the IOD site, the IED site, and Range 6. The scope of services for the field investigation will include installation and sampling of seven groundwater monitoring wells and seven soil borings, surface water and sediment sampling, field test-kit screening, groundwater monitoring, well development, aquifer testing, groundwater monitoring-well tagging, and surveying services.

A total of seven groundwater samples, four surface water samples, four sediment samples, and 28 soil samples will be collected during this investigation. In addition, a maximum of 25 field screening samples (each) will be collected at Area 8 and Range 6 prior to the initiation of the investigation at these sites. Site-specific groundwater monitoring well, soil boring, and analytical sampling activities are summarized in the following tables.

PROPOSED NUMBER OF GROUNDWATER MONITORING WELLS AND SOIL BORINGS

Wells/Borings	Area 8	IOD Site	IED Site	Range 6	Total
No. Groundwater Monitoring-Wells	3	0	3	1	7
Number of Soil Borings	3	0	4	0	7
Total	6	0	7	1	14

PROPOSED NUMBER OF ANALYTICAL SAMPLES

Types of Samples	Area 8	IOD Site	IED Site	Range 6	Total
Groundwater Samples	3	0	3	1	7
Monitoring Well Soil Samples	6	0	6	2	14
Soil Boring Samples	6	0	8	0	14
Shallow soil samples	0	2	0	0	0
Surface Water Samples	4	0	0	0	4
Sediment Samples	4	0	0	0	4
Field Screening Samples	25 (max)	0	0	25 (max)	50 (max)
Total Number of Samples	48	2	17	28	95

3.1.2 Mobilization/Demobilization

Following approval of the VI Work Plan, Halliburton NUS Corporation will prepare drilling specifications, obtain a drilling subcontractor, and begin mobilization activities. All field team members will review the Work Plan, Health and Safety Plan (HASP) (Appendix A) and Quality Assurance/Quality Control (QA/QC) Plan (Appendix C). In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

The Field Operations Leader (FOL) will be responsible for the day-to-day operations regarding all site activities. The FOL will coordinate the mobilization activities upon arrival at the facility. The FOL will also make any equipment purchases required to conduct the field investigation. The equipment required for the field activities will be driven to the site by the FOL and a technician/geologist. After field activities are completed, project personnel will demobilize the equipment. Identification and responsibilities of other key personnel are provided in the QA/QC Plan (Appendix C).

3.1.3 Field Test-Kit Screening

Field test-kit screening will be part of the environmental investigations to be conducted at Range 6 and Area 8. Field test-kit screening is a time-efficient means of gathering field chemistry data for large sites or sites where little information is presently available. The results of the field test-kit screening will be used to assist in the placement of soil borings and groundwater monitoring wells at Range 6 and Area 8.

The purpose of the field test-kit screening at Range 6 will be to investigate the near-surface soils for the presence or absence of TNT, HMX, and RDX. Near surface soils samples will be collected at the 0- to 2-foot below ground surface (ft bgs) soil interval. Soil samples will be collected following procedures detailed by the test-kit manufacturer's operations manual (Appendix C).

A site specific sampling reference grid will be established prior to the collection and screening of the near surface soils at Range 6. Proposed sample locations will be staked across a portion of the site located to the south of Archer Avenue at approximately 100 foot centers using labelled wire-pin flags. These staked locations will then be tied to the existing base grid system (if available) using a transit and electronic distance meter (EDM). The reference grid will facilitate accurate mapping and delineation of each sampling location and accurate reoccupation of a sampling location, if necessary. One field test-kit screening sample will then be collected at each of the staked locations for a total not to exceed 25 samples for Range 6. The results of the field test-kit screening will then be overlain onto a digital CADD base map for presentation purposes.

Field test-kit screening will also be performed at Area 8. The field test-kit screening at Area 8 will investigate for the presence or absence of TNT, HMX, and RDX in surface water, soil, and sediment samples collected at Area 8 water-shot and air-shot locations. Water-shot and air-shot locations will be selected for screening based upon historic documentation available for Area 8 and based upon information received during interviews with personnel familiar with Area 8. The air-shot and water-shot locations (a maximum of 25) most actively used during training classes will be screened. The twenty-five field test-kit screening locations will be staked with labelled, wire-pin flags. If necessary, key staked locations will then be tied to the existing base grid system (if available) using a transit and electronic distance meter (EDM). The results of the field test-kit screening will then be overlain onto a digital CADD base map for presentation purposes.

3.1.4 Sediment and Subsurface Soil Samples

3.1.4.1 Sediment Samples

Four sediment samples will be collected at Area 8. Two sediment samples will be collected at water-shot locations and two at locations along Chicamuxen Creek as discussed in Section 2.4.4. The purpose of these samples will be to determine the presence/absence of contamination at the water-shot location depressions and at locations along Chicamuxen Creek. The selection of the water-shot locations for sampling will be based upon historic documentation regarding usage of specific areas of this site and upon the results of the field test-kit screening. The sediment samples will be analyzed for parameters using analytical methods outlined in Table 3-9. Sediment sampling will be conducted in accordance with Halliburton NUS Standard Operating Procedures (SOP) SA-1.2 Section 5.4, included in Appendix C.

Sediment characteristics shall be noted on the sample log sheet for each sediment sample. Samples from sediments underlying the surface waters of water-shot locations or Chicamuxen Creek will be taken using stainless-steel sampling trowels or hand augers from a depth of 0 to 6 inches below the bottom of the surface water. Investigative Derived Wastes (IDW) generated during the sampling activities will be managed in accordance with procedures outlined in Section 3.1.9.

3.1.4.2 Soil Boring/Monitoring Well Soil Samples/Shallow Soil Samples

Fourteen soil samples will be collected during the installation of seven groundwater monitoring wells and 14 soil samples will be collected during the installation of seven soil borings. Soil samples will be obtained from two intervals at each monitoring well and soil boring location. Soil samples will be collected at depths of 0 to 2 feet below surface and from 2 feet to 5 feet below surface if shallow groundwater is not encountered during the installation of the monitoring well or soil boring. If the water table is shallow, (e.g.

less than 15 feet below surface) and groundwater is encountered during the installation of the well or boring, soil samples will be collected at the 0 to 2 foot interval and from the soil interval immediately above the water table. Two shallow soil samples (0 to 2 feet below surface) will also be collected at the IOD site using a hand auger.

A drilling subcontractor will be utilized during installation of the groundwater monitoring wells and the excavation of the soil borings. Hollow-stem auger methods will be used for advancing the soil borings. Soil samples will be collected using split-spoon sampling techniques and following American Society for Testing and Materials (ASTM) Method 1586 procedures. Drilling fluids will not be used during soil boring activities. Split-spoon samplers will be decontaminated between samples as described in Section 3.1.8. Sample handling and chain-of-custody requirements are addressed in Sections 3.2.4 and 3.2.5. All pertinent field data will be recorded using the appropriate sample log sheet and the field log book.

A lithologic description will be completed for each split-spoon sample and a complete log of each boring will be maintained in accordance with Halliburton NUS SOP GH-1.5, Sections 5.2, 5.4, and 5.5. A sample Soil Boring Log is attached in Appendix B. At a minimum, the boring log will contain the following information:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color and moisture
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, depth to water, OVA/HNu readings (if appropriate), drilling methods, and total depth of each borehole will be included on each boring log. Soil samples not used for analytical testing will be retained in an 8-ounce glass jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded by the field geologist. The driller will prepare a separate, written, boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities. All activities will be recorded within field log books maintained by site personnel.

Tables 3-2, 3-3, 3-5, and 3-7 summarize the surface and subsurface soil sampling program. Samples will be preserved in accordance with Halliburton NUS SOP SF-1.2. Sample handling and preservation requirements are shown in Table 3-10.

3.1.5 Monitoring Well Construction

3.1.5.1 Groundwater Monitoring Well Installation

Seven groundwater monitoring wells will be installed during the environmental investigation of Range 6, the IED, and Area 8. All regulatory requirements will be met concerning the application for, permitting of, construction of, and completion of all monitoring wells. The State of Maryland has issued a document updated September 1, 1991, establishing special standards for monitoring wells. Maryland Regulation 26.04.04 contains standards applicable to well construction. Section 26.04.04.07.m(6) states that "the approving authority may specify special construction standards for wells installed for the sole purpose of monitoring water quality or water levels." Following is a discussion of how these requirements will be met during monitoring well construction and where variances are requested. A typical well is shown on Figure 3-1.

Well Installation/Permits

The monitoring wells will be installed by a Maryland-licensed well driller. The well driller will apply for and obtain permits from the Charles County Health Department prior to well installation.

Well Casing/Screen Construction

Maryland specifications require that groundwater monitoring well casings and screens be constructed of 4-inch I.D. pipe. The groundwater monitoring wells will be constructed of 4-inch I.D., schedule 40 polyvinyl chloride (PVC), flush-joint threaded, riser pipe and well screens. Reduction fittings will not be used. Connections will not have protrusions or restricted diameters, which could cause a pump or bailer to become stuck in the well casing.

Slotted PVC well screens will be used for this project. The slot size for the screens for this project are to be 10 (thousandths of an inch) and will not exceed 20 (thousandths of an inch).

Screened Interval

Well screens will be 10 feet in length. The groundwater monitoring wells will be installed such that the screened interval approximately straddles the water table. It is anticipated that the total well depth of the screened interval will be approximately 12 to 15 feet below ground surface. After the borings are drilled to

the desired depth the well screen and riser pipe will be installed through the augers or temporary casing to the desired depth.

Boring Diameter

Well borings will be drilled at a minimum of 8-inches in diameter to allow adequate annular space between the well screen/casing and borehole sides. This will allow sufficient space for proper placement of the sand pack, bentonite pellet seal, and cement-bentonite grout.

Centralizers

Centralizers will not be used for the well installations. Due to the shallow depths of the wells (estimated maximum 15 feet) the use of centralizers is not necessary to ensure proper alignment of the wells in the borings.

Annual Space Packing

The annulus of the boring around the well screen, and 1 to 2 feet above the well screen, will be backfilled with clean silica sand (No. 20 to 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal with 2-foot minimum thickness will then be installed above the sand pack and allowed to hydrate as per the manufacturer's recommendations.

Annular Space Grouting

The remainder of the boring annulus, from the seal to the ground surface, will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel or plastic tape. Due to the anticipated shallow depth to groundwater and the resulting shallow depths of the wells, the thicknesses of the backfill materials above the well may require adjustment in the field.

Well Protection

A minimum 6-inch diameter protective steel casing equipped with a locking steel cap will be installed around each well. The casings will be grouted a minimum of 3 feet into the ground, will have at least one drain hole positioned approximately 0.5 feet above the ground surface, and will extend approximately 2 feet (± 0.5 feet) above the top of the surrounding concrete pad. A 0.5-foot thick concrete apron measuring 3 feet by 3 feet

will be constructed, equally portioned around the casing of each well, with the base set at least 3 inches below ground surface. Upon completion of groundwater sampling from monitoring wells, the protective casing will be painted glow-orange. All monitoring wells will be locked and will be identically keyed.

3.1.5.2 Well Development

The groundwater monitoring wells will be developed after installation to remove fine textured material and sediments from the area around the well screens and to remove drill cuttings and residual fluids from the area around the monitored interval of the boring. Wells will be developed by bailing and surging, or by pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist. Disposal of development and purge water removed from monitoring wells will be performed as discussed in Section 3.1.9.

3.1.5.3 Water Level Measurements

One complete round of water level measurements will be obtained from all monitoring wells. This round will be obtained either during high tide or during low tide conditions. The round of water level measurements will be taken within a 2-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements will be taken with an electronic water level indicator using a marked or notched location on the top of the well casing as the reference point for determining depths to water. Water level measurements will be recorded to the nearest 0.01 foot in the appropriate field logbook and on Groundwater Level Measurement Forms (attached in Appendix B).

3.1.5.4 Groundwater Sampling

One round of groundwater samples will be obtained from the seven newly installed groundwater monitoring wells. All groundwater wells will be sampled in accordance with Halliburton NUS SOP SA-1.1, included in Appendix C.

Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated bailer or a suction pump. Approximately three to six well volumes will be purged. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover to at least 70 percent of the original level prior to sampling. In the event that recovery is slow, samples will be collected within 24 hours of purging. Field measurements of pH, temperature, and specific conductance will be taken for each well volume during purging according to Halliburton NUS SOP SF-1.1, Section 5, included in Appendix C. Stabilization of the above parameters is defined as follows: temperature $\pm$ 1°C,

pH ± 0.2 units, specific conductivity ± 5 percent. If these parameters do not stabilize after three volumes, up to six volumes may be removed, as determined by the field geologist. Dedicated stainless-steel or disposable PVC bailers with dedicated polyethylene rope as bailing line will be used for sample collection. Groundwater samples will be poured directly from the bailer into the appropriate sample bottles for analysis.

All pertinent field data shall be recorded using the appropriate sample log sheet and the field log book (see Halliburton NUS SOP SA-6.3, included in Appendix C). A Monitoring Well Log Sheet is attached in Appendix B.

Tables 3-1, 3-4, and 3-6 summarize target analytes for groundwater sampling programs for Range 6, IED Site, and Area 8, respectively. Samples will be preserved in accordance with Halliburton NUS SOP SF-1.2, included in Appendix C. Sample handling and preservation requirements are shown in Table 3-10. Chain-of-custody requirements are discussed in Section 3.2.4 and in the Quality Assurance/Quality Control (QA/QC) Plan attached as Appendix D.

3.1.5.5 Aquifer Testing

Monitoring wells will be used for aquifer testing to determine the groundwater flow conditions in the water-bearing zone penetrated by each well. The data generated from these tests will be used to define the water-yielding characteristics of the formation, develop groundwater velocity values, and estimate rate of groundwater movement for the aquifer in the vicinity of the monitoring wells that are tested. In-situ hydraulic conductivity testing (slug tests) will be performed at all monitoring wells including the background well.

Procedures for performing slug tests will be in accordance with Halliburton NUS SOP GH-2.4, attached in Appendix C. Pressure transducers and data loggers will be used for data collection. Random checks of water levels will be made manually using an electric water level indicator (M-Scope). At a minimum, the following information will be collected for each well during slug tests:

- Well number/depth/screened interval/inside diameter of the screen/diameter of the sandpack.
- Static water level.
- Method of including water level change.
- Time/recovery data.
- Total time of test.

Data recorded during slug testing will be recorded on the Hydraulic Conductivity Testing Data Sheet attached in Appendix B. Hydraulic conductivities will be calculated upon return from the field using methods

applicable for the material and aquifer characteristics at the site. The locations of the wells will be in a format useable by the Public Works Department at Indian Head (i.e., wells will be located using the Maryland Plane Grid Coordinate System).

3.1.5.6 Well Tagging

All wells will be tagged with the well construction permit number clearly visible from the outside of the well.

Well completion reports will be completed for each well installed, and a copy of the well completion report forms will be submitted to the Charles County Health Department and to the State of Maryland within 30 days of well completion. A project summary describing the installation procedure will accompany the copies of the completion reports, and will contain an accurate map depicting the precise location of all wells installed at the site in relation to known landmarks; a detailed description of the construction of the wells installed including casing, screen, gravel pack and grout intervals; the elevation of the top of the concrete pad installed at the base of the protective outer well casing; the top-of-casing elevation; and both the static and pumping water levels to the nearest 1/100th of a foot.

3.1.5.7 Well Abandonment Procedures

In the event it becomes necessary to abandon any groundwater monitoring well, it will be filled and sealed in such a way that it will not act as a channel for the interchange of waters of undesirable quality with waters of desirable quality and will not present a hazard to humans or animals. Any abandoned well will be sealed by or under the supervision of a well driller licensed by the Maryland State Board of Well Drillers.

Materials for sealing wells will comply with COMAR 26.04.04.11(E). Procedures for sealing wells will comply with the requirements of COMAR 26.04.04.11(F). Placement of material used in abandoning wells will comply with COMAR 26.04.04.11(G).

3.1.6 Surface Water Sampling

Four surface water samples will collected from Area 8. Two samples are to be collected from water-shot locations and two sample are to be collected from Chicamuxen Creek. Sampling will be performed in accordance with procedures outlined in Halliburton NUS SOP SA-1.2, Section 5. Table 3-8 details the proposed chemical analyses and analytical methods for this site.

3.1.7 Surveying

All monitoring well and soil boring locations, and key test-kit screening locations, sediment sampling locations and surface water sampling locations will be surveyed following installation. Existing survey monuments and site grids within NAVEODTECHDIV will be utilized as reference points if applicable. The horizontal locations of all points will be surveyed to the nearest 0.1 foot. Vertical elevations will be referenced to the 1929 North American Datum. For monitoring wells the elevation shall be surveyed to the nearest 0.01 foot at the measuring point where the uncapped riser pipe is notched. Ground surface elevations will also be surveyed to the nearest 0.01 foot.

3.1.8 Decontamination of Equipment

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drilling rigs, downhole tools, augers, well casing and screens, and all sampling equipment (with the exception of the dedicated bailers and rope used to obtain groundwater samples).

3.1.8.1 Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well casing and screens shall be steam cleaned prior to being installed into the borings.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at a location determined during mobilization. It is assumed that the facility will provide a suitable location for decontamination operations along with potable water and electricity. Halliburton NUS will coordinate with site personnel several months in advance of field operations to determine the appropriate location of decontamination operations. If a decontamination site is set up at each of the four sites, then the water generated from the steam cleaning process can be returned to the site. However, if a central decontamination site is set up, then the water must be containerized, labeled as to its content, and dated using indelible ink. Additional requirements for drilling equipment decontamination can be found in Halliburton NUS SOP GH-1.6, Section 5 attached in Appendix C.

3.1.8.2 Sampling Equipment

With the exception of the dedicated bailers and rope used to obtain groundwater samples, all equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Distilled/deionized water rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Methanol double rinse
- Distilled/deionized water rinse
- Air dry

Field analytical equipment such as pH, conductivity, and temperature instrument probes will be rinsed first with analyte-free water, then with the sample liquid. Decontamination of sampling equipment will be done in accordance with Halliburton NUS SOP SF-2.3, Section 5. Halliburton NUS will provide all decontamination fluids except potable water for rinsing. All wash and rinse water shall be containerized, labeled as to its contents, and dated using indelible ink.

3.1.9 Handling of Investigative Derived Waste

All development and purge liquids will be collected, containerized, and stored in a central location at each site in DOT-approved (Specification 17-C) 55-gallon drums (provided by the Drilling Subcontractor). All drill cuttings will also be collected and stored on site in the DOT-approved drums. All drums will be sealed and labeled with site location, drum contents, well/boring number, and date in indelible ink. The Navy will take possession of the drums upon project completion, provide a storage area for these drums, and will determine whether offsite disposal and/or treatment is required after receiving analytical results from the sampling. Personnel of Halliburton NUS, the Naval School Explosive Ordnance Disposal, NAVEODTECHDIV, and IHDIVNAVSURFWARCEN will coordinate regarding the management of investigation derived waste prior to initiation of field activities.

3.1.10 Field Equipment Calibration and Maintenance

Field equipment, such as pH, temperature and specific conductance meters or organic vapor analyzers (OVA) and photo-ionization detectors (PID's) will be calibrated and maintained according to the manufacturer's SOP. Field equipment for which SOP's are not available will be calibrated and operated in accordance with the manufacturer's recommendations.

3.2 SAMPLE HANDLING AND ANALYSIS

3.2.1 Sample Analysis Summary

Samples collected during the field investigation will be submitted for analysis as presented in Tables 3-1 through 3-10. These tables include the analytical parameters, preservation methods, holding times, bottle requirements and analytical method for each sample. The majority of the samples collected will be analyzed by the analytical laboratory using a thirty (30) day turnaround time. Quality assurance samples (e.g., duplicates, trip blanks, equipment blanks, etc.) will be collected and analyzed per NEESA requirements. Additionally, environmental samples collected for TNT, RDX, and HMX will be screened using field test-kits to obtain rapid sample results.

3.2.2 Sample Handling

Each sample collected during the field operation will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alpha-numeric code that identifies the (1) site number, (2) sample medium, (3) location, and (4) the sample depth (in the case of sediment and soil samples). Any other pertinent information regarding sample identification will be recorded in the field logbooks and on sample log-sheets.

3.2.2.1 Sampling Identification System

The alpha-numeric coding to be used in the sample numbering system is explained in the following diagram and the subsequent definitions:

Site Number	Sample Type	Sample Location	Sample Depth
NNN	AA	NNN	NN

Character type:

A = Alpha

N = Numeric

Site Number:

S25 = Area 8

S27 = IOD Site

S26 = IED Site

S05 = Range 6

Sample Type:

SB = Soil boring sample

SS = Surface soil sample

SD = Sediment sample

MW = Groundwater monitoring well sample

SW = Surface water sample

TB = Trip Blank

FB = Field Blank

RB = Equipment Rinsate Blank

Sample Location:

Sample station locations of a given medium will be numbered sequentially beginning with "001" for all media.

Sample Depth:

Sample depths will represent the horizon from which the sample was obtained. For example, if ten split-spoon samples were collected from a boring, they would be numbered 01 through 10. This field will also be used for the designation of filtered and unfiltered samples. An unfiltered groundwater sample shall be designated as 1U. The corresponding filtered sample shall be designated as 1F.

Ten percent of all samples sent to the fixed-based laboratory for analysis shall be submitted as field duplicates to monitor precision of sample acquisition and laboratory analysis techniques. Field duplicates will be submitted with blinded identification.

3.2.2.2 Example of Sample Labeling System

The following are examples of sample identification schemes:

- The second sediment sample collected from Area 8 (SWMU 25) would be labeled: S25-SD-002
- The first monitoring well soil sample collected at Range 6 (SWMU 5) would be labeled: S05-MW-001
- The soil sample collected from the first soil horizon from the soil boring location at the IOD Site (SWMU 27) would be labeled: S27-SB-001-01.

3.2.3 Quality Control Samples

In addition to regular calibration of field equipment and appropriate documentation, quality control (QC) samples will be collected or generated during environmental sampling activities. QC samples include trip blanks, field duplicates, field blanks, and equipment rinsate blanks. Tables 3-1 through 3-9 present the type and number of required QC samples. Each type of field QC sample is defined as follows:

- **Trip Blanks**. Trip blanks are used to determine whether contamination of the sample or bottleware has occurred during transit or storage. Trip blanks consist of analyte-free water taken from the laboratory to the site, and returned. Trip blanks are taken at the rate of one per cooler of samples slated for VOCs analysis and will be analyzed for Appendix IX volatile organic compounds (VOCs) only.

- **Field Duplicates**. Field duplicates are two samples collected either: (1) independently at a sampling location in the case of groundwater or surface water; or (2) as a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory as the original sample.

- **Equipment Rinsate Blanks**. Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (split-spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Equipment rinsate blanks will be used to assess the effectiveness of decontamination procedures and are analyzed for the sample suite of parameters as the associated samples. Equipment rinsate blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. However, only the equipment blanks obtained every other day will be analyzed. Those not analyzed will be retained by the laboratory until completion of field activities. It will be the responsibility of the FOL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

- **Field Blanks**. Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of source water used in (1) steam cleaning of large equipment; and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures and to determine whether the analyte-free water or the potable water (used for steam cleaning) may be

contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event. Field blanks are analyzed for the entire suite of parameters (as applicable) identified in the project.

3.2.4 Sample Custody

Custody of samples will be maintained and documented at all times. Chain of custody begins with the collection of the samples in the field. A sample is in custody if:

- It is in the field investigator's or the transferee's actual possession;
- It is in the field investigator's or the transferee's view, after being in his/her physical possession;
- It was in the field investigator's or the transferee's physical possession and then secured to prevent tampering;
- It is placed in a designated secure area.

A chain-of-custody record form shall be used to record the custody of all samples collected and maintained by Halliburton NUS personnel. The chain of custody (COC) also serves as a sample logging mechanism for the laboratory. Section 5.3 of Halliburton NUS SOP SA-6.1, contained in Appendix C, provides a description of the COC procedures that will be followed. An example of the COC record form is included in Appendix B.

Samples will be packaged and shipped in accordance with Standard Operating Procedure SA-6.2, contained in Appendix C. The field operations leader will be responsible for contacting the laboratory for notification of shipment and will report the following:

- Site name/code
- Number(s), matrix, and concentration(s) of samples shipped
- Method of shipment (e.g., hand delivered, overnight carrier)
- Date of shipment
- Suspected hazards associated with the samples or site

3.2.5 Sampling Forms

3.2.5.1 Sample Labels

One label will be filled out for each sample container sent for onsite and fixed-base laboratory analysis. The sample label description and procedures for completion are found in Halliburton NUS SOP SA-6.1 Section 5.2 (see Appendix C).

3.2.5.2 Chain-of-Custody Record

The chain-of-custody record form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any sample collected for chemical or geotechnical analysis, whether on site or off site. An example of the chain-of-custody record form is included in Appendix B. Procedures for using this form are contained in SOP SA-6.1 (see Appendix C). At the completion of field activities, the chain-of-custody record form will be placed in the project file.

3.2.5.3 Custody Seal

The Custody Seal is a 1-inch by 3-inch 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. It is used whenever samples are shipped to an offsite laboratory with an accompanying chain-of-custody record form. Procedures for using chain-of-custody seals are described in SOP SA-6.1 (see Appendix C).

3.2.5.4 Sample Logsheet and Logbook

A sample logsheet will be filled out for each sample collected during the field investigation. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems encountered during sampling. Sample information, such as container source and description, sample description type, and disposition, as well as time, date, and sample method, are recorded on this form. All QA/QC samples (duplicates, rinsates, trip blanks, and field blanks) will have separate sample log sheets listing sample date and time, sample location, and any other important sample data. Appendix B contains an example of a sample logsheet for various sample media. The sample logsheets are sequentially numbered when placed in the sample logbook, and the sample number and logsheet page numbers are recorded in the sample logbook table of contents (placed at the front of the logbook) for easy reference and access. At the completion of field activities, the sample logbook containing all sample logsheets will be placed in the project file.

3.2.5.5 Equipment Calibration Log Form

Each Halliburton NUS field instrument requiring calibration will have a separate equipment calibration log form (see Appendix B) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. The information placed on the form documents the accuracy, precision or sensitivity of the measurement, and, if necessary, will be used to determine if correction should be applied to the readings. A separate form will be established and maintained for each of the field instruments used during this sampling activity. Field monitoring and measuring equipment will be calibrated daily (at a minimum) and as needed if calibration problems with the instruments are noted. All forms will be maintained in a secured central file. At the completion of field activities the notebook containing the forms will be placed in the project file.

TABLE 3-1

GROUNDWATER SAMPLING PROGRAM FOR RANGE 6 VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS[5]							
Nitrocellulose (NC)	UF05	1	0	1	1	1	4
Nitroguanidine (NQ)	UW29	1	0	1	1	1	4
Nitroglycerine (NG)	SW-846/8330	1	0	1	1	1	4
Pentaerythritol Tetranitrate (PETN)	SW-846/8330	1	0	1	1	1	4
Method 8330 Explosives[6]	SW-846/8330	1	0	1	1	1	4
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	2	0	1	1	1	5
Appendix IX, Volatiles[7]	SW-846/8240	1	1	1	1	1	5
Appendix IX, Semivolatiles[8]	SW-846/8270	1	0	1	1	1	4
Cyanide	CLP SOW ILM02.1, SW/7870	1	0	1	1	1	4
INDICATOR PARAMETERS							
Sulfate	SW-846/9035	1	0	1	1	1	4
Total Phosphate	EPA 365.1	1	0	1	1	1	4
TOX	SW-846/9020	1	0	1	1	1	4
TOC	SW-846/9060	1	0	1	1	1	4
Nitrate-Nitrite	EPA 353.3	1	0	1	1	1	4
Total Kjeldahl Nitrogen	EPA 351.3	1	0	1	1	1	4
Ammonia Nitrogen	EPA 350.3	1	0	1	1	1	4

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (trowels, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis, but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall

TABLE 3-1 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR RANGE 6
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

(a) Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane,

TABLE 3-1 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR RANGE 6
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-2

SOIL SAMPLING PROGRAM FOR RANGE 6
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS							
Nitrocellulose (NC)	UF05	2	0	1	1	1	5
Nitroguanidine (NQ)	UW29	2	0	1	1	1	5
Nitroglycerine (NG)	SW-846/8330	2	0	1	1	1	5
Pentaerythritol tetranitrate (PETN)	SW-846/8330	2	0	1	1	1	5
Method 8330 Explosives[6]	SW-846/8330	2	0	1	1	1	5
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	2	0	1	1	1	5
Appendix IX Volatiles[7]	SW-846/8240	2	1	1	1	1	6
Appendix IX Semivolatiles[8]	SW-846/8270	2	0	1	1	1	5
Cyanide	CLP SOW ILM02.1, SW/7870	2	0	1	1	1	5
INDICATOR PARAMETERS							
Total Organic Carbon	SW-846/9060	2	0	1	1	1	5
Nitrate-Nitrite	EPA 353.3	2	0	1	1	1	5
Ammonia-Nitrogen	EPA 350.3	2	0	1	1	1	5

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

TABLE 3-2 (Continued)
SOIL SAMPLING PROGRAM FOR RANGE 6
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene,

TABLE 3-2 (Continued)
SOIL SAMPLING PROGRAM FOR RANGE 6
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-3

SOIL SAMPLING PROGRAM FOR THE INERT ORDNANCE DISPOSAL (IOD) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS							
Nitrocellulose (NC)	UF05	2	0	1	0	0	3
Nitroguanidine (NQ)	UW29	2	0	1	0	0	3
Nitroglycerine (NG)	SW-846/8330	2	0	1	0	0	3
Pentaerythritol tetranitrate (PETN)	SW-846/8330	2	0	1	0	0	3
Method 8330 Explosives[5]	SW-846/8330	2	0	1	0	0	3
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	2	0	1	0	0	3
Appendix IX Volatiles[7]	SW-846/8240	2	1	1	0	0	4
Appendix IX Semivolatiles[8]	SW-846/8270	2	0	1	0	0	3
Cyanide	CLP SOW ILM02.1, SW/7870	2	0	1	0	0	3
INDICATOR PARAMETERS							
TOC	SW-846/9060	2	0	1	0	0	3
Nitrate-Nitrite	EPA 353.3	2	0	1	0	0	3
Ammonia-Nitrogen	EPA 350.3	2	0	1	0	0	3

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOA) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Blank - Samples obtained by pouring analyte-free water over sample collection equipment (trowels, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event. Field blanks are included on soil sample table.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

TABLE 3-3 (Continued)
SOIL SAMPLING PROGRAM FOR THE INERT ORDNANCE DISPOSAL (IOD) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene,

TABLE 3-3 (Continued)
SOIL SAMPLING PROGRAM FOR THE INERT ORDNANCE DISPOSAL (IOD) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-4

GROUNDWATER SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVE DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS							
Nitrocellulose (NC)	UFO5	3	0	1	0	0	4
Nitroguanidine (NQ)	UW29	3	0	1	0	0	4
Nitroglycerine (NG)	SW-846/8330	3	0	1	0	0	4
Pentaerythritol Tetranitrate (PETN)	SW-846/8330	3	0	1	0	0	4
Method 8330 Explosives	SW-846/8330	3	0	1	0	0	4
ORGANICS/INORGANICS							
Metals[5]	CLP SOW ILM02.1, SW/7870	6	0	1	0	0	7
Appendix IX, Volatiles[6]	SW-846/8240	3	1	1	0	0	5
Appendix IX, Semivolatiles[7]	SW-846/8270	3	0	1	0	0	4
Target Compound List/PCBs[8]	SW-846/8080	3	0	1	0	1	5
Cyanide	CLP SOW ILM02.1, SW/7870	3	0	1	0	0	4
PETROLEUM							
TPH	EPA 418.1	3	0	1	1	1	6
INDICATOR PARAMETERS							
Sulfate	SW-846/9035	3	0	1	0	0	4
Total Phosphate	EPA 365.1	3	0	1	0	0	4
TOX	SW-846/9020	3	0	1	0	0	4
TOC	SW-846/9060	3	0	1	0	0	4
Nitrate-Nitrite	EPA 353.3	3	0	1	0	0	4
Total Kjeldahl Nitrogen	EPA 351.3	3	0	1	0	0	4
Ammonia Nitrogen	EPA 350.3	3	0	1	0	0	4

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are only analyzed for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

TABLE 3-4 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVES DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

5 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

6 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

7 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol,

TABLE 3-4 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVES DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

8 Method Reference 40 CFR 261; PCBs analysis using Method SW-846/8080. Target Compound List PCBs list consists of the following: Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260.

TABLE 3-5

SOIL SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVE DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS							
Nitrocellulose (NC)	UF05	4	0	1	0	1	6
Nitroguanidine (NQ)	UW29	4	0	1	0	1	6
Nitroglycerine (NG)	SW-846/8330	4	0	1	0	1	6
Pentaerythritol Tetranitrate (PETN)	SW-846/8330	4	0	1	0	1	6
Method 8330 Explosives	SW-846/8330	4	0	1	0	1	6
ORGANICS/INORGANICS							
Metals[5]	CLP SOW ILM02.1, SW/7870	14	0	1	0	1	16
Appendix IX Volatiles[6]	SW-846/8240	14	2	1	0	1	18
Appendix IX Semivolatiles[7]	SW-846/8270	14	0	1	0	1	16
Target Compound List (TCL)/PCBs[8]	SW-846/8080	14	0	1	1	2	18
Cyanide	CLP SOW ILM02.1, SW/7870	14	0	1	0	1	16
PETROLEUM							
TPH	EPA 418.1	12	0	1	1	2	16
INDICATOR PARAMETERS							
Total Organic Carbon	SW-846/9060	12	0	1	0	1	16
Nitrate-Nitrite	SW-846/9020	12	0	1	0	1	16
Ammonia-Nitrogen	EPA 350.3	12	0	1	0	1	14

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

TABLE 3-5 (Continued)
SOIL SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVES DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

5 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

6 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

7 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-5 (Continued)
SOIL SAMPLING PROGRAM FOR THE IMPROVISED EXPLOSIVES DEVICES (IED) SITE VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

8 Method Reference 40 CFR 261; PCBs analysis using Method SW-846/8080. Target Compound/PCBs list consists of the following: Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260.

TABLE 3-6

GROUNDWATER SAMPLING PROGRAM FOR AREA 8, THE UNDERWATER ORDNANCE TRAINING AREA VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS							
Nitrocellulose (NC)	UF05	3	0	1	0	0	4
Nitroguanidine (NQ)	UW29	3	0	1	0	0	4
Nitroglycerine (NG)	SW-846/8330	3	0	1	0	0	4
Pentaerythritol tetranitrate (PETN)	SW-846/8330	3	0	1	0	0	4
Method 8330 Explosives[5]	SW-846/8330	3	0	1	0	0	4
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	6	0	1	0	1	8
Appendix IX, Volatiles[7]	SW-846/8240	3	1	1	0	0	5
Appendix IX, Semivolatiles[8]	SW-846/8270	3	0	1	0	0	4
Cyanide	CLP SOW ILM02.1, SW/7870	3	0	1	0	1	5
INDICATOR PARAMETERS							
Sulfate	SW-846/9035	3	0	1	0	0	4
Total Phosphate	EPA 365.1	3	0	1	0	0	4
TOX	SW-846/9020	3	0	1	0	0	4
TOC	SW-846/9060	3	0	1	0	0	4
Nitrate-Nitrite	EPA 353.3	3	0	1	0	0	4
Total Kjeldahl Nitrogen	EPA 351.3	3	0	1	0	0	4
Ammonia Nitrogen	EPA 350.3	3	0	1	0	0	4

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (trowels, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

TABLE 3-6 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR AREA 8
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, lead, iron, mercury, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane,

TABLE 3-6 (Continued)
GROUNDWATER SAMPLING PROGRAM FOR AREA 8
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-7

SOIL SAMPLING PROGRAM FOR AREA 8, THE UNDERWATER ORDNANCE TRAINING AREA VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS[5]							
Nitrocellulose (NC)	UF05	12	0	2	0	1	15
Nitroguanidine (NQ)	UW29	12	0	2	0	1	15
Nitroglycerine (NG)	SW-846/8330	12	0	2	0	1	15
Pentaerythritol tetranitrate (PETN)	SW-846/8330	12	0	2	0	1	15
Method 8330 Explosives[6]	SW-846/8330	12	0	2	0	1	15
ORGANICS/INORGANICS							
Metals[8]	CLP SOW ILM02.1, SW/7870	12	0	2	0	1	15
Appendix IX, Volatiles[7]	SW-846/8240	4	1	1	0	1	7
Appendix IX, Semivolatiles[8]	SW-846/8270	4	0	1	0	1	6
Cyanide	CLP SOW ILM02.1, SW/7870	12	0	2	0	1	15
INDICATOR PARAMETERS							
Nitrate-Nitrite	EPA 353.3	12	0	2	0	1	15
Total Organic Carbon	SW-846/9060	12	0	2	0	1	15
Ammonia Nitrogen	EPA 350.3	12	0	2	0	1	15

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

TABLE 3-7 (Continued)
SOIL SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite,

TABLE 3-7 (Continued)
SOIL SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-8

SURFACE WATER SAMPLING PROGRAM FOR AREA 8, THE UNDERWATER ORDNANCE TRAINING AREA VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS[5]							
Nitrocellulose (NC)	UF05	4	0	1	0	1	6
Nitroguanidine (NQ)	UW29	4	0	1	0	1	6
Nitroglycerine (NG)	SW-846/8330	4	0	1	0	1	6
Pentaerythritol tetranitrate (PETN)	SW-846/8330	4	0	1	0	1	6
Method 8330 Explosives[5]	SW-846/8330	4	0	1	0	1	6
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	8	0	1	0	1	10
Appendix IX, Volatiles[7]	SW-846/8240	4	2	1	0	1	8
Appendix IX, Semivolatiles[8]	SW-846/8270	4	0	1	0	1	6
Cyanide	CLP SOW ILM02.1, SW/7870	4	0	1	0	1	6
INDICATOR PARAMETERS							
Sulfate	SW-846/9035	4	0	1	0	1	6
Total Phosphate	EPA 365.1	4	0	1	0	1	6
TOX	SW-846/9020	4	0	1	0	1	6
TOC	SW-846/9060	4	0	1	0	1	6
Nitrate-Nitrite	EPA 353.3	4	0	1	0	1	6
Total Kjeldahl Nitrogen	EPA 351.3	4	0	1	0	1	6
Ammonia Nitrogen	EPA 350.3	4	0	1	0	1	6

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (trowels, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event. Field blanks are included on soil sample table.

TABLE 3-8 (Continued)
SURFACE WATER SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, lead, iron, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane,

TABLE 3-8 (Continued)
SURFACE WATER SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene, acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-9

SEDIMENT SAMPLING PROGRAM FOR AREA 8, THE UNDERWATER ORDNANCE TRAINING AREA VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Analysis	Analytical Method	No. of Samples	No. of Trip Blanks[1]	No. of Equipment Blanks[2]	No. of Field Blanks[3]	No. of Duplicates[4]	Total No. of Samples
ENERGETICS[5]							
Nitrocellulose (NC)	UF05	4	0	1	0	1	6
Nitroguanidine (NQ)	UW29	4	0	1	0	1	6
Nitroglycerine (NG)	SW-846/8330	4	0	1	0	1	6
Pentaerythritol tetranitrate (PETN)	SW-846/8330	4	0	1	0	1	6
Method 8330 Explosives[6]	SW-846/8330	4	0	1	0	1	6
ORGANICS/INORGANICS							
Metals[6]	CLP SOW ILM02.1, SW/7870	4	0	1	0	1	6
Appendix IX, Volatiles[7]	SW-846/8240	4	2	1	0	1	8
Appendix IX, Semivolatiles[8]	SW-846/8270	4	0	1	0	1	6
Cyanide	CLP SOW ILM02.1, SW/7870	4	0	1	0	1	6
INDICATOR PARAMETERS							
Total Organic Carbon	SW-846/9060	4	0	1	0	1	6
Nitrate-Nitrite	EPA 353.3	4	0	1	0	1	6
Ammonia Nitrogen	EPA 350.3	4	0	1	0	1	6

1 Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOC) samples. One trip blank per each cooler containing VOCs. Trip Blanks are analyzed only for VOCs.

2 Equipment Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (trowels, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but only samples taken every other day of sampling will be analyzed unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

3 Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

4 Duplicates - A single sample split into two portions during a single act of sampling. Assesses the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

TABLE 3-9 (Continued)
SEDIMENT SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

5 The following nitroaromatics and nitroamines are Method 8330 target analytes:

Compound	Abbrev	CAS No.[a]
Octahydro-1,3,5,-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-8
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0

a Chemical Abstracts Service Registry number

Pentaerythritol tetranitrate (PETN) and nitroglycerine (NG) will be analyzed as "add-ons" to Method SW-846/8330.

6 The metals target analyte list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, tin, vanadium, and zinc.

7 Method Reference 40 CFR 261; volatile organic compound (VOC) analysis using Method SW-846/8240. Appendix IX VOC target analyte list consists of the following: acetone, acetonitrile, acrolein, acrylonitrile, benzene, bromodichloromethane, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, 2-chloro-1,3-butadiene, chlorodibromomethane, chloroethane, chloroform, chloromethane, 3-chloropropene, 1,2-dibromomethane, dibromomethane, trans-1,4-dichloro-2-butene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, trans-1,2-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,4-dioxane, ethyl benzene, ethyl cyanide, ethyl methacrylate, 2-hexanone, iodomethane, isobutyl alcohol, methacrylonitrile, methyl ethyl ketone, methyl methacrylate, 4-methyl-2-pentanone, pentachloroethane, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, tribromomethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichloromonofluoromethane, 1,2,3-trichloropropane, vinyl acetate, vinyl chloride, and total xylenes.

8 Method Reference 40 CFR 261; semivolatile organic compound (SVOC) analysis using Method SW-846/8270. Appendix IX SVOC target analyte list consists of the following: acenaphthene,

TABLE 3-9 (Continued)
SEDIMENT SAMPLING PROGRAM FOR AREA 8,
THE UNDERWATER ORDNANCE TRAINING AREA
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

acenaphthylene, acetophenone, 2-acetylaminofluorene, 4-aminobiphenyl, aniline, anthracene, aramite, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, benzyl alcohol, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, 4-bromophenyl phenyl ether, butyl benzyl phthalate, p-chloroaniline, 2-chloronaphthalene, 4-chlorophenyl phenyl ether, chrysene, dibenzo(a,h)anthracene, dibenzofuran, 1,2-dibromo-3-chloropropane, di-n-butyl phthalate, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene, 3,3'-dichlorobenzidine, diethyl phthalate, 0,0-diethyl-0-2-pyrazinyl phosphorothioate, p-dimethylaminoazobenzene, 7,12-dimethylbenz(a)anthracene, 3,3'-dimethylbenzidine, alpha, alpha-dimethyl-phenethylamine, dimethyl phthalate, m-dinitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, di-n-octyl phthalate, diphenylamine, di-n-propylnitrosamine, ethyl methanesulfonate, fluoranthene, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, hexachloroethane, hexachlorophene, hexachloropropene, indeno(1,2,3-cd)pyrene, isophorone, isosafrole, methapyrilene, 3-methylcholanthrene, methyl methanesulfonate, 2-methylnaphthalene, naphthalene, 1,4-naphthoquinone, 1-naphthylamine, 2-naphthylamine, m-nitroaniline, o-nitroaniline, p-nitroaniline, nitrobenzene, 4-nitroquinoline 1-oxide, N-nitrosodi-n-butylamine, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodiphenylamine, N-nitrosomethylethylamine, N-nitrosomorpholine, N-nitrosopiperidine, N-nitrosopyrrolidine, 5-nitro-o-toluidine, pentachlorobenzene, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, phenacetin, phenanthrene, p-phenylenediamine, 2-picoline, pyrene, pyridine, safrole, 1,2,4,5-tetrachlorobenzene, 2,3,7,8-tetrachlorodibenzo-p-dioxin, tetrachlorodibenzo-p-dioxins, tetrachlorodibenzofurans, o-toluidene, 1,2,4-trichlorobenzene, 0,0,0-triethyl-phosphorothioate, sym-trinitrobenzene, 2-sec-butyl-4,6-dinitrophenol, p-chloro-m-cresol, 2-chlorophenol, meta-cresol, ortho-cresol, para-cresol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2,4-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,3,4,6-tetrachlorophenol, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol.

TABLE 3-10

SUMMARY OF BOTTLE REQUIREMENTS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL STUMP NECK ANNEX, INDIAN HEAD DIVISION INDIAN HEAD, MARYLAND

Parameter	Media	Container Material and Sample Volume	Preservation	Holding Time
ENERGETICS				
Nitrocellulose (NC) Nitroglycerine (NG) Nitroguanidine (NQ) Method 8330 Explosives[1] pentaerythritol tetranitrate (PETN)	Groundwater	1-Liter amber glass bottle	Cool to 4°C	7 days
	Soil/Sediment	1-pint glass jar	Cool to 4°C	7 days
ORGANICS/INORGANICS				
Target Analyte Metals, plus tin	Groundwater	1-Liter plastic bottle	4°C; HNO_3 to pH <2	6 months; Hg 28 days
	Soil/Sediment	8-oz. glass jar	Cool to 4°C	6 months; Hg 28 days
Appendix IX Volatiles	Groundwater	Three 40-mL VOA vials	HCl to pH < 2	14 days
	Soil/Sediment	Two 60-mL VOA vials	Cool to 4°C	14 days
PCBs, Semivolatiles	Groundwater	One 80-oz. amber glass bottle with Teflon-lined cap	Cool to 4°C	Extract 7 days; analyze 40 days
	Soil/Sediment	Two 60-mL	Cool to 4°C	Extract 7 days; analyze 40 days
pH	Groundwater	Analyzed in the field	None	None
	Soil/Sediment			
Specific Conductance	Groundwater	Analyzed in the field	None	None
Cyanide	Groundwater	1-Liter plastic bottle	4°C; NaOH to pH >12	14 days
	Soil/Sediment	Collected with metals	Cool to 4°C	14 days

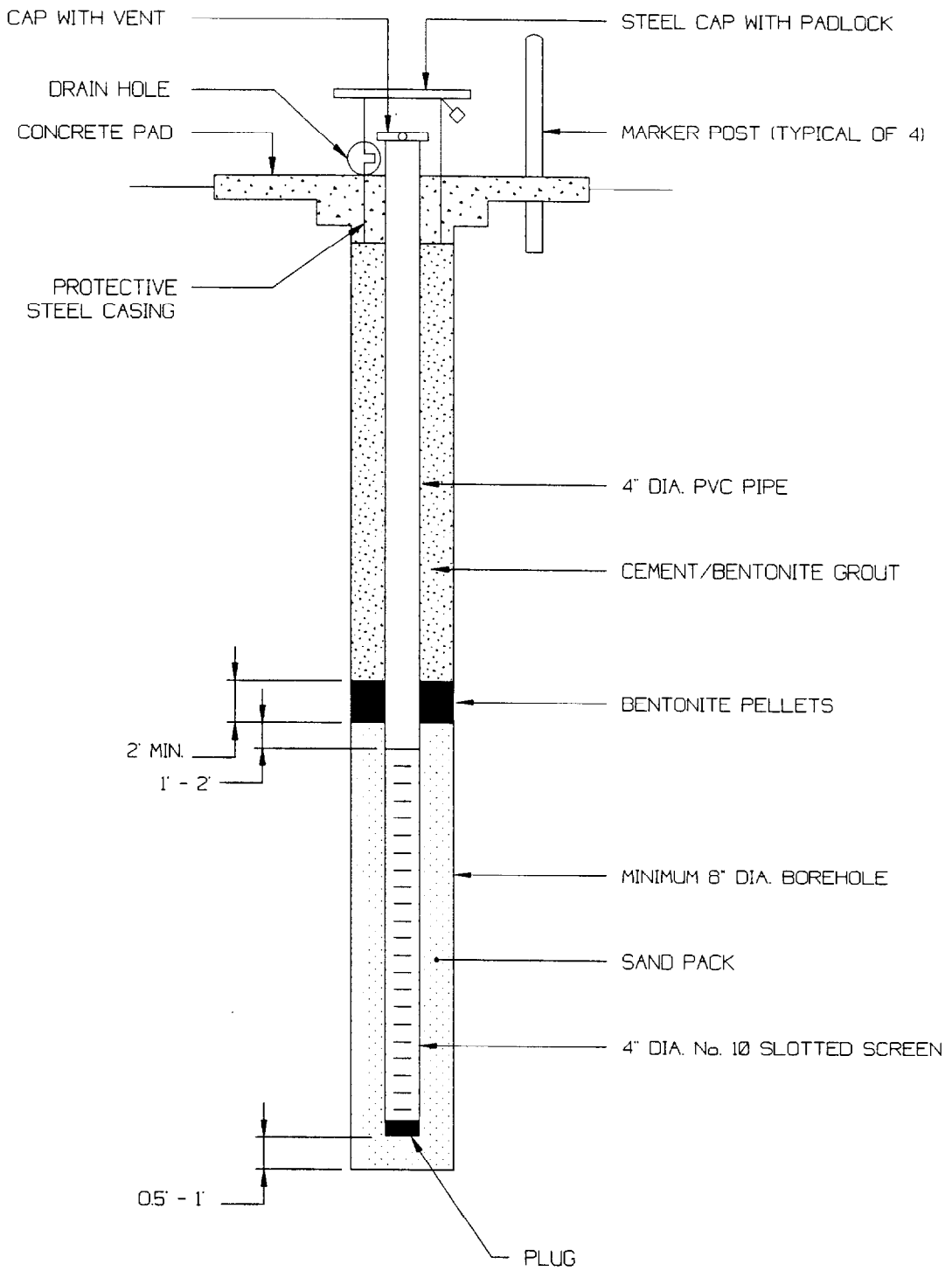
TABLE 3-10 (Continued)
SUMMARY OF BOTTLE REQUIREMENTS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Parameter	Media	Container Material and Sample Volume	Preservation	Holding Time
TPH	Groundwater	1-Liter glass bottle	HCl to pH <2, Cool to 4°C	28 days
	Soil/Sediment	1-Liter wide-mouth jar w/teflon liner	Cool to 4°C	28 days
INDICATOR PARAMETERS				
Sulphate	Groundwater	500-mL PE bottle	Cool to 4°C	28 days
TOX	Groundwater	1-Liter PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Phosphate, TOC, Nitrate/Nitrite	Groundwater	500-mL PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Total Kjeldahl Nitrogen	Groundwater	1-Liter PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Ammonia Nitrogen	Groundwater	1-Liter PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days

1 The following nitroaromatics and nitramines are Method 8330 target analytes:

Octahydro-1,3,5,7-tentranitro-1,3,5,7-tetrazocine (HMX)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
1,3,5-Trinitrobenzene (TNB)
1,3-Dinitrobenzene (DNB)
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
Nitrobenzene (NB)
2,4,6-Trinitrotoluene (TNT)
2,4-Dinitrotoluene (24DNT)
2,6-Dinitrotoluene (26DNT)
o-Nitrotoluene (2NT)
m-Nitrotoluene (3NT)
p-Nitrotoluene (4NT)

ACAD: N:\DATA\BBRK538\CTO222\MWDETAIL.DWG 05/30/95 VIEW = STICKUP



DETAIL OF TYPICAL MONITORING WELL
NAVEODTECHCEN
INDIAN HEAD, MARYLAND

FIGURE 3-1

Halliburton NUS CORPORATION

4.0 VERIFICATION INVESTIGATION REPORTS

As specified in Task 3 of the Implementation Plan for CTO No. 222, the results of the environmental investigations described in Sections 2.0 and 3.0 of this VI Work Plan will be summarized in a Verification Investigation (VI) Report. This section describes the subtasks which will be performed during the preparation of the DRAFT and FINAL VI reports.

4.1 DATA TRACKING AND VALIDATION

Upon completion of laboratory analysis and receipt of laboratory data by NUS, the analytical data will undergo a full data validation quality assurance/quality control review. NUS chemists will validate 100 percent of the analytical data generated by the fixed-based laboratory. The latest published EPA Region III validation protocol will be used to validate the analytical data.

Data validation is a systemic process of reviewing a body of data to provide assurance that the analytical results are adequate for their intended use. This process includes, but is not limited to, the following activities:

- Auditing measurement system calibration and calibration verification.
- Auditing quality control activities
- Screening data sets for outliers and assigning applicable data qualifiers
- Reviewing data for technical credibility
- Checking intermediate calculations
- Evaluating data with reference to the results of laboratory and field quality assurance/quality control samples

Data validation chemists will work with the Field Operations Leader to assure that analytical results have been received for all samples collected during the field investigation and listed on the chain-of-custody forms generated during the field investigation. A complete, validated, and accurate electronic database will be the product of this subtask.

4.2 DATA EVALUATION/INTERPRETATION

Data evaluation and interpretation will be initiated upon the receipt of validated data. Data will be summarized into a useable format for data manipulation and presentation. Tables will be created to exhibit data and contaminant concentrations will be plotted on site maps. Data evaluation and interpretation includes, but is not limited to, the following items:

- Evaluation/interpretation of the nature and potential extent of environmental contamination based on the results of the analysis of groundwater, soil, surface water, and sediment samples collected during the field investigation.

- Evaluation/interpretation of the potential for and/or existence of environmental contamination based on field observations and the results of interviews conducted with civilian/military personnel familiar with the areas of concern.

- Evaluation of hydrogeological data (i.e., water level measurements, results of slug tests) collected during the field investigation.

- Risk assessment of contaminant concentrations detected in the environmental media sampled at each area of concern. The human health component of the risk assessment will be performed in accordance with the guidelines established by EPA Region III (EPA Region III risk based concentrations for SW-846 Method 8330 analytes are presented in Table 4-1). The environmental health component of the risk assessment will be qualitative only (i.e., a comparison of environmental contaminant concentrations to applicable, relevant, or appropriate standards and criteria). The environmental component of the risk assessment will be qualitative only because of the limited nature of the environmental investigations scoped in Sections 2.0 and 3.0 of this VI Work Plan.

It should be noted that Section II, B, 4.b.(1) of the RCRA Corrective Action Permit (EPA I.D. No. MD 417 009 0001) states that the permittee must conduct a RCRA Facility Investigation (RFI) if a release of a hazardous waste of hazardous constituents from a SWMU to groundwater, surface water, soil, or sediment exceeds:

- The Practical Quantitation Limit (PQL) where the PQL is at or below the health-based level, or
- The method detection limit where the PQL is greater than the health based limit.

An exception is granted where an adequate number of samples have been taken and analyzed to demonstrate that concentrations of hazardous waste or hazardous constituents in groundwater, surface water, soil or sediment do not exceed health-based levels, and either:

- Future releases will not occur, e.g., wastes have been removed from the unit, or
- A monitoring program approved by the Regional Administrator has been established.

Because the VI Work Plan targets the MOST potentially contaminated areas at the IED, the IOD, and Area 8, the Navy assumes that this exception will apply to these sites if a risk assessment demonstrates:

- That constituent concentrations do not exceed background, or
- That risks incurred by potential human receptors do not exceed a cancer risk level or hazard index agreed upon by both the Navy and EPA Region III or ARARs agreed upon by both the Navy and EPA Region III.

Future releases are unlikely to occur because training operations will cease when the NAVSCOLEOD relocates. An RFI is already required at Range 6.

4.3 REPORT PREPARATION

The results of the data validation, data evaluation, and data interpretation tasks describe in Sections 4.1 and 4.2 will be presented in DRAFT and FINAL VI Reports. The VI report will:

- document the investigative activities conducted during the field investigations conducted at Range 6, the IED, the IOD, and Area 8;
- consolidate the results of the investigative activities conducted during the field investigations conducted at Range 6, the IED, the IOD, and Area 8;
- present the conclusions of the data evaluation, interpretation, and risk assessment;
- summarize the relevant information obtained from reference documents and interviews with civilian and military personnel;
- and identify risk assessment, hydrogeological, and engineering data gaps evident at the conclusion of the Verification Investigations implemented via this Work Plan.

The project manager will present the results and conclusions of the VI Report at a meeting with the Navy and EPA.

TABLE 4-1

RISK BASED CONCENTRATIONS FOR TARGET ENERGETIC MATERIALS[1]
VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

Compound	RfD_o[2] mg/Kg/d	RfD_i[3] mg/Kg/d	CPS_o[4] k-d/mg	CPS_i[5] Kg-d/mg	RBC[6] Drinking Water	RBC Soil[7]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	5.0E-02	-	-	-	1800[N]	3900[N]
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	3.0E-03	-	1.1E-01	-	0.61[C]	5.8[C]
1,3,5-Trinitrobenzene (TNB)	5.0E-05	-	-	-	1.8[N]	3.9[N]
1,3-Dinitrobenzene (DNB)	1.0E-04	-	-	-	3.7[N]	7.8[N]
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	1.0E-02	-	-	-	370[N]	780[N]
Nitrobenzene (NB)	5.0E-04	5.71E-04	-	-	3.4[N]	39[N]
2,4,6-Trinitrotoluene (TNT)	5.0E-04	-	3.0E-02	-	2.2[C]	21[C]
2,4-Dinitrotoluene (24DNT)	2.0E-03	-	-	-	73[N]	160[N]
2,6-Dinitrotoluene (26DNT)	1.0E-03	-	-	-	37[N]	78[N]
o-Nitrotoluene (2NT)	1.0E-02	-	-	-	61[N]	780[N]
m-Nitrotoluene (3NT)	1.0E-02	-	-	-	61[N]	780[N]
p-Nitrotoluene (4NT)	1.0E-02	-	-	-	61[N]	780[N]
Nitrocellulose (NC)	-	-	-	-	-	-
Nitroguanidine (NQ)	1.0E-01	-	-	-	3700[N]	7800[N]
Nitroglycerine (NG)	-	-	-	-	-	-
Pentaerythritoltetranitrate (PETN)	-	-	-	-	-	-

1 Risk-Based Concentration Table. January - June 1995. EPA Region III, March 7, 1995.
2 RfD_o: Reference dose - oral route of exposure. (A reference dose is the dose at which or below which adverse noncarcinogenic health effects are not anticipated to occur.)
3 RfD_i: Reference dose - inhalation route of exposure.
4 CPS_o: Carcinogenic potency slope - oral route of exposure. (The Carcinogenic potency slope is an indicator of the potency of a carcinogenic compound. The CPS is commonly estimated through the use of a linearized, multi-stage mathematical extrapolation model applied to animal bioassay results. The value used in reporting the factor is the upper 95 Percent Confidence Limit.)
5 CPS_i: Carcinogenic Potency Slope - inhalation route of exposure.
6 RBC - Drinking Water: Concentrations associated with a cancer risk estimate of 1 case in 1,000,000 exposed individuals (for carcinogenic compounds) or estimated not to cause adverse noncarcinogenic health effects (for noncarcinogenic compounds). The RBC is calculated assuming routine, long-term exposure to a water source.
7 RBC - Soil: Concentrations associated with a cancer risk estimate of 1 case in 1,000,000 exposed individuals (for carcinogenic compounds) or estimated not to cause adverse noncarcinogenic health effects (for noncarcinogenic compounds). The RBC is calculated assuming routine, long-term exposure to soil.

5.0 PROJECT MANAGEMENT APPROACH

This section describes the project management and organization and provides a schedule identifying the project milestones.

5.1 PROJECT ORGANIZATION

The proposed project organization for the verification investigations at Range 6, the IED, the IOD, and Area 8 is shown in Figure 5-1.

The Program Manager, Mr. John Trepanowski, and the Deputy Program Manager, Mr. Daryl Hutson, are responsible for the overall quality of work performed under CLEAN Contract No. N62472-90-D-1298. Mr. Trepanowski and Mr. Hutson will be responsible for all contract negotiations with the Navy and the subcontractors; will maintain client relationships; and will assume overall responsibility for staffing, maintenance of schedule, adherence to budget, and quality of technical work performed. They are Halliburton NUS' designated authority to commit resources to this effort. Mr. Trepanowski, Mr. Hutson, and the Project Manager are the focal points of all project activities; they will be immediately accessible to the Navy.

Ms. LeeAnn Sinagoga will serve as the Project Manager (PM). The PM has primary responsibility for implementing and executing the VI Work Plan. Ms. Sinagoga will coordinate and manage the day-to-day technical aspects of the project and project team activities, and will be responsible for maintenance and tracking of project schedule and budget, coordination and preparation of all required reports, assignment of technical responsibilities to appropriate Task Leaders and subcontractors, and administrative support activities. Her technical responsibilities include overall direction of the staff in the performance of the Verification Investigation and associated activities. The Project Manager will also review and/or prepare input for Work Plans/proposals and reports, and coordinate with subcontractors, as appropriate, to obtain necessary input to analyses and reports.

Supporting the PM are the Contracting Officer (Mr. Joe Farrell), the Quality Assurance Manager (Ms. Debra Scheib), the Health and Safety Manager (Mr. Matt Soltis), the Field Operations Leader (FOL), and other technical staff.

Subcontractors will be required for the fieldwork portions of VI Work Plan. The subcontractors required will be a driller, a surveyor and an analytical laboratory to analyze the samples collected. The Halliburton NUS Program Manager will maintain ultimate control and accountability for the project by means of formal subcontract agreements with subcontractors and through directives and communication with the subcontractors' program and project management staff. The Halliburton NUS Project Manager will have management and administrative authority for the subcontracts under authority of the Program Manager.

5.2 PROJECT SCHEDULE AND BUDGET

Figure 5-2 depicts the schedule of tasks and activities for the VI Work Plan. The schedule for the investigation assumes that minimal site restrictions will be encountered and is dependent on Navy and EPA approval of this work plan and subsequent deliverables.

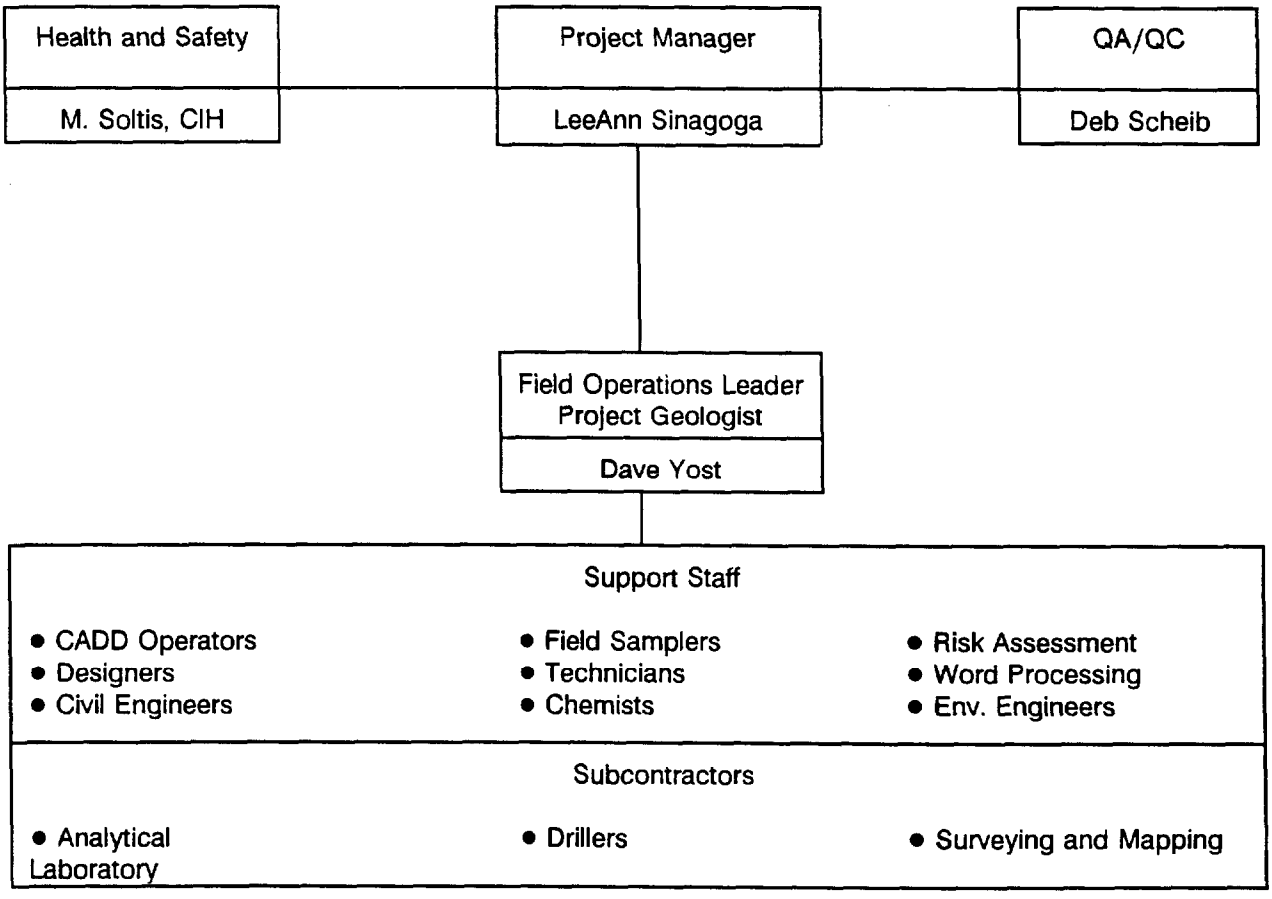
In addition to the milestones shown in Figure 5-2, additional task milestones are as follows:

Monthly Reports	7th working day of each month
Summary meeting minutes	5 working days after each meeting

FIGURE 5-1

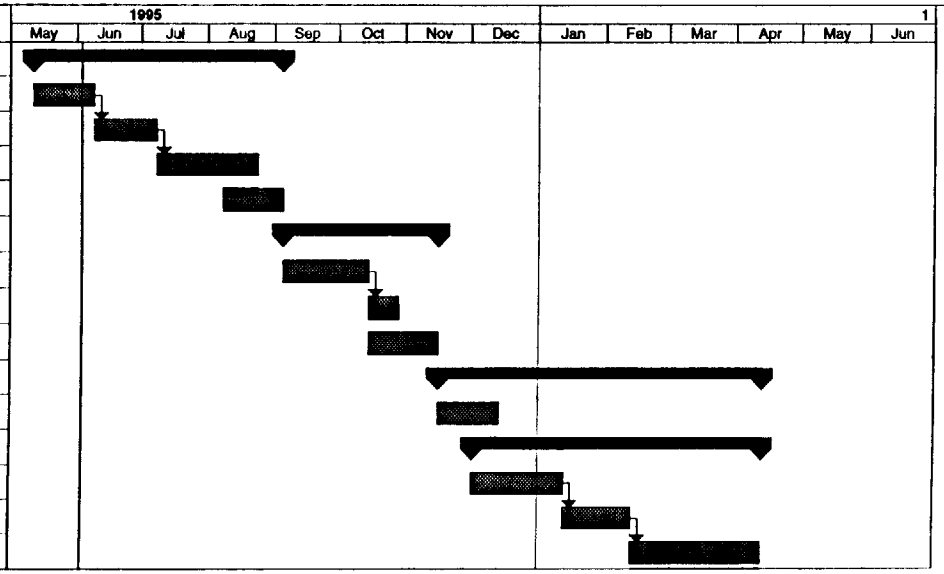
PROJECT ORGANIZATION CHART

VERIFICATION INVESTIGATION, THE NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND



Schedule for CTO 222

ID	Task Name	Duration	Start	Finish
1	**Task 1 - Engineering Services/Planning Documents**	**116d**	**5/12/95**	**9/4/95**
2	Draft Work Plan	28d	5/12/95	6/8/95
3	Review	29d	6/9/95	7/7/95
4	Final Work Plan	47d	7/8/95	8/23/95
5	Subcontractor Procurement	28d	8/8/95	9/4/95
6	**Task 2**	**72d**	**9/5/95**	**11/15/95**
7	Soil and Groundwater Sampling	40d	9/5/95	10/14/95
8	Schedule Reserve	14d	10/15/95	10/28/95
9	Lab Analysis *	32d	10/15/95	11/15/95
10	**Task 3**	**149d**	**11/16/95**	**4/12/96**
11	3.1 Validation of Data	28d	11/16/95	12/13/95
12	3.2 Prepare Report	**133d**	**12/2/95**	**4/12/96**
13	Draft	42d	12/2/95	1/12/96
14	Review	31d	1/13/96	2/12/96
15	Final Report	60d	2/13/96	4/12/96



SCHEDULE FOR CTO-222
STUMP NECK ANNEX
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MD

FIGURE 5-2

Halliburton NUS CORPORATION

Project:
Date: 6/3/95

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

REFERENCES

AWARE Corporation, 1982. Final Report, Portable Water Improvement Study, Naval Ordnance Station, Indian Head, Maryland, prepared under contract No. 62477-81-C-0170 for Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C.

Ensafe/Allen, and Hoshall, July 1991. Verification Investigation/RCRA Facility Investigation Work Plan, Naval Explosive Ordnance Disposal Technology Center, Stump Neck Annex, Indian Head, Maryland.

Greenhorne and O'Mara, Inc., 1990. Indian Head Hydrogeologic Study, Phase I Survey Report.

Hiortdahl, S.N., 1990. Changes in Groundwater Quality Caused by River-Water Intrusion in the Potomac Group Aquifer System of Northwestern Charles County, Maryland. In Groundwater Management, Proceedings of the FOCUS Conference on Eastern Regional Groundwater Issues, 1990.

Indian Head Naval Surface Warfare Center, February, 1995. Historical records maintained by Explosives Safety Officer.

Meyer, R., 1987. Explosives, Third, revised and extended edition. VCH Verlagsgesellschaft mbH, Weinheim, Federal Republic of Germany.

Sinagoga, L., July 20 and 21, 1995. On-site interviews with Indian Head personnel.

Tech International, 1988. Draft RCRA Part B, Subpart X Permit Application for Indian Head Naval Ordnance Station.

Windholz, M., ed., 1983. The Merck Index, Tenth edition. Merck and Company, Inc., Rahway, New Jersey.

ATTACHMENT A-V
VERIFICATION INVESTIGATION WORK PLAN
UNEXPLODED ORDNANCE SUPPORT
STANDARD OPERATING PROCEDURE

Verification Investigation Work plan
Naval School, Explosive Ordnance Disposal
Naval Surface Warfare Center
Stump Neck Annex, Indian Head Division
Indian Head, Maryland

Standard Operating Procedure
SOP No.

Subject: STANDARD OPERATING PROCEDURE (SOP)
UXO SUPPORT FOR THE Verification Investigation activities

Prepared by: _____ _____
Lead UXO Specialist Date Prepared

Reviewed by: _____ _____
Health & Safety Officer Date

Approved by:

EFACHES	Date	Environmental Branch/ Environmental Manager	Date
Project Manager	Date	Explosive Ordnance Disposal Team	Date
Field Team Leader	Date	Department Manager	Date
Explosive Safety Specialist	Date	Explosive Safety Manager	Date
Radiation Safety Officer	Date	Ass't. Radioactive Safety Officer	Date

Attendance Sheet for Hazard Control Brief

Purpose: Hazard Control Briefing

Subject: Standard Operating Procedures (SOP) Format/Guidance

Location: _____, Stump Neck Annex

Presenter: _____

Objectives:

1. Example of possible objectives
2. Overview of test item
3. Health hazards
4. Safety hazards
5. Environmental hazards

The following are personnel/visitors who have read and were presented the Hazard Control Brief. It is the responsibility of the process supervisor to ensure the hazard brief is presented to all persons in the area in which the test/operation shall be conducted.

Name	Signature	Date	Time

Additional copies of this page may be attached to accommodate additional signatures. Additional copies will be marked a, b, c, etc.

WORKER READ AND UNDERSTAND STATEMENT

Each person performing hands-on ordnance operations under this SOP must sign and date this form. Each person must sign and date this form every day prior to the operation, unless it is a continuous ongoing operation. In that case, the form will be signed every thirty (30) days.

I have read and understood my particular operation(s) of the Procedure. I have been briefed on the overall process and the hazards involved and have discussed it with my supervisor. My level of certification qualifies me to perform the operations contained in this SOP.

I have conducted drills, practice runs or observed operations to assure that the person whose signature appears opposite can perform the operations he/she is assigned in the procedure.

Certified	Cert. Level	Date	Verifying	Cert. Level	Date

The certifying authority must be an individual that understands the certification and SOP process and can be expected to verify that the one doing the work does have the level of certification required by the SOP. This function does not require a specific supervisory level or certification board position.

Additional copies of this page may be attached to accommodate additional signatures. Additional copies will be marked a, b, c, etc.

Annual Review

This SOP must be signed annually (based on approved effective date) by the immediate supervisor of ordnance personnel performing the operation. After three annual reviews, a new SOP must be written.

1st Annual Review:

Supervisor's Name	Supervisors Signature	Date
Supervisor's Name	Supervisors Signature	Date

2nd Annual Review:

Supervisor's Name	Supervisors Signature	Date
Supervisor's Name	Supervisors Signature	Date

3rd Annual Review:

Supervisor's Name	Supervisors Signature	Date
Supervisor's Name	Supervisors Signature	Date

I have read the SOP. I understand it. To the best of my knowledge, the process described within this SOP can be done in a safe, healthful, and environmentally sound manner. I have made sure all persons assigned to the process are qualified and have read and understand the requirements of this SOP and have signed the worker's statement for this process. I will conduct an annual review of this SOP during recurring processes. If deviations from this SOP are necessary, I will ensure that this process is stopped until the SOP is revised and approved. If unexpected safety, health or environmental hazards are found, I will make sure this process is stopped until the hazards have been eliminated.

Supervisor's Name	**Date**	**Supervisor's Name**	**Date**

Subject: Standard Operating Procedure

REFERENCES

(a) OP 5, vol.1, 5th Rev.. subj: Ammunition and Explosives Ashore; Safety Regulations for Handling, Storing, Production, Renovation and Shipping

(b) NAVSEA SW020-AC-SAF-101, Transportation and Storage Data for Ammunitions, Explosives and Related Hazardous Materials

(c) OSHA 29 CFR 1910.120

(d) Verification Investigation Work Plan, for the Naval School Explosive Ordnance Disposal, Stump Neck Annex, Indian Head Division, Indian Head Maryland
- Appendix A: Health & Safety Plan
- Appendix B: Field Forms
- Appendix C: Standard Operating Procedures
- Appendix D: Quality Assurance/Quality Control

1.0 GENERAL

This Standard Operating Procedure (SOP) was prepared as outlined in references (a) and (b) above, for conducting the Verification Activities, presented in the Verification Investigation Work Plan (VI), for the Naval School Explosive Ordnance Disposal, Stump Neck Annex. The procedures are as described in Section 14 of this SOP. All personnel conducting operations under this SOP must read and understand applicable parts of references (a) through (l) prior to commencing any work described within this SOP. The Verification Investigation Work Plan and referenced SOPs submitted for the purpose of accomplishing work covered by this SOP are to be considered supporting documents to this SOP.

2.0 PURPOSE

The purposes of the VI activities covered by this SOP are:

a: Collect a maximum of 50 surface soil samples at Area 8 and Range 6.

b: Collect four surface water samples at Area 8 site.

c: Collect 4 sediment samples at Area 8.

d: Install ground water monitors at Area 8, the IED Site and Range 6.

e: Install soil borings at Area 8, IOD site and the IED Site.

3.0 APPLICABILITY

This SOP applies to all personnel performing activities as a part of the VI field activities of the SSP while on the Stump Neck facility. This includes personnel of the prime contractor as well as personnel of any subcontractor. This SOP also applies to persons who may visit the site during the conduct of this investigation.

4.0 RESPONSIBILITY

The HNUS Project Manager is directly responsible for seeing that all applicable rules and regulations are complied with, and that all necessary safety precautions are taken to conduct operations in accordance with this SOP.

It is the responsibility of the Project Manager to ensure that personnel conducting VI activities in accordance with this SOP have the proper training and, if required, the proper certifications for the job being performed.

The on-site Halliburton NUS Health and Safety Officer will assume these responsibilities in the absence of the Project Manager.

5.0 LOCATIONS OF OPERATIONS

The verification investigation activities to be conducted during the site study will be performed at the following locations:

- Range 6
- Improvised Exposive Devices (IED) Site
- Inert Ordnance Disposal (IOD) Site
- Area 8

Required detailed site background information is provided in the VI Work Plan, and therefore is not repeated here. This information includes:

- Detailed site descriptions, discussions of known or suspected contamination sources, and results of previous studies.

- Range 6 - is located on the eastern tip of the Stump Neck peninsula. Water surrounds the site on three sides, the Potomac River to the northeast and the Chicamuxen Creek the southwest. Access to the site is obtained via an asphalt road named Archer Avenue which bisects the site terminating close to the water's edge at a tidal swampy area. Access is controlled by fencing and a gate located on Archer Avenue. The site lies completely within the 100 year flood plain. The site consists of approximately 11 acres. This area is surrounded by wetlands. An illustration of this site is provided in Figure 1-4 of the VI Work Plan.

  Range 6 was used as a demolition training area consisting of five ranges which were used for open detonation training. Small amounts (less than two to three pounds) of explosives were used. The site operated from the early 1950's until early in 1988. It is not expected that this site will ever be used as a training facility again. The amount the site was used depended on the number of recruits (students) being trained at any one given time, but it is estimated this site was used weekly. Based on this estimate, approximately 100 pounds of ordnance was used each year. Ordnance used at this site contained various chemicals including COMPD, nitric acid, and sulfuric acid. Wastes also include small quantities of shrapmetel and castings from the detonation of explosives. It was reported that in 1956/1957 approximately 1500 to 2000 pounds of arsenic powder in plastic bags were buried at Range 6 in a pit measuring 40 feet deep and 6 feet in diameter.

  Range 6 was identified in the Notice of Decision for RCRA Corrective Action Permit EPA I.D. No. MD 417 009 0001 (January 24, 1991 through January 23, 2001) as Solid Waste Management Unit number five (SWMU 5). A Verification Investigation/RCRA Facility Investigation Work Plan was prepared by Ensafe, Allen and Hoshall (July 17, 1991), which establishes the field work necessary to determine the lateral and vertical extent of contamination, if any, in the soil and ground water of Range 6. It should be noted that the RCRA Corrective Action Permit does not make mention of the Arsenic disposal pit and that the Indian Head Base drawing (Dwg. No. 15455-A) indicates that SWMU 5 is only 300 feet by 300 feet and does not include the area where the pit is located.

- The Improvised Explosive Devices (IED) Site - The IED is use to test the explosive potential of chemical mixtures. The site was first used in November of 1957 and is still in use. Activities at the site are performed year round and it is estimated that approximately 10 pound (net explosive weight) of ordnance is used in this area each year. A list of the chemicals tested at this site includes but is not limited to gasoline, glycerin, nitrates, and peroxides. Historical records are maintained by the Explosive Safety Officer and are

considered accurate and complete dating back to January 1990.

Figure 1-5 of the VI Work Plan shows the major features of the IED Site.

- The Inert Ordnance Disposal (IOD) Site - The IOD is located off a dirt road in the vicinity of the intersection of Archer Avenue and Lewis Road. Figure 1-6 of the VI Work Plan illustrates the location of the IOD Site. The site consists of a deteriorating concrete pad measuring approximately 18 by 12 feet. The pad is located on the slope of a hill. Immediately below the pad is a 4 to 5 foot culvert. Access to the site is controlled by fencing and a gate located on Archer Avenue.

  The IOD was used for disposal of inert ordnance.

- Area 8 - Area 8, also known as the Underwater Ordnance Training Area, is located on an asphalt road named Roach Road which bisects the site. Buildings 2104 and 2125 are locate within the boundaries of this site. The site measures approximately 9.6 acres. Access to the site is controlled by fencing and a gate located on Archer Avenue. Two acres of wetlands have been identified on this site. An illustration of this site is provided in figure 1-7 of the VI Work Plan.

  Area 8 is used for the training and testing of underwater ordnances. This area is also used to train military personnel in the defusing of explosive devices. Activities in Area 8 are performed 10 months out of the year and it is estimated that approximately 50 to 75 pounds (net explosive weight) of ordnance is used is this area each year. The type of ordnance used includes TNT Block, Blasting Caps, Detonation Cord, and similar devices. Area 8 is defined by numerous water-shot and air-shot locations, a major stagnant water hole, and a large pond, as illustrated in Figure 1-7 of the VI Work Plan. The stagnant water hole has been inactive since 1993. The water-shot and air-shot locations have been the primary locations for training and testing activities. The water-shot locations consist of depressions measuring a few feet in diameter and 6 to 9 feet deep. Water 4 to 5 feet deep fill these depressions. Location #28 is the most used water-shot and water-shot location #7 is the closest location to Chicamuxen Creek. Historical records are maintained by the Explosive Safety Officer and are considered accurate and complete dating back to January 1990.

6.0 PERSONNEL LIMITS

The activities to be conducted during the Verification Investigation field activities will be conducted in areas that do not require maximum personnel limitations. Work will not be permitted unless at least two persons are present in the work area. The provisions of 29 CFR 1910.120 concerning personnel qualifications and requirements will be followed while working on site. Any personnel limitation requirements that may be in force by the Stump Neck Safety Office will be adhered to at all times.

During all hazardous operations related to searching or screening for unexploded ordnance (UXO) or any hazardous UXO/explosive-related service, the "buddy system" (29 CFR 1910.120, Para (d) (3) must be used, with one of these persons being a qualified EOD technician.

7.0 MATERIAL LIMITS

Explosive materials will not be used during the operations covered by this SOP. Bulk liquids to be used for the decontamination of equipment will be in 2-gallon containers or less. MSDSs will be kept on file at the HNUS Command Post.

8.0 SAFETY REQUIREMENTS

The safety requirements that apply to the operations covered under this SOP are:

a. All applicable Indian Head Health and Safety Programs
b. OSHA 29 CFR 1910.120 and .134
c. Stump Neck Verification Investigation (VI) Work Plan with Appendices.
d. NRC Title 10 Code of Federal Regulations, Parts 19, 20, and 40

The specific safety requirements of this operations are stated below:

a. If UXO or suspected UXO is encountered, all operations in the affected area will cease, the affected area will be evaluated, and notification will be made in accordance with Section 10.0 of this SOP.

b. HNUS UXO specialists (EOD-qualified) will be present during UXO-related operations.

c. Station-approved communications equipment (two-way communication equipment) will be on site during any operations.

d. SOPs as outlined in the VI Work Plan, will apply.

9.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following PPE will be worn by personnel on site. Items marked with an asterisk (*) will be available and will be used, if necessary, as determined by the HNUS Site Safety Officer.

a. Safety glasses
b. Safety shoes (and protective overboots/or steel-toe rubber boots*)
c. Cotton clothing (with protective coveralls*)
d. Gloves (type to be determined by HNUS Site Safety Officer)
e. Respiratory protective equipment* (29 CFR 1910.134)
f. Hearing protection*
g. Hard hats*

Additional equipment may be required on a site-specific basis. Equipment will be selected by the Site Safety Officer (SSO) and the Project Manager in accordance with the VI Work Plan.

10.0 EMERGENCY RESPONSE AND CONTINGENCY PLANS

In the event of an emergency, notification will be made to the following in the order presented.

a. Stump Neck, Emergency Fire and Medical Assistance, Phone x 743-4333.
b. Stump Neck, Ordnance Officer, x_____.*
c. Stump Neck, Explosive Safety Manager, x_____.*
d. Stump Neck, Safety Branch, x_____.
e. Stump Neck, Emergency Preparedness Coordinator, x_____.*
f. Stump Neck, EOD Office (for UXO items), x_____.*
g. Stump Neck, Environmental Office Site Contact, x 743-6745 (Shawn Jorgensen).
h. Halliburton NUS Site Supervisor, x_____.*

i. Rescue Squad x 743-4333.

*** Numbers can be filled in by FOL.**

The activities to be performed during the implementation of the VI Work Plan will not be conducted in buildings. In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. Emergency Response Planning will follow in accordance with 29 CFR 1910.38(a). Halliburton NUS will utilize Base Fire Protection and Emergency Services in emergencies or potential emergencies. Emergency medical services will be provided by Branch Medical Clinic.

The following contingency plans will be implemented.

a. Pre-Planning

Upon arrival at the base, the Halliburton NUS Field Operations Leader/Site Safety Officer (FOL/SSO) will meet with the Base Fire Protection Department, Base Security Personnel, and Emergency Services to notify coordinators what activities are to be undertaken and where. All site personnel will be required to follow base emergency procedures and will rely on base services to handle emergency calls when needed. Medical service will be provided by Base Fire Department.

Hand-held radios will be available at the work site for communication between field teams.

b. Emergency Escape Procedures and Assignments

Upon notification of a site emergency that requires evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind directions. If personnel cannot reach those locations without danger to their lives or health, an alternate meeting place will be designated during the daily hazard control brief. Personnel will be trained to remain at the refuge location until directed to resume work, or leave the site.

c. Procedure to Account for Site Personnel

The site work force will be small enough that accounting for personnel will not be a problem. Accounting for personnel will be the FOL's responsibility. This will be accomplished by taking a roll call using the site log book.

d. Rescue and Medical Duties

A physician-approved first aid kit, an American National Standard Institute (ANSI) approved eye wash station, and a Class ABC fire extinguisher will be readily available on site.

e. Activation of Emergency Response Procedures

Should any emergency occur which requires the support of outside services, the appropriate contacts will be made by the FOL/SSO. A list of the appropriate contacts will be posted at the Command

Post. Hand-held radios will be the primary method of communication.

f. Airborne Chemical Release Contingency Plan

Chemical Release Monitoring

Every member of the site team will be responsible for observing and reporting any gross chemical releases or conditions that could lead to releases. Air monitoring will be performed as described in the Health and Safety Plan (HASP) of the VI Work Plan.

Response to Measured Airborne Chemical Releases

The readings obtained on these instruments will be compared to the action levels specified in the HASP VI Work Plan for the purpose of protecting the health and safety of on-site personnel.

If the concentrations shown on the instruments suggest that the hazardous materials can exceed the following levels at the perimeter of neighboring residential or commercial property, the Halliburton NUS FOL/SSO will notify the base fire department (X 743-4333).

Parameter	Action Level	NOTE: SUGGESTED LEVELS ONLY
Total Organic Vapors	50 parts per million	
Flammable Vapor	10% of the lower explosive limit	

Response to Sudden Airborne Chemical Releases

If field operations on site result in a release of concentrated vapor from a pressurized container (which will normally result in a visible plume), personnel will leave the area for the pre-determined-upwind reassembly point quickly, but without panic. Halliburton NUS FOL/SSO will notify the base fire department (X 743-4333) as soon as possible. The potential for such an event to occur during planned activities is not considered to be significant.

g. Liquid Release Monitoring

Every member of the site team will be responsible for observing and reporting any liquid chemical releases or conditions that could lead to releases.

Response to Liquid Releases

If field operations on site result in a release of liquid chemicals in the absence of vapor, field personnel will attempt to contain the liquid by means of berms constructed with available equipment. If the work team cannot control the spill, they will leave the area for the reassembly point quickly, but without panic. The Halliburton NUS FOL/SSO will notify the base fire department (X 743-4333). Due to the nature of planned activities, this is not considered to be a significant potential event. However, in the unlikely instance that it should occur, field personnel may effect defensive efforts such as these, providing that such a response does not appear to present a chemical overexposure or other personal health or safety concern.

11.0 SAFETY POINTS OF CONTACT - Stump Neck,

a. Stump Neck, Explosives Safety Manager, Phone x_____*
b. Stump Neck, Safety Management Branch, Phone x_____*

c. Stump Neck, Ordnance Officer, Phone x_____*
d. Stump Neck, Assistant Radiation Safety Officer, Phone x_____*
e. Stump Neck, Environmental Office, x_____*

*** Numbers can be filled in by FOL.**

12.0 TOOLS AND EQUIPMENT

Major items of equipment that may be required for the operations covered by this SOP are presented below by category.

a. Protective Equipment
   1. Respiratory Protective Equipment
   2. Dermal (chemical-resistant) protective equipment
   3. Other items (i.e., hard hats, safety glasses, etc.)

b. Air Monitoring Equipment
   1. Explosive/Oxygen (O_2) meters
   2. Direct reading organic vapor instrumentation (Photo Ionization Detection [PID] or Flame Ionization Detection [FID])

c. Hydrology/Survey Equipment
   1. Water level recorder
   2. Survey equipment as required
   3. pH/Temperature/Conductivity meter for water samples

d. UXO Support Equipment
   1. GA-72CV Magnetometer (passive instrument)
   2. MG-220, Magnetometer (for down hole surveys)

e. Decontaminating Equipment
   As required by the level of protection for each site.

f. Hand Tools
   As may be required.

g. Miscellaneous
   As may be required.

13.0 ENVIRONMENTAL CONCERNS

The field investigation program covered by this SOP will be performed in such a manner as to minimize the effects of pollution of air, water, or land and to control noise and dust within reasonable limits.

Every effort will be made to:

a. Protect the land areas and preserve them in their existing condition

b. Protect water resources, including measures for run-on or run-off controls if applicable.

c. Implement sediment control measures, where warranted. These measures will also be

implemented to control erosion.

The field investigation program will generate solid and liquid waste requiring proper handling and possible off-site disposal. The major types of waste to be generated, their environmental concerns, and their handling and disposition are summarized below.

a. Personnel and equipment decontamination fluid containers will be disposed of according to facility regulations for disposal of hazardous waste.

b. Personal Protective Equipment (PPE) will be double-bagged and will be the responsibility of the contractor to dispose of according to applicable regulations.

It is not anticipated that any chemical releases will occur during these investigative activities.

The MSDSs for chemicals being brought onto the facility for use in this investigation are located at the Fire Department and filed at the HNUS Command Post.

14.0 PROCEDURES

a. General

The proposed field activities for the Verification Investigative Study will include:

- Installation of ground water monitoring wells using a drilling rig.
- Installation of soil borings using a drilling rig or hand tools.
- Collection of multi-media samples.

The following general procedures apply to the conduct of these activities.

b. Sampling Procedures

Sampling will be conducted in accordance with established protocols and methodologies. Site-specific sampling requirements are present in Reference (l): VI Work Plan.

Sites potentially contaminated with UXO will be screened by HNUS UXO specialists prior to sampling. A magnetometer will be used to conduct the screening. Based on current information, Range 6 is the only site covered by the VI Work Plan which may involve UXO.

c. UXO Operations

Due to the potential of unexploded ordnance (UXO) material being encountered during VI field activities, UXO support will be provided at Range 6. The UXO support provided will include the following:

1) Base EOD qualified personnel will provide the necessary equipment and support for the disposal of UXO items.

2) HNUS Explosive Ordnance Disposal-qualified Personnel and the necessary equipment for UXO support will be available for all activities.

3) Screening for UXO will be conducted by HNUS UXO personnel at sampling locations on sites where UXO is a potential hazard.

d. Borehole and Monitor Well Installation

Downhole magnetometer screening for UXO will be performed at all locations where intrusive work is being conducted in boreholes or monitoring well installation. The general procedures to be used for downhole magnetometer screening and UXO support are outlined below.

1) Prior to the start of any drilling operation or subsurface sampling, the proposed work area shall be swept and cleared of all surface and subsurface UXO that may be detected. The work area shall include the off-road access path to the borehole and the area within a 50-foot radius of the borehole (areas where vehicles will be operated).

2) Using engineering tape and wooden stakes, outline the work area.

3) When given clearance, maneuver drill rig as close as practical to the proposed borehole. Assistant driver will act as ground guide and direct the driver who backs the drill rig into position.

4) Position the drill auger over the proposed borehole. Drill to a depth of 2 feet.

5) Remove the drill auger from the borehole.

6) The drill crew chief will make observations of soil from the core barrel and the soil removed from the hole by the drill auger.

7) The drilling log and lithologic log shall be maintained in accordance to standard practices.

8) Insert a 4-inch PVC pipe in the drill hole.

9) Secure the derrick and move the drill rig to a position at least 20 feet from the borehole.

10) EOD shall conduct a magnetometer check of the borehole.

11) If a UXO is present, abandon the borehole and select another location. The new borehole shall be at least 6 feet from the borehole with the UXO.

12) If clearance has been given, the drill rig shall be positioned back on the borehole and drilling will proceed to the next depth.

13) Repeat steps 4-l2, at intervals of 2 feet, until a 10-feet depth is reached. At 10 feet, a magnetometer reading shall be taken with the instrument set on the maximum sensitivity.

14) If no objects are detected at the 10-foot reading, standard drilling will be performed until desired depth is reached.

15) Standard Operating Procedures will be used for the installation of the monitoring well or for collecting subsurface soil samples.

15.0 HAZARD CONTROL BRIEF

A Health and Safety, Hazard Control briefing will be conducted prior to the start of on-site activities. The briefing will be detailed and will cover the information contained in this SOP and the HASP (Reference (l), VI Work Plan, Appendix B. Refresher briefings will be conducted, as necessary, for specific or unique activities. New personnel assigned to the project will receive an in-depth briefing prior to starting work.

a. Overview of Task to Be Performed

Verification Investigation field activities for the proposed investigation will include the activities presented in reference (l), VI Work Plan.

Overview of Hazards

1) Unexploded Ordnance (UXO) Hazards

Range 6 is a military installation that has been used as a training facility for evaluation and disposal of ordnance and/or explosive materials. If UXO is discovered at any time during operations at Range 6, the following actions will be taken:

a. All operations in the affected area will be stopped immediately.

b. The area will be evacuated.

c. The location of the UXO will be marked.

d. Notifications will be made in accordance with Section 10.0 of this SOP.

The following are hazards associated with UXO:

*	Fire	*	Jet
*	Blast	*	Overpressure
*	Heat	*	Ejection
*	Fragmentation	*	Propulsion

These are all produced in varying combinations as a result of the intended or unintended functioning of a high or low explosive. The most effective protection from all hazards of explosives is a safe separation distance. The risk of exposure to these hazards by personnel conducting UXO operations must be kept to the absolute minimum necessary to perform the operation. All other personnel must be at or beyond the safe separation distance. This distance will be adjusted by the UXO team leader as the situation dictates.

2) Physical Hazards

Physical hazards which could be involved in the execution of this scope of work include, but are not limited to, the following items:

- Uneven or unstable terrain (slip/trip hazards)
- Strain/muscle pulls from manual lifting
- Fall from elevated surfaces
- Exposure to pinch/compression points
- Water hazards

- Natural hazards (e.g., snakes, ticks, mosquitoes, poisonous plants)
- Inclement weather
- Heat stress
- Cold stress

Efforts to control these potential hazards will encompass and possibly combine the use of proper equipment maintenance, guarding, and operation. Additionally, adherence to proper standard work practices (Reference (l), VI Work Plan, Appendix B: Health and Safety Plan.

c. Overview of Standard Work Practices

The following Standard Work Practices are to be applied in addition to the Health and Safety SOPs:

- Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited in the exclusion or decontamination zones, or any location where there exists a possibility for contact with site contaminants.

- Upon leaving the exclusion zone, personnel must wash their hands and face thoroughly with soap and potable water. Any protective outer clothing is to be decontaminated and removed as specified in the Health and Safety Plan (Reference (l)), and left at a designated area (identified during the daily Hazard Control Briefing) before personnel enter the clean area.

- Contact with potentially contaminated substances must be avoided. Contact with the ground or with contaminated equipment must also be avoided.

- No facial hair, which interferes with a satisfactory fit of the mask-to-face seal, is permitted on personnel required to wear respiratory protective equipment.

- All personnel must satisfy all training requirements (40-hr, 8-hr refresher, site-specific training, emergency response training) prior to commencing site activities.

- All personnel must have a working knowledge of this SOP and the HASP, including being aware of the action levels for upgrading/downgrading levels of protective equipment, and emergency procedures.

- All personnel must satisfy medical monitoring procedures.

- All personnel must complete a medical data sheet to be maintained on site (see Attachment D-II of Reference (l), VI Work Plan, Appendix B: Health and Safety Plan).

- All personnel working in sight-restriction areas of heavy vegetation or where the topography does not permit line-of- sight contact must utilize the buddy system.

- When lifting or moving equipment or material, use proper lifting techniques.

- All work areas must be kept free of ground clutter.

- No flames, smoking, welding, or open fires will be permitted on site.

- Site personnel must immediately notify Halliburton NUS Health Sciences of all incidents for OSHA record keeping purposes.

- If personnel note any warning properties of chemicals (irritation, odors, symptoms, etc.) or even remotely suspect the occurrence of exposure, they must immediately notify the SSO for further direction.

- Site personnel are not to undertake any activity which would be considered a confined-space entry.

- A full-size copy of the OSHA poster included as Attachment D-IV of the HASP shall be conspicuously posted on site.

- Any new information must be promptly conveyed to the Project SSO and the Field Operations Leader.

- All compressed gas cylinders (empty or full) must be stored, secured, and used properly to protect them from damage.

d. Overview of Personnel Training Requirements

Consistent with OSHA's 29 CFR 1910/120 regulation covering Hazardous Waste Operations and Emergency Response, all site personnel are required to be trained in accordance with the standard. At a minimum, all personnel are required to be trained to recognize the hazards on site and the provisions of the Health and Safety Plan.

1) Preassignment and Annual Refresher Training

Prior to arrival on site, all employees will have met the requirements of preassignment training, consistent with OSHA 29 CFR 1910.120 paragraph (e) 3).

2) Site Supervisor Training

Consistent with OSHA 29 CFR 1910.120 paragraph (e) (8), individuals designated as site supervisors require an additional 8 hours of specialized training.

3) Training and Briefing Topics

The following will be discussed by a qualified individual at the site pre-entry briefing(s), as well as additional necessary site briefings.

Training

Chemical Hazards
Physical Hazards
Emergency Procedures
Site-Specific Hazards
UXO Hazards
Radiological Hazards

It is the responsibility of the Site Health and Safety Officer to ensure these requirements are met.

e. Overview of Emergency Response

In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. Emergency Response Planning will follow in accordance with 29 CFR 1910.38(a). Contractor shall notify the Fire Department, extension 743-4333 of any emergency.

1) Pre-Planning

Upon arrival at the base, the Halliburton NUS FOL/SSO will meet with the Base Fire Protection Department, Base Security, and Emergency Services to notify coordinators what activities are to be undertaken and where. All site personnel will be required to follow base emergency procedures and will rely on base services to handle emergency situations if encountered.

2) Emergency Escape Procedures and Assignments

Upon notification of a site emergency that requires evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind directions. If personnel cannot reach those locations without endangering their lives or their health, an alternate meeting place will be selected. Personnel will be trained to remain at the refuge location until directed to resume work, or to leave the site.

3) Procedure to Account for Site Personnel

The site work force will be small enough that accounting for personnel will not be a problem. Accounting for personnel will be the FOL's responsibility. This will be accomplished by taking a roll call using the site log book.

4) Rescue and Medical Duties

A physician-approved first aid kit, an ANSI-approved eye wash station, and a Class ABC fire extinguisher will be readily available on site. Site personnel will not be authorized to participate in emergency rescue operations.

5) Activation of Emergency Response Procedures

Should any emergency occur which requires the support of outside services, the appropriate contacts will be made by the FOL/SSO. A list of the appropriate contacts will be posted at the Command Post.

f. Location of MSDSs

The MSDSs for the materials being used will be located at the Command Post.

16.0 SECURITY

There are no special security requirements. This operation is unclassified, and normal security measures apply in accordance with references (e) and (i). Contractor personnel cannot get on the base without escort unless prior arrangements are made.

APPENDIX B

FORMS FOR FIELD INVESTIGATION
FOR
NAVAL SCHOOL, EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

- Soil Boring Log
- Monitoring Well Construction Form
- Groundwater-Level Measurement Form
- Hydraulic Conductivity Testing Data Sheet
- Monitoring Well Sample Log Sheet
- Soil Sample Log Sheet
- Surface Water Log Sheet
- Daily Activities Record
- Chain-of-Custody Form
- Equipment Calibration Log

PROJECT: ..... BORING NO.: .....

PROJECT NO.: ..... DATE: ..... DRILLER: .....

ELEVATION: ..... FIELD GEOLOGIST: .....

WATER LEVEL DATA : .....

(Date, Time & Conditions) .....

SAMPLE NO. & 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			BROKEN CORE SCRAPS	REMARKS
					SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		

REMARKS _____

_____

_____

BORING _____

PAGE ____ OF _____

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" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>¼"-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%(+)<¼"-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 ML)	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" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
	Identification procedures on fraction smaller than No 40 sieve size				
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & 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 & 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.

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. 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

12/18
▼ 12.6' Initial Level ~/Date & Depth

12/18
▼ 12.6' Stabilized Level ~/Date & Dept

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated 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 BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

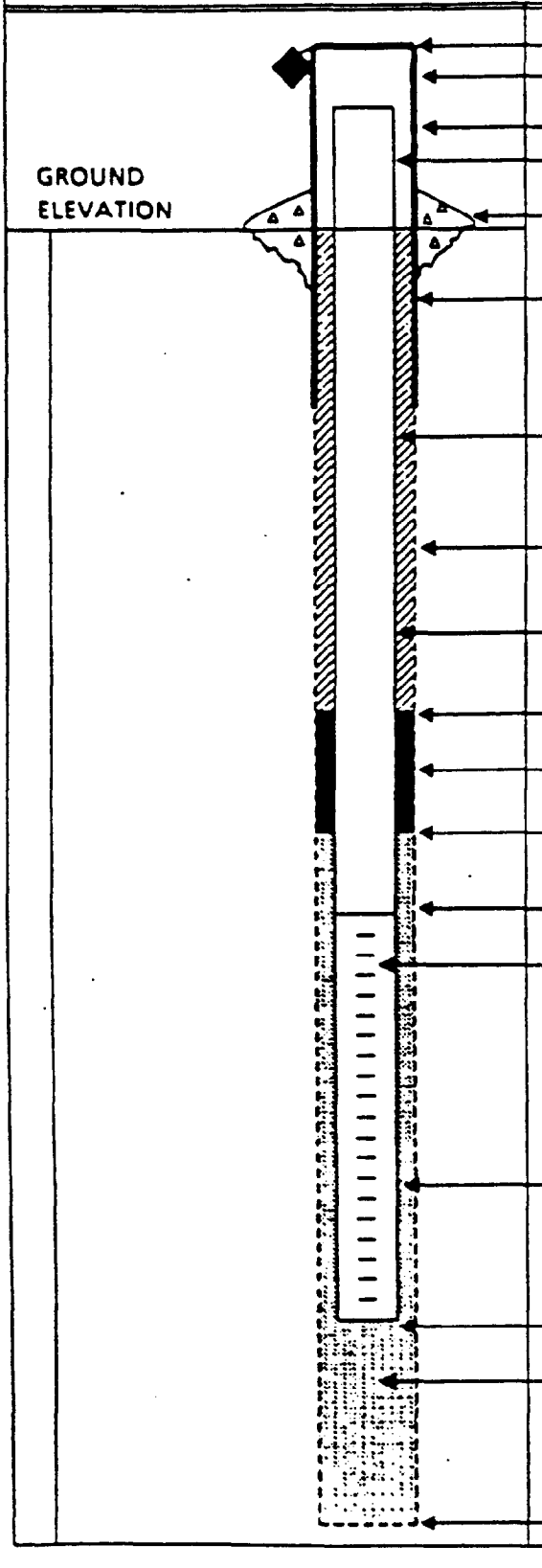
BORING NO. _____

HALLIBURTON NUS
Environmental Corporation

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: _____

GROUNDWATER LEVEL MEASUREMENT SHEET

Halliburton NUS

Project Name: _____ Location: _____
Project No.: _____ Weather Conditions: _____
Personnel: _____ Measuring Device: _____
Date: _____ Remarks: _____
Tidally Influenced: Yes _____ No _____

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Correction Factor	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* ALL MEASUREMENTS TO NEAREST 0.01 FOOT

ACAD: 1049\GW-LEVEL.DWG 3/18/91 MJJ

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — HALLIBURTON NUS CORPORATION

PROJECT NAME: ..... WELL/BORING NO.: .....

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

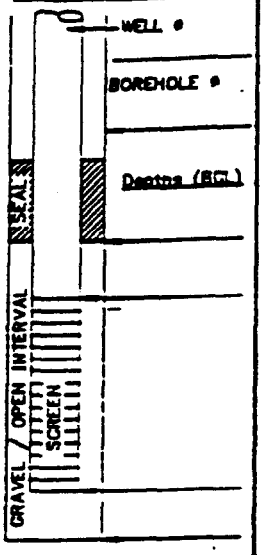
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

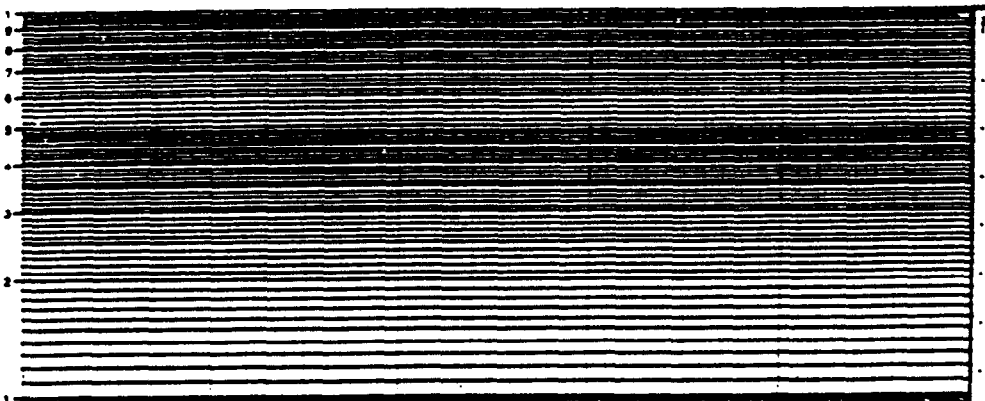
REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

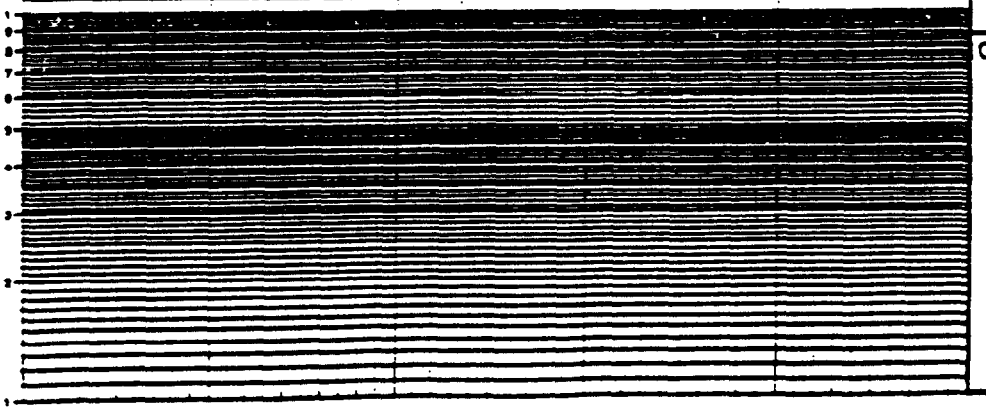
ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



▽ Indicate SWL Depth on Drawing





REMARKS:

CALCS, SKETCH MAPS, ETC.:

Halliburton NUS CORPORATION

SAMPLE LOG SHEET

- ☐ Monitoring Well Data
- ☐ Domestic Well Data
- ☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

	Purge Data				
Total Well Depth:					
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

Sample Date & Time:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):

Observations / Notes:

Type of Sample

- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET

PAGE____OF____

☐ SURFACE SOIL
☐ SUBSURFACE SOIL
☐ SEDIMENT
☐ LAGOON/POND
☐ OTHER

SAMPLERS SIGNATURE_____

SITE NAME_____

SITE NUMBER_____

SAMPLE No.	SAMPLE METHOD	DEPTH (FT)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G)GRAB (C)COMPOSITE	ANALYSES							No. OF CONT (TOTAL)	SOIL DESCRIPTION

REMARKS:

LAB:

ACAD: FORMS\LOG.DWG 2/11/93 MB

SAMPLE LOG SHEET

HALLIBURTON NUS
Environmental Corporation

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Depth Sampled:					
Sample Date & Time:					
	DO	Eh	SALINITY		
Sampled By:					
Signatures:					

Type of Sample

☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative	Bottle Req.

DAILY ACTIVITIES RECORD **HALLIBURTON NUS**

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

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
SAMPLERS (SIGNATURE):	

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

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:	

Order No. 7 (93)

HALLIBURTON NUS
Environmental Corporation

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): _____

Manufacturer _____ Date Purchased _____

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

APPENDIX C

STANDARD OPERATING PROCEDURES
FOR
NAVAL SCHOOL EXPLOSIVE ORDNANCE DISPOSAL
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

- GH-1-3, Section 5: Soil and Rock Sampling
- GH-1.5, Section 5: Borehold and Sample Logging
- GH-1.6, Section 5: Decontamination of Drilling Rigs and Monitoring Well Materials
- GH-1.7, Section 5: Groundwater Monitoring Point Installation
- GH-2.4, Section 5: In-Situ Hydraulic Conductivity Testing
- SA-1.1, Section 5: Groundwater Sample Acquisition
- SA-1.2, Section 5.4: Surface Water and Sediment Sampling
- SA-6.1, Section 5: Sample Identification and Chain-of-Custody
- SA-6.2, Section 5: Sampling Packaging and Shipping
- SA-6.3, Section 5: Site Logbook
- SF-1.1, Section 5: Onsite Water Quality Testing
- SF-1.2, Section 5: Sample Preservation
- SF-2.3, Section 5: Decontamination of Chemical Sampling and Field Analytical Equipment

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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- 5.3 WASTE PILE SAMPLES
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6.0 REFERENCES

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailigs, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchϕ-1/2 inchϕ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated 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
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts shall not be used unless specified by the project manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.

- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, siliceous, hematitic)

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to

provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG — **NUS CORPORATION**

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA : .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR ROD (%)	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	BLOWS/ 6" OR ROCK RECOVERY %	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

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" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>¼"	CLEAN GRAVELS Less % 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 Appr. % 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%(-)<¼"	CLEAN SANDS Less % 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 Appr. % fines	Non plastic fines (for identification procedures see ML)	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" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
	Identification procedures on fraction smaller than No. 40 sieve size				
	DRY STRENGTH (Crushing characteristics)	DILATANCY (Reaction to shaking)	TOUGHNESS (Consistency near Plastic Limit)		
SILTS & 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 & 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 dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated 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 BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(Ms.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. 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 - BQ (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
▼ 13.6' Stabilized Level w/Date & Depth

EXHIBIT 4-2

D334901

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-21-87 — DRILLER: B. GOLLIHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

	SAMPLE NO & TYPE/ RQD	DEPTH (FT) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) & SCREEN INT	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-1	0.0	3/6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
		1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
		5.0								
	S-2	6.0	11/100/.5	0.5/1.0	5.5/6.0	M. SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
						TO				REFUSAL @ 6' 5.5 TOP OF DEC ROCK
						M. HARD				
										AUGERED TO 15' W/SOLID STEM AUG.
										CUTTING MOIST @ 2-8' WATER @ 11'±
										WL @ 12.10 PM WAS ≈ 9' FROM GS.
										SET 4" PVC CAS. @ 15.0'
9-21		15.0								
9-22						M. HARD	BRN GRAY	SILTY SHALE - FEW	VBR	SEVERAL 0 PPM
								QUARTZ PCS		Fe STAINED JOINTS ON CORE THRUOUT RUN.
										JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/VUGS ON LOWER
	0.8/100	①	0.8/0	7.9/100						PORTION 23 TO 25 OF CORE
		25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT @ 30" DROP - TO TAKE 2" Φ SP SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A

PAGE 1 OF 3

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

	SAMPLE NO & TYPE / RQD	DEPTH (Ft.) / RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO 1.0 ± JNTS
								(SILTSTONE)		≈26 TO 27 2" VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 - 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS. WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1.0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE
PROJECT NO.: 619Y
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)
DATE: 9-22-87
FIELD GEOLOGIST: SJ CONTI
BORING NO.: MW 3A
DRILLER: B. GOLLHUE

SAMPLE NO & TYPE	DEPTH (Ft.)	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR W/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY W/ SOFT ZONES.
0/10	5	0%	1.8/10.0						
	65.0								
				66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	6	0%	1.5/10.0						
									POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE.
AT 1:50 PM. CORED HOLE TO 75' REAMED TWICE
DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED
2ND TIME TO 81'. SET WELL 66'-76'.

BORING MW 3A
PAGE 3 OF 3

* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO. 473 Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: S.J CONTI — PENN - DRILL
WATER LEVEL DATA (Date, Time & Conditions): 5.54' @ 9:50 AM 7-23-87 T-PVC — ACKER AD-II

SAMPLE NO. & TYPE OR RQD	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/ft) OR GRADIENT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU) (HEAD SP)
	0.0	5/3	1.4/1.5		LOOSE	BLK BRN	SLAKEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR. COAL FRAG.		3/4" Φ FRAG - NEAR OLD
							TR. CC FRAG		R.R. LINE.
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT - TR OFG TO	SM	MOIST TO WET (0PPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND @ 6'±
									INCREASING LOSS + NATURAL
									DRILLER NOTE H2O
	10.0								8-10'
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS. (GRAVEL)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/2	.9/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON FORD 8000 TRUCK

SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: S. ERVSON
ELEVATION: — FIELD GEOLOGIST: S.J. CONTI
WATER LEVEL DATA: (Date, Time & Conditions)

	SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	DESCRIPTION SOIL OR ROCK USCS	REMARKS (HNU)
	S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY S/ND - SOME	GM	WET OPPM
		26.5	30				GRAY	GRAVEL - TR CLAY		C.S.: IS FRIABLE FIRST CHANGE IN
								TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
										NOTE: MAY SET ZONE 2
7/7		30.0					MOTTLED			CASING @ 28'
7/8	S-7		17 / 27	1.4/1.5		V. DENSE	BRN BLUE GRAY	SILTY SAND - SOME GRAVEL	SM/GM	MOIST WET (OPPM)
		31.5	36					TR. SS. FRAG		CLASSIFICATION IS FROM GRAY & FRIABLE. SUBROUNDED GRAVEL
								TR CLAY		NOT HIGH CLAY - BUT MAY BE SEMI-CON-
		35.0								FINING.
	S-8	35.3	30 / 50/.1	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/GM	MOIST → WET (OPPM)
								SOME GRAVEL		V.SL. TR CLAY - LESS
								TR. SS. FRAG.		THAN S-7 1" D FRAG - MORE
										DENSE. SAND THAN ABOVE.
		40.0					BLUE			POSSIBLE 38 TO 45 SCREEN LOC. SQUEEZED
	S-9		31 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	HOLES WOULD NOT WHEN MOIST → WET (OPPM)
		41.5	24					SOME GRAVEL - TR	GM	LITTLE MORE CLAY THAN
								CLAY		S-8 SUBROUNDED GRAVEL
										VERY SLOW DRILLING 40-45 (RIG STALLS)
		45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
	S-10		13 / 34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	MOIST → WET (OPPM)
		46.5	50					SOME GRAVEL - TR	GM	1" D SIZE - HOLDS TO - GETHER WHEN SQUEEZED
								CLAY		BUT NOT COHESIVE CLASS-IFICATION
										SLOW DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 @

BORING MW013

PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473Y — DATE: 7-8-87 — DRILLER: B. ERICSSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA: (Date, Time & Conditions)

	SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGES (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY, CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15 41	1.9/1.3		V. DENSE	MOTTLED BLUE GRAY	SILTY SAND - SOME GR.	GM	MOIST - (OPPM)
		51.3	50/.3					TR CLAY	SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE
										MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11 15 26	1.4/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (OPPM)
		56.5						SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE SUB-ROUNDED GRAINS
										FIRST COHESIVE TYPE CLASSIF.
		60.0	90							
	S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SOME	SC / GW	MOIST → WET (OPPM)
								GRAVEL		NOT AS TACKY CLAY AS S-12 BUT VERY COHESIVE. SUBROUNDED GRAINS
										SET CAS. @ 66'.
		65.0								
7/13	S-14	65.8	37 50/.3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR.	SM / GW	MOIST (OPPM)
								AND ROCK FRAG -		MORE CLAY TOWARDS TOP OF SAMPLE
					68.0			TR. CLAY		MAX 3/4" Ø SIZE
							YELLOW BRN			COLOR CHANGE AT ≈ 68' MORE SAND PER
		70.0								DRILLER - BOTH OF SEMI CONF LAYER ?
7/14	S-15		39 39 41	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME	SC / GC	MOIST → WET (OPPM)
		71.5						GRAVEL - TR		1" MAX GRAVEL
								ROCK FRAG.		MORE GRAVEL @ 72' PER DRILLER

REMARKS: USING HOLLOW STEM TO ADVANCE BORING - WASHING OUT THRU AUGERS, UNITED DRILLED TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Ø STEEL CASING TO 66' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:00 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW 013
PAGE 3 OF 4

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved D. Senovich	

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1.0 PURPOSE

2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

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- 5.2 WELL DESIGN
- 5.2.1 Well Depth, Diameter, and Monitored Interval
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- 5.3 MONITORING WELL INSTALLATION
- 5.3.1 Monitoring Wells in Unconsolidated Sediments
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- 5.3.3 Bedrock Monitoring Wells
- 5.3.4 Drive Points
- 5.3.5 Innovative Monitoring Well Installation Techniques
- 5.4 WELL DEVELOPMENT METHODS

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of

contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells.in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation;-risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. this system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon●
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton●*	Silicone	Neoprene	Teflon●*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon●
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton●
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
Source: Barcelona et al., 1983
* Trademark of DuPont

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

* See also Attachment A.

ATTACHMENT C

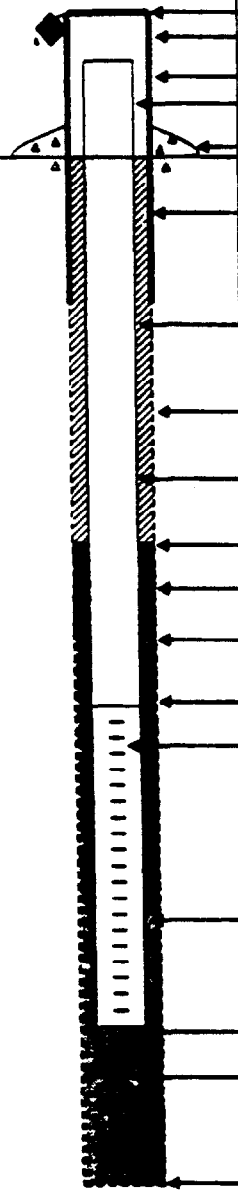
NUS CORPORATION
A Halliburton Company

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
PAGE TWO

NUS CORPORATION

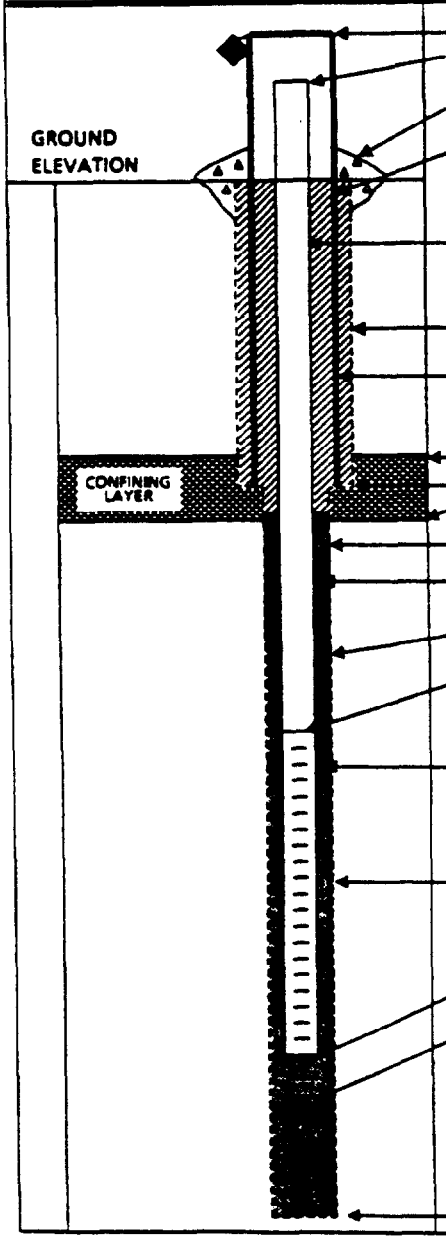
BORING NO.: _____

CONFINING LAYER MONITORING WELL SHEET

11/5/87

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF PERM. 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: _____

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: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE THREE

NUS CORPORATION
A Halliburton Company

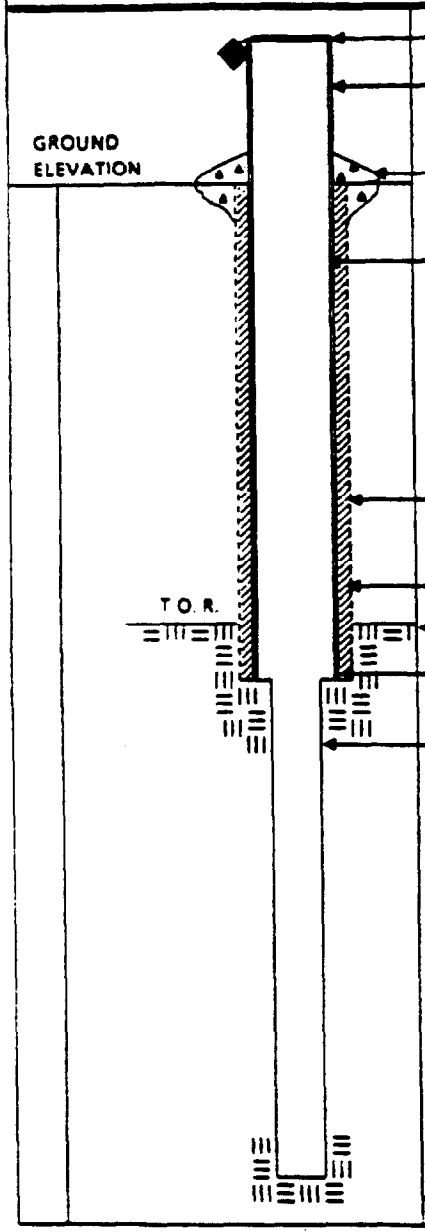
BORING NO.: _____

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: _____

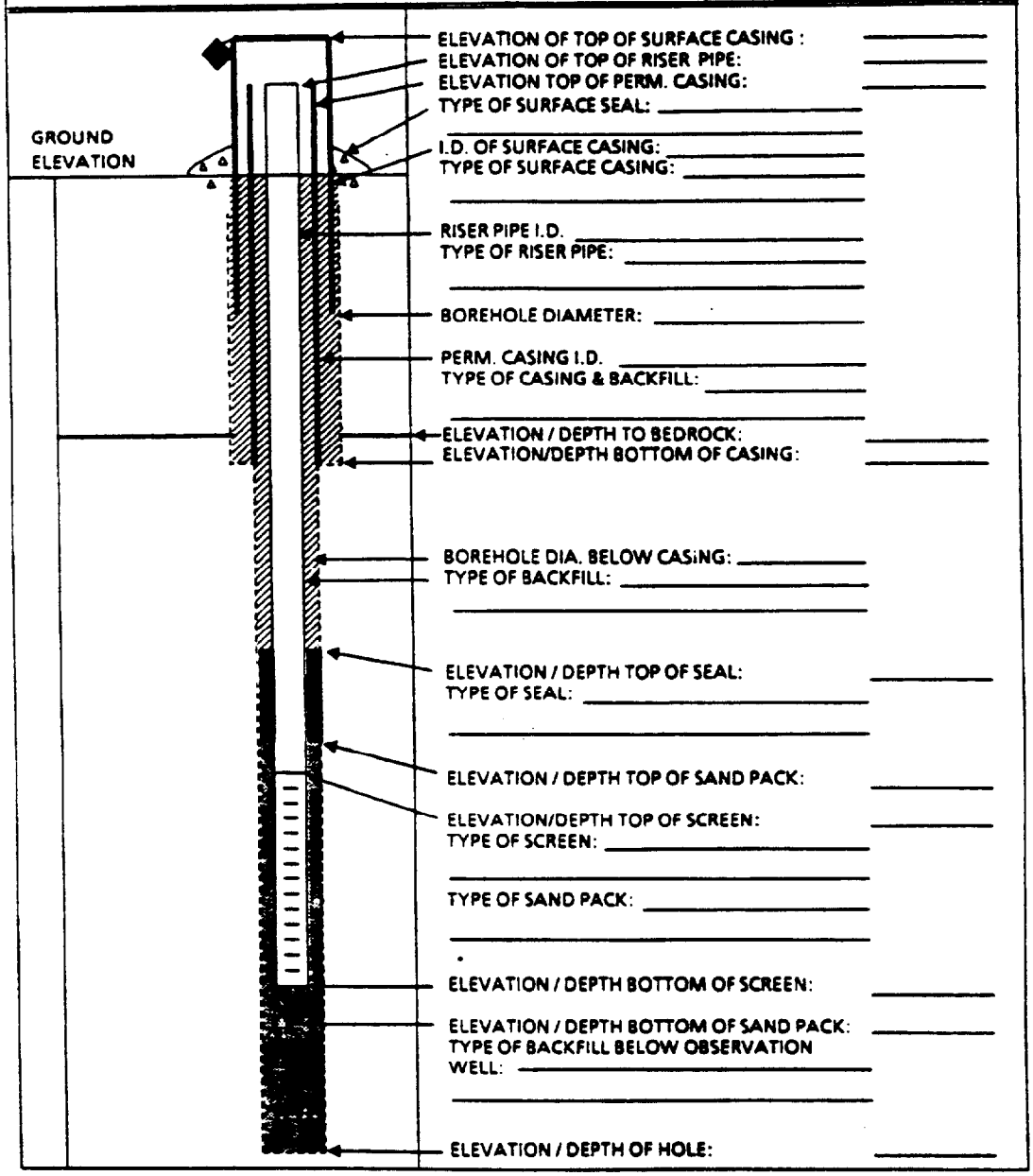
ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ATTACHMENT C
PAGE FIVE

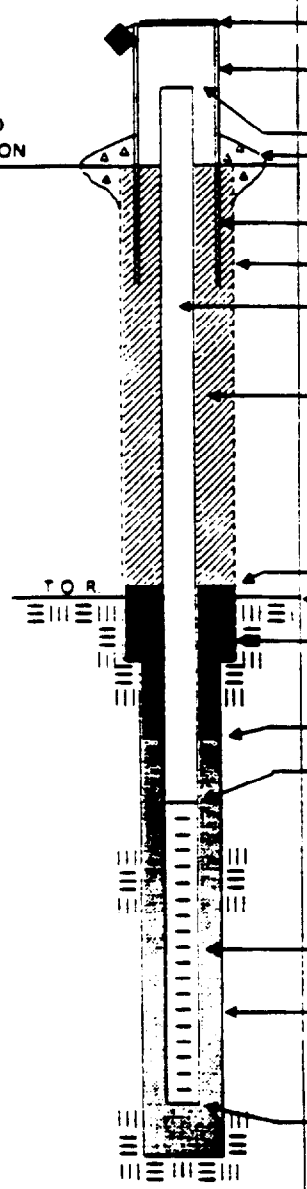
NUS CORPORATION
A Halliburton Company

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 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: _____

TABLE OF CONTENTS

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1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly describe :

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies required and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system, which might raise doubts regarding the representativeness of future groundwater samples. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow

recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape, coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate

of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 DATA ANALYSIS

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) may be used as the

screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A*. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

* If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
HYDRUALIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO.: .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

- Sample preservation requirements.

- Working schedule.

- List of team members.

- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer).

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

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7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					
Signature(s):	Observations / Notes:				

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-inch								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
2-inch								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
4-inch								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
6-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
8-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors available; must be primed
Geitek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive displacement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	999	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thickness of "floating" contaminants
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas; piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	portable, peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selected, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton® acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; optional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tole Devices Co.	Sampling Pump	portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials Abbreviations

PE Polyethylene
PP Polypropylene
PVC Polyvinyl Chloride
SS Stainless Steel
PC Polycarbonate
EPDM Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA Not Applicable
AC Alternating Current
DC Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

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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 on-site examination and chemical testing or for 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 5.4), 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 - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

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 quality 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 scrutiny and quality control applied during laboratory analyses, 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; flow, mixing and other physical characteristics of the water body; 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 an adsorption/desorption). The hydrologist 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 in 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: (a) overland runoff; (b) leachate influx to the waterbody; (c) 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 be absorbed by particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples will 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 description 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 will 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 hydrologist 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 work plan. 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, 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 work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on 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 multipoint 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 water course 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 river's transports. The greater 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.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have as 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. 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 multiparameter 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 fresh waters (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:

- 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 required. The most frequently used samplers are:

- Open tube
- Dip sampler
- Hand pump
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for:

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

as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

5.3.4.1 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.

5.3.4.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample 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 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 sampler 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. The bottle can be used as the sample container (as long as original bottle is an approved container).

5.3.4.3 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 to allow free passage of water through the cylinder. "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 0.6 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.

- 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. 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 is combined into one sample, or several grids are selected at random.

- Care should be taken to avoid excessive agitation of the water that results in the loss of volatile constituents.

- When ob[illegible]ing samples in 40 ml septum vials for volatile organics, analysis, it is important to exclu[illegible] air space in the top of the bottle and to be sure that the Teflon liner faces in after the [illegible]s filled and capped. The bottle 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 month of the bottle facing upstream.

5.4 SEDIMENT SAMPLING

5.4.1 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 site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center 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 (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (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). It is therefore important to minimize the loss of low-density "fines" during any sampling process.

5.4.2 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 on-shore or off-shore techniques.

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

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

5.4.2.1 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 "cleanest" 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 in the sample 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.

5.4.2.2 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 materials 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 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. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

6.0 REFERENCES

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

U.S. EPA, 1980. Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

7.0 ATTACHMENTS

None.

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1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project**: EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location**: The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date**: A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time**: A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium**: Water, soil, sediment, sludge, waste, etc.

- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.

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

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

	PROJECT NAME					NO. OF CON-TAINERS							REMARKS
SAMPLERS: *(Signature)*													
STA. NO.	DATE	TIME	COMP.	GRAB	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
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II
(Original is 8 by 10-1/2)

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08837

Name of Unit and Address		
Sample Number	Number of Containers	Description of Samples

Person Assuming Responsibility for Samples	Time	Date

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME					NO. OF CONTAINERS							REMARKS
SAMPLERS: (Signature)													
STA. NO.	DATE	TIME	COMP.	GRAB	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	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

D334901

ATTACHMENT D
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV
(Original is 8-1/2 by 14)

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION 4

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ. NO.	PROJECT NAME
SAMPLERS (Signature)	

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Water/Wastewater	Soil/Sed	Solid/Waste	Misc.	REMARKS/TAG NUMBERS

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

DISTRIBUTION: Original and Pink copies accompany sample shipment to laboratory. Pink copy returned by laboratory. Yellow copy retained by samplers. Blue copy extra copy as needed

№ 4 3526

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ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT F
SAMPLE IDENTIFICATION TAG

☆ GPO 805-882

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No.	Lab Sample No.
3 60966	

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

CUSTODY SEAL

Date

Signature

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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	S O	CONTAINER NUMBERS	PVC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-[illegible]	C	1	✓	
1	55 gal	450 lbs	x	Flammable liquid, n.o.s.	Flammable Liquid	55-[illegible]	—	2		✓
1	55 gal	250 lbs	x	Flammable liquid, n.o.s.	Flammable liquid	55-[illegible]	B	3	✓	
1	15-A	12 lbs.	x	Bromine	Corrosive Material	55-[illegible]	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd _____

Shipment Date _____ Manifest No _____

Shipper Work Order _____

Service Order No _____

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. 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 notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. 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 must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are 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 may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

NUS	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 offsite, gate locked.

_____
Field Operations Leader

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1.0 PURPOSE

This procedure describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements

2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 GLOSSARY

3.1 pH MEASUREMENT

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

5.0 GUIDELINES

5.1 MEASUREMENT OF pH

5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse the electrode(s) with deionized water.

l. Keep the electrode(s) immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

2. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.

- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.

- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.

- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendence of organic or inorganic compounds to exist in an oxidized state. The technique therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.

- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.

- Thoroughly rinse the electrode with demineralized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

Temperature (°C)	Specific Conductance (µmhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

[1] Data derived from the International Critical Tables 1-3-8.

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008

ATTACHMENT B
VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY
PAGE TWO

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concenration (and therefore used to correct measured D.O. concentration) using Attachment A.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SF-1.2	Page 1 of 10
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		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE PRESERVATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4- Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. EPA-EMSL, Cincinnati, Ohio.

7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

ATTACHMENT A
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

FT-7.06
REVISION 0

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	Extractables Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	Metals Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	Cyanide Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H_2SO_4 to pH <2	28 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 l	H_2SO_4 to pH <2	28 days
Phenols	--	h.d. polyethylene	1.0 l	H_2SO_4 to pH <2	28 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
SOIL					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	Extractables Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
Air					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 1

Parameter No./Name	Container(1)	Preservation(2,3)	Maximum Holding Time(4)
INORGANIC TESTS:			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid(5)	14 days(6)
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
METALS:(7)			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO_3 to pH 2	6 months

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 2

Parameter No./Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] HCl to pH 2[9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5[10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
Benzidines[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate Esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines[11,14]	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PCBs[11] Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PESTICIDES TESTS:			
Pesticides[11]	G, Teflon-lined cap	Cool, 4°C, pH 5-9[15]	7 days until extraction, 40 days after extraction
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4° until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid factions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

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* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

** If sampling for pesticides, PCBs, or fuels.

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2 FIELD ANALYTICAL EQUIPMENT

5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.

TNT EXPLOSIVES TEST KIT INSTRUCTION GUIDE

TK-1004-1
800-222-0342

IMPORTANT

Read all instructions and handling procedures before using this kit. For assistance call the TECHNICAL SERVICE HOT LINE 1-800-222-0342.

INTENDED USE

The D TECH™ TNT on-site and laboratory test kit is designed to provide quick, semiquantitative, and reliable test results for making environmental decisions.
The D TECH TNT Explosives Test Kit can be used on-site for identifying "hot spots", site mapping, monitoring of remediation processes and selecting site samples for laboratory analysis.
In the laboratory, the D TECH TNT Explosives Test can screen highly contaminated samples that require pre-dilution prior to instrumental analysis.

PRINCIPLE

The D TECH system for analyzing trace amounts of explosives is based on immunoassay technology.
An antibody specific for TNT and closely related compounds has been linked to solid particles which are collected on the membrane of the cup assembly.
A color developing solution added to the surface of the cup assembly develops a color inversely proportional to the concentration of TNT Equivalents in the sample (less color indicates more TNT present in sample).
TNT Equivalents are measured at parts per million (ppm) in soil and parts per billion (ppb) in water samples.

TEST KIT DESCRIPTION

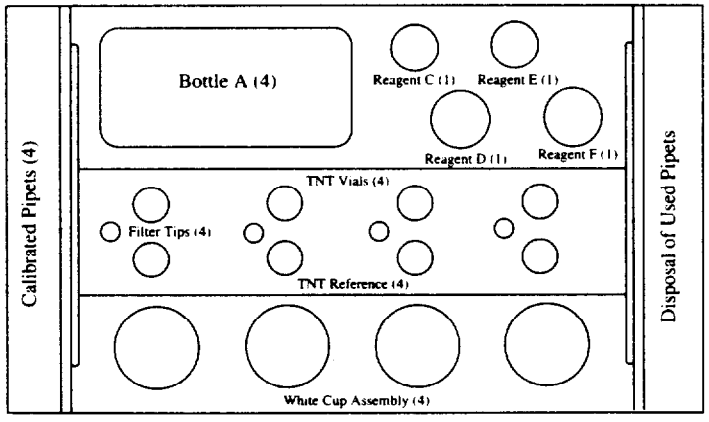
The D TECH TNT Explosives Test Kit, Item #TK-1004-1, contains sufficient materials to perform four tests.
This kit can test water samples or be used with the D TECH TNT/RDX Soil Extraction Pac, Item #TK-1001S-1, to test soil samples.
The TNT/RDX Soil Extraction Pac contains only the materials needed to extract TNT from soil for semi-quantitation with this D TECH TNT Explosives Test Kit. The results can be obtained by using the enclosed Color Card or the DTECHTOR Meter, Item #TK-1001M-1.

STORAGE AND STABILITY

This kit has excellent stability at room temperature and under refrigeration. For expiration datin under these conditions, see the package label.

MATERIALS PROVIDED

See tray diagram below. This diagram includes the kit component names and quantity of each item.



Not shown in diagram

Used Kit Label (1)

Instruction Guide (1)

Color Card (1)

Data Labels (4) for Cup Assembly

Red Dot Labels (4) for identifying used Bottle A components

ACCESSORIES SUPPLIED BY USER

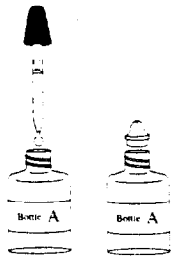
Timing Device (minutes)
D TECH TNT/RDX Soil Extraction Pac, Item #TK-1001S-1 (if testing soil samples)
the DTECHTOR Meter, Item #TK-1001M-1 (optional)

This package is designed to serve as a WORK STATION. At the conclusion of the test, the components can be left in the package for proper disposal.
Important: Read all Health/Safety Comments on page 4 prior to use.

Step 1: Choose corresponding sample source to determine the first step.

WATER SAMPLE: Using a new calibrated pipet, transfer **1 ml** of sample to **Bottle A**. Snap filter tip on **Bottle A**. Gently mix.

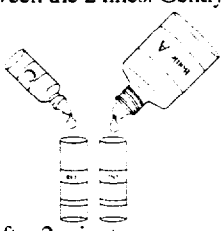
SOIL SAMPLE: Using a new calibrated pipet, transfer **1 ml** of **Bottle 2** solution from D TECH TNT/RDX Soil Extraction Pac, (Item #TK-1001S-1) to **Bottle A**; snap filter tip on **Bottle A**. Gently mix. Re-cap **Bottle 2** and set aside.



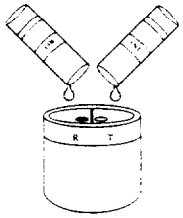
Note: The vials in the next two steps need to stand 2 minutes after dispensing the liquid. The solutions in these vials will remain hazy.

Step 2: Squeeze **Bottle A** filling the **TNT Vial** to a level between the two lines (approximately 13-14 drops). Gently mix.

Step 3: Squeeze the contents of **Reagent C** (white cap) to fill the **TNT Reference** vial to a level between the 2 lines. Gently mix.

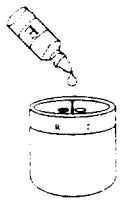


Step 4: After 2 minutes, pour contents of **TNT Vial** onto the **T** (test) side of the cup assembly. Pour the contents of the **Reference** vial onto the **R** side of the cup assembly. Allow liquid to drain completely through on both sides.

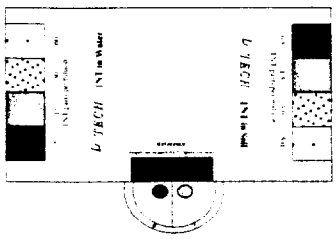


Step 5: Add approximately 8-12 drops of **Reagent D** solution (yellow cap) into each side of the cup assembly. Drain completely.

Step 6: Add approximately 5 drops of **Reagent E** solution (blue cap) to each side of the cup assembly. Be sure to add this solution immediately to the second well after addition to the first well. Drain completely.



Step 7: Read results when color of **R** (left) side of cup assembly matches the color of the reference bar of the **Color Card**. (The color development time is approximately 10 minutes at 70°F. More time is required at lower temperatures and less time is required at higher temperatures.)



COLOR CARD: Match the color on the **T** side of the cup assembly to the **Color Card**.
and/or
the DTECHTOR: Quantitate the result using *the* DTECHTOR Meter (see Instrument Operator's Guide for complete instructions).

See Interpretation of the Test section (page 3) to determine concentration of TNT Equivalents. Record result on a **Cup Assembly** label and apply to the cup.

*Note: To preserve the color for up to 4 hours (optional), add approximately 8 drops of **Reagent F** solution (red cap) into each side of the cup assembly. Drain completely.*

the DTECHTOR Meter Set Up

the DTECHTOR light sources must be calibrated whenever the meter is turned on. Calibrators are provided with the meter for this purpose. The **Calibrator** must be clean and white to insure valid results.

Step 1: Insert **Calibrator** into the **Meter Head** and hold firmly in place. (ZERO)

Step 2: Press the Square Button 1 time. When calibration is complete the meter will display..... (SET)

Step 3: Remove **Calibrator** and return it to its protective cannister. Display remains..... (SET)

Step 4: Press the Square Button 1 time to select meter program #1 (Program to be used for this D TECH test kit). (SET #1)

Step 5: Insert Cup Assembly (test) into the Meter Head and firmly hold in place. (TEST #1)

Note: The #1 in the upper right corner of the display window in Steps 4 & 5 corresponds to the meter program number being used to obtain the meter reading.

Step 6: Press the Square Button 1 time. (- - -)

Note: If the meter displays "WAIT", remove Cup Assembly. Allow reference color to develop further and try again.

Obtain the meter reading. For example..... (46%)
Use *the* DTECHTOR Table (see page 3) and the meter reading to determine the concentration of TNT.

Step 7: Record result then press Square Button 1 time while holding the **Cup Assembly** in place. (- - - -)

Step 8: Key in 4 digit Label. (Optional)

Step 9: Remove **Cup Assembly**. (SET #1)

Step 10: Insert next **Cup Assembly** (test) and repeat Steps 5 - 9.

PERFORMANCE CHARACTERISTICS

INTERPRETATION OF THE TEST The results from the D TECH TNT Explosives Test Kit can be interpreted using either the **Color Card** supplied with the kit or *the* DTECHTOR and the table provided below. If the color of the test does not exactly match a panel of the color card, user interpretation is required.

the DTECHTOR Table

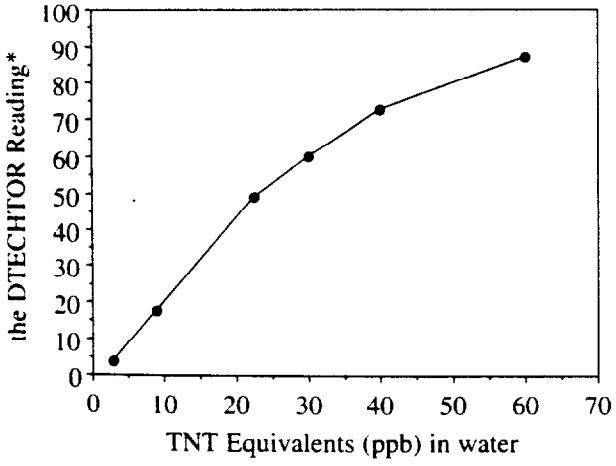
Sample	*the* DTECHTOR Reading	TNT Equivalents (ppb)
Water	LO	< 5
	1 - 30	5 - 15
	30 - 50	15 - 25
	50 - 75	25 - 45
	HI	> 45
		(ppm)
Soil	LO	<0.5
	1 - 15	0.5 - 1.5
	15 - 45	1.5 - 3.0
	45 - 60	3.0 - 4.0
	60 - 75	4.0 - 5.0
	HI	>5.0

SENSITIVITY The D TECH TNT Explosives Test Kit can be used to reliably measure TNT in the following ranges:

Sample	*the* DTECHTOR	Color Card
Water (ppb)	5 - 45	5 - 60
Soil (ppm)	0.5 - 5.0	0.5 - 5.0

The Minimum Detection Limit (MDL) of the test for TNT in a water sample is 5 ppb and in soil is 0.5 ppm. The graph below is a typical standard curve for the D TECH TNT Explosives Test Kit.

D TECH TNT Explosives
Test Kit Standard Curve



*Percent Reflectance Relative to Reference

SPECIFICITY The D TECH TNT Explosives Test Kit has been tested for cross-reactivity with analogues and degradation products of TNT and other explosives. The table below summarizes the cross-reactivity of these compounds in water samples using *the* DTECHTOR. A positive test result may be due to the presence of TNT, cross-reactants or mixtures of compounds (TNT Equivalents). Samples testing positive for TNT should be confirmed by standard methods. The D TECH TNT Explosives Test Kit has been designed to minimize the effect of environmental interferences. Sample pH, nitrate, nitrite and ammonium do not effect test results.

Compound	IC_{50}[a] (ppb)	MDL[b] (ppb)	Cross-reactivity[c]
TNT (2,4,6-trinitrotoluene)	22	5	NA
Tetryl[d]	65	15	+
1,3,5-trinitrobenzene	96	20	+
2-amino-4,6-dinitrotoluene	200	30	+
2,4-dinitrotoluene	>500	120	+
4-amino-2,6-dinitrotoluene	>500	>500	-
2,6-dinitrotoluene	>500	>500	-
2,6-diaminonitrotoluene	>500	>500	-
2-nitrophenol	>500	>500	-
4-nitrophenol	>500	>500	-
2,4-dinitrophenol	>500	>500	-
RDX[d]	>500	>500	-
HMX[d]	>500	>500	-

a The IC_{50} is defined as the concentration of compound required to produce a test response equivalent to 50% of the maximum response.

b The Minimum Detection Limit (MDL) is defined as the lowest concentration of compound that yields a positive test result.

c A compound is considered cross-reactive when a concentration 100 times the MDL of TNT (500 ppb) yields a positive test result.

d Chemical Names: Tetryl (methyl-2,4,6-trinitrophenyl-nitramine), RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)

NA - Not Applicable

TESTING HIGHER TNT CONCENTRATIONS

TNT concentrations greater than the upper limit of the test may be determined by diluting the extract with acetone. For example, an extract from a 100 ppm soil sample, processed using the D TECHTNT/RDX Soil Extraction Pac, may be diluted 1:25 in acetone and run in the D TECH TNT Explosives Test Kit. The concentration of the undiluted sample (100 ppm) is determined by multiplying the TNT concentration of the diluted sample (4.0 ppm) by the dilution factor (25). For further information, please call our technical service hotline 1-800-222-0342

HEALTH/SAFETY

Material Safety Data Sheets (MSDS) have been supplied with the purchase of this product. The MSDS should be read before using this test. During the execution of the test, any excess TNT is absorbed into the **Cup Assembly** absorbant plug. It is not retained on the surface of the **Cup Assembly**.
In this section we have emphasized health and safety precautions that should be followed when handling these solutions.

PROTECT EYES WITH SAFETY GLASSES
PROTECT SKIN WITH PROTECTIVE GLOVES

Associated Hazards
May be irritating to skin, eyes, and mucous membranes.

Symptoms of Exposure
May be irritating on contact with skin, eyes, and mucous membranes.

First Aid Measures
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE

Skin:	Wash thoroughly with soap and water.
Eyes:	Immediately flush with water for at least 15 minutes.
Inhalation:	Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion:	Get immediate medical attention; if conscious, give water freely.

QUALITY CONTROL

All D TECH Test Kits are thoroughly quality controlled and manufactured at Strategic Diagnostics Incorporated's GMP facility. All products undergo extensive validation and field testing to assure accuracy and reliability.
All lots of product are thoroughly quality controlled to consistently meet the published specification.

GENERAL LIMITED WARRANTY All EM SCIENCE products are warranted to meet the specifications set forth on their label only. All other warranties, expressed or implied, including the warranties of MERCHANTABILITY AND FITNESS OF USE, are excluded. Any change or modification of an EM SCIENCE product or of its prescribed procedure for use may adversely affect its stated specification.

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Prices and specifications are subject to change without notice. We reserve the right to discontinue items without prior notice.

EM SCIENCE/Strategic Diagnostics Inc.
480 Democrat Road
P.O. Box 70
Gibbstown, N.J. 08027
(800) 222-0342

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IMPORTANT

Read all instructions and handling procedures before using this kit. For assistance call the TECHNICAL SERVICE HOT LINE 1-800-222-0342.

INTENDED USE

The D TECH™ TNT/RDX Soil Extraction Pac is designed to extract TNT and RDX from soil samples. This extract is analyzed using the D TECH TNT Explosives Test Kit (Item #TK-1004-1), the D TECH TNT/ RDX Screening Kit (Item #TK1001-1), or the D TECH RDX Explosives Test Kit (Item #TK-1005-1).

PRINCIPLE

Trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) are explosives commonly found in munitions. The presence of these compounds in soil is an indication of contamination from explosive waste residue. TNT and RDX physically bind to soil particles and must be extracted to be analyzed.

The D TECH TNT/RDX Soil Extraction Pac uses an organic solvent to extract these compounds for analysis. Following this step, the extracted compounds in the solvent are further prepared for analysis by an aqueous dilution. This enables the sample to be tested with the D TECH™ TNT Explosives Test Kit, (Item #TK-1004-1), the D TECH TNT/RDX Screening Kit (Item #TK1001-1), or the D TECH RDX Explosives Test Kit (Item #TK-1005-1).

KIT DESCRIPTION

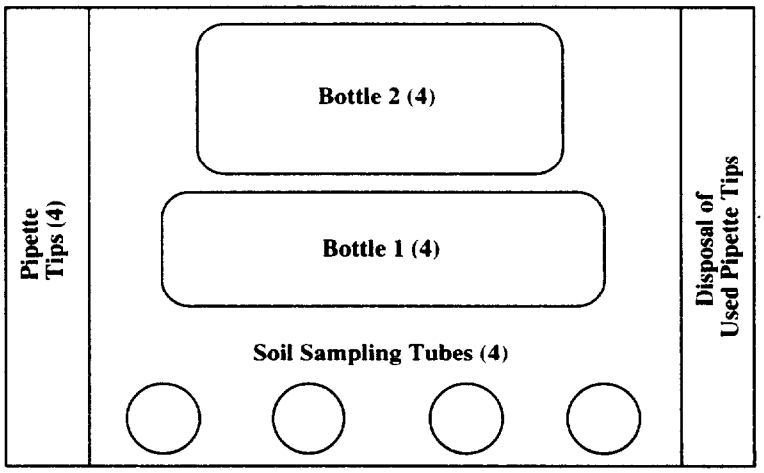
The D TECH TNT/RDX Soil Extraction Pac contains sufficient materials to perform four (4) sample extractions.

STORAGE AND STABILITY

This kit has excellent stability at room temperature and under refrigeration. For expiration dating under these conditions, see the package label.

MATERIALS PROVIDED

See tray diagram below. This diagram includes the D TECH TNT/RDX Soil Extraction Pac component names and quantity of each item.



Not shown in diagram

Used Kit Label (1)

Instruction Guide (1)

Red dot labels (4) for used Bottle 2 components.

HEALTH/SAFETY

Material Safety Data Sheets (MSDS) have been supplied with the purchase of this product. The MSDS should be read before using this test.
Included in this section, we have emphasized health and safety precautions that should be followed when handling these solutions.

PROTECT EYES WITH SAFETY GLASSES
PROTECT SKIN WITH PROTECTIVE GLOVES

Bottle 1 (50664) 100% ACETONE

Associated Hazards
Extremely Flammable Liquid and Vapor (NO SMOKING OR OPEN FLAME)
Harmful if Inhaled or Swallowed
Causes Eye Irritation

May cause damage to the central nervous system, liver, and kidneys. Chronic exposure during pregnancy may be harmful.

Symptoms of Exposure
High concentrations or prolonged exposure causes headache, dizziness, nausea, irritation of eyes and respiratory tract, narcosis and eventually unconsciousness.
Prolonged or repeated skin contact may cause irritation.

First Aid Measures
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE

Skin:	Wash thoroughly with soap and water.
Eyes:	Immediately flush with water for at least 15 minutes.
Inhalation:	Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion:	If conscious, drink water and induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

Bottle 2 (50663) Buffer Solution

Associated Hazards
May be irritating to skin, eyes and mucous membranes.

Symptoms of Exposure
May be irritating on contact with skin, eyes or mucous membranes.

First Aid Measures
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE

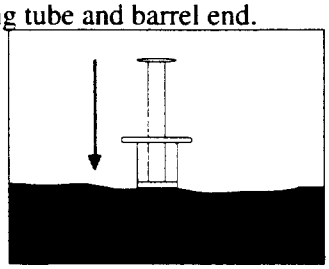
Skin:	Wash thoroughly with soap and water.
Eyes:	Immediately flush with water for at least 15 minutes.
Inhalation:	Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion:	Get immediate medical attention; if conscious, give water freely.

This package is designed to serve as a WORK STATION. At the conclusion of the test, the components can be left in the package for proper disposal.

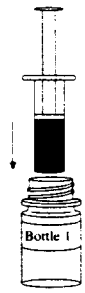
TEST PROCEDURE

Sampling

Step 1: Break up the soil so that it is a **uniform** sample. See Sample Preparation Information (page 4) for further instructions. Draw back the **Soil Sampling Tube** plunger until it stops. Push the **Soil Sampling Tube** into the soil several times with a twisting action to firmly pack and fill the tube. Remove excess soil from external surface of the sampling tube and barrel end.



Step 2: Dispense the soil into **Bottle 1** by positioning the barrel into the neck of the bottle and firmly pushing the plunger. If soil lodges in the neck of the bottle, use the sampling tube to push it into the bottle. If soil adheres to the threads of the bottle neck and cap, wipe clean before placing cap on bottle. Cap bottle tightly.



Extraction From Soil

Step 3: Mix the soil and liquid in **Bottle 1** by **shaking** continuously over a **3 minute period**.

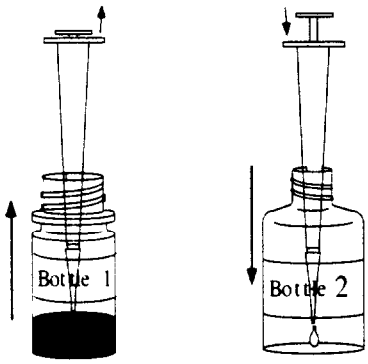
Step 4: Allow the soil to settle until a clear, liquid layer forms. Some soils will settle more slowly than others.

Diluting the Extraction Solution

Step 5: Remove cap from **Bottle 2**.

Step 6: Place an unused tip on the pipetter.

Step 7: Fully depress the plunger of the pipetter. With the plunger fully depressed, place the pipette tip into the clear, liquid layer and slowly release the plunger. Take care not to aspirate any soil.



Step 8: Dispense the contents of the pipette tip into **Bottle 2** by placing the pipette tip into the liquid and depressing the plunger. Mix **Bottle 2** thoroughly. Replace the cap tightly on **Bottle 1** and return it to the tray. Place the used pipette tip in the right side tray compartment.

Step 9: Use **Bottle 2** as a sample in Step 1 under **Test Procedure** for analysis in the D TECH TNT Explosives Test Kit (Item # TK-1004-1), the D TECH TNT/RDX Screening Kit (Item # TK1001-1), or the D TECH RDX Explosives Test Kit (Item # TK-1005-1). If the last extraction has been performed, place the "Used Kit" label on Soil Extraction Pac box to seal it shut.

Helpful Hint: Cap **Bottle 2** tightly and return it to the tray. Red dot labels have been provided to indicate used Bottle 2 components.

SAMPLE PREPARATION INFORMATION

To achieve a more homogeneous distribution and to insure reproducible test results, the soil sample should be mixed thoroughly. Remove all debris, such as sticks, stones and leaves, prior to using the D TECH **Soil Sampling Tube**. Sandy soil may require a scooping action to fill the tube. Squeezing the barrel of the Soil Sampling Tube will help to expel a tightly packed sample. Extraction of TNT and RDX is more effective if the soil plug is broken into sections during the addition to Bottle 1.

Acetone has been proven to be an efficient TNT and RDX extractant. Due to the volatile nature of acetone, bottles should be kept capped to minimize evaporation.

VOLUME SAMPLING TECHNIQUE

The D TECH TNT/RDX Soil Extraction Pac measures sample size using an efficient and economical volumetric technique. As with weight-based measurements, volumetric measurements of soils in field testing applications are not absolute and are subject to the influence of moisture content, organic matter content, soil type, etc. Variation in sample size can be minimized by insuring the **Soil Sampling Tube** is evenly filled. The sample size of the D TECH **Soil Sampling Tube** is 3 cubic centimeters, which is equivalent to an average of 4.5 grams of dry soil.

QUALITY CONTROL

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IMPORTANT

Read all instructions and handling procedures before using this kit. For assistance call the TECHNICAL SERVICE HOT LINE 1-800-222-0342.

INTENDED USE

The D TECH™ RDX on-site and laboratory test kit is designed to provide quick, semiquantitative, and reliable test results for making environmental decisions.
The D TECH RDX Explosives Test Kit can be used on-site for identifying "hot spots", site mapping, monitoring of remediation processes and selecting site samples for laboratory analysis.
In the laboratory, the D TECH RDX Explosives Test can screen highly contaminated samples that require pre-dilution prior to instrumental analysis.

PRINCIPLE

The D TECH system for analyzing trace amounts of explosives is based on immunoassay technology.
An antibody specific for RDX compounds has been linked to solid particles which are collected on the membrane of the cup assembly.
A color developing solution added to the surface of the cup assembly develops a color inversely proportional to the concentration of RDX Equivalents in the sample (less color indicates more RDX present in sample).
RDX Equivalents are measured at parts per million (ppm) in soil and parts per billion (ppb) in water samples.

TEST KIT DESCRIPTION

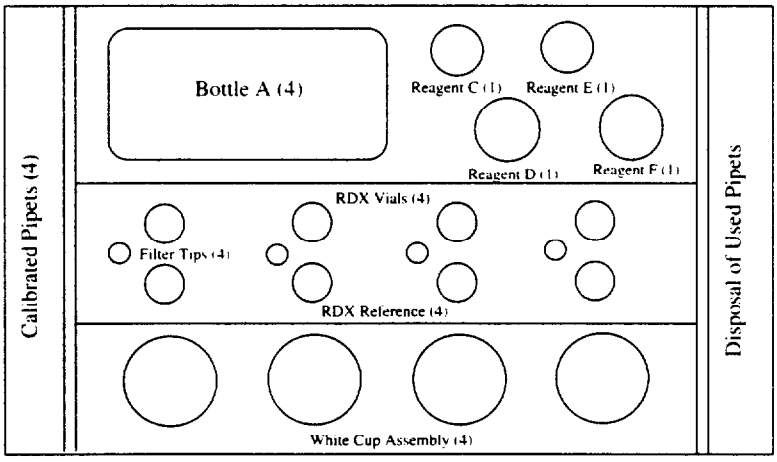
The D TECH RDX Explosives Test Kit, Item #TK-1005-1, contains sufficient materials to perform four tests.
This kit can test water samples or be used with the D TECH TNT/RDX Soil Extraction Pac, Item #TK-1001S-1, to test soil samples.
The TNT/RDX Soil Extraction Pac contains only the materials needed to extract RDX from soil for semiquantitation with this D TECH RDX Explosives Test Kit. The results can be obtained by using the enclosed Color Card or the DTECHTOR Meter, Item #TK-1001M-1.

STORAGE AND STABILITY

This kit has excellent stability at room temperature and under refrigeration. For expiration dating under these conditions, see the package label.

MATERIALS PROVIDED

See tray diagram below. This diagram includes the kit component names and quantity of each item.



Not shown in diagram

Used Kit Label (1)

Instruction Guide (1)

Color Card (1)

Data Labels (4)
for Cup Assembly

Red Dot Labels (4)
for identifying used
Bottle A components

ACCESSORIES SUPPLIED BY USER

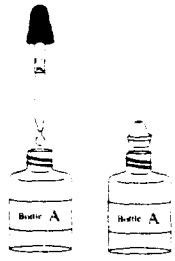
Timing Device (minutes)
D TECH TNT/RDX Soil Extraction Pac, Item #TK-1001S-1 (if testing soil samples)
the DTECHTOR Meter, Item #TK-1001M-1 (optional)

This package is designed to serve as a WORK STATION. At the conclusion of the test, the components can be left in the package for proper disposal.
Important: Read all Health/Safety Comments on page 4 prior to use.

Step 1: Choose corresponding sample source to determine the first step.

WATER SAMPLE: Using a new calibrated pipet, transfer **1 ml** of sample to **Bottle A**. Snap filter tip on **Bottle A**. Gently mix.

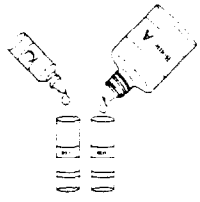
SOIL SAMPLE: Using a new calibrated pipet, transfer **1 ml** of **Bottle 2** solution from D TECH TNT/RDX Soil Extraction Pac, (Item #TK-1001S-1) to **Bottle A**; snap filter tip on **Bottle A**. Gently mix. Re-cap **Bottle 2** and set aside.



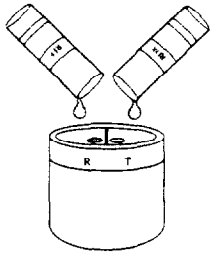
Note: The vials in the next two steps need to stand 5 minutes after dispensing the liquid. The solutions in these vials will remain hazy.

Step 2: Squeeze **Bottle A** filling the **RDX Vial** to a level between the two lines (approximately 13-14 drops). Gently mix.

Step 3: Squeeze the contents of **Reagent C** (white cap) to fill the **RDX Reference** vial to a level between the 2 lines. Gently mix.

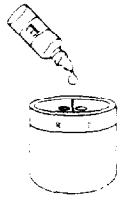


Step 4: After 5 minutes, pour contents of **RDX Vial** onto the **T** (test) side of the cup assembly. Pour the contents of the **Reference** vial onto the **R** side of the cup assembly. Allow liquid to drain completely through on both sides.

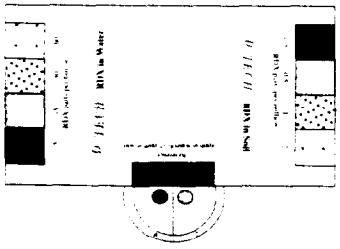


Step 5: Add approximately 8-12 drops of **Reagent D** solution (yellow cap) into each side of the cup assembly. Drain completely.

Step 6: Add approximately 5 drops of **Reagent E** solution (blue cap) to each side of the cup assembly. Be sure to add this solution immediately to the second well after addition to the first well. Drain completely.



Step 7: Read results when color of **R** (left) side of cup assembly matches the color of the reference bar of the **Color Card**. (The color development time is approximately 10 minutes at 70°F. More time is required at lower temperatures and less time is required at higher temperatures.)



COLOR CARD: Match the color on the **T** side of the cup assembly to the **Color Card**.
and/or
the DTECHTOR: Quantitate the result using *the* DTECHTOR Meter (see Instrument Operator's Guide for complete instructions).

See Interpretation of the Test section (page 3) to determine concentration of RDX Equivalents. Record result on a **Cup Assembly** label and apply to the cup.

*Note: To preserve the color for up to 4 hours (optional), add approximately 8 drops of **Reagent F** solution (red cap) into each side of the cup assembly. Drain completely.*

the DTECHTOR Meter Set Up

the DTECHTOR light sources must be calibrated whenever the meter is turned on. Calibrators are provided with the meter for this purpose. The **Calibrator** must be clean and white to insure valid results.

Step 1: Insert **Calibrator** into the **Meter Head** and hold firmly in place. (ZERO)

Step 2: Press the Square Button 1 time. When calibration is complete the meter will display..... (SET)

Step 3: Remove **Calibrator** and return it to its protective cannister. Display remains..... (SET)

Step 4: Press the Square Button 2 times to select meter program #2 (Program to be used for this D TECH test kit). (SET #2)

Step 5: Insert Cup Assembly (test) into the Meter Head and firmly hold in place. (TEST #2)

Note: The #2 in the upper right corner of the display window in Steps 4 & 5 corresponds to the program number being used to obtain the meter reading.

Step 6: Press the Square Button 1 time. (- - -)

Note: If the meter displays "WAIT", remove the Cup Assembly. Allow the reference color to develop further and try again.

Obtain the meter reading. For example..... (46%)
Use *the* DTECHTOR Table (see page 3) and the meter reading to determine the concentration of RDX.

Step 7: Record result then press Square Button 1 time while holding the **Cup Assembly** in place. (- - - -)

Step 8: Key in 4 digit Label. (Optional)

Step 9: Remove **Cup Assembly**. (SET #2)

Step 10: Insert next **Cup Assembly** (test) and repeat Steps 5 - 9.

PERFORMANCE CHARACTERISTICS

INTERPRETATION OF THE TEST The results from the D TECH RDX Explosives Test Kit can be interpreted using either the **Color Card** supplied with the kit or *the* DTECHTOR and the table provided below. If the color of the test does not exactly match a panel of the color card, user interpretation is required.

the DTECHTOR Table

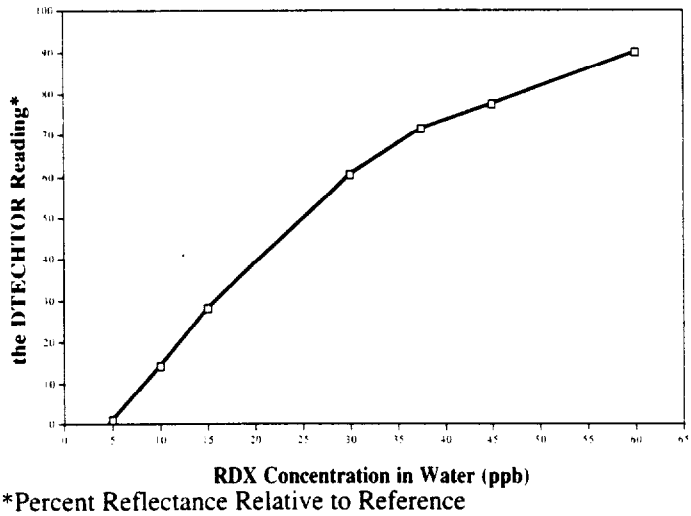
Sample	*the* DTECHTOR Reading	RDX Equivalents (ppb)
Water	LO	< 5
	1 - 30	5 - 15
	30 - 50	15 - 25
	50 - 80	25 - 45
	HI	> 45
		(ppm)
Soil	LO	< 0.5
	1 - 20	0.5 - 1.5
	20 - 45	1.5 - 2.5
	45 - 60	2.5 - 4.5
	60 - 80	4.6 - 6.0
	HI	> 6.0

SENSITIVITY The D TECH RDX Explosives Test Kit can be used to reliably measure RDX in the following ranges:

Sample	*the* DTECHTOR	Color Card
Water (ppb)	5 - 45	5 - 60
Soil (ppm)	0.5 - 6.0	0.5 - 6.0

The Minimum Detection Limit (MDL) of the test for RDX in a water sample is 5 ppb and in soil is 0.5 ppm. The graph below is a typical standard curve for the D TECH RDX Explosives Test Kit.

D TECH RDX Explosives Text Kit Standard Curve



*Percent Reflectance Relative to Reference

SPECIFICITY The D TECH RDX Explosives Test Kit has been tested for cross-reactivity with various explosives, including those found in EPA SW-846 Method 8330. The table below summarizes the cross-reactivity of these compounds in water samples using *the* DTECHTOR. A positive test result may be due to the presence of RDX, HMX or a mixture of these compounds (RDX Equivalents). Samples testing positive for RDX should be confirmed by standard methods. The D TECH RDX Explosives Test Kit has been designed to minimize the effect of environmental interferences. Sample pH, nitrate, nitrite and ammonium do not effect test results.

Compound	IC_{50}[a] (ppb)	MDL[b] (ppb)	Cross-reactivity[c]
RDX[d]	21	5	+
HMX[d]	>500	150	+
TNT[d]	>500	>500	-
Tetryl[d]	>500	>500	-
1,3,5-Trinitrobenzene	>500	>500	-
2-amino-4,6-dinitrotoluene	>500	>500	-
4-amino-2,6-dinitrotoluene	>500	>500	-
2,4-dinitrotoluene	>500	>500	-
2,6-diaminonitrotoluene	>500	>500	-
1,3-dinitrobenzene	>500	>500	-
Nitrobenzene	>500	>500	-
2-nitrotoluene	>500	>500	-
3-nitrotoluene	>500	>500	-
4-nitrotoluene	>500	>500	-
Nitroglycerin	>500	>500	-
PETN[d]	>500	>500	-

a The IC_{50} is defined as the concentration of compound required to produce a test response equivalent to 50% of the maximum response.

b The Minimum Detection Limit (MDL) is defined as the lowest concentration of compound that yields a positive test result.

c A compound is considered cross-reactive when a concentration 100 times the MDL of RDX (5 ppb) yields a positive test result.

d Chemical Names: RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), HMX(octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), TNT (trinitrotoluene) Tetryl (methyl-2,4,6-trinitrophenylnitramine), PETN (pentaerythritol tetranitrate).

TESTING HIGHER RDX CONCENTRATIONS

RDX concentrations greater than the upper limit of the test may be determined by diluting the extract with acetone. For example, an extract from a 100 ppm soil sample, processed using the D TECH TNT/RDX Soil Extraction Pac, may be diluted 1:25 in acetone and run in the D TECH RDX Explosives Test Kit. The concentration of the undiluted sample (100 ppm) is determined by multiplying the RDX concentration of the diluted sample (4.0 ppm) by the dilution factor (25). For further information, please call our technical service hot line 1-800-222-0342.

HEALTH/SAFETY

Material Safety Data Sheets (MSDS) have been supplied with the purchase of this product. The MSDS should be read before using this test. During the execution of the test, any excess RDX is absorbed into the **Cup Assembly** absorbant plug. It is not retained on the surface of the **Cup Assembly**.
When all kit components have been used, apply the warning label to seal the box and set it aside for proper disposal.
In this section, we have emphasized health and safety precautions that should be followed when handling these solutions.

PROTECT EYES WITH SAFETY GLASSES
PROTECT SKIN WITH PROTECTIVE GLOVES

Associated Hazards
May be irritating to skin, eyes, and mucous membranes.

Symptoms of Exposure
May be irritating on contact with skin, eyes, and mucous membranes.

First Aid Measures
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE

Skin:	Wash thoroughly with soap and water.
Eyes:	Immediately flush with water for at least 15 minutes.
Inhalation:	Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion:	Get immediate medical attention; if conscious, give water freely.

QUALITY CONTROL

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D TECH™ RDX Explosives Field Test Kit

EPA SW-846 Method 4051 (RDX)

D TECH RDX TEST KIT FEATURES

Sensitive
- 5 ppb RDX in water
- 0.5 ppm RDX in soil

Field Tested
- Results correlated to SW-846 Method 8330
- Designed for on-site conditions

Fast
- Provides test results for water or soil samples in less than 20 minutes

Easy-to-use
- Requires no special training

Convenient
- Basic kit includes all necessary materials for water samples; soil samples require D TECH TNT/RDX Soil Extraction Pac (TK-1001S-1)
- Kit package is designed for use as on-site workstation
- *the* DTECHTOR meter (TK-1001M-1) is sold separately for semiquantitative results

D TECH TNT/RDX SOIL EXTRACTION PAC

Fast
- Extracts RDX and TNT from soil samples in five minutes

Easy-to-use
- Only six easy steps

Performance
- Extraction efficiency >95%

D TECH™
Environmental Detection Systems

RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) along with TNT (2,4,6-trinitrotoluene) are the major components of many military munitions. Their long-term stability, widespread use, and rapid migration characteristics make these compounds (and associated degradation products) a serious contamination issue for both soil and groundwater. Contamination from these compounds is common at or near military installations, munitions manufacturing, depot, destruction (disposal) facilities, and ballistic test ranges.

Testing water and soil samples for RDX has never been easier or faster. Use the D TECH RDX Explosives Field Test Kit to identify hot spots, map sites, monitor remediation, determine risk, and select field samples for laboratory analysis. The D TECH RDX test kit gives you results in less than 20 minutes to help you make on-the-spot decisions in the field.

The D TECH RDX test kit has been extensively field tested to maximize its performance and convenience for on-site applications. The field trial data demonstrate correlation of field results with SW-846 Method 8330 for RDX analysis.*

General Description

The basic D TECH RDX kit contains all the necessary materials to test four (4) water samples. Soil samples require prior extraction using the D TECH TNT/RDX Soil Extraction Pac. Extraction takes less than five minutes, and multiple samples can be extracted simultaneously.

The D TECH test kit package is designed for use as an on-site workstation. Step-by-step instructions guide the user through the analysis procedure – previous laboratory or field testing experience is not required.

Methodology

The D TECH RDX test is based on an Enzyme Linked Immunosorbent Assay (ELISA). Immunoassay is a technology recognized by the EPA as a valuable field screening tool. For the D TECH RDX test, antibodies specific to RDX are linked to latex particles. RDX molecules present in the sample are captured by these latex particles and collected on the membrane surface of the collection device, then a color-developing solution is added. The presence (or absence) of RDX can then be quantitated with a hand-held DTECHTOR meter or, for quick screening, with the color comparison card supplied with the kit. The working range for the D TECH RDX kit is in parts per billion for RDX in water, and in parts per million for RDX in soil.

*For further technical information on field results, ask your EM Science representative.

Assay Range

	Water	Soil
RDX w/ DTECHTOR	5-45 ppb	0.5-6.0 ppm
RDX w/ Color Card	5-60 ppb	0.5-6.0 ppm

Upper limit of the test can easily be extended by simple dilution procedures

Method Correlation

Based on 262 field and laboratory samples, the D TECH RDX test kit with the DTECHTOR meter, correlates to the EPA SW-846 HPLC Method 8330. Correlation studies indicate that the methods agreed on the presence or absence of RDX in the samples in the detectable range of the kit. The false positive and false negative results are interpreted according to the recommended EPA definitions.

Correlated values	96%
False positives	4%
False negatives	<0.1%

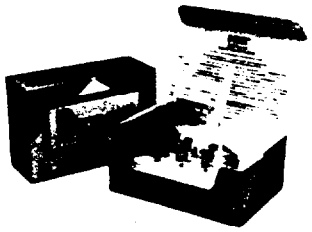
(no false negatives recorded)

Specificity

The D TECH RDX test kit has been tested for cross-reactivity with various explosives, including those found in EPA SW-846 Method 8330. A positive test result may be due to the presence of RDX, cross-reactants or mixtures of detectable compounds.

Compound	Cross-reactivity	MDL* (ppb)
RDX	+	5
HMX	+	150
TNT	-	>500
Tetryl	-	>500
1,3,5-Trinitrobenzene	-	>500
2-amino-4,6-dinitrotoluene	-	>500
4-amino-2,6-dinitrotoluene	-	>500
2,4-dinitrotoluene	-	>500
2,6-diaminonitrotoluene	-	>500
1,3-dinitrobenzene	-	>500
Nitrobenzene	-	>500
2-nitrotoluene	-	>500
3-nitrotoluene	-	>500
4-nitrotoluene	-	>500
Nitroglycerin	-	>500
PETN	-	>500

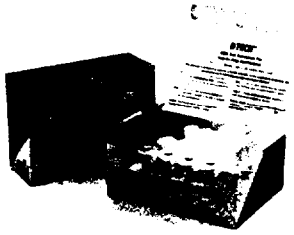
*The Minimum Detection Limit (MDL) is defined as the lowest concentration of compound that yields a positive test result.



D TECH RDX Explosive Field Test Kit

Order No. TK-1005-1

- Includes materials necessary to test four (4) samples
- Step-by-step instruction guide
- Color Comparison card



D TECH TNT/RDX Soil Extraction Pac

Order No. TK-1001S-1

- Includes all materials necessary to perform four (4) sample extractions
- Step-by-step instruction guide

the DTECHTOR Environmental Field Test Meter

The DTECHTOR is a hand-held reflectometer for interpreting results of D TECH RDX test samples. It is completely portable and powered with a 9-volt, plug-in battery. Operation is a simple push-button procedure that takes only one minute. Readings are displayed in a large, easy-to-read window, along with a sample ID, date, and time of analysis. Results for up to 127 samples can be stored in memory. Size: 7" x 2" x 1.5" Weight: 170 gm (6 oz) with battery

Order No. TK-1001M-1

- Includes calibrators, protective canisters, and meter cover
- Step-by-step instruction guide
- Maintenance and service manual

Ordering Information

D TECH Field Test Products can be ordered from EM Science by calling toll-free **1-800-222-0342** or by sending a fax to **1-800-336-4422**.

D TECH Field Test Products currently available from EM Science are RDX, TNT, BTEX, PAH and PCB soil and wipe test kits, the D TECH Soil Extraction Pacs, and the DTECHTOR Environmental Field Test Meter.

For complete technical information on D TECH Field Test Products, call the EM Science Technical Support Group at **1-800-222-0342.**

D TECH™ Environmental Detection Systems

EM Science/Strategic Diagnostics Incorporated
480 Democrat Road
Gibbstown, NJ 08027
800-222-0342

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D TECH® TNT Explosives Field Test Kit

EPA SW-846 Method 4050
(TNT)

D TECH TNT EXPLOSIVES TEST KIT FEATURES

Sensitive
- ppb TNT in water
- ppm TNT in soil

Field Tested
- Results correlated to SW-846 Method 8330
- Designed for on-site conditions

Fast
- Provides test results for water or soil samples in less than 20 minutes

Easy-to-use
- Requires no special training

Complete
- Basic kit includes all necessary materials for water samples; soil samples require D TECH TNT RDX Soil Extraction Pac (TK-1001S-1)
- Kit package is designed for use as on-site workstation
- *the* DTECHTOR meter (TK-1001M-1) is sold separately for semiquantitative results

D TECH TNT/RDX SOIL EXTRACTION PAC

Fast
- Extracts TNT from soil samples in five minutes

Easy-to-use
- Only six easy steps

Performance
- Extraction efficiency > 95%

Testing water and soil samples for TNT has never been easier or faster. Use the D TECH TNT Explosives Field Test Kit to identify hot spots, map sites, monitor remediation, determine risk, and select field samples for laboratory analysis. The D TECH TNT test kit gives you results in less than 20 minutes to help you make on-the-spot decisions in the field.

The D TECH TNT test kit has been extensively field tested to maximize its performance and convenience for on-site applications. The field trial data demonstrated correlation of field results with SW-846 Method 8330 for TNT analysis.*

General Description

The basic D TECH TNT kit contains all the necessary materials to test four (4) water samples. Soil samples require prior extraction using the D TECH TNT RDX Soil Extraction Pac. Extraction takes less than five minutes, and multiple samples can be extracted simultaneously.

The D TECH test kit package is designed for use as an on-site workstation. Step-by-step instructions guide the user through the analysis procedure—previous laboratory or field testing experience is not required.

Methodology

The D TECH TNT test is based on an Enzyme Linked Immunosorbent Assay (ELISA). Immunoassay is a technology recognized by the EPA as a valuable field screening tool. For the D TECH TNT test, antibodies specific to TNT are linked to solid particles. TNT molecules present in the sample are captured by these solid particles and collected on the membrane surface of the collection device. A color developing solution is then added and the presence (or absence) of TNT can be semiquantitated with a hand-held DTECHTOR meter or, for quick screening purposes, the color in the device can be compared to a color card supplied with the kit. The working range for the D TECH TNT kit is in parts per billion for TNT in water, and in parts per million for TNT in soil.

D TECH
Environmental Detection Systems

*For further technical information on field results, ask your EM Science representative.

Assay Range

	Water	Soil
TNT w/ DTECHTOR	5–45 ppb	0.5–5 ppm
TNT w/ Color Card	5–60 ppb	0.5–5 ppm

Method Correlation

Based on 376 field and laboratory samples, the D TECH TNT test kit with the DTECHTOR meter correlates to the EPA SW-846 HPLC Method 8330. Correlation indicates that the methods agreed on the presence or absence of TNT in the samples in the detectable range of the kit. The false positive and false negative results are interpreted according to the recommended EPA definitions.

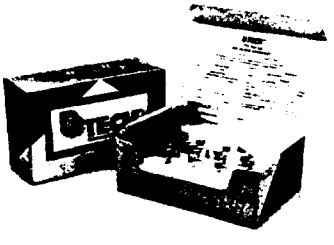
Correlated values	96%
False positives	3%
False negatives	<1%

Specificity

The D TECH TNT test kit has been tested for cross-reactivity with the following compounds:

Compound	Cross-reactivity TNT	TNT MDL* (ppb)
TNT (2,4,6-trinitrotoluene)	NA	5
TETRYL	+	15
2-amino-4,6-dinitrotoluene	+	15
1,3,5-trinitrobenzene	+	20
2,4-dinitrotoluene	+	120
4-amino-2,6-dinitrotoluene	–	> 500
2,6-dinitrotoluene	–	> 500
2,6-diaminonitrotoluene	–	> 500
2-nitrophenol	–	> 500
4-nitrophenol	–	> 500
2,4-dinitrophenol	–	> 500
RDX	–	> 500
PLMX	–	> 500

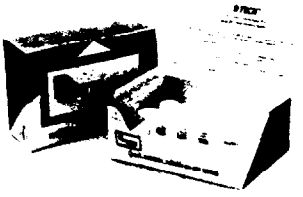
*The Minimum Detection Limit (MDL) is defined as the lowest concentration of compounds that yield a positive test result equivalent to 5 ppb TNT.



D TECH TNT Explosives Field Test Kit

Order No. TK-1004-1

- Includes materials necessary to test four (4) samples
- Step-by-step instruction guide
- Color comparison card



D TECH TNT/RDX Soil Extraction Pac

Order No. TK-1001S-1

- Includes materials necessary to perform four (4) sample extractions
- Step-by-step instruction guide

the DTECHTOR Environmental Field Test Meter

The DTECHTOR is a hand-held reflectometer for interpreting results of D TECH TNT test samples. It is completely portable and powered with a 9-volt, plug-in battery. Operation is a simple push-button procedure that takes only one minute. Readings are displayed in a large, easy-to-read window, along with a sample ID, date, and time of analysis. Results for up to 127 samples can be stored in memory. Size: 7" x 2" x 1.5"
Weight: 170 gm (6 oz) with battery

Order No. TK-1001M-1

- Includes calibrators, protective canisters, and meter cover
- Step-by-step instruction guide
- Maintenance and service manual

Ordering Information

D TECH Field Test Products can be ordered from EM Science by calling toll-free **1-800-222-0342** or by sending a fax to 1-800-336-4422.

D TECH Field Test Products currently available from EM Science are TNT (Quantitative), RDX, BTEX, and PCB test kits, the D TECH Soil Extraction Pacs, and the DTECHTOR Environmental Field Test Meter.

For complete technical information on D TECH Field Test Products, call the EM Science Technical Support Group at **1-800-222-0342.**

D TECH
Environmental Detection Systems

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800-222-0342

APPLICATION FOR METHOD 40xx (TNT) CERTIFICATION

United States Environmental Protection Agency

Methods Section (5304)

Office of Solid Waste

TNT USEPA SUBMISSION
MAR 1994

On-Site Sample Screening Has Never Been Easier

APPLICATION FOR METHOD 40XX CERTIFICATION
United States Environmental Protection Agency
Methods Section (5304)
Office of Solid Waste

APPLICANT INFORMATION

Product Name:

D TECH™ TNT Kit

Assay Development:

STRATEGIC DIAGNOSTICS INCORPORATED
128 Sandy Drive
Newark, Delaware 19713
(302) 456-6789
(302) 456-6770 (fax)

Contacts:
Bob Hudak -- Group Leader, D TECH Development
Joe Dautlick -- Marketing Manager

Marketing Group:

EM SCIENCES
480 Democrat Road
Gibbstown, New Jersey
(800) 222-0342

Contacts:
Bruce Crane -- Marketing Manager
Wayne Sawyer -- D TECH Product Manager

ASSAY DESCRIPTION AND SPECIFICS

The D TECH™ TNT kit is based on a latex particle immunoassay format. The antibody is attached to a latex particle which is greater than 3 microns in diameter. These particles are lyophilized in a glass vial to achieve long term room temperature storage stability. A competition reaction occurs in this tube when analyte in the sample and analyte enzyme conjugate compete for antibody binding sites. Rapid binding is facilitated by having all reagent suspended in solution rather than affixed to the walls of a reaction tube. Separation of bound and unbound reagents is accomplished by pouring the reaction mixture through a filter with a 1 micron nominal pore size. Conjugate (enzyme marker) bound to latex particles is retained on the filter surface due to the particle's larger size relative to the pore size. A clear chromogenic substrate is added. Bound enzyme catalyzes the formation of a non-soluble colored compound, whose intensity is proportional to bound enzyme conjugate concentration. A reference sample with a known quantity of analyte is processed similarly and simultaneously. The inclusion of the reference controls the effect of temperature on the test (the rate of the enzyme reaction) while setting the minimum detection limit of the test. Color intensity and thus concentration are determined either by comparison to a color chart or by inserting the separation cup into the optional DTECHTOR, a hand held reflectometer. The DTECHTOR yields a value for the test sample which is given as percent relative reflectance (%RR) to the reference reaction. The %RR can be converted to a concentration range by comparison to a look-up chart provided with the kit.

The D TECH TNT test kit is designed for the semiquantitative determination of TNT with reportable concentrations as shown:

ANALYTE	SAMPLE	DTECHTOR	COLOR CARD
TNT	Soil (ppm)	0.5 - 5.0	0.5 - 5.0
	Water (ppb)	5 - 45	5 - 60

Similar immunoassays have been used for in-vitro diagnostics during the past twenty-five (25) years to determine therapeutic drug levels, drugs of abuse monitoring, blood bank screening of hepatitis, HIV, etc., and hormone concentrations. Convenient, easy to use unit dose immunoassay tests in a format similar to D TECH are commonly used for home pregnancy tests and physicians' office tests.

The technology employed in these products is not patent protected; however, proprietary antibodies, conjugates and buffer formulations are used to deliver the unique performance found in this D TECH assay.

The kit is calibrated against Trinitrotoluene (TNT), but because of the antiserum's cross reactivity characteristics, the results are reported as ppm of TNT equivalents.

The test kit is a self contained workstation. The base kit provides the materials required to perform four (4) analyses. A supplementary D TECH TNT extraction pac, for four (4) soil extractions, is designed for integration into the base kit to provide soil results.

The specificity of this method is included in the test kit instruction guide. It indicates the compounds the test will detect along with their relative sensitivity as well as compounds of similar structure which will not react.

The method detection level (MDL) of the D TECH TNT kit is 5 ppb in water and 0.5 ppm in soil. The reference produces a color equivalent to these concentrations. This reference reaction is set at a level that gives 96% confidence that the MDL is distinguished from zero.

To assure competent handling of the D TECH kits in the field, all products have been designed with the following features:

1. All materials needed for an assay are included in the kit except for a timing device and the optional DTECHTOR. This minimizes error opportunity due to inaccurate, mislabeled, or contaminated pipets, glassware or reagents.

2. Each kit is set up as its own self-contained and preassembled workstation.

3. Caps are color coded for easy identification.

4. Each kit contains a fully detailed and diagrammatic set of instructions.

5. An 800 toll-free hot line is provided for technical support.

6. Kits are set up with side by side sample and reference processing to assure identical processing conditions for both. In addition, the development of the blue color in the reference well indicates all assay steps were completed with the appropriate reagent in correct order.

METHOD 40xx

SOIL SCREENING FOR TRINITROTOLUENE (TNT) BY IMMUNOASSAY

1.0 SCOPE AND APPLICATION

1.1 Method 40XX is a procedure for screening waters and soils to determine when Trinitrotoluene is present at concentrations above 0.5 mg/Kg in soil and 5 µg/L in water. Method 40xx provides an estimate of the concentration of TNT by comparison with a reference.

1.2 Using this test, 93% of soil samples containing 0.25 ppm or less of TNT will produce a negative result and 99+% of soil samples containing 1.0 ppm or greater of TNT will produce a positive result. In addition, 93% of water samples containing 2.5 ppb or less of TNT will produce a negative result and 99%+ of water samples containing 10 ppb or more of TNT will produce a positive result.

1.3 In cases where the exact concentrations of TNT are required, quantitative techniques (i.e., Methods 8330) should be used.

2.0 SUMMARY OF METHOD

2.1 Test kits are commercially available for this immunoassay method. For optimal results, the manufacturer's instructions should be followed. In general, the method is performed using an extract of a soil sample. Samples and an enzyme-analyte conjugate reagent are added to immobilized TNT antibody. The enzyme conjugate "competes" with TNT present in the sample for binding to immobilized TNT antibody. The enzyme-analyte conjugate bound to the antibody then catalyzes a colorless substrate to a colored product. The test is interpreted by comparing the color produced by a sample to the response produced by a reference reaction.

3.0 INTERFERENCES

3.1 Chemically similar compounds and compounds that might be expected to be found in conjunction with TNT contamination were tested to determine the concentration required to produce a positive test result. These data are shown in Tables 1 and 2.

4.0 APPARATUS AND MATERIALS

4.1 The D TECH TNT test kit or equivalent. Each commercially available kit will supply or specify all materials necessary for successful completion of the test.

5.0 REAGENTS

5.1 The D TECH TNT test contains all the reagents necessary for successful completion of four (4) analyses. A supplementary soil extraction pac is required for soil analyses.

6.0 SAMPLE COLLECTION, PRESERVATION, AND TRANSPORTATION

6.1 See the introductory material to this chapter, Organic Analytes, Section 4.1.

6.2 Soil and water samples may be contaminated, and should therefore be considered hazardous and handled accordingly.

7.0 PROCEDURE

7.1 Follow the manufacturer's instructions for the test kit being used. Those test kits used must meet or exceed the performance indicated in Tables 3-13

8.0 QUALITY CONTROL

8.1 Follow the manufacturer's instructions for the test kit being used for quality control procedures specific for that test. Additionally, guidance is provided in Chapter One.

8.2 Do not use test kits past their expiration date.

8.3 Do not use reagents designated for the TNT kit with another kit type.

8.4 Do not mix reagents from one kit lot with a different kit lot.

8.5 Use the test kits within their specified storage temperature and operating temperature limits.

9.0 METHOD PERFORMANCE

9.1 This method has been tested in the laboratory with a wide range of soil and water matrices. Spike and recovery studies, matrix effect studies, and real world sample analysis have proven this method to be accurate and reliable over a wide range of matrix chemistries. See Tables 1-13

10.0 REFERENCES

1. D TECH™ TNT Users Guide , SDI/EM Sciences 1994

2. Hutter,L., G. Teaney, and J.W.Stave, "A Novel Field Screening System for TNT Using EIA", in Field Screeening Methods for Hazardous Wastes and Toxic Chemicals, Vol 1, Proceedings of the 1993 U.S. EPA/A&WMA International Symposium, p.472, 1993.

3. Teaney,G., J.Melby, L.Hutter and J.Stave, "A Novel Field Analytical Method for TNT", Proceedings of the American Association of Analytical Chemists, 1993

TABLE 1
CROSS REACTANTS

METHOD: The compounds listed below were assayed at various concentrations and compared against an inhibition curve generated using TNT. The concentration of the compound required to elicit a positive response at the MDL as well as the concentration required to yield 50% inhibition compared to the standard curve were determined. The results are given below:

SAMPLE	MDL[a] (ppm)	IC 50[b] (ppm)	% CROSS REACTIVITY[c]
TNT (2,4,6-trinitrotoluene)	0.5	17	100
Tetryl[d]	3	48	35
1,3,5-trinitrobenzene	4	75	23
2-amino-4,6-dinitrotoluene	13	150	11
4-amino-2,6-dinitrotoluene	>500	>500	<1
2,4-dinitrotoluene	90	390	4
2,6-diaminonitrotoluene	>500	>500	<1
2-nitrophenol	>500	>500	<1
4-nitrophenol	>500	>500	<1
2,4-dinitrophenol	>500	>500	<1
RDX[d]	>500	>500	<1
HMX[d]	>500	>500	<1

a The Method Detection Limit (MDL) is defined as the lowest concentration of compound that yields a positive test result.

b The IC_{50} is defined as the concentration of compound required to produce a test response equivalent to 50% of the maximum response.

c % Crossreactivity is determined by dividing the equivalent TNT concentration by the actual compound concentration at IC_{50}

d Tetryl = methyl-2,4,6-trinitrophenylnitramine
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
HMX = octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

TABLE 1A
CROSS REACTANTS

Below is the data used to calculate the cross reactivity shown in Table 1.

COMPOUND	PPM ASSAYED	D TECH %RR *
TNT	5,15,30,45,60	10,27,60,74,87
Tetryl	5,15,30,50,90	5,7,20,43,61,
1,3,5-trinitrobenzene	5,15,30,50,90	3,6,10,23,46
2-amino-4,6-dinitrotoluene	30,45,75,150,300	13,15,17,43,65
4-amino-2,6-dinitrotoluene	500	<0
2,4-dinitrotoluene	30,75,150,300,600	-1,-1,10,30,54
2,6-diaminonitrotoluene	500	<0
2-nitrophenol	500	<0
4-nitrophenol	500	<0
2,4-dinitrophenol	500	<0
RDX	500	<0
HMX	500	<0

Tetryl = methyl-2,4,6-trinitrophenylnitramine
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
HMX = octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

D TECH %RR = % Relative Reflectance. This is a mathematical expression of the reflectance of the color produced using the DTECHTOR. % Relative Reflectance can be calculated using the following formula:

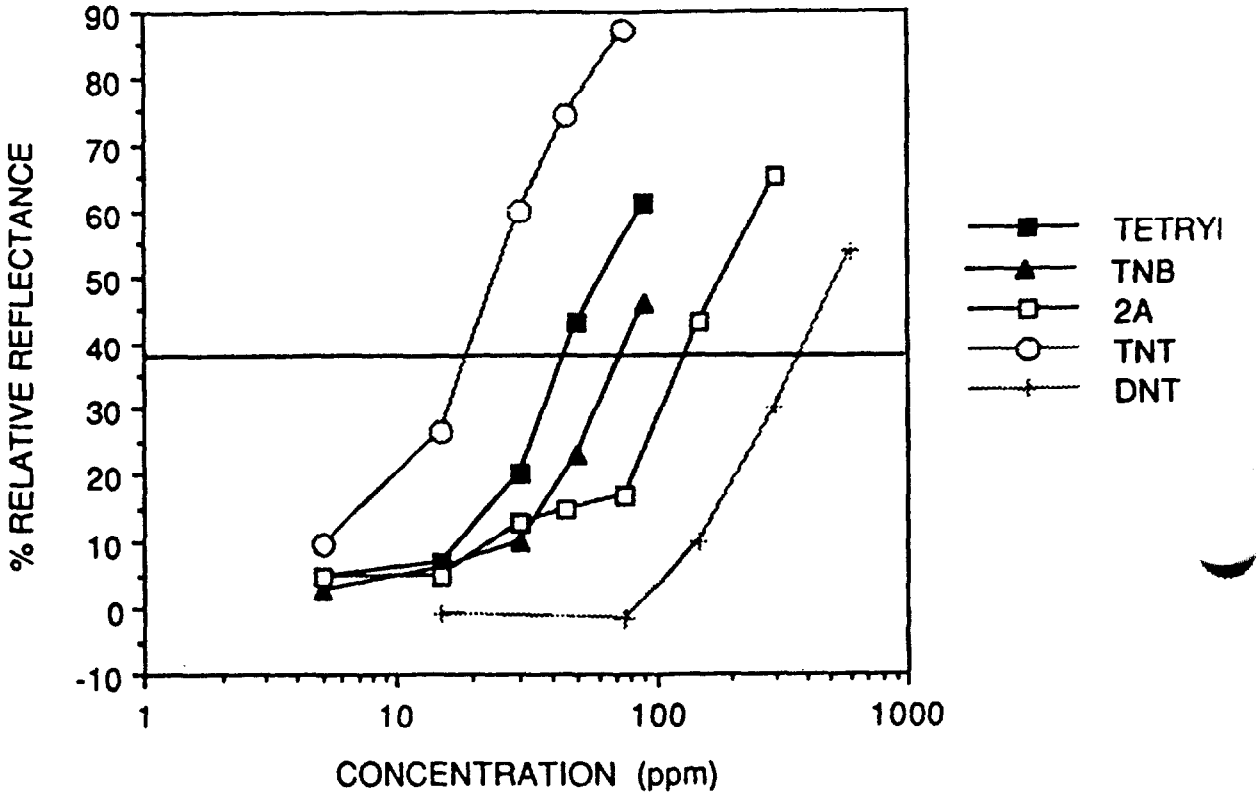
$$\% RR = \frac{(\text{sample reflectance}) - (\text{reference reflectance})}{(\text{white}) - (\text{reference reflectance})} \times 100$$

where 700 is defined as white for the TNT assay.

TABLE 1B
CROSS REACTANTS

Below is a graphic representation of the cross reactivity data given in Table 1A

D TECH TNT CROSS REACTIVITY GRAPH



NOTE: Since the effective working range of the assay is 0 to 75% Relative Reflectance when using the DTECHTOR, IC_{50} occurs at 37.5% Relative Reflectance. This is the point on the curve from which cross reactivites have been calculated.

TABLE 2A
POSSIBLE INTERFERING COMPOUNDS

COMPOUND	PPM ASSAYED	D TECH %RR
Benzene	100	-9
Toluene	100	-9
Ethylbenzene	100	-8
Xylenes	100	-7
PAHs	100	-7
PCB 1254	100	-6
PCP	100	-7
Triazine	100	-5

NOTE: Since all % relative reflectances are <0, none of the compounds tested are detectable at 100 ppm in the assay.

TABLE 3
D TECH TNT COMPOSITE STANDARD CURVE DATA

CONFIDENTIAL

METHOD: Seven (7) standard curves were run by different technicians over the course of one week to determine the variance. The results are given below.

TNT CONCENTRATION (ppb)	MEAN REFLECTANCE	STANDARD DEVIATION	% CV
5	257	25	10
9	316	14	5
15	337	23	7
30	501	28	6
40	565	20	3
60	635	20	3

D TECH TNT STANDARD CURVE

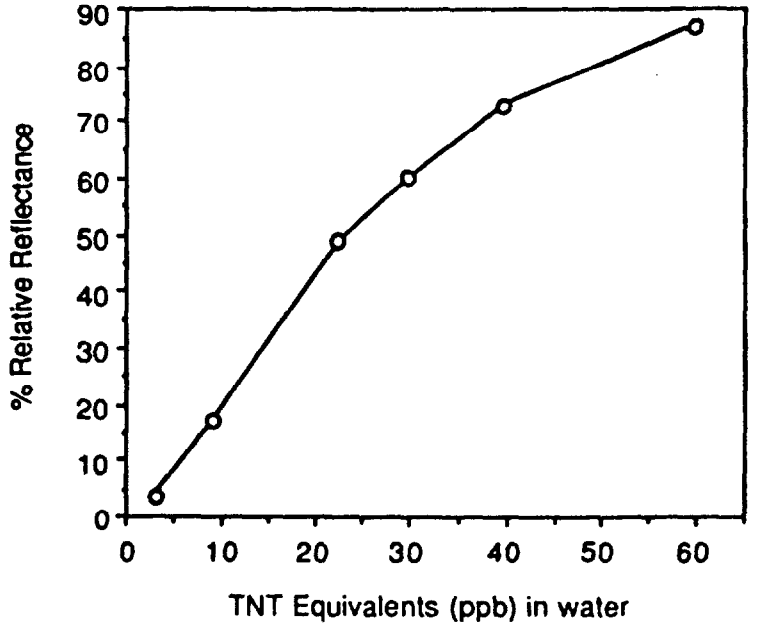


TABLE 4
D TECH TNT REALWORLD NEGATIVE SOILS

METHOD: Twenty five (25) real world negative soils were extracted and analyzed using the D TECH TNT kit to determine the extent of soil matrix effects.The results are given below.

Soil	Soil type		D TECH RANGE (ppm)	D TECH %RR
133	Avonburg Fine Sine Silt	N/A	<0.5	-2
101	Matapeake Silt Loam	DE	<0.5	-3
100	Clay Loam	DE	<0.5	-7
102	Sassafras Sand Loam	DE	<0.5	-6
106	Evesboro Low Organic	DE	<0.5	-6
107	Pokomoke High OM Sand	DE	<0.5	-3
109	Davidson Clay Loam	GA	<0.5	-4
111	Shontic Casa Grande Sand	AZ	<0.5	-1
112	Casa Grande Clay Loam	AZ	<0.5	-5
113	Trix Sand Clay Loam	AZ	<0.5	-4
114	Trix Casa Grande Clay	AZ	<0.5	-8
115	Yolo Loam	CA	<0.5	-2
116	Capay Silt Clay	CA	<0.5	-2
117	Sycamore Silt Loam	CA	<0.5	-5
118	Dennis Silt Loam	KS	<0.5	-5
119	Grundy Silt Clay Loam	KS	<0.5	-3
120	Luray Silt Clay Loam	OH	<0.5	-2
121	Wooster Silt Loam	OH	<0.5	-5
122	Vienna Loam	SD	<0.5	-7
123	Opal Clay	SD	<0.5	-4
124	Raub Silt Loam	IN	<0.5	-3
125	Rockfield Silt Loam	IN	<0.5	-6
127	Cisne	IL	<0.5	-4
128	Muscatine Loam	IL	<0.5	-5
130	Sandy Brae	DE	<0.5	-6

NOTE: All soil %RR are less than 0 (the %RR of the MDL) therefore all soils have a concentration less than 0.5 ppm (the concentration of the MDL).

TABLE 5
D TECH TNT REALWORLD NEGATIVE WATERS

METHOD: Thirty (30) real world negative waters were analyzed using the D TECH TNT kit to determine the extent of water matrix effects. The results are given below.

Water #	Water type		D TECH RANGE(ppm)	D TECH % RR
1	Ground Water, Burlington	IA	<5.0	-10
2	Well Water, Burlington	IA	<5.0	-1
3	Surface Water #1, Houston	TX	<5.0	-4
4	Unknown Creek, Dartmouth	MA	<5.0	-1
5	City Well Water, Ontario	CA	<5.0	-14
6	Pacific Ocean, Victoria	CA	<5.0	-5
7	Surface Water, Harmony Woods	DE	<5.0	-13
8	Adamsville River, Adamsville	RI	<5.0	-3
9	Suface Water #2, Houston	TX	<5.0	-14
10	Buttermilk Falls, White Haven	PA	<5.0	-6
11	Main St Pond, Germantown	NY	<5.0	-10
12	Hudson River, Germantown	NY	<5.0	-1
13	Atlantic Ocean	NJ	<5.0	-7
14	Ground Water #1, Dover	DE	<5.0	-16
15	Ground Water #2, Dover	DE	<5.0	-14
16	Ground Water #3, Dover	DE	<5.0	-13
17	Drinking Well Water, Landenberg	PA	<5.0	-2
18	Ground Water, Elsmere	DE	<5.0	-4
19	Ground Water, Elsmere	DE	<5.0	-13
20	Ground Water, Elsmere	DE	<5.0	-4
21	Lab Sample 20643	N/A	<5.0	-7
22	Lab Sample 20645	N/A	<5.0	-5
23	Lab Sample 20659	N/A	<5.0	-8
24	Lab Sample 20826	N/A	<5.0	-5
25	Lab Sample 20827	N/A	<5.0	-11
26	Lab Sample 20843	N/A	<5.0	-4
27	Lab Sample 20850	N/A	<5.0	-8
28	Lab Sample 20848	N/A	<5.0	-4
29	Ground Water, Adrian	GA	<5.0	-7
30	Ground Water, Adrian	GA	<5.0	-7

NOTE: All soil %RR are less than 0 (the %RR of the MDL) therefore all waters have a concentration less than 5 ppb (the concentration of the MDL).

TABLE 6
ESTIMATE ERROR RATE FOR MINIMUM DETECTION LEVEL (MDL) IN SOILS

METHOD: Thirty (30) real world negative soils were spiked with TNT at one-half and two times the MDL (0.25 and 1.0 ppm respectively). These samples were analyzed in the D TECH assay to determine the error rate of the assay as defined by the USEPA. The actual data are given in Table 5A.

True ppm	0.25 ppm	1.0 ppm
Positive Rate (%)	7	100
Negative Rate (%)	93	0

TABLE 7
ESTIMATE ERROR RATE FOR MINIMUM DETECTION LEVEL (MDL) IN WATER

METHOD: Thirty (30) real world negative waters were spiked with TNT at one-half and two times the MDL (2.5 and 10 ppb respectively). These samples were analyzed in the D TECH assay to determine the error rate of the assay as defined by the USEPA. The actual data are given in Table 5A.

True ppb	2.5 ppb	10 ppb
Positive Rate (%)	7	100
Negative Rate (%)	93	0

TABLE 6A

ESTIMATE ERROR RATE FOR MINIMUM DETECTION LEVEL (MDL) IN SOILS

CONFIDENTIAL

Below is the actual data used to determine the error rate in soil samples.

0.25 ppm TNT			1.0 ppm TNT		
Sample	% RR	Conc	Sample	% RR	Conc (ppm)
100	-9	<0.5	100	6	0.5-1.5
102	-6	<0.5	102	10	0.5-1.5
108	-10	<0.5	108	8	0.5-1.5
109	-3	<0.5	109	15	0.5-1.5
111	-3	<0.5	111	7	0.5-1.5
113	-3	<0.5	113	10	0.5-1.5
114	-3	<0.5	114	7	0.5-1.5
115	-6	<0.5	115	10	0.5-1.5
116	-3	<0.5	116	4	0.5-1.5
117	-3	<0.5	117	13	0.5-1.5
118	-2	<0.5	118	12	0.5-1.5
120	-4	<0.5	120	11	0.5-1.5
121	-3	<0.5	121	11	0.5-1.5
122	-6	<0.5	122	6	0.5-1.5
123	1	0.5-1.5	123	9	0.5-1.5
124	-2	<0.5	124	6	0.5-1.5
125	-5	<0.5	125	4	0.5-1.5
127	-4	<0.5	127	7	0.5-1.5
128	-8	<0.5	128	6	0.5-1.5
133	1	0.5-1.0	133	4	0.5-1.5
101	-7	<0.5	101	12	0.5-1.5
106	-2	<0.5	106	7	0.5-1.5
110	-4	<0.5	110	14	0.5-1.5
112	-6	<0.5	112	11	0.5-1.5
119	-5	<0.5	119	13	0.5-1.5
126	-5	<0.5	126	6	0.5-1.5
27	-7	<0.5	27	13	0.5-1.5
28	-4	<0.5	28	11	0.5-1.5
29	-9	<0.5	29	8	0.5-1.5
30	-12	<0.5	30	8	0.5-1.5

TABLE 7A

ESTIMATE ERROR RATE FOR MINIMUM DETECTION LEVEL (MDL) IN WATERS

CONFIDENTIAL

Below is the actual data used to determine the error rate in water samples.

2.5 ppb TNT			10 ppb TNT		
Sample	% RR	Conc	Sample	% RR	Conc (ppm)
1	-14	<5.0	1	24	5.0-15
2	-3	<5.0	2	36	15-25
3	-11	<5.0	3	17	5.0-15
4	-3	<5.0	4	17	5.0-15
5	-16	<5.0	5	22	5.0-15
6	-8	<5.0	6	14	5.0-15
7	-8	<5.0	7	19	5.0-15
8	0	<5.0	8	16	5.0-15
9	-3	<5.0	9	13	5.0-15
10	-2	<5.0	10	17	5.0-15
11	-3	<5.0	11	11	5.0-15
12	-7	<5.0	12	5	5.0-15
13	2	5.0-15	13	10	5.0-15
14	4	5.0-15	14	27	5.0-15
15	-6	<5.0	15	14	5.0-15
16	-6	<5.0	16	26	5.0-15
17	-11	<5.0	17	11	5.0-15
15	-8	<5.0	18	23	5.0-15
19	-8	<5.0	19	16	5.0-15
20	-6	<5.0	20	13	5.0-15
21	-4	<5.0	21	17	5.0-15
22	-1	<5.0	22	21	5.0-15
23	-6	<5.0	23	36	15-25
24	-7	<5.0	24	23	5.0-15
25	-12	<5.0	25	17	5.0-15
26	-1	<5.0	26	21	5.0-15
27	-7	<5.0	27	25	5.0-15
28	0	<5.0	28	36	15-25
29	-14	<5.0	29	52	15-25
30	-9	<5.0	30	38	25-45

TABLE 8
EXTRACTION EFFICIENCY DETERMINATION

METHOD: Ten (10) different soil types (TNT negative soils) were spiked with an acetone solution containing approximately 1.0 ppm TNT. This spiking solution was later quantitated by method 8330 and found to contain 0.77 ppm TNT. The spiked soil samples were analyzed three (3) times in the D TECH kit to determine the extraction efficiency of the method. The data are presented below:

SOIL ID	MEAN TNT CONC. (ppm)	SD	%CV	%RECOVERY
101	0.54	0.04	7	70
106	0.64	0.06	9	84
108	0.87	0.18	20	113
109	0.63	0.08	13	82
110	0.88	0.15	17	115
116	1.02	0.15	17	115
117	0.82	0.15	15	132
123	0.87	0.23	26	113
126	0.95	0.26	28	123
128	0.65	0.11	16	84
SPIKING SOLUTION	0.77	N/A	N/A	100

TABLE 8A
CHARACTERIZATION OF SOIL USED IN EXTRACTION EFFICIENCY EXPERIMENT

METHOD: The ten (10) soils used for the extraction efficiency study were sent to soil testing laboratory for content analysis. The data are given below:

Sample ID	OM (%) by LOI	pH	Ca (mg/Kg)	Mn (mg/Kg)	Zn (mg/Kg)	Cu (mg/Kg)	Fe (mg/Kg)	Sand %	Silt %	Clay %
101	1.5	6.0	486.1	111.3	1.7	1.4	61.9	34	46	20
106	0.1	5.5	67.7	1.2	0.3	0.4	18.8	93	4	3
108	2.2	6.6	453.8	10.2	0.1	0.5	45.7	31	15	54
109	2.3	5.4	243.5	105.4	0.1	0.4	167.7	37	12	51
110	12.1	4.9	1468.9	4.3	5.0	0.7	8.8	88	6	6
116	2.2	6.8	1154.6	55.5	0.9	2.9	16.5	14	35	51
117	2.8	7.6	1577.8	99.2	14.1	2.5	18.6	52	30	18
123	3.6	6.7	2638.3	109.9	1.0	1.5	8.1	11	27	62
126	5.2	5.2	2587.8	79.3	1.9	1.3	66.8	15	46	39
128	4.4	6.2	2913.9	14.3	1.4	0.8	1.4	68	68	10

TABLE 9
RECOVERY OF TNT SPIKED INTO REAL SOILS

METHOD: Three (3) soils were spiked at approximately 1 and 3 ppm TNT. Each sample was analyzed once by method 8330 and ten (10) times by D TECH. The results are given below.

SAMPLE ID	AMOUNT SPIKED	D TECH %RR	D TECH (ppm)	HPLC METHOD 8330
106-1	1.0	4	0.5 - 1.5	0.69
		5	0.5 - 1.5	
		6	0.5 - 1.5	
		3	0.5 - 1.5	
		5	0.5 - 1.5	
		8	0.5 - 1.5	
		6	0.5 - 1.5	
		8	0.5 - 1.5	
		6	0.5 - 1.5	
		16	1.5 - 3.0	
116-1	1.0	9	0.5 - 1.5	0.73
		8	0.5 - 1.5	
		16	1.5 - 3.0	
		12	0.5 - 1.5	
		8	0.5 - 1.5	
		9	0.5 - 1.5	
		11	0.5 - 1.5	
		10	0.5 - 1.5	
		9	0.5 - 1.5	
		16	1.5 - 3.0	
128-1	1.0	8	0.5 - 1.5	0.75
		9	0.5 - 1.5	
		12	0.5 - 1.5	
		10	0.5 - 1.5	
		11	0.5 - 1.5	
		16	1.5 - 3.0	
		14	0.5 - 1.5	
		10	0.5 - 1.5	
		9	0.5 - 1.5	
		11	0.5 - 1.5	

TABLE 9 (cont)
RECOVERY OF TNT SPIKED INTO REAL SOILS

SAMPLE ID	AMOUNT SPIKED	D TECH %RR	D TECH (ppm)	HPLC METHOD 8330
106-3	3.0	31	1.5 - 3.0	1.53
		20	1.5 - 3.0	
		25	1.5 - 3.0	
		14	0.5 - 1.5	
		18	1.5 - 3.0	
		15	1.5 - 3.0	
		19	1.5 - 3.0	
		23	1.5 - 3.0	
		20	1.5 - 3.0	
		14	0.5 - 1.5	
116-3	3.0	20	1.5 - 3.0	2.12
		26	1.5 - 3.0	
		28	1.5 - 3.0	
		31	1.5 - 3.0	
		24	1.5 - 3.0	
		20	1.5 - 3.0	
		18	1.5 - 3.0	
		16	1.5 - 3.0	
		14	0.5 - 1.5	
		19	1.5 - 3.0	
128-3	3.0	14	0.5 - 1.5	2.07
		16	1.5 - 3.0	
		18	1.5 - 3.0	
		22	1.5 - 3.0	
		25	1.5 - 3.0	
		24	1.5 - 3.0	
		29	1.5 - 3.0	
		21	1.5 - 3.0	
		18	1.5 - 3.0	
		19	1.5 - 3.0	

TABLE 10
COMPARISON OF D TECH WITH METHOD 8330

FIELD TRIAL A

METHOD: Samples from borings were obtained at a West Coast site using a split spoon technique. The samples were homogenized by placing approximately six cubic inches of soil into a stainless steel vessel and mixing for five minutes with a stainless steel trowel. The soil was aliquotted into two (2) six ounce glass bottles, tested on-site using the D TECH method and transported to Roy F. Weston (Lionville, Pa) for method 8330 analysis.

SAMPLE ID	D TECH %RR	D TECH RANGE (ppm)	METHOD 8330 TNT (ppm)
61-1	4	< 0.2	< 0.09
61-10	11	< 0.2	< 0.09
61-11	0	< 0.2	< 0.09
61-12	-2	< 0.2	< 0.09
61-13	-3	< 0.2	< 0.09
61-14	5	< 0.2	< 0.09
61-15	5	< 0.2	< 0.09
61-16	5	< 0.2	< 0.09
61-17	-1	< 0.2	< 0.09
61-18	1	< 0.2	< 0.09
61-19	12	< 0.2	< 0.09
61-2	82	> 1.5	> 3.0
61-20	4	< 0.2	< 0.09
61-21	36	0.5-1.0	2.44
61-22	11	< 0.2	< 0.09
61-23	8	< 0.2	< 0.09
61-24	67	1.0-1.5	1.4
61-25	14	< 0.2	< 0.09
61-26	9	< 0.2	< 0.09
61-27	21	0.2-0.5	0.27
61-28	1	< 0.2	< 0.09
61-29	2	< 0.2	< 0.09
61-3	64	1.0-1.5	1.3

SAMPLE ID	D TECH %RR	D TECH RANGE (ppm)	METHOD 8330 TNT (ppm)
61-30	4	< 0.2	< 0.09
61-4	90	> 1.5	1.1
61-5	52	0.5-1.0	1.0
61-6	91	> 1.5	> 3.0
61-7	1	< 0.2	< 0.09
61-8	38	0.5-1.0	1.0
61-9	25	0.2-0.5	0.56
TET-1	56	0.5-1.0	< 0.09
TET-2	12	< 0.2	< 0.09
TET-3	2	< 0.2	< 0.09
TL-1	21	0.2-0.5	0.99
TL-2	96	> 1.5	1.2
TL-3	95	> 1.5	> 3.0
TL-4	29	0.2-0.5	0.66
TL-5	89	> 1.5	> 3.0
TL-6	19	0.2-0.5	0.66
TL-7	16	0.2-0.5	0.71
TL-8	36	0.5-1.0	1.46
TL-9	23	0.2-0.5	0.92

FIELD TRIAL B

METHOD: Samples from borings were obtained at a Western state site using a split spoon technique. The samples were homogenized by placing approximately six cubic inches of soil into a stainless steel vessel and mixing for five minutes with a stainless steel trowel. The soil was aliquotted into two (2) six ounce glass bottles, tested on-site using the D TECH method and transported to DataChem (Salt Lake City, Utah) for method 8330 analysis.

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
1	2	0.2 - 0.5	<2.0	< 1.0	<2.25
1	4	> 1.5	5.75	< 1.0	5.75-6.0
1	6	< 0.2	<2.0	< 1.0	<2.25
1	8	< 0.2	<2.0	< 1.0	<2.25
1	10	< 0.2	<2.0	< 1.0	<2.25
1	12	< 0.2	<2.0	< 1.0	<2.25
2	2	> 1.5	3.32	< 1.0	3.32-3.57
2	4	> 1.5	166	< 1.0	166
2	6	< 0.2	<2.0	< 1.0	<2.25
2	8	< 0.2	<2.0	< 1.0	<2.25
2	10	< 0.2	<2.0	< 1.0	<2.25
2	12	< 0.2	<2.0	< 1.0	<2.25
3	2	> 1.5	2500	18.50	2504
3	4	> 1.5	2.72	< 1.0	2.72-2.97
3	6	1.0 - 1.5	<2.0	< 1.0	<2.25
3	8	0.2 - 0.5	<2.0	< 1.0	<2.25
3	10	0.2 - 0.5	<2.0	< 1.0	<2.25
3	12	> 1.5	<2.0	7.02	1.76-3.76
4	2	< 0.2	<2.0	< 1.0	<2.25
4	4	< 0.2	<2.0	< 1.0	<2.25
4	6	< 0.2	<2.0	< 1.0	<2.25
4	8	< 0.2	<2.0	< 1.0	<2.25
4	10	< 0.2	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
4	12	< 0.2	<2.0	< 1.0	<2.25
5	2	< 0.2	<2.0	< 1.0	<2.25
5	4	< 0.2	<2.0	< 1.0	<2.25
5	6	< 0.2	<2.0	< 1.0	<2.25
5	8	< 0.2	<2.0	< 1.0	<2.25
5	10	< 0.2	<2.0	< 1.0	<2.25
5	12	< 0.2	<2.0	< 1.0	<2.25
6	2	< 0.2	<2.0	< 1.0	<2.25
6	4	> 1.5	<2.0	5.12	1.28-3.28
6	6	> 1.5	140	12.2	143
6	8	> 1.5	230	20.2	235
6	10	> 1.5	1100	16.9	1104
6	12	> 1.5	23.5	11.5	26.0
7	2	< 0.2	<2.0	< 1.0	<2.25
7	4	< 0.2	<2.0	< 1.0	<2.25
7	6	< 0.2	<2.0	< 1.0	<2.25
7	8	< 0.2	<2.0	< 1.0	<2.25
7	10	< 0.2	<2.0	< 1.0	<2.25
7	12	0.5 - 1.0	<2.0	2.95	0.74-2.74
8	2	< 0.2	<2.0	< 1.0	<2.25
8	4	< 0.2	<2.0	< 1.0	<2.25
8	6	0.2 - 0.5	<2.0	< 1.0	<2.25
8	8	0.2 - 0.5	<2.0	< 1.0	<2.25
8	10	0.5 - 1.0	<2.0	1.30	0.33-2.33
8	12	0.5 - 1.0	<2.0	1.89	0.47-2.47
9	2	0.5 - 1.0	<2.0	< 1.0	<2.25
9	4	< 0.2	<2.0	< 1.0	<2.25
9	6	< 0.2	<2.0	< 1.0	<2.25
9	8	> 1.5	<2.0	3.94	0.99-2.99
9	10	0.5 - 1.0	<2.0	4.54	1.14-3.14

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
10	2	< 0.2	<2.0	< 1.0	<2.25
10	4	< 0.2	<2.0	< 1.0	<2.25
10	6	< 0.2	<2.0	< 1.0	<2.25
10	8	< 0.2	<2.0	< 1.0	<2.25
10	10	< 0.2	<2.0	< 1.0	<2.25
10	12	0.2 - 0.5	<2.0	< 1.0	<2.25
11	2	0.5 - 1.0	<2.0	< 1.0	<2.25
11	4	< 0.2	<2.0	< 1.0	<2.25
11	6	0.2 - 0.5	<2.0	< 1.0	<2.25
11	8	0.5 - 1.0	<2.0	< 1.0	<2.25
11	10	1.0 - 1.5	<2.0	< 1.0	<2.25
11	12	1.0 - 1.5	<2.0	< 1.0	<2.25
12	2	< 0.2	<2.0	< 1.0	<2.25
12	4	< 0.2	<2.0	< 1.0	<2.25
12	6	0.2 - 0.5	<2.0	< 1.0	<2.25
12	8	0.5 - 1.0	<2.0	< 1.0	<2.25
12	10	> 1.5	<2.0	< 1.0	<2.25
12	12	1.0 - 1.5	<2.0	< 1.0	<2.25
12	15	> 1.5	<2.0	4.57	1.14-3.14
12	20	> 1.5	<2.0	10.5	2.63-4.63
12	25	> 1.5	3.23	24.3	9.3
12	30	> 1.5	<2.0	81	20.3
12	35	> 1.5	<2.0	1.61	0.40-2.40
12	40	1.0 - 1.5	<2.0	< 1.0	<2.25
12	45	0.2 - 0.5	<2.0	< 1.0	<2.25
12	50	< 0.2	<2.0	< 1.0	<2.25
12	55	< 0.2	<2.0	< 1.0	<2.25
12	60	< 0.2	<2.0	< 1.0	<2.25
13	8	< 0.2	<2.0	< 1.0	<2.25
13	10	< 0.2	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
13	12	0.5 - 1.0	<2.0	< 1.0	<2.25
13	20	> 1.5	<2.0	< 1.0	<2.25
14	2	< 0.2	<2.0	< 1.0	<2.25
14	4	< 0.2	<2.0	< 1.0	<2.25
14	6	< 0.2	<2.0	< 1.0	<2.25
14	8	< 0.2	<2.0	< 1.0	<2.25
14	10	< 0.2	<2.0	< 1.0	<2.25
14	12	< 0.2	<2.0	< 1.0	<2.25
15	2	< 0.2	<2.0	< 1.0	<2.25
15	4	< 0.2	<2.0	< 1.0	<2.25
15	6	< 0.2	<2.0	< 1.0	<2.25
15	8	< 0.2	<2.0	< 1.0	<2.25
15	10	< 0.2	<2.0	< 1.0	<2.25
15	12	< 0.2	<2.0	< 1.0	<2.25
16	2	< 0.2	<2.0	< 1.0	<2.25
16	4	< 0.2	<2.0	< 1.0	<2.25
16	6	< 0.2	<2.0	< 1.0	<2.25
16	8	< 0.2	<2.0	< 1.0	<2.25
16	10	0.2 - 0.5	<2.0	< 1.0	<2.25
16	12	< 0.2	<2.0	< 1.0	<2.25
17	2	< 0.2	<2.0	< 1.0	<2.25
17	4	< 0.2	<2.0	< 1.0	<2.25
17	6	< 0.2	<2.0	< 1.0	<2.25
17	8	< 0.2	<2.0	< 1.0	<2.25
17	10	< 0.2	<2.0	< 1.0	<2.25
17	12	< 0.2	<2.0	< 1.0	<2.25
18	2	< 0.2	<2.0	< 1.0	<2.25
18	4	< 0.2	<2.0	< 1.0	<2.25
18	6	< 0.2	<2.0	< 1.0	<2.25
18	8	< 0.2	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
18	10	< 0.2	<2.0	< 1.0	<2.25
18	12	< 0.2	<2.0	< 1.0	<2.25
19	2	< 0.2	<2.0	< 1.0	<2.25
19	4	< 0.2	<2.0	< 1.0	<2.25
19	6	< 0.2	<2.0	< 1.0	<2.25
19	8	< 0.2	<2.0	< 1.0	<2.25
19	10	0.2 - 0.5	<2.0	< 1.0	<2.25
19	12	< 0.2	<2.0	< 1.0	<2.25
20	2	< 0.2	<2.0	< 1.0	<2.25
20	4	0.5 - 1.0	<2.0	< 1.0	<2.25
20	6	> 1.5	<2.0	< 1.0	<2.25
20	8	> 1.5	4.75	2.60	5.40
20	10	> 1.5	<2.0	2.97	0.74-2.74
20	12	> 1.5	<2.0	6.29	1.57-3.57
21	2	> 1.5	<2.0	< 1.0	<2.25
21	4	> 1.5	3.64	5.05	4.90
21	6	> 1.5	<2.0	6.62	1.66-3.66
21	8	> 1.5	<2.0	1.94	0.49-2.49
21	10	> 1.5	<2.0	8.53	2.13-4.13
21	12	> 1.5	<2.0	6.77	1.69-3.69
21	15	> 1.5	<2.0	6.75	1.69-3.69
21	20	> 1.5	<2.0	17.6	4.40-6.41
21	25	> 1.5	6.39	39.2	16.2
21	30	> 1.5	<2.0	< 1.0	<2.25
21	35	> 1.5	4.20	1.39	4.55
21	40	> 1.5	<2.0	< 1.0	<2.25
21	45	1.0 - 1.5	<2.0	< 1.0	<2.25
21	50	0.5 - 1.0	<2.0	< 1.0	<2.25
21	55	< 0.2	<2.0	< 1.0	<2.25
21	60	< 0.2	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
22	2	> 1.5	5.14	< 1.0	5.14-5.39
22	4	> 1.5	<2.0	< 1.0	<2.25
22	6	< 0.2	<2.0	< 1.0	<2.25
22	8	< 0.2	<2.0	< 1.0	<2.25
22	10	< 0.2	<2.0	< 1.0	<2.25
22	12	< 0.2	<2.0	< 1.0	<2.25
22	15	> 1.5	<2.0	2.68	0.67-2.67
22	20	> 1.5	<2.0	7.65	1.91-3.91
22	25	> 1.5	<2.0	27.70	6.9-8.9
22	30	> 1.5	<2.0	9.01	2.25-4.25
22	35	> 1.5	<2.0	30.90	7.7-9.7
22	40	> 1.5	<2.0	35.70	8.9-10.9
22	45	0.5 - 1.0	<2.0	< 1.0	<2.25
22	50	< 0.2	<2.0	< 1.0	<2.25
22	55	< 0.2	<2.0	< 1.0	<2.25
22	60	< 0.2	<2.0	< 1.0	<2.25
23	2	> 1.5	820	5.69	821
23	4	> 1.5	1200	24.0	1206
23	6	> 1.5	27.6	11.9	31
23	8	> 1.5	7.43	9.01	9.70
23	10	> 1.5	4.98	9.46	7.40
23	12	> 1.5	3.32	10.4	5.90
23	15	> 1.5	3.42	16.5	7.60
23	20	> 1.5	4.32	28.2	11.4
23	25	> 1.5	7.57	44.8	18.8
23	30	> 1.5	5.12	81.2	25.4
23	35	> 1.5	<2.0	1.64	0.41-2.41
23	40	0.5 - 1.0	<2.0	2.27	0.57-2.57
23	45	0.2 - 0.5	<2.0	< 1.0	<2.25
23	50	0.5 - 1.0	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
23	60	< 0.2	<2.0	< 1.0	<2.25
24	2	> 1.5	33.5	23.4	39.4
24	4	> 1.5	2.19	8.43	4.30
24	6	> 1.5	7.00	11.0	9.75
24	8	> 1.5	2.84	4.69	4.01
24	10	> 1.5	<2.0	5.67	1.42-3.42
24	12	> 1.5	2.23	12.8	5.43
24	15	> 1.5	5.38	31.4	13.23
24	20	> 1.5	2.60	13.0	5.85
24	25	> 1.5	4.43	31.1	12.2
24	30	> 1.5	4.79	25.9	11.3
24	35	> 1.5	2.29	18.2	6.8
24	40	1.0 - 1.5	8.84	148	45.8
24	45	> 1.5	9.01	< 1.0	9.01
24	50	0.5 - 1.0	<2.0	< 1.0	<2.25
24	55	1.0 - 1.5	<2.0	< 1.0	<2.25
24	60	0.5 - 1.0	<2.0	< 1.0	<2.25
25	2	> 1.5	29.00	6.02	30.50
25	4	> 1.5	<2.0	< 1.0	<2.25
25	6	> 1.5	<2.0	1.30	0.33-2.33
25	8	> 1.5	<2.0	7.50	1.88-3.88
25	10	> 1.5	<2.0	4.70	1.18-3.18
25	12	> 1.5	2.49	30.0	9.99
25	15	> 1.5	<2.0	29.1	7.28-9.28
25	20	> 1.5	<2.0	8.86	2.22-4.22
25	25	> 1.5	<2.0	30.7	7.68-9.68
25	30	> 1.5	<2.0	38.1	9.59-11.6
25	35	> 1.5	3.98	183	49.7
25	40	> 1.5	5.67	122	36.2
25	45	> 1.5	7.05	< 1.0	7.05-7.3

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
25	50	0.2 - 0.5	<2.0	< 1.0	<2.25
25	55	< 0.2	<2.0	< 1.0	<2.25
25	60	< 0.2	<2.0	< 1.0	<2.25
26	2	> 1.5	8.04	< 1.0	8.04-8.29
26	4	> 1.5	1000	7.49	1001
26	6	0.5 - 1.0	2.12	2.99	2.87
26	8	0.5 - 1.0	8.83	5.56	10.20
26	10	1.0 - 1.5	3.64	3.20	4.44
26	12	> 1.5	3.22	10.6	5.87
26	15	> 1.5	<2.0	18.3	4.58-6.58
26	20	> 1.5	<2.0	17.4	4.43-6.43
26	25	> 1.5	<2.0	20.4	5.10-7.10
26	30	> 1.5	<2.0	117	29.2-31.2
26	35	1.0 - 1.5	<2.0	1.96	0.49-2.49
26	40	1.0 - 1.5	<2.0	< 1.0	<2.25
26	45	< 0.2	<2.0	< 1.0	<2.25
26	50	0.2 - 0.5	<2.0	< 1.0	<2.25
26	55	< 0.2	<2.0	< 1.0	<2.25
26	60	< 0.2	<2.0	< 1.0	<2.25
27	2	0.5 - 1.0	<2.0	< 1.0	<2.25
27	4	> 1.5	351	5.77	352
27	6	> 1.5	116	39.2	126
27	8	> 1.5	4.29	3.92	5.27
27	10	> 1.5	<2.0	11.6	2.9-4.9
27	12	> 1.5	2.34	9.26	4.66
27	15	> 1.5	<2.0	48.7	12.2-14.2
27	20	0.5 - 1.0	<2.0	5.05	1.26-3.26
27	25	> 1.5	<2.0	12.6	3.15-5.15
27	30	> 1.5	<2.0	10.7	2.68-4.68
27	35	0.2 - 0.5	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
27	40	0.5 - 1.0	<2.0	< 1.0	<2.25
27	45	< 0.2	<2.0	< 1.0	<2.25
27	50	< 0.2	<2.0	< 1.0	<2.25
27	55	< 0.2	<2.0	< 1.0	<2.25
27	60	< 0.2	<2.0	< 1.0	<2.25
28	2	< 0.2	<2.0	< 1.0	<2.25
28	4	< 0.2	<2.0	< 1.0	<2.25
28	6	< 0.2	<2.0	< 1.0	<2.25
28	8	< 0.2	<2.0	< 1.0	<2.25
28	10	< 0.2	<2.0	< 1.0	<2.25
28	12	< 0.2	<2.0	< 1.0	<2.25
28	15	0.2 - 0.5	<2.0	< 1.0	<2.25
28	20	0.2 - 0.5	<2.0	< 1.0	<2.25
28	25	> 1.5	<2.0	11.1	2.78-4.78
28	30	> 1.5	<2.0	3.74	0.94-2.94
28	35	< 0.2	<2.0	1.88	0.47-2.47
28	40	0.2 - 0.5	<2.0	< 1.0	<2.25
28	45	< 0.2	<2.0	< 1.0	<2.25
28	50	< 0.2	<2.0	< 1.0	<2.25
28	55	< 0.2	<2.0	< 1.0	<2.25
28	60	< 0.2	<2.0	< 1.0	<2.25
29	2	< 0.2	<2.0	< 1.0	<2.25
29	4	> 1.5	<2.0	< 1.0	<2.25
29	6	> 1.5	4.24	< 1.0	4.24-4.49
29	8	> 1.5	<2.0	1.10	0.28-2.28
29	10	0.5 - 1.0	<2.0	1.28	0.32-2.32
29	12	1.0 - 1.5	<2.0	2.70	0.68-2.68
29	15	> 1.5	<2.0	10.5	2.63-4.63
29	20	> 1.5	<2.0	14.1	3.53-5.53
29	25	> 1.5	<2.0	18.4	4.6-6.6

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
29	30	0.5 - 1.0	<2.0	6.35	1.59-3.59
29	35	1.0 - 1.5	<2.0	6.66	1.67-3.67
29	40	0.5 - 1.0	<2.0	21.8	5.45-7.45
29	45	< 0.2	<2.0	< 1.0	<2.25
29	50	< 0.2	<2.0	< 1.0	<2.25
29	55	< 0.2	<2.0	< 1.0	<2.25
29	60	< 0.2	<2.0	< 1.0	<2.25
30	2	< 0.2	<2.0	< 1.0	<2.25
30	4	< 0.2	<2.0	< 1.0	<2.25
30	6	< 0.2	<2.0	< 1.0	<2.25
30	8	< 0.2	<2.0	< 1.0	<2.25
30	10	< 0.2	<2.0	< 1.0	<2.25
30	12	0.5 - 1.0	<2.0	5.29	1.32-3.32
30	15	0.5 - 1.0	<2.0	4.49	1.12-3.12
30	20	1.0 - 1.5	<2.0	16.3	4.08-6.08
30	25	> 1.5	<2.0	28.7	7.18-9.18
30	30	> 1.5	<2.0	17.7	4.43-6.43
30	35	> 1.5	<2.0	24.1	6.03-8.03
30	40	< 0.2	<2.0	< 1.0	<2.25
30	45	0.5 - 1.0	<2.0	< 1.0	<2.25
30	50	< 0.2	<2.0	< 1.0	<2.25
30	55	< 0.2	<2.0	< 1.0	<2.25
30	60	< 0.2	<2.0	< 1.0	<2.25
31	2	0.2 - 0.5	6.35	< 1.0	6.35-6.6
31	4	< 0.2	<2.0	< 1.0	<2.25
31	6	< 0.2	<2.0	< 1.0	<2.25
31	8	< 0.2	<2.0	2.52	0.63-2.63
31	10	0.5 - 1.0	<2.0	2.40	0.60-2.6
31	12	0.2 - 0.5	<2.0	4.70	1.18-3.18
31	15	0.5 - 1.0	<2.0	11.6	2.9-4.9

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
31	20	> 1.5	<2.0	56.9	14.2-16.2
31	25	> 1.5	<2.0	45.6	11.4-13.4
31	30	> 1.5	<2.0	67.7	16.9-18.9
31	35	0.5 - 1.0	<2.0	< 1.0	<2.25
31	40	0.2 - 0.5	<2.0	< 1.0	<2.25
31	45	< 0.2	<2.0	< 1.0	<2.25
31	50	< 0.2	<2.0	< 1.0	<2.25
31	55	< 0.2	<2.0	< 1.0	<2.25
31	60	< 0.2	<2.0	< 1.0	<2.25
32	2	< 0.2	<2.0	< 1.0	<2.25
32	4	< 0.2	<2.0	< 1.0	<2.25
32	6	< 0.2	<2.0	< 1.0	<2.25
32	8	< 0.2	<2.0	< 1.0	<2.25
32	10	< 0.2	<2.0	< 1.0	<2.25
32	12	< 0.2	<2.0	< 1.0	<2.25
32	15	< 0.2	<2.0	< 1.0	<2.25
32	20	< 0.2	<2.0	< 1.0	<2.25
32	25	< 0.2	<2.0	< 1.0	<2.25
32	30	0.2 - 0.5	<2.0	2.78	0.7-2.7
32	35	< 0.2	<2.0	< 1.0	<2.25
32	40	1.0 - 1.5	<2.0	< 1.0	<2.25
32	45	< 0.2	<2.0	< 1.0	<2.25
32	50	< 0.2	<2.0	< 1.0	<2.25
32	55	< 0.2	<2.0	< 1.0	<2.25
32	60	< 0.2	<2.0	< 1.0	<2.25
33	2	< 0.2	<2.0	< 1.0	<2.25
33	4	< 0.2	<2.0	< 1.0	<2.25
33	6	< 0.2	<2.0	< 1.0	<2.25
33	8	< 0.2	<2.0	< 1.0	<2.25
33	10	< 0.2	<2.0	< 1.0	<2.25

Well #	Depth	D TECH Range (ppm)	8330 TNT (ppm)	8330 TNB (ppm)	TNT Equivalent (ppm)
33	12	< 0.2	<2.0	< 1.0	<2.25
33	15	< 0.2	<2.0	1.61	0.4-2.4
33	20	< 0.2	<2.0	4.07	1.02-3.02
33	25	0.2 - 0.5	<2.0	3.12	0.78-2.78
33	30	0.2 - 0.5	<2.0	< 1.0	<2.25
33	35	0.2 - 0.5	<2.0	< 1.0	<2.25
33	40	< 0.2	<2.0	< 1.0	<2.25
33	45	< 0.2	<2.0	< 1.0	<2.25
33	50	< 0.2	<2.0	< 1.0	<2.25
33	55	0.2 - 0.5	<2.0	< 1.0	<2.25
33	60	< 0.2	<2.0	< 1.0	<2.25

TABLE 11
KIT COMPONENT STABILITY

METHOD: To determine the stability of the D TECH TNT reagents, kits were stored at 37°C and tested over the course of thirty-five (35) days. Two (2) test solutions were made in assay diluent on day 0 and run in these kits to determine the stability of the reagents at this temperature. The results are given below.

	Day 0 % Blue	Day 4 % Blue	Day 11 % Blue	Day 21 % Blue	Day 28 % Blue	Day 35 % Blue
0 ppb	60	60	50	50	55	55
10 ppb	30	20	20	20	20	20

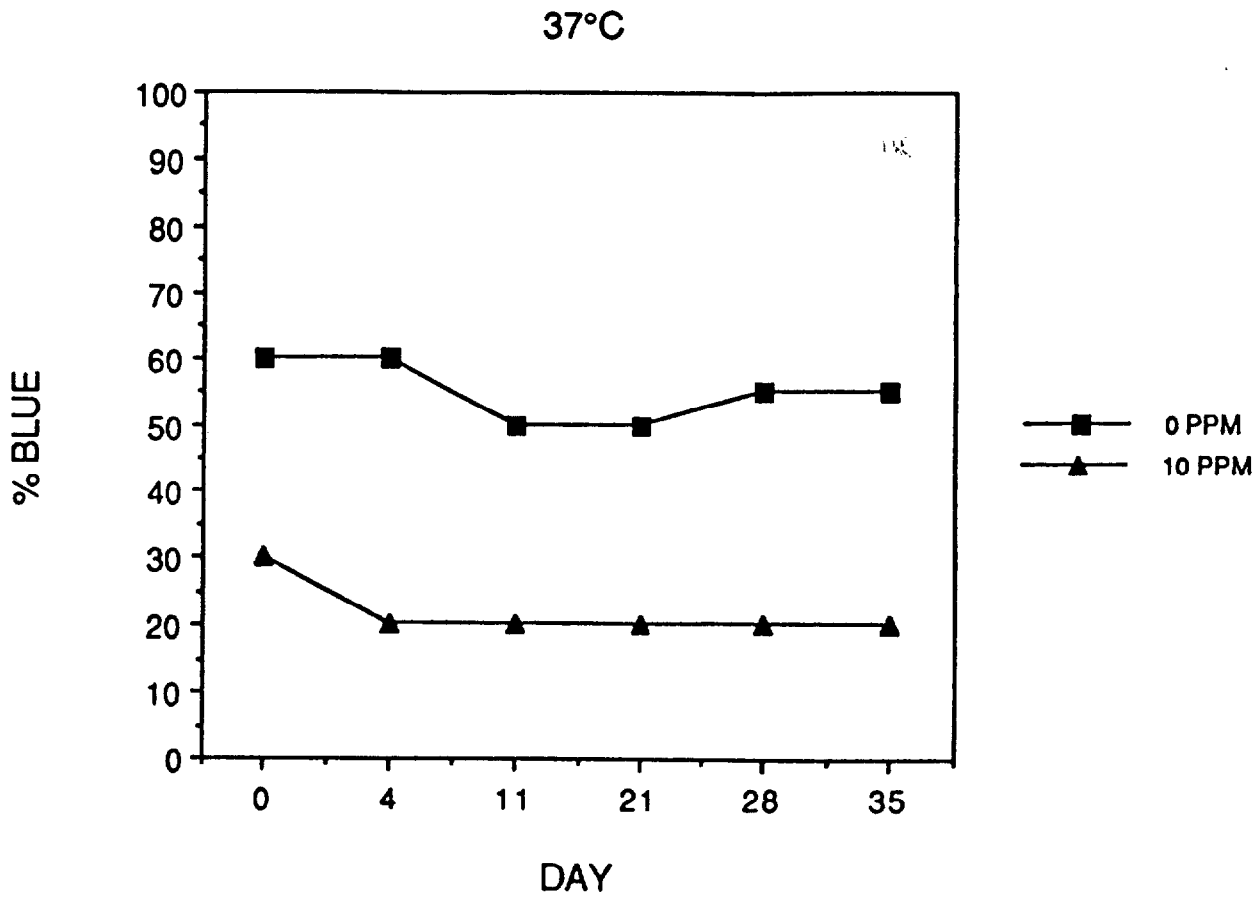


TABLE 12
KIT COMPONENT STABILITY

METHOD: To determine the stability of the D TECH TNT reagents, kits were stored at 22°C and tested over the course of one hundred twenty (120) days. Two (2) test solutions were made in assay diluent on day 0 and run in these kits to determine the stability of the reagents at this temperature. The results are given below.

	Day 0 % Blue	Day 30 % Blue	Day 60 % Blue	Day 90 % Blue	Day 120 % Blue
0 ppb	65	70	65	65	65
10 ppb	40	40	40	40	40

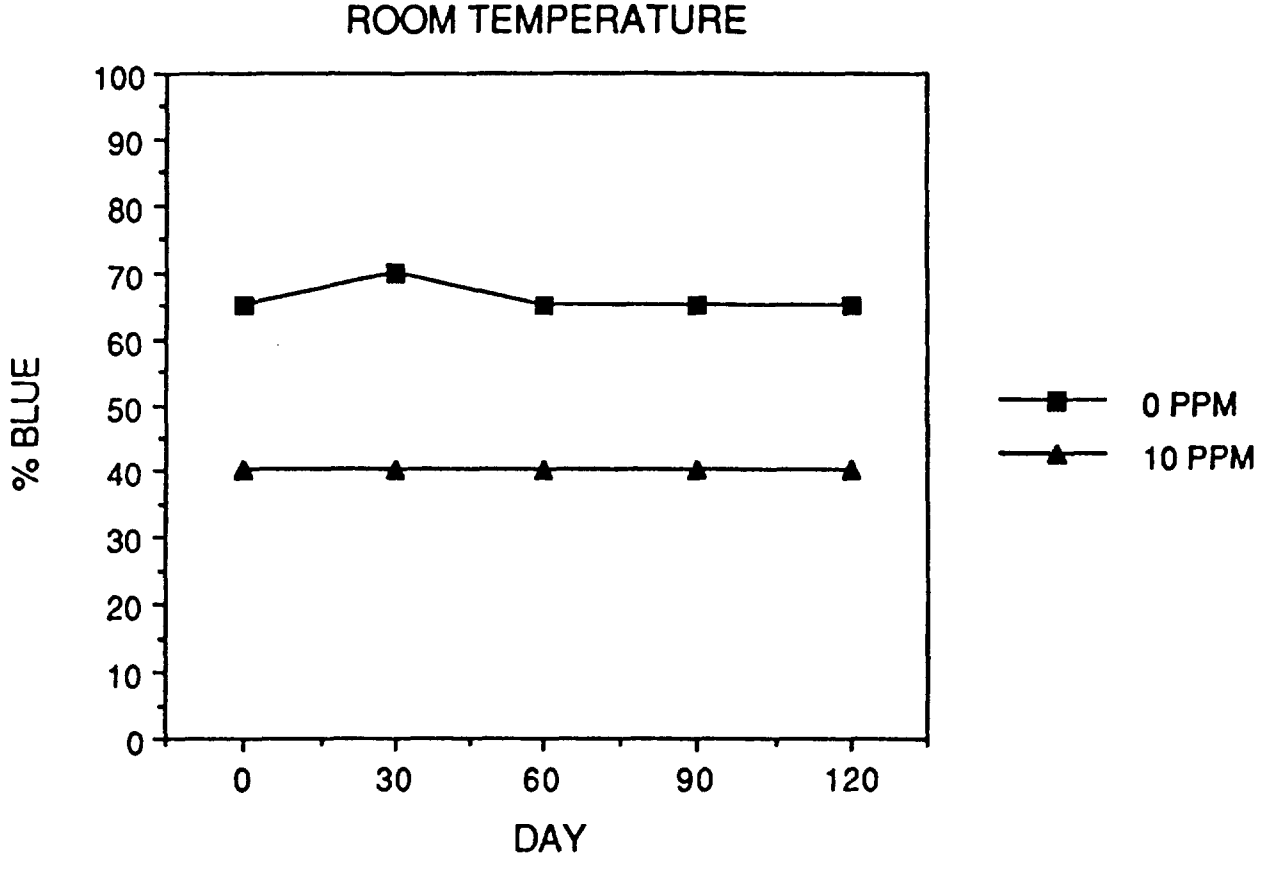


TABLE 13
ASSAY VARIABILITY

METHOD: Three (3) discrete real world water samples were spiked with TNT at different concentrations and run the same day by the same technician to determine the Inter-Assay Coefficient of Variation. Discrete sample concentrations were determined (for internal assay development purposes only) by running a TNT standard curve and using a point-to-point curve-fitting data reduction method.

	Sample 1	Sample 2	Sample 3
MEAN	9.8	16.7	28.6
SD	1.0	1.7	2.4
%CV	10.2	10.2	8.4

APPENDIX D

QUALITY ASSURANCE/QUALITY CONTROL PLAN (QA/QC)

Appendix D
Quality Assurance/Quality Control Plan (QA/QC)

for

Verification Investigation Work Plan for The Naval School EOD Sites at The Naval Explosive Ordnance Disposal Technology Division NSWC Stump Neck Annex Indian Head Division

Indian Head, Maryland

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command

Northern Division Contract Number N62472-90-D-1298
Contract Task Order 222

September 1995

069501/P

APPENDIX D
QUALITY ASSURANCE/QUALITY CONTROL PLAN (QA/QC)
FOR
VERIFICATION INVESTIGATION WORK PLAN
FOR
THE NAVAL SCHOOL EOD SITES
AT
THE NAVAL EXPLOSIVE ORDNANCE DISPOSAL TECHNOLOGY DIVISION
NAVAL SURFACE WARFARE CENTER
STUMP NECK ANNEX, INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
Design Branch Code 04
Naval Facilities Engineering Command
Washington Navy Yard, Building 212
Washington, D.C. 20374-2121

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 222

SEPTEMBER 1995

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1.0 PROJECT DESCRIPTION

As requested by the U.S. Navy, Halliburton NUS Corporation (Halliburton NUS) has prepared this Quality Assurance/Quality Control (QA/QC) Plan for field and laboratory work to be performed to support the implementation of a Verification Investigations (VI) Work Plan for four sites at the Stump Neck Annex, Indian Head Division, Indian Head, Maryland. The four study areas are:

- Range 6
- The Improved Explosives Devices (IED) Site
- The Inert Ordnance Disposal (IOD) Site
- Area 8, the Underwater Ordnance Training Area

Halliburton NUS has established quality assurance/quality control (QA/QC) measures and a program to ensure that these measures are applied to the collection and interpretation of all environmental data obtained in support of the VI Work Plan. The QA/QC Plan is designed to assure that the precision, accuracy, representativeness, comparability, and completeness (the PARCC parameters) of the data are known, documented, and adequate to satisfy the data quality objectives of the study. Accordingly, the plan incorporates all QA/QC elements in accordance with U.S. Environmental Protection Agency guidance (USEPA, 1980; 1988).

This plan represents the policies, organization, objectives, data-collection activities, and QA/QC activities that will be utilized to ensure that all data collected during, and reported by, these investigations are representative of existing conditions. Chemical analyses will be conducted by a subcontracted fixed base laboratory. The laboratory will have prior Navy approval. QA/QC procedures for the chemical analyses will satisfy Naval Energy and Environmental and Support Activity (NEESA) requirements for Level C as defined in the guidelines document "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B; June, 1988). The VI Work Plan outlines the procedures that will be followed for the inventory, control, storage, and retrieval of data collected during the performance of the fieldwork.

2.0 SCOPE OF WORK

The field activities will be performed as described in the VI Work Plan. Details of the field activities, such as the technical approach, selection of drilling locations, and sample collection activities are found in Sections 2.0 and 3.0 of the VI Work Plan. Descriptions of physical features and site history can be found in Section 1.0 of the VI Work Plan.

3.0 SAMPLE PARAMETERS AND COLLECTION

As part of the field activities, soil, sediment, groundwater, and surface water samples will be collected for chemical analysis. Sampling rationale is presented in Section 2.0 of the VI Work Plan; a listing of the sample matrices, frequency of collection, and analysis parameters is found in Tables 3-1 through 3-9. Table 3-10 of the VI Work Plan presents the sample containers, preservatives, and maximum allowable holding times for the analyses requested. Sampling protocols to be used for these investigations are provided in Appendix C of VI Work Plan.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Halliburton NUS will be responsible for the overall management of the project, including the field inspection and conduct of all drilling and sampling activities. Personnel from the Navy will be actively involved in the investigation and will coordinate with personnel from Halliburton NUS in a number of areas.

4.1 PROJECT ORGANIZATION

Key personnel, responsibilities, and the chain-of-communication are depicted in Figure D.4-1 and discussed in the following sections:

Mr. Shawn Phillips
EPA Chesapeake, Naval Facilities Engineering Command
901 M Street 5B
Building 212, Washington Navy Yard
Washington, D.C. 20374-2121

Mr. Shawn Jorgensen
Naval Surface Warfare Center, Indian Head Division
Building D-28
Indian Head, Maryland 20640-5035

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John Trepanowski, P.E.
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Foster Plaza VII
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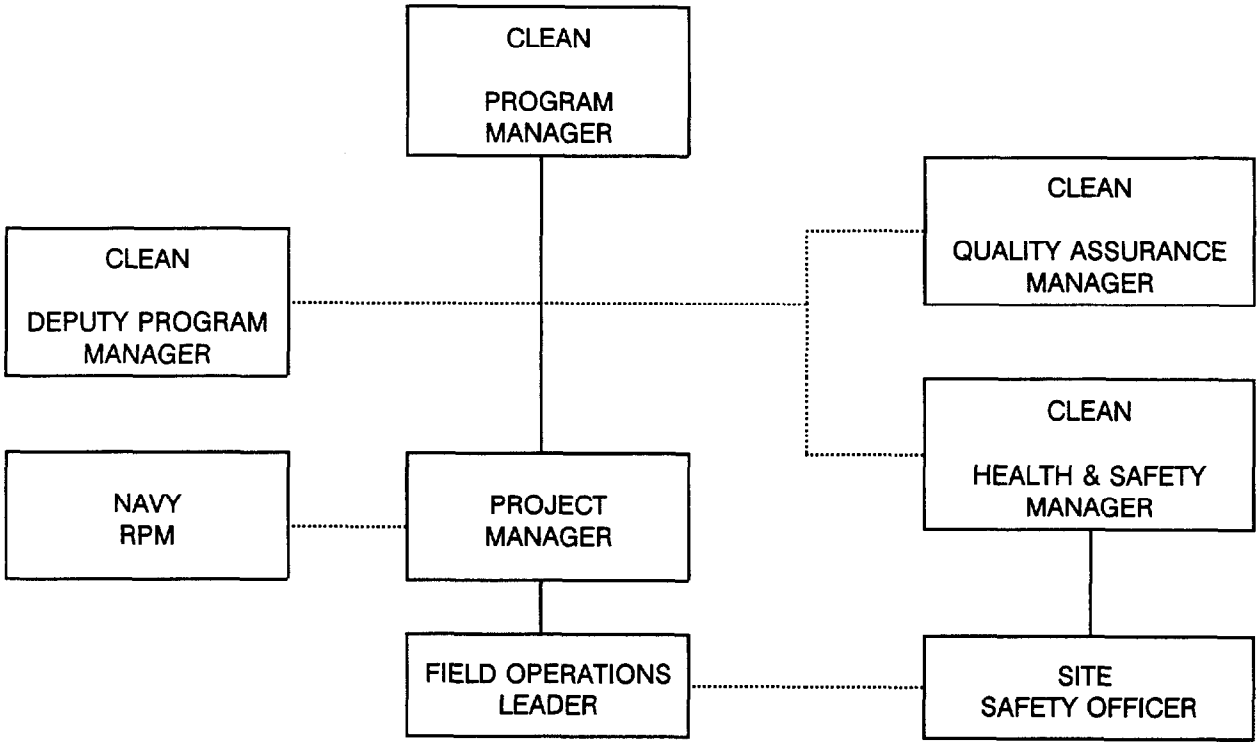
Daryl Hutson
Deputy Program Manager

Debra Scheib
Quality Assurance/Quality Control Manager

Matt Soltis
Health and Safety Manager

FIGURE D.4-1

PROJECT ORGANIZATION



LeeAnn Sinagoga
Project Manager

David Yost
Field Operations Leader (FOL)

The Program Manager, Mr. John Trepanowski, and the Deputy Program Manager, Mr. Daryl Hutson, are responsible for the overall quality of work performed under CLEAN Contract No. N62473-90-D-1298. Mr. Trepanowski and Mr. Hutson will be responsible for all contract negotiations with the Navy and the subcontractors; will maintain client relationships; and will assume overall responsibility for staffing, maintenance of schedule, adherence to budget, and quality of technical work performed. They are the firm's designated authority to commit resources to this effort. Mr. Trepanowski, Mr. Hutson, and the Project Manager are the focal points of all project activities; they will be immediately accessible to the Navy.

The Project Manager has the primary responsibility for project and technical management. She is the primary contact with the Navy Remedial Project Manager (RPM) and is responsible for the coordination of all onsite personnel, and for providing technical assistance for all activities that are directly related to the attainment of project objectives. The Project Manager assists with subcontractor procurement and is responsible for monitoring subcontractor performance. The review of all environmental and hydrogeologic data will also be conducted by the Project Manager. If quality assurance problems or deficiencies requiring special action are identified, the Project Manager and QA/QC manager (as applicable) will identify the appropriate corrective action.

Responsibilities of the FOL include:

- Interface with PM and Site Safety Officer
- Coordinate all onsite activities
- Provide technical assistance to onsite personnel
- Coordinate sampling activities
- Ensure availability and maintenance of all sampling materials and equipment
- Ensure proper handling and shipping of samples including chain of custody
- Supervise drilling subcontractor
- Maintain field documentation *e.g., geologic log, borings log, chain of custody)

4.2 FIELD ORGANIZATION

The Halliburton NUS field investigation team will be organized according to the activity planned. For onsite sampling, the sampling team members will be selected based upon the type and extent of effort required. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL)
- Field Hydrogeologist/Geologist/EOD Specialist
- Sampling technicians
- Site Health and Safety Officer

The FOL is responsible for the coordination of all onsite personnel and for providing technical assistance when required. The FOL, or his or her designee, will coordinate and be present during all sampling activities and will assure adherence to all sample acquisition and handling protocols and the availability and maintenance of all sampling materials/equipment. The FOL is responsible for the completion and quality assurance review of all sampling, well construction, and chain-of-custody documentation, and will assume custody of all samples and ensure the proper handling and shipping of samples. The FOL will interface with the QA/QC manager as deemed appropriate. All site personnel are responsible for adherence to all QA/QC guidelines as defined in this QA/QC Plan. Strict adherence to these procedures is critical to the collection of acceptable and representative data.

The FOL will also be responsible for providing technical supervision of the drilling subcontractor and for maintaining a geologic log of all borings drilled. Copies of the forms to be used in this investigation are provided in Appendix B.

The site Health and Safety Officer is responsible for assuring that all team members adhere to the designated health and safety requirements. Additional responsibilities of the site Health and Safety Officer are as follows:

- Updating equipment or procedures based on new information gathered during the site operation.

- Modifying the levels of protection based on site observations.

- Determining and posting locations and routes to medical facilities, including poison control centers, and arranging for emergency transportation to medical facilities.

- Notifying local public emergency officers, including police and fire departments, of the nature of the team's operations and posting these departments' telephone numbers.

- Examining work-party members for symptoms of exposure or stress.

- Providing onsite emergency medical care and first aid as necessary. The site Health and Safety Officer also has the responsibility to stop any field operation that threatens the health or safety of the team or the surrounding populace.

It is not anticipated that the Health and Safety Officer will be required on site at all times. The FOL or his or her designee, will function in this capacity during part of the field investigation and interface with the Health and Safety Manager on an as-needed basis.

4.3 LABORATORY OPERATIONS

Analyses of all environmental samples will be performed by a Naval Facilities Engineering Services Center (NFESC; formerly NEESA) approved laboratory. The laboratory work to support the VI Work Plan field activities will be performed as NEESA (20.2-047B, June 1988) Level C which requires use of EPA-approved methods and generation of CLP-type deliverables. To achieve/maintain approval status, the laboratory must successfully analyze a performance sample, undergo an audit, and correct deficiencies found during the audit.

5.0 QUALITY ASSURANCE OBJECTIVES

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide environmental monitoring data of known and acceptable quality. Specific procedures to be used for sampling, chain-of-custody, calibration of field instruments, laboratory analysis, reporting, internal quality control, audits, preventative maintenance, and corrective actions are described previously in the VI Work Plan or in later sections of this QA/QC Plan. The purpose of this section is to address the data quality objectives in terms of the (PARCC) parameters, quantitation and detection limits, and external field quality control measures such as field quality control blanks, duplicates, and bottleware cleanliness.

5.1 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the verification investigation activities. DQO level definitions are contained in the NEESA guidelines document (20.2 - 047B, June 1988). Criteria for Level C are shown in Table D.5-1. The sampling rationale provided in the VI Work Plan explains the choice of sample locations and media which will supply information needed for the Verification Investigation. The use of standardized sampling protocols and EPA-approved analytical methodologies is expected to satisfy project data quality needs in accordance with Navy and EPA requirements. Sampling SOPs are provided in Appendix C of the VI Work Plan. A summary of site-specific environmental samples, related quality control samples and associated analyses is presented in Tables 3-1 through 3-9 of the VI Work Plan.

5.2 PARCC PARAMETERS

The quality of a data set is measured by certain characteristics of the data, namely precision, accuracy, representativeness, comparability, and completeness, collectively referred to as the PARCC parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the VI and the intended use of the data define the PARCC goals.

5.2.1 Precision

Precision characterizes the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions.

TABLE D.5-1

NEESA DQO LEVEL DESCRIPTION

Level	Definition
C	A site requiring level C QC would be a site near a populated area not on the NPL, and not likely to be undergoing litigation. Level C QC includes review and approval of the laboratory QA and the site work plan. The laboratory must successfully analyze a performance sample, undergo an audit, and correct deficiencies found during the audit. These audits are administered and evaluated by NFESC. The Navy audit and performance sample are required in addition to any specified by the EPA Superfund Program. The laboratory that performs level C QC must have successfully analyzed the performance sample furnished by the Superfund CLP in the past year. The laboratory does not need to be receiving CLP bid lots of samples. Level C allows the use of non-CLP methods but requires that the methods be accepted EPA methods. All methods used must be EPA methods or be equivalent to EPA methods.

Precision can be expressed as a relative percent difference (RPD; the range relative to the mean, expressed as a percent) or relative standard deviation (RSD). Range and RPD values are calculated as follows:

$$Range = [OR - DR]$$

$$\% \ RPD = [\frac{OR - DR}{1/2(OR + DR)}] \times 100$$

where

OR = original sample result

DR = duplicate sample result

Alternatively, RSD involves the statistical comparison of the results of replicate analyses.

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a quality assurance check. Laboratory duplicates will be analyzed at the rate required by the analytical methods specified. Field duplicates will be collected for 10 percent of all samples collected.

5.2.2 Accuracy

Accuracy is the comparison between a sample result and a known or calculated value expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (blank spike recovery) or into actual samples (matrix spike or surrogate spike recovery). Recovery is calculated as follows:

$$\%R = \frac{SSR - SR}{SA} \times 100$$

where

SSR = Spiked Sample Result

SR = Sample Result

SA = Spike Added

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series of %R values. Organic control limits are set at the mean plus or minus two times the standard deviation of a series of %R values.

Out-of-criteria results will be reviewed for data applicability as a part of data validation. Aliquots of samples obtained from the site will be provided for the matrix spike analyses.

5.2.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location. The Work Plan and QA/QC Plan are designed to ensure this by specifying the use of standard sampling and analytical procedures, including the collection and analysis of field quality control blanks.

5.2.4 Comparability

Use of standardized sampling and analysis methods and data reporting format will ensure that comparability of the data will be achieved. Using consistent units will ensure that data are comparable both within the data set and as compared to previous data. Both field and laboratory data will be expressed in Standard International Units (SIUs). Results for aqueous organic samples will be reported in μg/L. Organic results for solid samples will be expressed in μg/kg for organics and mg/kg for inorganics. Results for wet-chemistry parameters will be expressed as mg/L or mg/Kg as applicable per matrix. Additionally, consideration will be given to seasonal conditions and other environmental conditions that could influence analytical results.

5.2.5 Completeness

Completeness is a measure of the amount of valid analytical data obtained compared to the amount expected to be obtained. Completeness is typically expressed as a percentage and is determined using the following equation:

$$\textit{Completeness}\ (\%) = \frac{\textit{number of samples having valid data}}{\textit{number of planned samples}} \times 100$$

The ideal objective for completeness is 100 percent; that is, every sample planned to be collected should be collected, and every sample submitted for analysis should result in the generation of valid data.

Realistically, samples can be compromised during shipping, handling, preparation, or analysis, and sample homogenicity or matrix interference factors can result in data that do not meet QA/QC acceptance criteria. Consequently, the completeness objective will be 90 percent on an installation-wide basis with additional consideration given to the collection of data at all critical sampling locations.

5.3 FIELD BLANKS

Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of source water used in (1) steam cleaning of large equipment; and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures and to determine whether the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event.

5.4 TRIP BLANKS

To determine whether contamination of samples or bottleware has occurred during transit or storage, trip blanks will be used. Trip blanks consist of analyte-free water preserved with hydrochloric acid (HCl) taken from the laboratory to the site and returned. Trip blanks are taken at the rate of one per cooler of samples designated for VOC analysis and, for the purpose of these investigations, will be analyzed for Apendix IX VOCs only.

5.5 EQUIPMENT RINSATE BLANKS

An equipment rinsate blank consists of the final analyte-free water rinse from equipment cleaning and is analyzed to monitor the effectiveness of the decontamination processes. Rinsate blanks are collected daily during the sampling event and the rinsate blanks generated from every other day are analyzed for the same suite of analyses as the associated samples.

5.6 FIELD DUPLICATES

Field duplicates are two samples collected either: (1) independently at a sampling location in the case of groundwater or surface water; or (2) as a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program (See also QA/QC Plan Section 5.2.1). Ten percent of all

samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory.

5.7 BOTTLEWARE

NFESC requires specific bottleware cleaning procedures. Precleaned bottles will be used at the Stump Neck Annex sites; the required certification will be provided.

5.8 QUANTITATION AND DETECTION LIMITS

Quantitation limits are those indicated as Practical Quantitation Limits (PQLs) within each analytical methodology. The quantification limits for the metals analyses will be expressed as Contract Required Detection Limits (CRDLs), as defined in the current Contract Laboratory Program (CLP) Statement of Work (SOW) for Inorganic Analysis. For both PQLs and CRDLs, allowances are made for dilutions and dry-weight conversions.

As required by the Navy, organic method detection limits (MDLs) and inorganic instrument detection limits (IDLs), will also be reported. MDLs and IDLs illustrate methodological and instrumental capabilities (independent of any sample considerations) and must be less than or equal to the applicable PQL or CRDL.

6.0 SAMPLING PROCEDURES

Sampling performed for the Verification Investigation will be governed by this QA/QC Plan (which considers specific EPA regional protocol), the Work Plan, and appended SOPs. If sampling conditions require deviations from the Work Plan and SOPs, such deviations will be documented in the field notebook and via a Field Task Modification Request (FTMR) in accordance with Section 13.2 of the CLEAN Quality Control Management Plan (Halliburton NUS, 1991) (QCMP). Section 7.4 of this QA/QC Plan further details use of the FTMR.

A copy of the approved QA/QC Plan and Work Plan containing all applicable SOPs will be made available to all field personnel by secured copies in the field office. As part of the mobilization activity, the Project Manager will hold a Fieldwork Orientation Meeting with the field team to review the applicable sampling documentation. The requirements of this orientation meeting are provided in CLEAN QA Standard Operating Guideline (SOG) QA-5, Training (Halliburton NUS, 1991).

7.0 SAMPLE MANAGEMENT

This section describes the guidelines and procedures to be implemented during the various activities involved in managing the samples collected during the VI. The following items are discussed:

- Sample Designation
- Sample Handling
- Sample Packaging and Shipping
- Sample Documentation
- Sample Custody

7.1 SAMPLE DESIGNATION

Each sample collected during the VI will be assigned a unique tracking number. The sample designation includes the sample or well location number, site number, and an indication of the sample matrix (e.g., soil, groundwater, surface water, or sediment). Sample designation procedures are described in Section 3.0 of the Work Plan.

7.2 SAMPLE HANDLING

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. The USEPA User's Guide to the CLP (USEPA, 1988b), the October 26, 1984 Federal Register (49 FR43260) (USEPA, 1984), and the Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document (USEPA, 1986a) address the topics of containers and sample preservation. Table 3-10 of the Work Plan provides a site-specific summary of all sample handling considerations.

7.3 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with Halliburton NUS SOPs SA-6.2 and 6.6 (Halliburton NUS, 1991), which are in accordance with the USEPA User's Guide to the Contract Laboratory Program (USEPA, 1988b). The FOL will be responsible for contacting the laboratory representative for each shipment and will report the following:

- Sampler name and telephone number
- Site name/code
- Number(s), matrix(ces), and concentration(s) of samples shipped
- Carrier name and air bill number(s) for the shipment
- Method of shipment (e.g., overnight)
- Date of shipment
- Suspected hazards associated with the samples or site

7.4 SAMPLE DOCUMENTATION

Custody of samples must be maintained and documented at all times. Chain of custody begins with the mobilization of sample containers and contaminant-free water. Section 5.3 of Halliburton NUS SOP SA-6.1 (Halliburton NUS, 1991) provides a description of the chain-of-custody procedures to be followed.

In addition, a sample log sheet will be completed for each sample collected. This form will contain the sample description and will document time and date, location, field measurements, and other pertinent data relative to the various samples. One form is specifically used for soil (and sediment) samples, another for groundwater samples. An example of these forms can be found in Halliburton NUS SOP SA-6.4 (Halliburton NUS,1991).

Separate bound/weatherproof field notebooks will be maintained by each sampling event leader and the Site Health and Safety Officer. The FOL, sampling event leader (or designee), and Site Health and Safety Officer will record all information related to sampling or field activities. This may include such information as sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, and description of photographs.

A site logbook will be maintained by the FOL. The requirements of the site logbook are outlined in Halliburton NUS SOP SA-6.3, Sections 5 and 7. This book will contain a summary of the day's activities and will reference the field notebook(s), when applicable.

Each supervisor of a drilling subcontractor activity must complete a Daily Activities Record Field Investigation Report, which documents the activities and progress of the daily drilling activities. The information in this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and material used. An example of this form is provided in Halliburton NUS SOP SA-6.5.

At the completion of field activities, the FOL will send the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc. The Project

Manager will ensure that these materials are entered into the Halliburton NUS document control system in accordance with appropriate administrative guidelines.

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The FOL notifies the Project Manager of the need for the change.
- If necessary, the Project Manager will discuss the change with the pertinent individuals (e.g., the Navy RPM, Halliburton NUS Quality Assurance Manager) and will provide a verbal approval or denial to the FOL for the proposed change.
- The FOL will document the change on a Field Task Modification Request (FTMR) form (Halliburton NUS, 1991) and forward the form to the Project Manager at the earliest convenient time (e.g., end of the workweek).
- The Project Manager will sign the form and distribute copies to the Navy RPM, Quality Assurance Manager, FOL, and project file.
- A copy of the completed FTMR will be attached to the field copy of the affected document (i.e., the Work Plan).

7.5 SAMPLE CUSTODY

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form that will be used during this investigation is included in Halliburton NUS SOP SA-6.1 (Halliburton NUS, 1991).

Samples collected during the verification investigation will be the responsibility of identified persons from the time they are collected until they are delivered to the analytical laboratory or entrusted to a carrier. Stringent chain-of-custody procedures will be followed to document sample possession.

7.5.1 Field Custody

- The FOL, or designee, is responsible for the care and custody of the samples collected until they are delivered to the analytical laboratory or entrusted to a carrier.

- Sample logs and other records will always be signed and dated.

- Chain-of-custody forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample (grab or composite designation), preservative, and specific analyses requested. These forms will be filled out legibly, using waterproof ink, and will be signed by the sampler or designated custodian. Similar information will be provided on the sample label, which will be securely attached to the sample bottle. The label will also include the general analyses to be conducted. In addition, sampling forms will be used to document collection, filtration, and preparation procedures.

7.5.2 Transfer of Custody and Shipment

The following procedures will be used when transferring custody of samples:

- Samples will always be accompanied by a chain-of-custody record. When samples are transferred, the individuals relinquishing and receiving them will sign, date, and note the time of the chain-of-custody record. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon the sample's arrival at the laboratory, internal sample custody procedures will be followed.

- Prior to being shipped to the laboratory for analysis, samples will be properly packaged. The methods of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record. Shipping containers will then be sealed for shipment to the laboratory. The original record will accompany the shipment and a copy will be retained by the field sampler. Sample packaging and transportation requirements are described in SOP SA-6.2. Sample custody procedures are also discussed in Section 3.0 of the Work Plan.

7.5.3 Laboratory Custody

When samples are received at the laboratory, the shipping manifest must be signed and dated to acknowledge sample receipt. Additionally, the laboratory must:

- keep a copy of the shipping manifest
- examine the shipping container's seal and verify the integrity of all the containers. (Sample container breakages or documentation discrepancies must be reported to the Halliburton NUS Project Manager.)

- review information in the accompanying paperwork (chain-of-custody, airbill, packing list, sample labels) to note any discrepancies.
- check the pH of incoming preserved samples (using hydrion paper) and document on receipt. (Improper preservation will be documented as out of control and the Halliburton NUS Project Manager notified.)

7.5.4 Sample Shipment Procedures

The following procedures will be followed when samples are shipped for laboratory analysis:

- Samples requiring refrigeration will be promptly chilled with ice or Blue Ice to a temperature of 4°C and will be packaged in an insulated cooler for transport to the laboratory. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

- Only shipping containers that meet all applicable State and Federal standards for safe shipment will be used.

- Shipping containers will be sealed with nylon strapping tape, and custody seals will be signed, dated, and affixed, in a manner that will allow the receiver to quickly identify any tampering during transport to the laboratory.

- The field chain-of-custody document will be placed inside the shipping container in a sealed plastic envelope after the courier has signed the document.

- Shipment will be made by overnight courier. After samples have been taken, they must be sent to the laboratory within 24 hours.

7.5.5 Field Documentation Responsibilities

It will be the responsibility of the FOL to secure all documents produced in the field (geologist's daily logs, lithologic and sampling logs, communications) at the end of each workday.

Only the project FOL or designee may remove field data from the site for reduction and evaluation.

The FOL will transfer all site records and notebooks to the Project Manager at the conclusion of the field activities.

The Project Manager will ensure that all records and notebooks are properly docketed into the project file.

Data generated by the laboratory will be sent to Halliburton NUS, validated, and stored by Halliburton NUS until completion and acceptance of the VI investigation report, or initiation of the project file closeout, as directed by the Navy.

8.0 CALIBRATION PROCEDURES

8.1 FIELD INSTRUMENTS

The equipment used for field data collection activities (and health and safety monitoring) will be calibrated and maintained according to Halliburton NUS SOP ME-11 and manufacturer's instructions. Calibration must be documented on an Equipment Calibration Log Sheet and an example of this form is included within Appendix B. During calibration an appropriate maintenance check must be performed on each piece of equipment. If damaged or failed parts are identified during the daily maintenance check, and it is determined that the damage could have an impact on the instrument's performance, the instrument must be removed from service until the identified parts are repaired or replaced. Additional details regarding the control of measuring and test equipment are provided in Section 13.0 (Preventive Maintenance) of this QA/QC Plan.

8.2 LABORATORY INSTRUMENTS

Instruments used in the laboratory will be calibrated according to method-specific requirements and the laboratory's quality assurance plan. Tables 3-1 through 3-9 of the VI Work Plan list all the analytical methods planned for this project. Analytical procedures are also discussed in Section 9.0 of this QA/QC Plan.

9.0 ANALYTICAL PROCEDURES

Environmental samples collected during the field investigation for chemical analyses will be analyzed using the appropriate analytical procedures as outlined in Section 3.0 of the VI Work Plan.

Field analytical measurements for this project include field test kit screening for TNT, HMX, and RDX; and testing for temperature, pH, eH, specific conductance, turbidity, and dissolved oxygen. Non-test kit field analytical procedures are included within the various fieldwork SOPs.

10.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation, and reporting are basic steps in the control and processing of field and laboratory project-generated data. These processes are discussed in detail below.

10.1 DATA REDUCTION AND COMPUTER STORAGE

The reduction of field and analytical data will consist of summarizing water-level measurements, soil boring logs, well construction and sampling logs, field parameters, and laboratory analytical results. These data will be presented in the form of tables, illustrations, and/or graphs. The original data and reduction forms will be maintained by Halliburton NUS as part of the project file.

Chemical data will be provided to Halliburton NUS in electronic form by the laboratory, and will be stored and managed by means of a data-management computer system which utilizes dBase files. Halliburton NUS incorporates a rigorous review of programs used for data reporting. Data entry is performed by a designated person, keeping access to the data base limited. If data entry is done manually, 100 percent of all data entries are checked by the operator and the printouts are checked against the original laboratory sets by an independent reviewer. Replicate measurements of a single sample are averaged prior to further data reduction for data summary tables; the RPD will be presented in summary tables for review. All tables generated will include the following:

- Sample identification
- Sample location
- Sample matrix
- Analyses performed
- Analytical results
- Relevant notes regarding analyses

10.2 DATA VALIDATION

Data validation consists of a stringent review of an analytical chemical data package with respect to sample receipt and handling, analytical methods, data reporting and deliverables, and document control. The quality of data generated by a laboratory is extremely important; it is an integral part of the investigation and is closely tied to the project goals. Data used to develop qualitative trends, for example, will not have the same data validation requirements as data used for litigation purposes. All analyses performed in support of the VI Work Plan will be conducted as NEESA DQO Level C.

A qualified Halliburton NUS chemist will review the analytical data package in accordance with Section 7.3 of Sampling and Chemical Analysis Quality Assurance Requirements for the Naval Installation Restoration Program (NEESA 20.2-047B, June 1988). Data validation will also reference the EPA Region III modifications to the National Functional Guidelines Protocols (6/92 Organics; 3/90 Inorganics), and method-specific quality control criteria. There will be 100 percent data validation of all samples. Data qualifiers will be assigned in accordance with the referenced protocols, and letter reports will be generated. The project database will incorporate the assigned data qualifiers through the processes discussed in the previous section.

10.3 DATA REPORTING

As required, a QC data report will be sent to the Navy. The report will indicate the duration and location of storage for all raw data, QC charts, corrective action information, sample lists, chain-of-custody forms, notebooks, work sheets, and automated data processing system output and calibration.

A summary of field activities conducted and analytical results generated will be submitted to the Navy in the form of a draft final report. The summary of analytical data (included as an appendix to this report) will incorporate all results, including nondetected compounds. All trip, field, and rinsate blanks will be marked. No subtraction of blank contaminants will be allowed; data will be flagged if blank contamination occurs. All data flags will follow the result in the summary. A format approved by the Navy will be used to present the data.

The draft final report will also include a QC summary section, which will discuss issues such as subcontractor performance and PARRC parameters evaluation results.

Field logs and forms will be included in another appendix, as directed by the Navy.

11.0 EXTERNAL/INTERNAL QUALITY CONTROL CHECKS

11.1 EXTERNAL QC CHECKS

In addition to standardized sample acquisition, handling and shipment procedures, external quality control checks will include the generation of field duplicates, field and equipment rinsate blanks, and laboratory-prepared trip blanks (see VI Work Plan Tables 3-1 through 3-9). A description of the nature, frequency, and analyses associated with each of these checks is included in Section 5.0 of this QA/QC Plan.

Other types of external quality control mechanisms include:

- Proper storage of samples.
- Use of qualified and/or certified technicians.
- Use of calibrated equipment traceable to Halliburton NUS, Navy, and EPA-approved protocol.
- Use of standardized test procedures.
- Formal independent confirmation of all computation and reduction of laboratory data and results.

The frequency of each control, the compounds to be used for spikes and the QC acceptance criteria are defined by the specific analytical methodology and laboratory quality assurance plan. It is the laboratory's responsibility to document in each data package that all analytical QC criteria have been met, and to detail where problems occured during analyses and what corrective actions were taken.

11.2 INTERNAL QC CHECKS

Internal quality control checks refer to those procedures existing as specific components of the analytical methodology. Internal quality control checks are preferred by the analytical laboratory and include:

- Use of surrogate spikes for organic analyses
- Performance of matrix spike, laboratory duplicate, and check sample analyses

- Development and use of control charts establishing procedural warning and action levels.

- Conduct of corrective actions

12.0 SYSTEM AND PERFORMANCE AUDITS

System audits will be performed periodically, as appropriate, to ensure that the work is being implemented in accordance with the approved project plans, SOPs, and in an overall satisfactory manner.

- The FOL will supervise and check daily that the monitoring wells are installed and developed correctly, field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and fieldwork is documented accurately and neatly.

- The data validator will review (on a timely basis) the data packages submitted by the laboratory. The data validator will check that the data were obtained through the approved methodology, that the appropriate level of QC effort and reporting was conducted, that holding times were met, and that the results are in conformance with the QC criteria. On the basis of these factors, the data validator will evaluate the data quality and limitations.

- The Project Manager will oversee the FOL and data validator and will check that management of the acquired data proceeds in an organized and expeditious manner according to established systems.

System audits for the laboratory will be performed regularly in conjuction with the laboratory's quality assurance plan.

A formal performance audit of the field sampling procedures may be conducted (at the discretion of the Navy and the Halliburton NUS Quality Assurance Manager) in addition to the auditing that is an inherent part of the daily project activities. If a formal audit is conducted (i.e., if the site is selected to be monitored as part of the oversight program), the auditor will check that sample collection, sample handling, decontamination protocols, and instrument calibration and use are in accordance with the approved project SOPs. The auditor will also check that the field documentation logs and chain-of-custody forms are being filled out properly. The results of audits will be distributed as described in the CLEAN QCMP.

The FOL, Project Manager, and CLEAN Quality Assurance Manager will determine and implement corrective actions as the need arises. Corrective action for nonconforming conditions is addressed in the CLEAN QCMP as QASOG No. 1.

Performance audits of chemical analytical laboratories are conducted by NFESC.

13.0 PREVENTATIVE MAINTENANCE

Halliburton NUS has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The equipment manager keeps an inventory of the equipment in terms of items (model and serial number), quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness.

- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.

- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.

Additional guidance covering the control of measuring and test equipment is provided in Halliburton NUS SOP ME-11 and CLEAN QCMP protocol QA SOG No. 2.

The analytical laboratory must follow a well-defined program to prevent the failure of laboratory equipment and instrumentation. This preventive program includes the periodic inspection, lubrication, cleaning, and replacement of parts of the equipment. All preventive maintenance must be documented (auditable). In particular, the performance history of all major laboratory equipment must be documented in instrument maintenance logs. In addition, equipment used to calibrate analytical equipment must be certified by National Institute of Standards and Technology (NIST) and/or calibrated periodically against standards having known and valid traceability to recognized standards. The analytical laboratory must also maintain an inventory of critical spare parts to decrease instrument downtime. The laboratory's preventative maintenance program is defined in the laboratory quality assurance plan.

14.0 DATA ASSESSMENT PROCEDURES

14.1 PARCC PARAMETERS

All data generated in the investigations will be assessed for precision, accuracy, representativeness, comparability, and completeness as discussed in QA/QC Plan Sections 5.0 and 10.0.

14.2 DATA VALIDATION

One hundered percent of the chemical analytical data generated to support this project will be formally validated. Validation processes are discussed in Section 10.0.

14.3 DATA EVALUATION

Evaluation of data collected during the field investigation will include a comparison of chemical concentrations in the hydraulically upgradient groundwater wells (when they exist) versus the chemical concentration in the downgradient groundwater wells; chemical concentrations in groundwater versus applicable or relevant and appropriate requirements (ARARs) (such as the Safe Drinking Water Act Maximum Contaminant Levels) and risk-based concentrations; and chemical concentrations in soils versus background and risk-based concentrations.

Chemical concentrations in hydraulically upgradient groundwater will be compared to those in downgradient groundwater. If there is a significant increase in contaminant concentrations, this increase may indicate that the site is a source of the contamination. Evidence of groundwater contamination would be considered relatively conclusive if there is a significant (one or more orders of magnitude) increase in contaminant concentrations from the upgradient wells to the downgradient wells. If the contaminant concentrations are nearly identical in the upgradient and downgradient wells, this would indicate that the site is not causing the groundwater contamination. Otherwise, the data are inconclusive and the additional rounds of groundwater sampling may be necessary to form a conclusion.

The approach for evaluating contaminant concentrations in soils is different than that for groundwater, since most target organics are not naturally found in soils and TAL metals are naturally found in soils. Any detectable concentration of organic concentrations may be potentially significant and may be an indication of past operations. Contaminant fate and transport properties (using soil/water partitioning calculations) and

risk-based calculations will be used to determine if the target organic chemicals in the soils represent a significant risk to groundwater (environment) or to human health. If inorganic chemicals are found at concentrations above background, a risk assessment will be performed to determine if the concentrations represent a significant risk to human health.

The field sampling program will also include the collection of background soil samples (surface and subsurface) at Range 6, the IED, and Area 8. The sample locations will be determined in the field. These samples will be taken at locations that have not been impacted by past site operations.

15.0 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the Project Manager. The Project Manager, with the assistance of the QA/QC Manager, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action taken has been effective. Corrective actions may include the following: resampling and/or reanalysis of sample, amending or adjusting project procedures. As applicable, FTMKs will be initiated as discussed in QA/QC Plan Section 7.4. If warranted by the severity of the problem (for example, if a change in the approved Work Plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the problem has been eliminated.

The laboratory maintains an internal closed-loop corrective action system. Acceptability of laboratory data is defined by method-specific QC criteria and limits established in the laboratory quality assurance plan. Performance oversight and corrective action identification and implementation is the responsibility of the laboratory QA coordinator.

16.0 QUALITY ASSURANCE REPORTS

The QA/QC Manager (or designee) will review all aspects of the implementation of the QA/QC Plan on a regular basis and will provide regular input to the Project Manager. This information will be incorporated into the monthly progress reports for CTO #222. The reviews will include an assessment of field activities, of data quality, and the results of system and/or performance audits. Any significant QA deficiencies will be reported and identified, and corrective actions discussed.

If significant, unsatisfactory problems or trends are identified in laboratory analytical data, the Quality Assurance Manager will submit a recommendation for data rejection or payment reduction to the Halliburton NUS Contracting Officer.

The Quality Assurance Manager will maintain a data base of the following factors related to analytical services performed in support of the VI Work Plan:

- Source of the sample
- Number of samples analyzed
- Type of analysis
- Parameters measured and sample matrix
- Name of the company where samples were sent for analysis
- Total cost of analysis
- Cost per sample
- Turnaround time for analysis
- QA/QC requirements
- Protocol used
- Acceptance rate of product

An annual report on these factors, with an overall analysis of the effectiveness of the analytical programs/services used, is prepared by the Quality Assurance Manager and submitted to the Navy.

APPENDIX E

USEPA REGION III
RISK-BASED CONCENTRATION TABLE, JANUARY - JUNE 1995

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region III
841 Chestnut Street
Philadelphia, Pennsylvania 19107

March 7, 1995

SUBJECT: Risk-Based Concentration Table, January - June 1995

FROM: Roy L. Smith, Ph.D., Senior Toxicologist
Technical Support Section (3HW13)

TO: RBC Table Mailing List

Attached is the EPA Region III Risk-Based Concentration (RBC) table, which we have distributed quarterly to all interested parties since 1991. Please see below for some important announcements concerning changes in the Table and administrative issues with our mailing list.

Major Changes in this Issue of the RBC

1. IRIS and HEAST have matured, and EPA has revised them at a decreasing rate over the last few years. Lately, each quarterly RBC update has been virtually the same as its predecessor. Meanwhile, the mailing list for the RBC table has expanded exponentially and the quarterly mailings have become a substantial burden to the Region. Upon reflection, we've decided to change to semi-annual distribution. We think this change will extend our ability to keep producing the RBC table, while having little effect on the table's usefulness. (For example, there have been *no* changes to toxicity constants in IRIS or HEAST in the three months since the 4th quarter table was published.)

2. The RBC table now includes soil screening levels (SSLs) for protection of groundwater and air. Most of the new entries were taken directly from EPA/OSWER's newly proposed SSL guidance document. We've added some additional SSLs based on the same proposed methodology. Sources of SSLs are noted in the table. SSLs incorporate all the same exposure assumptions as RBCs, plus many additional assumptions needed for inter-media extrapolation. SSLs are therefore distinct from RBCs, and should be used only in the framework proposed in the OSWER document. If you have not yet seen this proposal, you can obtain it from NTIS (703-487-4650, as document numbers 9355.4-1, PB95-963530, or EPA540/R-94/105).

Administrative Issues

Our situation on the administrative front can be summarized in one word--"HELP"!! The RBC mailing list now includes more than 1300 recipients and we are experiencing significant problems with our current "delivery system." We would appreciate your suggestions for making our future mailings more efficient. We are also exploring the possibility of providing access to the RBC through an electronic bulletin board and would like your feedback on that idea. In the meantime, we will be examining our current mailing list and limiting future mailings to one individual per organization; we need your help in distributing the RBC within your organization if there are others who would like copies.

We have installed a new phone line to help with your questions about the RBC: 215-597-1116. This is Anna Poulton's number and it has a voice-mail system to take your calls if we're not available. Please limit your questions to RBC issues; if you have a question about applying the RBC to a site, please call the EPA Regional office handling the project.

Thanks for your patience and cooperation with these administrative issues!

Minor Changes

1. As many have requested, the soil ingestion rate for commercial/industrial exposure has been revised to include EPA's national default assumption that only 50% of ingested soil is associated with work. The worker soil exposure is now fully consistent with EPA's standard exposure factors for Superfund.

2. Many callers have complained about the lower case 'e' and 'o' notations on the table, which can't be easily distinguished. All such notations have been capitalized.

Still the Same

The table contains reference doses and carcinogenic potency slopes (obtained from IRIS through January 1, 1995, HEAST through March 1994, the Superfund Health Risk Technical Support Center, and other EPA sources) for nearly 600 chemicals. These toxicity constants have been combined with "standard" exposure scenarios to calculate RBCs - chemical concentrations corresponding to fixed levels of risk (*i.e.*, a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration) in water, air, fish tissue, and soil.

The Region III toxicologists use the table to screen sites not yet on the NPL, respond rapidly to citizen inquiries, and spot-check formal baseline risk assessments. The background materials provide the complete basis for all the calculations, with the intent of showing users exactly how the RBCs were developed. Simply put, RBCs are risk assessments run in reverse. For a single contaminant in a single medium, under standard default exposure assumptions, the RBC corresponds to the target risk or hazard quotient.

The RBCs also have several important limitations. Specifically excluded from consideration are (1) transfers from soil to air and groundwater, and (2) cumulative risk from multiple contaminants or media. Also, the toxicity information in the table has been assembled by hand, and (despite extensive checking and years of use) may contain errors. It's advisable to cross-check before relying on any RfDs or CPSs in the table. If you find any errors, please send me a note.

Many people want to know if the risk-based concentrations can be used as valid no-action levels or cleanup levels, especially for soils. The answer is a bit complex. First, it is important to realize that the RBC table does not constitute regulation or guidance, and should not be viewed as a substitute for a site-specific risk assessment. For sites where:

1. A single medium is contaminated;

2. A single contaminant contributes nearly all of the health risk;

3. Volatilization or leaching of that contaminant from soil is expected not to be significant;

4. The exposure scenarios used in the RBC table are appropriate for the site;

5. The fixed risk levels used in the RBC table are appropriate for the site; and

6. Risk to ecological receptors is expected not to be significant;

the risk-based concentrations would probably be protective as no-action levels or cleanup goals. However, to the extent that a site deviates from this description, as most do, the RBCs would not necessarily be appropriate.

To summarize, the table should generally not be used to (1) set cleanup or no-action levels at CERCLA or RCRA Corrective Action sites, (2) substitute for EPA guidance for preparing baseline risk assessments, or (3) determine if a waste is hazardous under RCRA.

Attachment

EPA Region III Risk-Based Concentration Table

Background Information

Roy L. Smith, Ph.D.
Senior Toxicologist
February 9, 1995

Development of Risk-Based Concentrations

General

Separate carcinogenic and non-carcinogenic risk-based concentrations were calculated for each compound for each pathway. The concentration in the table is the lower of the two, rounded to two significant figures. The following terms and values were used in the calculations:

Exposure variables	Value	Symbol
General:		
Carcinogenic potency slope oral (risk per mg/kg/d):	*	CPSo
Carcinogenic potency slope inhaled (risk per mg/kg/d):	*	CPSi
Reference dose oral (mg/kg/d):	*	RfDo
Reference dose inhaled (mg/kg/d):	*	RfDi
Target cancer risk:	1e-06	TR
Target hazard quotient:	1	THQ
Body weight, adult (kg):	70	BWa
Body weight, age 1-6 (kg):	15	BWc
Averaging time carcinogens (d):	25550	ATc
Averaging time non-carcinogens (d):	ED*365	ATn
Inhalation, adult (m3/d):	20	IRAa
Inhalation, child (m3/d):	12	IRAc
Inhalation factor, age-adjusted (m3-y/kg-d):	11.66	IFAadj
Tap water ingestion, adult (L/d):	2	IRWa
Tap water ingestion, age 1-6 (L/d):	1	IRWc
Tap water ingestion factor, age-adjusted (L-y/kg-d):	1.09	IFWadj
Fish ingestion (g/d):	54	IRF
Soil ingestion, adult (mg/d):	100	IRSa
Soil ingestion, age 1-6 (mg/d):	200	IRSc
Soil ingestion factor, age adjusted (mg-y/kg-d):	114.29	IFSadj
Residential:		
Exposure frequency (d/y):	350	EFr
Exposure duration, total (y):	30	EDtot
Exposure duration, age 1-6 (y):	6	EDc
Volatilization factor (L/m3):	0.5	K

Exposure variables	**Value**	**Symbol**
Occupational:		
Exposure frequency (d/y):	250	EFo
Exposure duration (y):	25	EDo
Fraction of contaminated soil ingested (unitless)	0.5	FC

*: Contaminant-specific toxicological constants. The priority among sources of toxicological constants was as follows: (1) IRIS, (2) HEAST, (3) HEAST alternative method, (4) EPA Superfund Health Risk Technical Support Center, (5) withdrawn from IRIS or HEAST, and (6) other EPA documents. Each source was used only if numbers from higher-priority sources were unavailable. The EPA Superfund Health Risk Technical Support Center, part of the Chemical Mixtures Branch of ECAO-Cincinnati, develops provisional RfDs and CPSs on request for contaminants not in IRIS or HEAST. These provisional values are labeled "E = EPA-ECAO provisional" in the table. It is possible they may be obsolete. If one of the "E" constants is important to a Superfund risk assessment, consider requesting, through a Regional risk assessor, a new provisional value.

Age-adjusted factors

Because contact rates with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximated the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations for two age groups - small children and adults. The age-adjusted factor for soil was obtained from RAGS IB; the others were developed by analogy.

Air inhalation

$$IFAadj \quad \frac{m^3 \cdot y}{kg \cdot d} = \frac{EDc \cdot IRAc}{BWc} + \frac{(EDtot - EDc) \cdot IRAa}{BWa}$$

Tap water ingestion

$$IFWadj \quad \frac{L \cdot y}{kg \cdot d} = \frac{EDc \cdot IRWc}{BWc} + \frac{(EDtot - EDc) \cdot IRWa}{BWa}$$

Soil ingestion

$$IFSadj \quad \frac{mg \cdot y}{kg \cdot d} = \frac{EDc \cdot IRSc}{BWc} + \frac{(EDtot - EDc) \cdot IRSa}{BWa}$$

Residential water

Volatilization terms were calculated only for compounds with a mark in the "VOC" column. Compounds having a Henry's Law constant greater than 10^{-5} were considered volatile. The list may be incomplete, but is unlikely to include false positives. The equations and the volatilization factor (K, above) were obtained from RAGS IB. Oral potency slopes and reference doses were used for both oral and inhaled exposures for volatile compounds lacking inhalation values. Inhaled potency slopes were substituted for unavailable oral potency slopes only for volatile compounds; inhaled RfDs were substituted for unavailable

oral RfDs for both volatile and non-volatile compounds. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

Carcinogens

$$RBC\ \frac{\mu g}{L} = \frac{TR \cdot ATc \cdot 1000\ \frac{\mu g}{mg}}{EFr \cdot ([K \cdot IFAadj \cdot CPSi] + [IFWadj \cdot CPSo])}$$

Non-carcinogens

$$RBC\ \frac{\mu g}{L} = \frac{THQ \cdot BWa \cdot ATn \cdot 1000\ \frac{\mu g}{mg}}{EFr \cdot EDtot \cdot \left(\frac{K \cdot IRAa}{RfDi} + \frac{IRWa}{RfDo}\right)}$$

Ambient air

Oral potency slopes and references were used where inhalation values were not available. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

Carcinogens

$$RBC\ \frac{\mu g}{m^3} = \frac{TR \cdot ATc \cdot 1000\ \frac{\mu g}{mg}}{EFr \cdot IFAadj \cdot CPSi}$$

Non-carcinogens

$$RBC\ \frac{\mu g}{m^3} = \frac{THQ \cdot RfDi \cdot BWa \cdot ATn \cdot 1000\ \frac{\mu g}{mg}}{EFr \cdot EDtot \cdot IRAa}$$

Edible fish

All RBCs were based on adult exposure.

Carcinogens

$$RBC\ \frac{mg}{kg} = \frac{TR \cdot BWa \cdot ATc}{EFr \cdot EDtot \cdot \frac{IRF}{1000\ \frac{g}{kg}} \cdot CPSo}$$

Non-carcinogens

$$RBC\ \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFr \cdot EDtot \cdot \frac{IRF}{1000\ \frac{g}{kg}}}$$

Commercial/industrial soil ingestion

RBCs were based on adult occupational exposure, including an assumption that only 50% of total soil ingestion is work-related.

Carcinogens

$$RBC\ \frac{mg}{kg} = \frac{TR\ BWa\ ATc}{EFo \cdot EDo \cdot \frac{IRSa}{10^6\ \frac{mg}{kg}} \cdot FC \cdot CPSo}$$

Non-carcinogens

$$RBC\ \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFo \cdot EDo \cdot \frac{IRSa}{10^6\ \frac{mg}{kg}} \cdot FC}$$

Residential soil ingestion

RBCs for carcinogens were based on combined childhood and adult exposure: RBCs for non-carcinogens were based on childhood exposure only.

Carcinogens

$$RBC\ \frac{mg}{kg} = \frac{TR \cdot ATc}{EFr \cdot \frac{IFSadj}{10^6\ \frac{mg}{kg}} \cdot CPSo}$$

Non-carcinogens

$$RBC\ \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWc \cdot ATn}{EFr \cdot EDc \cdot \frac{IRSc}{10^6\ \frac{mg}{kg}}}$$

Development of Soil Screening Levels

General

In December 1994 the EPA Office of Solid Waste and Emergency Response proposed Soil Screening Guidance (Document 9355.4-1, PB95-963530, EPA540/R-94/101, available through NTIS at 703-487-4650). This draft document provides (1) a framework in which soil screening levels are to be used, (2) a detailed methodology for calculating soil screening levels, and (3) soil screening levels for 107 substances.

Consistent with this new guidance, the risk-based concentration table now includes two columns of generic soil screening levels (SSLs). OSWER's 107 proposed soil screening levels have been added verbatim. In addition, the proposed SSL methodology has been used to calculate soil screening levels for more substances, which are also included in the

new table. The table clearly distinguishes the OSWER SSLs from the "unofficial" ones.

These SSLs provide reasonable maximum estimates of transfers of contaminants from soil to other media. One column contains soil concentrations protective of groundwater quality; the other contains soil concentrations protective of air quality. "Protective" is defined in the same terms as the risk-based concentrations for tap water and air -- that residential contact scenarios will yield a fixed upper bound risk of 10^{-6} or a fixed hazard quotient of 1 (whichever occurs at the lower concentration).

OSWER's SSLs should be used only within the framework proposed in the guidance document. The additional SSLs included in the RBC table are intended for the same uses (although they obviously carry less weight than the formally proposed numbers).

The SSLs are based on the following assumptions:

Input variables	**Value**	**Symbol***
Surface soil moisture content (g/g)	0.1	W_s
Vadose zone soil moisture content (kg/kg)	0.2	W_v
Surface soil bulk density (g/cm^3)	1.5	ρ_{bs}
Vadose zone soil bulk density (kg/L)	1.5	ρ_{bv}
Surface soil particle density (g/cm^3)	2.65	ρ_{ss}
Vadose zone soil particle density (g/cm^3)	2.65	ρ_{sv}
Total surface soil porosity (L pore /L soil)	0.43	N_s
Total vadose zone soil porosity (L pore/L soil)	0.43	N_v
Air-filled surface soil porosity (L air/L soil)	0.28	θ_{as}
Water-filled surface soil porosity (L water/L soil)	0.15	θ_{ws}
Air-filled vadose zone soil porosity (L air/L soil)	0.13	θ_{av}
Water-filled vadose zone soil porosity (L water/L soil)	0.30	θ_{wv}
Organic carbon fraction of surface soil (g/g)	0.006	FOC_s
Organic carbon fraction of vadose zone soil (g/g)	0.002	FOC_v
Dispersion factor for 0.5 acres (g/m^{2}s per kg/m^3)	35.1	Q/C
Particulate emission factor (m^3/kg)	6.79e+08	PEF
Exposure interval (s)	9.50e+08	T
Dilution-attenuation factor (unitless)	10	DAF

*: Symbols were adjusted, variables were rearranged, and derived and chemical-specific variables were omitted for simplicity and clarity. Presentation of the input variables in a single table using the same terms as in the OSWER SSL document would have been confusing. The terms used here are generally similar to OSWER's, and can easily be compared with the SSL guidance document.

With two exceptions described in the following section, SSL calculations were based on the same algorithms presented in the OSWER draft SSL guidance document. For details of the calculations (and for general background information on SSLs), I strongly recommend

consulting that document. The "unofficial" SSLs were developed under the following conditions:

Soil Screening Levels for Inhalation

Inhaled reference doses and potency slopes were used if available. If inhalation values were not available, oral RfDs and potency slopes were substituted. SSLs were calculated only for substances for which aqueous solubility, Koc, Henry's Law constant, and diffusivity in air were available. SSLs were calculated only for substances for which a volatilization factor could be calculated. This was done because OSWER's large proposed particulate emission factor rendered it pointless to estimate SSLs for particulate emissions alone. The final calculated SSL shown in the RBC table is the smaller of the risk-based SSL and the soil saturation concentration. All calculated SSLs were rounded to 2 significant figures.

The OSWER risk algorithms for inhalation were revised in order to be consistent with the rest of the RBC table. Only calculated SSLs were affected by this; SSLs proposed by OSWER are presented verbatim. Calculated SSLs for inhalation of carcinogens were based on an integrated lifetime exposure rather than adult exposure. SSLs for inhalation of noncarcinogens were based on adult exposure for 350 days per year rather than 365 days per year. The following algorithms were used to calculate inhalation SSLs:

Carcinogens

$$SSL \ \frac{mg}{kg} = \frac{TR \cdot ATc}{EFr \cdot IFAadj \cdot \left(\frac{1}{VF} + \frac{1}{PEF}\right) \cdot CPSi}$$

Non-carcinogens

$$SSL \ \frac{mg}{kg} = \frac{THQ \cdot BWa \cdot ATn \cdot RfDi}{EFr \cdot EDtot \cdot IRAa \cdot \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Soil Screening Levels for Groundwater Use

All algorithms were as proposed by OSWER. MCLs were used as target groundwater concentrations if available. If MCLs were unavailable the risk-based concentration in the "tap water" column of the RBC table was used as the target groundwater concentration. All SSLs for groundwater are based on a dilution-attenuation factor (DAF) of 10. Since these SSLs scale linearly with DAF, the SSLs for DAF=1 would be ten times lower. They were omitted to conserve space. All groundwater SSLs were rounded to 2 significant figures and capped at unity.

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-ECAO Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration.

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Soil Ingestion: Residential mg/kg	Soil Screening Levels-Transfers from Soil to: Air mg/kg	Groundwater mg/kg
Acephate	30560191	4.00E-03 I		8.70E-03 I			7.7 C	0.72 C	0.36 C	660 C	73 C		
Acetaldehyde	75070		2.57E-03 I		7.70E-03 I		94 N	0.81 C					
Acetochlor	34256821	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Acetone	67641	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	62000 E	8 E
Acetone cyanohydrin	75865	7.00E-02 H	4.00E-02 A				2600 N	150 N	95 N	140000 N	5500 N		
Acetonitrile	75078	6.00E-03 I	1.43E-02 A				220 N	52 N	8.1 N	12000 N	470 N		
Acetophenone	98862	1.00E-01 I	5.71E-06 W			☒	0.042 N	0.021 N	140 N	200000 N	7800 N		
Acifluorfen	62476599	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Acrolein	107028	2.00E-02 H	5.71E-06 I				730 N	0.021 N	27 N	41000 N	1600 N		
Acrylamide	79061	2.00E-04 I		4.50E+00 I	4.55E+00 I		0.015 C	0.0014 C	0.0007 C	1.3 C	0.14 C		
Acrylic acid	79107	5.00E-01 I	1.00E-03 I				18000 N	3.7 N	680 N	1E+06 N	39000 N		
Acrylonitrile	107131	1.00E-03 H	5.71E-04 I	5.40E-01 I	2.38E-01 I		0.12 C	0.026 C	0.0058 C	11 C	1.2 C		
Alachlor	15972608	1.00E-02 I		8.00E-02 H			0.84 C	0.078 C	0.039 C	72 C	8 C		
Alar	1596845	1.50E-01 I					5500 N	550 N	200 N	310000 N	12000 N		
Aldicarb	116063	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N	570 S	0.036 N
Aldicarb sulfone	1646884	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Aldrin	309002	3.00E-05 I		1.70E+01 I	1.71E+01 I		0.004 C	0.00037 C	0.00019 C	0.34 C	0.038 C	0.5 E	0.005 E
Ally	74223646	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Allyl alcohol	107186	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Allyl chloride	107051	5.00E-02 W	2.86E-04 I				1800 N	1 N	68 N	100000 N	3900 N		
Aluminum	7429905	1.00E+00 E					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Aluminum phosphide	20859738	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Amdro	67485294	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Ametryn	834128	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		
m-Aminophenol	591275	7.00E-02 H					2600 N	260 N	95 N	140000 N	5500 N		
4-Aminopyridine	504245	2.00E-05 H					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Amitraz	33089611	2.50E-03 I					91 N	9.1 N	3.4 N	5100 N	200 N		
Ammonia	7664417		2.86E-02 I				1000 N	100 N					
Ammonium sulfamate	7773060	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Aniline	62533		2.86E-04 I	5.70E-03 I			10 N	1 N	0.55 C	1000 C	110 C	45 N	0.031 N
Antimony and compounds	7440360	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Antimony pentoxide	1314609	5.00E-04 H					18 N	1.8 N	0.68 N	1000 N	39 N		
Antimony potassium tartrate	304610	9.00E-04 H					33 N	3.3 N	1.2 N	1800 N	70 N		
Antimony tetroxide	1332316	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
Antimony trioxide	1309644	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
Apollo	74115245	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Aramite	140578	5.00E-02 H		2.50E-02 I	2.49E-02 I		2.7 C	0.25 C	0.13 C	230 C	26 C		
Arsenic	7440382	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N	380 E	15 E
Arsenic (as carcinogen)	7440382			1.75E+00 I	1.51E+01 I		0.038 C	0.00041 C	0.0018 C	3.3 C	0.37 C	380 E	15 E
Arsine	7784421		1.43E-05 I				0.52 N	0.052 N					
Assure	76578148	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		
Asulam	3337711	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		

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Atrazine	1912249	3.50E-02 I		2.22E-01 H			0.3 C	0.028 C	0.014 C	26 C	2.9 C		
Avermectin B1	65195553	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Azobenzene	103333			1.10E-01 I	1.08E-01 I		0.61 C	0.058 C	0.029 C	52 C	5.8 C		
Barium and compounds	7440393	7.00E-02 I	1.43E-04 A				2600 N	0.52 N	95 N	140000 N	5500 N	350000 E	32 E
Baygon	114261	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Bayleton	43121433	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Baythroid	68359375	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Benefin	1861401	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N		
Benomyl	17804352	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Bentazon	25057890	2.50E-03 I					91 N	9.1 N	3.4 N	5100 N	200 N		
Benzaldehyde	100527	1.00E-01 I				☒	610 N	370 N	140 N	200000 N	7800 N		
Benzene	71432		1.71E-03 E	2.90E-02 I	2.90E-02 I	☒	0.36 C	0.22 C	0.11 C	200 C	22 C	0.5 E	0.02 E
Benzenethiol	108985	1.00E-05 H					0.37 N	0.037 N	0.014 N	20 N	0.78 N		
Benzidine	92875	3.00E-03 I		2.30E+02 I	2.35E+02 I		0.00029 C	0.00003 C	0.00001 C	0.025 C	0.0028 C	1.3 C	1.100E-06 C
Benzoic acid	65850	4.00E+00 I					150000 N	15000 N	5400 N	1E+06 N	310000 N	320 S	280 E
Benzotrichloride	98077			1.30E+01 I			0.0052 C	0.00048 C	0.00024 C	0.44 C	0.049 C	0.012 C	0.000073 C
Benzyl alcohol	100516	3.00E-01 H					11000 N	1100 N	410 N	610000 N	23000 N		
Benzyl chloride	100447			1.70E-01 I		☒	0.062 C	0.037 C	0.019 C	34 C	3.8 C	0.5 C	0.00036 C
Beryllium and compounds	7440417	5.00E-03 I		4.30E+00 I	8.40E+00 I		0.016 C	0.00075 C	0.00073 C	1.3 C	0.15 C	690 E	180 E
Bidrin	141662	1.00E-04 I					3.7 N	0.37 N	0.14 N	200 N	7.8 N		
Biphenthrin (Talstar)	82657043	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
1,1-Biphenyl	92524	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N	9000 S	110 N
Bis(2-chloroethyl)ether	111444			1.10E+00 I	1.16E+00 I	☒	0.0092 C	0.0054 C	0.0029 C	5.2 C	0.58 C	0.3 E	0.0003 E
Bis(2-chloroisopropyl)ether	39638329	4.00E-02 I		7.00E-02 H	3.50E-02 H	☒	0.26 C	0.18 C	0.045 C	82 C	9.1 C		
Bis(chloromethyl)ether	542881			2.20E+02 I	2.17E+02 I	☒	0.00005 C	0.00003 C	0.00001 C	0.026 C	0.0029 C	0.00004 C	1.000E-07 C
Bis(2-chloro-1-methylethyl)ether				7.00E-02 W	7.00E-02 W		0.96 C	0.089 C	0.045 C	82 C	9.1 C		
Bis(2-ethylhexyl)phthalate (DEHP)	117817	2.00E-02 I		1.40E-02 I			4.8 C	0.45 C	0.23 C	410 C	46 C	210 E	11 E
Bisphenol A	80057	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Boron (and borates)	7440428	9.00E-02 I	5.71E-03 H				3300 N	21 N	120 N	180000 N	7000 N		
Boron trifluoride	7637072		2.00E-04 H				7.3 N	0.73 N					
Bromodichloromethane	75274	2.00E-02 I		6.20E-02 I		☒	0.17 C	0.1 C	0.051 C	92 C	10 C	1800 E	0.3 E
Bromoethene	593602				1.10E-01 H	☒	0.096 C	0.057 C					
Bromoform (tribromomethane)	75252	2.00E-02 I		7.90E-03 I	3.85E-03 I	☒	2.4 C	1.6 C	0.4 C	720 C	81 C	46 E	0.5 E
Bromomethane	74839	1.40E-03 I	1.43E-03 I			☒	8.7 N	5.2 N	1.9 N	2900 N	110 N	2 E	0.1 E
4-Bromophenyl phenyl ether	101553	5.80E-02 O					2100 N	210 N	78 N	120000 N	4500 N		
Bromophos	2104963	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		
Bromoxynil	1689845	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Bromoxynil octanoate	1689992	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
1,3-Butadiene	106990				9.80E-01 I	☒	0.011 C	0.0064 C				0.0013 C	0.000072 C
1-Butanol	71363	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	9700 E	8 E
Butyl [illegible] thalate	85687	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N	530 [illegible]	68 E
Butyla[illegible]	2008415	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		

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sec-Butylbenzene	135988	1.00E-02 E				☒	61 N	37 N	14 N	20000 N	780 N	80 S	0.27 N
tert-Butylbenzene	104518	1.00E-02 E				☒	61 N	37 N	14 N	20000 N	780 N		
Butylphthalyl butylglycolate	85701	1.00E+00 I					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Cacodylic acid	75605	3.00E-03 H					110 N	11 N	4.1 N	6100 N	230 N		
Cadmium and compounds	7440439	5.00E-04 I			6.30E+00 I		18 N	0.00099 C	0.68 N	1000 N	39 N	920 E	6 E
Caprolactam	105602	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Captafol	2425061	2.00E-03 I		8.60E-03 H			7.8 C	0.73 C	0.37 C	670 C	74 C		
Captan	133062	1.30E-01 I		3.50E-03 H			19 C	1.8 C	0.9 C	1600 C	180 C		
Carbaryl	63252	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	0.34 S	23 N
Carbofuran	1563662	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Carbon disulfide	75150	1.00E-01 I	2.86E-03 H			☒	21 N	10 N	140 N	200000 N	7800 N	11 E	14 E
Carbon tetrachloride	56235	7.00E-04 I	5.71E-04 E	1.30E-01 I	5.25E-02 I	☒	0.16 C	0.12 C	0.024 C	44 C	4.9 C	0.2 E	0.03 E
Carbosulfan	55285148	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Carboxin	5234684	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Chloral	75876	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Chloramben	133904	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Chloranil	118752			4.03E-01 H			0.17 C	0.016 C	0.0078 C	14 C	1.6 C		
Chlordane	57749	6.00E-05 I		1.30E+00 I	1.29E+00 I		0.052 C	0.0049 C	0.0024 C	4.4 C	0.49 C	10 E	2 E
Chlorimuron-ethyl	90982324	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Chlorine	7782505	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Chlorine dioxide	10049044		5.71E-05 I				2.1 N	0.21 N					
Chloroacetaldehyde	107200	6.90E-03 O					250 N	25 N	9.3 N	14000 N	540 N		
Chloroacetic acid	79118	2.00E-03 H					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Chloroacetophenone	532274		8.57E-06 I				0.31 N	0.031 N					
4-Chloroaniline	106478	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N	1200 S	0.3 E
Chlorobenzene	108907	2.00E-02 I	5.71E-03 A			☒	39 N	21 N	27 N	41000 N	1600 N	94 E	0.6 E
Chlorobenzilate	510156	2.00E-02 I		2.70E-01 H	2.70E-01 H		0.25 C	0.023 C	0.012 C	21 C	2.4 C		
p-Chlorobenzoic acid	74113	2.00E-01 H					7300 N	730 N	270 N	410000 N	16000 N		
4-Chlorobenzotrifluoride	98566	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N	86 N	7.5 N
2-Chloro-1,3-butadiene	126998	2.00E-02 A	2.00E-03 H			☒	14 N	7.3 N	27 N	41000 N	1600 N		
1-Chlorobutane	109693	4.00E-01 H				☒	2400 N	1500 N	540 N	820000 N	31000 N		
Chlorodibromomethane	124481	2.00E-02 I		8.40E-02 I		☒	0.13 C	0.075 C	0.038 C	68 C	7.6 C	1900 E	0.2 E
Chlorodifluoromethane	75456		1.43e+01 I			☒	87000 N	52000 N					
Chloroethane	75003	4.00E-01 E	2.86E+00 I			☒	8600 N	10000 N	540 N	820000 N	31000 N	2600 S	33 N
2-Chloroethyl vinyl ether	110758	2.50E-02 O				☒	150 N	91 N	34 N	51000 N	2000 N		
Chloroform	67663	1.00E-02 I		6.10E-03 I	8.05E-02 I	☒	0.15 C	0.078 C	0.52 C	940 C	100 C	0.2 E	0.3 E
Chloromethane	74873			1.30E-02 H	6.30E-03 H	☒	1.4 C	0.99 C	0.24 C	440 C	49 C	0.063 C	0.0066 C
4-Chloro-2,2-methylaniline hydrochloride	3165933			4.60E-01 H			0.15 C	0.014 C	0.0069 C	12 C	1.4 C		
4-Chloro-2-methylaniline	95692			5.80E-01 H			0.12 C	0.011 C	0.0054 C	9.9 C	1.1 C		
beta-Chloronaphthalene	91587	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N	2.8 S	140 N
o-Chloronitrobenzene	88733			2.50E-02 H		☒	0.42 C	0.25 C	0.13 C	230 C	26 C		
p-Chloronitrobenzene	100005			1.80E-02 H		☒	0.59 C	0.35 C	0.18 C	320 C	35 C		

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2-Chlorophenol	95578	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N	53000 E	2 E
2-Chloropropane	75296		2.86E-02 H			☒	170 N	100 N				22 N	0.64 N
Chlorothalonil	1897456	1.50E-02 I		1.10E-02 H			6.1 C	0.57 C	0.29 C	520 C	58 C		
o-Chlorotoluene	95498	2.00E-02 I				☒	120 N	73 N	27 N	41000 N	1600 N	1200 N	5.6 N
Chlorpropham	101213	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Chlorpyrifos	2921882	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Chlorpyrifos-methyl	5598130	1.00E-02 H					370 N	37 N	14 N	20000 N	780 N		
Chlorsulfuron	64902723	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Chlorthiophos	60238564	8.00E-04 H					29 N	2.9 N	1.1 N	1600 N	63 N		
Chromium III and compounds	16065831	1.00E+00 I	5.71E-07 W				37000 N	0.0021 N	1400 N	1E+06 N	78000 N		
Chromium VI and compounds	7440473	5.00E-03 I			4.20E+01 I		180 N	0.00015 C	6.8 N	10000 N	390 N	140 E	19 E
Coal tar	8001589				2.20E+00 W			0.0028 C					
Cobalt	7440484	6.00E-02 E					2200 N	220 N	81 N	120000 N	4700 N		
Coke Oven Emissions	8007452				2.17E+00 I			0.0029 C					
Copper and compounds	7440508	3.71E-02 H					1400 N	140 N	50 N	76000 N	2900 N		
Crotonaldehyde	123739	1.00E-02 W		1.90E+00 H	1.90E+00 W		0.035 C	0.0033 C	0.0017 C	3 C	0.34 C		
Cumene	98828	4.00E-02 I	2.57E-03 H				1500 N	9.4 N	54 N	82000 N	3100 N	81 N	65 N
Cyanides:													
Barium cyanide	542621	1.00E-01 W					3700 N	370 N	140 N	200000 N	7800 N		
Calcium cyanide	592018	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Copper cyanide	544923	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Cyanazine	21725462	2.00E-03 H		8.40E-01 H			0.08 C	0.0075 C	0.0038 C	6.8 C	0.76 C		
Cyanogen	460195	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Cyanogen bromide	506683	9.00E-02 I					3300 N	330 N	120 N	180000 N	7000 N		
Cyanogen chloride	506774	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Free cyanide	57125	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Hydrogen cyanide	74908	2.00E-02 I	8.57E-04 I				730 N	3.1 N	27 N	41000 N	1600 N		
Potassium cyanide	151508	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Potassium silver cyanide	506616	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Silver cyanide	506649	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Sodium cyanide	143339	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Zinc cyanide	557211	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Cyclohexanone	108941	5.00E+00 I				☒	30000 N	18000 N	6800 N	1E+06 N	390000 N		
Cyclohexlamine	108918	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Cyhalothrin/Karate	68085858	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Cypermethrin	52315078	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Cyromazine	66215278	7.50E-03 I					270 N	27 N	10 N	15000 N	590 N		
Dacthal	1861321	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Dalapon	75990	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Danitol	39515418	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
DDD	72548			2.40E-01			0.28 C	0.026 C	0.013 C	24 C	2.7 C		0.7 E
DDE	72559			3.40E-01			0.2 C	0.018 C	0.0093 C	17 C	1.9 C		0.5 E

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DDT	50293	5.00E-04 I		3.40E-01 I	3.40E-01 I		0.2 C	0.018 C	0.0093 C	17 C	1.9 C	80 E	1 E
Decabromodiphenyl ether	1163195	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N		
Demeton	8065483	4.00E-05 I					1.5 N	0.15 N	0.054 N	82 N	3.1 N		
Diallate	2303164			6.10E-02 H		☒	0.17 C	0.1 C	0.052 C	94 C	10 C		
Diazinon	333415	9.00E-04 H					33 N	3.3 N	1.2 N	1800 N	70 N	5400 S	2.8 N
Dibenzofuran	132649	4.00E-03 E					150 N	15 N	5.4 N	8200 N	310 N	120 S	120 N
1,4-Dibromobenzene	106376	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N		
1,2-Dibromo-3-chloropropane	96128		5.71E-05 I	1.40E+00 H	2.42E-03 H	☒	0.048 C	0.21 N	0.0023 C	4.1 C	0.46 C	1.9 N	0.00061 N
1,2-Dibromoethane	106934		5.71E-05 H	8.50E+01 I	7.70E-01 I	☒	0.00075 C	0.0081 C	0.00004 C	0.067 C	0.0075 C	0.0058 C	0.00018 N
Dibutyl phthalate	84742	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	100 E	120 E
Dicamba	1918009	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
1,2-Dichlorobenzene	95501	9.00E-02 I	4.00E-02 A			☒	270 N	150 N	120 N	180000 N	7000 N	300 E	6 E
1,3-Dichlorobenzene	541731	8.90E-02 O				☒	540 N	320 N	120 N	180000 N	7000 N		
1,4-Dichlorobenzene	106467		2.29E-01 I	2.40E-02 H		☒	0.44 C	0.26 C	0.13 C	240 C	27 C	7700 E	1 E
3,3'-Dichlorobenzidine	91941			4.50E-01 I			0.15 C	0.014 C	0.007 C	13 C	1.4 C	52 S	0.01 E
1,4-Dichloro-2-butene	764410				9.30E+00 H	☒	0.0011 C	0.00067 C					
Dichlorodifluoromethane	75718	2.00E-01 I	5.71E-02 A			☒	390 N	210 N	270 N	410000 N	16000 N	37 N	7.5 N
1,1-Dichloroethane	75343	1.00E-01 H	1.43E-01 A			☒	810 N	520 N	140 N	200000 N	7800 N	980 E	11 E
1,2-Dichloroethane (EDC)	107062		2.86E-03 E	9.10E-02 I	9.10E-02 I	☒	0.12 C	0.069 C	0.035 C	63 C	7 C	0.3 E	0.01 E
1,1-Dichloroethylene	75354	9.00E-03 I		6.00E-01 I	1.75E-01 I	☒	0.044 C	0.036 C	0.0053 C	9.5 C	1.1 C	0.04 E	0.03 E
1,2-Dichloroethylene (cis)	156592	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	1500 E	0.2 E
1,2-Dichloroethylene (trans)	156605	2.00E-02 I				☒	120 N	73 N	27 N	41000 N	1600 N	3600 E	0.3 E
1,2-Dichloroethylene (mixture)	540590	9.00E-03 H				☒	55 N	33 N	12 N	18000 N	700 N		
2,4-Dichlorophenol	120832	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N	4800 S	0.5 E
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N	7000 S	1.7 N
4-(2,4-Dichlorophenoxy)butyric Acid	94826	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
1,2-Dichloropropane	78875		1.14E-03 I	6.80E-02 H		☒	0.16 C	0.092 C	0.046 C	84 C	9.4 C	11 E	0.02 E
2,3-Dichloropropanol	616239	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
1,3-Dichloropropene	542756	3.00E-04 I	5.71E-03 I	1.75E-01 H	1.30E-01 H	☒	0.077 C	0.048 C	0.018 C	33 C	3.7 C	0.1 E	0.001 E
Dichlorvos	62737	5.00e-04 I	1.43E-04 I	2.90E-01 I			0.23 C	0.022 C	0.011 C	20 C	2.2 C	3.5 C	0.00072 C
Dicofol	115322			4.40E-01 W			0.15 C	0.014 C	0.0072 C	13 C	1.5 C		
Dicyclopentadiene	77736	3.00E-02 H	5.71E-05 A			☒	0.42 N	0.21 N	41 N	61000 N	2300 N		
Dieldrin	60571	5.00E-05 I		1.60E+01 I	1.61E+01 I		0.0042 C	0.00039 C	0.0002 C	0.36 C	0.04 C	2 E	0.001 E
Diesel emissions			1.43E-03 I				52 N	5.2 N					
Diethyl phthalate	84662	8.00E-01 I					29000 N	2900 N	1100 N	1E+06 N	63000 N	520 E	110 E
Diethylene glycol, monobutyl ether	112345		5.71E-03 H				210 N	21 N					
Diethylene glycol, monoethyl ether	111900	2.00E+00 H					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Diethylforamide	617845	1.10E-02 H					400 N	40 N	15 N	22000 N	860 N		
Di(2-ethylhexyl)adipate	103231	6.00E-01 I		1.20E-03 I			56 C	5.2 C	2.6 C	4800 C	530 C		
Diethylstilbestrol	56531			4.70E+03 H			0.00001 C	1E-06 C	7E-07 C	0.0012 C	0.00014 C		
Difenzoquat (Avenge)	43222486	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Diflubenzuron	35367385	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		

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1,1-Difluoroethane	75376		1.14E+01 I			☒	69000 N	42000 N					
Diisopropyl methylphosphonate (DIMP)	1445756	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Dimethipin	55290647	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Dimethoate	60515	2.00E-04 I					7.3 N	0.73 N	0.27 N	410 N	16 N		
3,3'-Dimethoxybenzidine	119904			1.40E-02 H			4.8 C	0.45 C	0.23 C	410 C	46 C		
Dimethylamine	124403		5.71E-06 W				0.21 N	0.021 N					
2,4-Dimethylaniline hydrochloride	21436964			5.80E-01 H			0.12 C	0.011 C	0.0054 C	9.9 C	1.1 C		
2,4-Dimethylaniline	95681			7.50E-01 H			0.09 C	0.0083 C	0.0042 C	7.6 C	0.85 C		
N-N-Dimethylaniline	121697	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
3,3'-Dimethylbenzidine	119937			9.20E+00 H			0.0073 C	0.00068 C	0.00034 C	0.62 C	0.069 C	29 C	0.00039 C
N,N-Dimethylformamide	68122	1.00E-01 H	8.57E-03 I				3700 N	31 N	140 N	200000 N	7800 N		
1,1-Dimethylhydrazine	57147			2.60E+00 W	3.50E+00 W		0.026 C	0.0018 C	0.0012 C	2.2 C	0.25 C		
1,2-Dimethylhydrazine	540738			3.70E+01 W	3.70E+01 W		0.0018 C	0.00017 C	0.00009 C	0.15 C	0.017 C		
2,4-Dimethylphenol	105679	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N	5400 S	3 E
2,6-Dimethylphenol	576261	6.00E-04 I					22 N	2.2 N	0.81 N	1200 N	47 N		
3,4-Dimethylphenol	95658	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Dimethyl phthalate	131113	1.00E+01 H					370000 N	37000 N	14000 N	1E+06 N	780000 N	1600 E	1200 E
Dimethyl terephthalate	120616	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
1,2-Dinitrobenzene	528290	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
1,3-Dinitrobenzene	99650	1.00E-04 I					3.7 N	0.37 N	0.14 N	200 N	7.8 N		
1,4-Dinitrobenzene	100254	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
4,6-Dinitro-o-cyclohexyl phenol	131895	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
2,4-Dinitrophenol	51285	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N	360 N	0.1 E
Dinitrotoluene mixture				6.80E-01 I			0.099 C	0.0092 C	0.0046 C	8.4 C	0.94 C		
2,4-Dinitrotoluene	121142	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N	120 S	0.2 E
2,6-Dinitrotoluene	606202	1.00E-03 H					37 N	3.7 N	1.4 N	2000 N	78 N	370 S	0.1 E
Dinoseb	88857	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
di-n-Octyl phthalate	117840	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N	1000000 S	1000000 E
1,4-Dioxane	123911			1.10E-02 I			6.1 C	0.57 C	0.29 C	520 C	58 C		
Diphenamid	957517	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Diphenylamine	122394	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
1,2-Diphenylhydrazine	122667			8.00E-01 I	7.70E-01 I		0.084 C	0.0081 C	0.0039 C	7.2 C	0.8 C		
Diquat	85007	2.20E-03 I					80 N	8 N	3 N	4500 N	170 N		
Direct black 38	1937377			8.60E+00 H			0.0078 C	0.00073 C	0.00037 C	0.67 C	0.074 C		
Direct blue 6	2602462			8.10E+00 H			0.0083 C	0.00077 C	0.00039 C	0.71 C	0.079 C		
Direct brown 95	16071866			9.30E+00 H			0.0072 C	0.00067 C	0.00034 C	0.62 C	0.069 C		
Disulfoton	298044	4.00E-05 I					1.5 N	0.15 N	0.054 N	82 N	3.1 N		
1,4-Dithiane	505293	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Diuron	330541	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Dodine	2439103	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Endo[illegible]	115297	6.00E-03 I					220 N	22 N	8.1 N	12000 N	470 N		3 E
Endothal	145733	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		

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Endrin	72208	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N	16 S	0.4 E
Epichlorohydrin	106898	2.00E-03 H	2.86E-04 I	9.90E-03 I	4.20E-03 I		6.8 C	1 N	0.32 C	580 C	65 C		
1,2-Epoxybutane	106887		5.71E-03 I				210 N	21 N					
Ethephon (2-chloroethyl phosphonic acid)	16672870	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Ethion	563122	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
2-Ethoxyethanol acetate	111159	3.00E-01 A					11000 N	1100 N	410 N	610000 N	23000 N		
2-Ethoxyethanol	110805	4.00E-01 H	5.71E-02 I				15000 N	210 N	540 N	820000 N	31000 N		
Ethyl acrylate	140885			4.80E-02 H			1.4 C	0.13 C	0.066 C	120 C	13 C		
EPTC (S-Ethyl dipropylthiocarbamate)	759944	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Ethyl ether	60297	2.00E-01 I				☒	1200 N	730 N	270 N	410000 N	16000 N		
Ethyl methacrylate	97632	9.00E-02 H					3300 N	330 N	120 N	180000 N	7000 N		
Ethyl acetate	141786	9.00E-01 I					33000 N	3300 N	1200 N	1E+06 N	70000 N		
Ethylbenzene	100414	1.00E-01 I	2.86E-01 I			☒	1300 N	1000 N	140 N	200000 N	7800 N	260 E	5 E
Ethylene cyanohydrin	109784	3.00E-01 H					11000 N	1100 N	410 N	610000 N	23000 N		
Ethylene diamine	107153	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Ethylene glycol	107211	2.00E+00 I					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Ethylene glycol, monobutyl ether	111762		5.71E-03 H				210 N	21 N					
Ethylene oxide	75218			1.02E+00 H	3.50E-01 H		0.066 C	0.018 C	0.0031 C	5.6 C	0.63 C		
Ethylene thiourea (ETU)	96457	8.00E-05 I		1.19E-01 H			0.57 C	0.053 C	0.027 C	48 C	5.4 C		
Ethyl p-nitrophenyl phenylphosphorothioate	2104645	1.00E-05 I					0.37 N	0.037 N	0.014 N	20 N	0.78 N		
Ethylnitrosourea	759739			1.40E+02 W			0.00048 C	0.00005 C	0.00002 C	0.041 C	0.0046 C		
Ethylphthalyl ethyl glycolate	84720	3.00E+00 I					110000 N	11000 N	4100 N	1E+06 N	230000 N		
Express	10120	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
Fenamiphos	22224926	2.50E-04 I					9.1 N	0.91 N	0.34 N	510 N	20 N		
Fluometuron	2164172	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Fluoride	7782414	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Fluoridone	59756604	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Flurprimidol	56425913	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Flutolanil	66332965	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Fluvalinate	69409945	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Folpet	133073	1.00E-01 I		3.50E-03 I			19 C	1.8 C	0.9 C	1600 C	180 C		
Fomesafen	72178020			1.90E-01 I			0.35 C	0.033 C	0.017 C	30 C	3.4 C		
Fonofos	944229	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Formaldehyde	50000	2.00E-01 I			4.55E-02 I		7300 N	0.14 C	270 N	410000 N	16000 N		
Formic Acid	64186	2.00E+00 H					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Fosetyl-al	39148248	3.00E+00 I					110000 N	11000 N	4100 N	1E+06 N	230000 N		
Furan	110009	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Furazolidone	67458			3.80E+00 H			0.018 C	0.0016 C	0.00083 C	1.5 C	0.17 C		
Furfural	98011	3.00E-03 I	1.43E-02 A				110 N	52 N	4.1 N	6100 N	230 N		
Furium	531828			5.00E+01 H			0.0013 C	0.00013 C	0.00006 C	0.11 C	0.013 C		
Furmecyclox	60568050			3.00E-02 I			2.2 C	0.21 C	0.11 C	190 C	21 C		
Glufosinate-ammonium	77182822	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		

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Glycidaldehyde	765344	4.00E-04 I	2.86E-04 H				15 N	1 N	0.54 N	820 N	31 N		
Glyphosate	1071836	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Haloxyfop-methyl	69806402	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Harmony	79277273	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
HCH (alpha)	319846			6.30E+00 I	6.30E+00 I		0.011 C	0.00099 C	0.0005 C	0.91 C	0.1 C	0.9 E	0.0004 E
HCH (beta)	319857			1.80E+00 I	1.80E+00 I		0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C	16 E	0.002 E
HCH (gamma) Lindane	58899	3.00E-04 I		1.30E+00 H			0.052 C	0.0048 C	0.0024 C	4.4 C	0.49 C	4.2 C	0.006 E
HCH-technical	608731			1.80E+00 I	1.79E+00 I		0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C		
Heptachlor	76448	5.00E-04 I		4.50E+00 I	4.55E+00 I	☒	0.0023 C	0.0014 C	0.0007 C	1.3 C	0.14 C	0.3 E	0.06 E
Heptachlor epoxide	1024573	1.30E-05 I		9.10E+00 I	9.10E+00 I	☒	0.0012 C	0.00069 C	0.00035 C	0.63 C	0.07 C	1 E	0.03 E
Hexabromobenzene	87821	2.00E-03 I				☒	12 N	7.3 N	2.7 N	4100 N	160 N		
Hexachlorobenzene	118741	8.00E-04 I		1.60E+00 I	1.61E+00 I	☒	0.0066 C	0.0039 C	0.002 C	3.6 C	0.4 C	1 E	0.8 E
Hexachlorobutadiene	87683	2.00E-04 N		7.80E-02 I	7.70E-02 I	☒	0.14 C	0.081 C	0.04 C	73 C	8.2 C	1 E	0.1 E
Hexachlorocyclopentadiene	77474	7.00E-03 I	2.00E-05 H			☒	0.15 N	0.073 N	9.5 N	14000 N	550 N	2 E	10 E
Hexachlorodibenzo-p-dioxin mixture	19408743			6.20E+03 I	4.55E+03 I		0.00001 C	1E-06 C	5E-07 C	0.0009 C	0.0001 C		
Hexachloroethane	67721	1.00E-03 I		1.40E-02 I	1.40E-02 I	☒	0.75 C	0.45 C	0.23 C	410 C	46 C	49 E	0.2 E
Hexachlorophene	70304	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Hexahydro-1,3,5-trinitro-1,3,5-triazine	121824	3.00E-03 I		1.10E-01 I			0.61 C	0.057 C	0.029 C	52 C	5.8 C		
1,6-Hexamethylene diisocyanate	822060		2.86E-06 I				0.1 N	0.01 N					
n-Hexane	110543	6.00E-02 N	5.71E-02 I			☒	350 N	210 N	81 N	120000 N	4700 N	32 N	13 N
Hexazinone	51235042	3.30E-02 I					1200 N	120 N	45 N	67000 N	2600 N		
Hydrazine, hydrazine sulfate	302012			3.00E+00 I	1.71E+01 I		0.022 C	0.00037 C	0.0011 C	1.9 C	0.21 C		
Hydrogen chloride	7647010		2.00E-03 I				73 N	7.3 N					
Hydrogen sulfide	7783064	3.00E-03 I	2.57E-04 I				110 N	0.94 N	4.1 N	6100 N	230 N		
Hydroquinone	123319	4.00E-02 H					1500 N	150 N	54 N	82000 N	3100 N		
Imazalil	35554440	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Imazaquin	81335377	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Iprodione	36734197	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Isobutanol	78831	3.00E-01 I				☒	1800 N	1100 N	410 N	610000 N	23000 N		
Isophorone	78591	2.00E-01 I		9.50E-04 I			71 C	6.6 C	3.3 C	6000 C	670 C	3400 E	0.2 E
Isopropalin	33820530	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Isopropyl methyl phosphonic acid	1832548	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Isoxaben	82558507	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Kepone	143500			1.80E+01 E			0.0037 C	0.00035 C	0.00018 C	0.32 C	0.035 C		
Lactofen	77501634	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Linuron	330552	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Lithium	7439932	2.00E-02 E					730 N	73 N	27 N	41000 N	1600 N		
Londax	83056996	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Malathion	121755	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Maleic [illegible]ydride	108316	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Malei[illegible]te	123331	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Malonon.	109773	2.00E-05 H					0.73 N	0.073 N	0.027 N	41 N	1.6 N		

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Mancozeb	8018017	3.00E-02 H					1100 N	110 N	41 N	61000 N	2300 N		
Maneb	12427382	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Manganese and compounds	7439965	5.00E-03 I	1.43e-05 I				180 N	0.052 N	6.8 N	10000 N	390 N		
Mephosfolan	950107	9.00E-05 H					3.3 N	0.33 N	0.12 N	180 N	7 N		
Mepiquat chloride	24307264	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Mercury (inorganic)	7439976	3.00E-04 H	8.57E-05 H				11 N	0.31 N	0.41 N	610 N	23 N	7 E	3 E
Mercury (methyl)	22967926	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Merphos	150505	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
Merphos oxide	78488	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
Metalaxyl	57837191	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Methacrylonitrile	126987	1.00E-04 I	2.00E-04 A				3.7 N	0.73 N	0.14 N	200 N	7.8 N		
Methamidophos	10265926	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Methanol	67561	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Methidathion	950378	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Methomyl	16752775	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Methoxychlor	72435	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N	41 S	62 E
2-Methoxyethanol acetate	110496	2.00E-03 A					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Methoxyethanol	109864	1.00E-03 H	5.71E-03 I				37 N	21 N	1.4 N	2000 N	78 N		
2-Methoxy-5-nitroaniline	99592			4.60E-02 H			1.5 C	0.14 C	0.069 C	120 C	14 C		
Methyl acetate	79209	1.00E+00 H					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Methyl acrylate	96333	3.00E-02 A					1100 N	110 N	41 N	61000 N	2300 N		
2-Methylaniline hydrochloride	636215			1.80E-01 H			0.37 C	0.035 C	0.018 C	32 C	3.5 C		
2-Methylaniline	95534			2.40E-01 H			0.28 C	0.026 C	0.013 C	24 C	2.7 C		
Methyl chlorocarbonate	79221	1.00E+00 W					37000 N	3700 N	1400 N	1E+06 N	78000 N		
4-(2-Methyl-4-chlorophenoxy) butyric acid	94815	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-Methyl-4-chlorophenoxyacetic acid	94746	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
2-(2-Methyl-14-chlorophenoxy)propionic aci	93652	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Methylcyclohexane	108872		8.57E-01 H				31000 N	3100 N				60 S	1500 N
Methylene bromide	74953	1.00E-02 A				☒	61 N	37 N	14 N	20000 N	780 N		
Methylene chloride	75092	6.00E-02 I	8.57E-01 H	7.50E-03 I	1.64E-03 I	☒	4.1 C	3.8 C	0.42 C	760 C	85 C	7 E	0.01 E
4,4'-Methylene bis(2-chloroaniline)	101144	7.00E-04 H		1.30E-01 H	1.30E-01 H		0.52 C	0.048 C	0.024 C	44 C	4.9 C		
4,4'-Methylenebisbenzeneamine	101779			2.50E-01 W			0.27 C	0.025 C	0.013 C	23 C	2.6 C		
4,4'-Methylene bis(N,N'-dimethyl)aniline	101611			4.60E-02 I			1.5 C	0.14 C	0.069 C	120 C	14 C		
4,4'-Methylenediphenyl isocyanate	101688		5.71E-06 I			☒	0.035 N	0.021 N					
Methyl ethyl ketone	78933	6.00E-01 I	2.86E-01 I			☒	1900 N	1000 N	810 N	1E+06 N	47000 N		
Methyl hydrazine	60344			1.10E+00 W			0.061 C	0.0057 C	0.0029 C	5.2 C	0.58 C		
Methyl isobutyl ketone	108101	8.00E-02 H	2.29E-02 A				2900 N	84 N	110 N	160000 N	6300 N		
Methyl methacrylate	80626	8.00E-02 H					2900 N	290 N	110 N	160000 N	6300 N		
2-Methyl-5-nitroaniline	99558			3.30E-02 H			2 C	0.19 C	0.096 C	170 C	19 C		
Methyl parathion	298000	2.50E-04 I					9.1 N	0.91 N	0.34 N	510 N	20 N	28 S	0.041 N
2-Methylphenol (o-cresol)	95487	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N	12000 S	6 E
3-Methylphenol (m-cresol)	103394	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		

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4-Methylphenol (p-cresol)	106445	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		
Methyl styrene (mixture)	25013154	6.00E-03 A	1.14E-02 A			☒	60 N	42 N	8.1 N	12000 N	470 N		
Methyl styrene (alpha)	98839	7.00E-02 A				☒	430 N	260 N	95 N	140000 N	5500 N	8.8 S	7.5 N
Methyl tertbutyl ether (MTBE)	1634044	5.00E-03 E	8.57E-01 I			☒	180 N	3100 N	6.8 N	10000 N	390 N		
Metolaclor (Dual)	51218452	1.50E-01 H					5500 N	550 N	200 N	310000 N	12000 N		
Metribuzin	21807649	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Mirex	2385855	2.00E-04 I		1.80E+00 W			0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C		
Molinate	2212671	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Molybdenum	7439987	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Monochloramine	10599903	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Naled	300765	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Naphthylamine	91598			1.30e+02 E			0.00052 C	0.00005 C	0.00002 C	0.044 C	0.0049 C		
Napropamide	15299997	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Nickel refinery dust					8.40E-01 I			0.0075 C					
Nickel and compounds	7440020	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N	6900 E	21 E
Nickel subsulfide	12035722				1.70E+00 I			0.0037 C					
Nitrapyrin	1929824	1.50E-03 W					55 N	5.5 N	2 N	3100 N	120 N		
Nitrate	14797558	1.60E+00 I					58000 N	5800 N	2200 N	1E+06 N	130000 N		
Nitric Oxide	10102439	1.00E-01 W					3700 N	370 N	140 N	200000 N	7800 N		
Nitrite	14797650	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
2-Nitroaniline	88744	6.00E-05 W	5.71E-05 H				2.2 N	0.21 N	0.081 N	120 N	4.7 N		
3-Nitroaniline	99092	3.00E-03 O					110 N	11 N	4.1 N	6100 N	230 N		
4-Nitroaniline	100016	3.00E-03 O					110 N	11 N	4.1 N	6100 N	230 N		
Nitrobenzene	98953	5.00E-04 I	5.71E-04 A			☒	3.4 N	2.1 N	0.68 N	1000 N	39 N	110 E	0.09 E
Nitrofurantoin	67209	7.00E-02 H					2600 N	260 N	95 N	140000 N	5500 N		
Nitrofurazone	59870			1.50E+00 H	9.40E+00 H		0.045 C	0.00067 C	0.0021 C	3.8 C	0.43 C		
Nitrogen dioxide	10102440	1.00E+00 W					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Nitroguanidine	556887	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
4-Nitrophenol	100027	6.20E-02 O					2300 N	230 N	84 N	130000 N	4800 N		
2-Nitropropane	79469		5.71E-03 I		9.40E+00 H		210 N	0.00067 C					
N-Nitrosodi-n-butylamine	924163			5.40E+00 I	5.60E+00 I		0.012 C	0.0011 C	0.00058 C	1.1 C	0.12 C		
N-Nitrosodiethanolamine	1116547			2.80E+00 I			0.024 C	0.0022 C	0.0011 C	2 C	0.23 C		
N-Nitrosodiethylamine	55185			1.50E+02 I	1.51E+02 I		0.00045 C	0.00004 C	0.00002 C	0.038 C	0.0043 C		
N-Nitrosodimethylamine	62759			5.10E+01 I	4.90E+01 I		0.0013 C	0.00013 C	0.00006 C	0.11 C	0.013 C		
N-Nitrosodiphenylamine	86306			4.90E-03 I			14 C	1.3 C	0.64 C	1200 C	130 C	29 C	0.2 E
N-Nitroso di-n-propylamine	621647			7.00E+00 I			0.0096 C	0.00089 C	0.00045 C	0.82 C	0.091 C	0.014 C	0.00002 E
N-Nitroso-N-methylethylamine	10595956			2.20E+01 I			0.0031 C	0.00028 C	0.00014 C	0.26 C	0.029 C		
N-Nitrosopyrrolidine	930552			2.10E+00 I	2.13E+00 I		0.032 C	0.0029 C	0.0015 C	2.7 C	0.3 C		
m-Nitrotoluene	99081	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	460 S	0.42 N
o-Nitr[illegible]ene	88722	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	460 S	0.42 N
p-Nitr[illegible]	99990	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	[illegible]	0.42 N
Norflura[illegible]	27314132	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		

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NuStar	85509199	7.00E-04 I					26 N	2.6 N	0.95 N	1400 N	55 N		
Octabromodiphenyl ether	32536520	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Octahydro-1357-tetranitro-1357-tetrazocine	2691410	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Octamethylpyrophosphoramide	152169	2.00E-03 H					73 N	7.3 N	2.7 N	4100 N	160 N		
Oryzalin	19044883	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Oxadiazon	19666309	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Oxamyl	23135220	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Oxyfluorfen	42874033	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Paclobutrazol	76738620	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Paraquat	1910425	4.50E-03 I					160 N	16 N	6.1 N	9200 N	350 N		
Parathion	56382	6.00E-03 H					220 N	22 N	8.1 N	12000 N	470 N	110 S	3.9 N
Pebulate	1114712	5.00E-02 H					1800 N	180 N	68 N	100000 N	3900 N		
Pendimethalin	40487421	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Pentabromo-6-chloro cyclohexane	87843			2.30E-02 H			2.9 C	0.27 C	0.14 C	250 C	28 C		
Pentabromodiphenyl ether	32534819	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Pentachlorobenzene	608935	8.00E-04 I				O	4.9 N	2.9 N	1.1 N	1600 N	63 N	570 N	48 N
Pentachloronitrobenzene	82688	3.00E-03 I		2.60E-01 H		O	0.041 C	0.024 C	0.012 C	22 C	2.5 C		
Pentachlorophenol	87865	3.00E-02 I		1.20E-01 I			0.56 C	0.052 C	0.026 C	48 C	5.3 C	7.9 C	0.2 E
Permethrin	52645531	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Phenmedipham	13684634	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Phenol	108952	6.00E-01 I					22000 N	2200 N	810 N	1E+06 N	47000 N	21000 S	49 E
m-Phenylenediamine	108452	6.00E-03 I					220 N	22 N	8.1 N	12000 N	470 N		
p-Phenylenediamine	106503	1.90E-01 H					6900 N	690 N	260 N	390000 N	15000 N		
Phenylmercuric acetate	62384	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
2-Phenylphenol	90437			1.94E-03 H			35 C	3.2 C	1.6 C	3000 C	330 C		
Phorate	298022	2.00E-04 H					7.3 N	0.73 N	0.27 N	410 N	16 N		
Phosmet	732116	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Phosphine	7803512	3.00E-04 I	8.57E-06 H				11 N	0.031 N	0.41 N	610 N	23 N		
Phosphorus (white)	7723140	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
p-Phthalic acid	100210	1.00E+00 H					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Phthalic anhydride	85449	2.00E+00 I	3.43E-02 H				73000 N	130 N	2700 N	1E+06 N	160000 N		
Picloram	1918021	7.00E-02 I					2600 N	260 N	95 N	140000 N	5500 N		
Pirimiphos-methyl	29232937	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Polybrominated biphenyls		7.00E-06 H		8.90E+00 H			0.0076 C	0.0007 C	0.00035 C	0.64 C	0.072 C		
Polychlorinated biphenyls (PCBs)	1336363			7.70E+00 I			0.0087 C	0.00081 C	0.00041 C	0.74 C	0.083 C		8.2 E
Aroclor 1016	12674112	7.00E-05 I					2.6 N	0.26 N	0.095 N	140 N	5.5 N		
Aroclor 1254	11097691	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Polychlorinated terphenyls (PCTs)				4.50E+00 E			0.015 C	0.0014 C	0.0007 C	1.3 C	0.14 C		
Polynuclear aromatic hydrocarbons													
Acenaphthene	83329	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N	120 S	200 E
Anthracene	120127	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N	6.8 S	4300 E
Benz[a]anthracene	56553			7.30E-01 E	6.10E-01 E		0.092 C	0.01 C	0.0043 C	7.8 C	0.88 C	27 S	0.7 E

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Benzo[b]fluoranthene	205992			7.30E-01 E	6.10E-01 E		0.092 c	0.01 c	0.0043 c	7.8 c	0.88 c	23 s	4 E
Benzo[k]fluoranthene	207089			7.30E-02 E	6.10E-02 E		0.92 c	0.1 c	0.043 c	78 c	8.8 c		4 E
Benzo[a]pyrene	50328			7.30E+00 I	6.10E+00 W		0.0092 c	0.001 c	0.00043 c	0.78 c	0.088 c	11 s	4 E
Carbazole	86748			2.00E-02 H			3.4 c	0.31 c	0.16 c	290 c	32 c	11 s	0.5 E
Chrysene	218019			7.30E-03 E	6.10E-03 E		9.2 c	1 c	0.43 c	780 c	88 c	3.6 s	1 E
Dibenz[ah]anthracene	53703			7.30E+00 E	6.10E+00 E		0.0092 c	0.001 c	0.00043 c	0.78 c	0.088 c	7.2 s	11 E
Fluoranthene	206440	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N	68 s	980 E
Fluorene	86737	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N	89 s	160 E
Indeno[1,2,3-cd]pyrene	193395			7.30E-01 E	6.10E-01 E		0.092 c	0.01 c	0.0043 c	7.8 c	0.88 c	280 s	35 E
Naphthalene	91203	4.00E-02 W					1500 N	150 N	54 N	82000 N	3100 N	180 s	30 E
Pyrene	129000	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N	56 s	1400 E
Prochloraz	67747095	9.00E-03 I		1.50E-01 I			0.45 c	0.042 c	0.021 c	38 c	4.3 c		
Profluralin	26399360	6.00E-03 H					220 N	22 N	8.1 N	12000 N	470 N		
Prometon	1610180	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Prometryn	7287196	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Pronamide	23950585	7.50E-02 I					2700 N	270 N	100 N	150000 N	5900 N		
Propachlor	1918167	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Propanil	709988	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Propargite	2312358	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propargyl alcohol	107197	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Propazine	139402	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propham	122429	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propiconazole	60207901	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Propylene glycol	57556	2.00E+01 H					730000 N	73000 N	27000 N	1E+06 N	1000000 N		
Propylene glycol, monoethyl ether	52125538	7.00E-01 H					26000 N	2600 N	950 N	1E+06 N	55000 N		
Propylene glycol, monomethyl ether	107982	7.00E-01 H	5.71E-01 I				26000 N	2100 N	950 N	1E+06 N	55000 N		
Propylene oxide	75569		8.57E-03 I	2.40E-01 I	1.29E-02 I		0.28 c	0.49 c	0.013 c	24 c	2.7 c		
Pursuit	81335775	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Pydrin	51630581	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Pyridine	110861	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Quinalphos	13593038	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
Quinoline	91225			1.20E+01 H			0.0056 c	0.00052 c	0.00026 c	0.48 c	0.053 c		
Resmethrin	10463868	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Ronnel	299843	5.00E-02 H					1800 N	180 N	68 N	100000 N	3900 N		
Rotenone	83794	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Savey	78587050	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Selenious Acid	7783008	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Selenium	7782492	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		3 E
Selenourea	630104	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		
Sethox[illegible]	74051802	9.00E-02 I					3300 N	330 N	120 N	180000 N	7000 N		
Silver [illegible] pounds	7440224	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Simazine	122349	5.00E-03 I		1.20E-01 H			0.56 c	0.052 c	0.026 c	48 c	5.3 c		

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Sodium azide	26628228	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Sodium diethyldithiocarbamate	148185	3.00E-02 I		2.70E-01 H			0.25 C	0.023 C	0.012 C	21 C	2.4 C		
Sodium fluoroacetate	62748	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Sodium metavanadate	13718268	1.00E-03 H					37 N	3.7 N	1.4 N	2000 N	78 N		
Strontium, stable	7440246	6.00E-01 I					22000 N	2200 N	810 N	1E+06 N	47000 N		
Strychnine	57249	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Styrene	100425	2.00E-01 I	2.86E-01 I			X	1600 N	1000 N	270 N	410000 N	16000 N	1400 E	2 E
Systhane	88671890	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
2,3,7,8-TCDD (dioxin)	1746016			1.56E+05 H	1.16E+05 H		4E-07 C	5E-08 C	C	4E-05 C	4E-06 C		
Tebuthiuron	34014181	7.00E-02 I					2600 N	260 N	95 N	140000 N	5500 N		
Temephos	3383968	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Terbacil	5902512	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Terbufos	13071799	2.50E-05 H					0.91 N	0.091 N	0.034 N	51 N	2 N		
Terbutryn	886500	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
1,2,4,5-Tetrachlorobenzene	95943	3.00E-04 I				X	1.8 N	1.1 N	0.41 N	610 N	23 N	91 N	0.69 N
1,1,1,2-Tetrachloroethane	630206	3.00E-02 I		2.60E-02 I	2.59E-02 I	X	0.41 C	0.24 C	0.12 C	220 C	25 C		
1,1,2,2-Tetrachloroethane	79345			2.00E-01 I	2.03E-01 I	X	0.052 C	0.031 C	0.016 C	29 C	3.2 C	0.4 E	0.001 E
Tetrachloroethylene (PCE)	127184	1.00E-02 I		5.20E-02 E	2.03E-03 E	X	1.1 C	3.1 C	0.061 C	110 C	12 C	11 E	0.04 E
2,3,4,6-Tetrachlorophenol	58902	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
p,a,a,a-Tetrachlorotoluene	5216251			2.00E+01 H		X	0.00053 C	0.00031 C	0.00016 C	0.29 C	0.032 C		
Tetrachlorovinphos	961115	3.00E-02 I		2.40E-02 H			2.8 C	0.26 C	0.13 C	240 C	27 C		
Tetraethyldithiopyrophosphate	3689245	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
Lead (tetraethyl)	78002	1.00E-07 I					0.0037 N	0.00037 N	0.00014 N	0.2 N	0.0078 N	0.00068 N	0.000034 N
Thallic oxide	1314325	7.00E-05 W					2.6 N	0.26 N	0.095 N	140 N	5.5 N		
Thallium													0.4 E
Thallium acetate	563688	9.00E-05 I					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium carbonate	6533739	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thallium chloride	7791120	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thallium nitrate	10102451	9.00E-05 I					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium selenite	12039520	9.00E-05 W					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium sulfate	7446186	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thiobencarb	28249776	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-(Thiocyanomethylthio)-benzothiazole	21564170	3.00E-02 H					1100 N	110 N	41 N	61000 N	2300 N		
Thiofanox	39196184	3.00E-04 H					11 N	1.1 N	0.41 N	610 N	23 N		
Thiophanate-methyl	23564058	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Thiram	137268	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Tin and compounds		6.00E-01 H					22000 N	2200 N	810 N	1E+06 N	47000 N		
Toluene	108883	2.00E-01 I	1.14E-01 I			X	750 N	420 N	270 N	410000 N	16000 N	520 E	5 E
Toluene-2,4-diamine	95807			3.20E+00 H			0.021 C	0.002 C	0.00099 C	1.8 C	0.2 C		
Toluene-2,5-diamine	95705	6.00E-01 H					22000 N	2200 N	810 N	1E+06 N	47000 N		
Toluene-2,6-diamine	823405	2.00E-01 H					7300 N	730 N	270 N	410000 N	16000 N		
p-Toluidine	106490			1.90E-01 H			0.35 C	0.033 C	0.017 C	30 C	3.4 C		

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Toxaphene	8001352			1.10E+00 I	1.12E+00 I		0.061 C	0.0056 C	0.0029 C	5.2 C	0.58 C	5 E	0.04 E
Tralomethrin	66841256	7.50E-03 I					270 N	27 N	10 N	15000 N	590 N		
Triallate	2303175	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Triasulfuron	82097505	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
1,2,4-Tribromobenzene	615543	5.00E-03 I				X	30 N	18 N	6.8 N	10000 N	390 N		
Tributyltin oxide (TBTO)	56359	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
2,4,6-Trichloroaniline hydrochloride	33663502			2.90E-02 H			2.3 C	0.22 C	0.11 C	200 C	22 C		
2,4,6-Trichloroaniline	634935			3.40E-02 H			2 C	0.18 C	0.093 C	170 C	19 C		
1,2,4-Trichlorobenzene	120821	1.00E-02 I	5.71e-02 H			X	190 N	210 N	14 N	20000 N	780 N	240 E	2 E
1,1,1-Trichloroethane	71556	9.00E-02 W	2.86E-01 W			X	1300 N	1000 N	120 N	180000 N	7000 N	980 E	0.9 E
1,1,2-Trichloroethane	79005	4.00E-03 I		5.70E-02 I	5.60E-02 I	X	0.19 C	0.11 C	0.055 C	100 C	11 C	0.8 E	0.01 E
Trichloroethylene (TCE)	79016	6.00E-03 E		1.10E-02 W	6.00E-03 E	X	1.6 C	1 C	0.29 C	520 C	58 C	3 E	0.02 E
Trichlorofluoromethane	75694	3.00E-01 I	2.00E-01 A			X	1300 N	730 N	410 N	610000 N	23000 N	790 N	13 N
2,4,5-Trichlorophenol	95954	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	8200 S	120 E
2,4,6-Trichlorophenol	88062			1.10E-02 I	1.09E-02 I		6.1 C	0.57 C	0.29 C	520 C	58 C	150 C	0.05 E
2,4,5-Trichlorophenoxyacetic acid	93765	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-(2,4,5-Trichlorophenoxy)propionic acid	93721	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
1,1,2-Trichloropropane	598776	5.00E-03 I				X	30 N	18 N	6.8 N	10000 N	390 N	13 N	0.14 N
1,2,3-Trichloropropane	96184	6.00E-03 I		7.00e+00 I		X	0.0015 C	0.00089 C	0.00045 C	0.82 C	0.091 C	0.00003 C	6.000E-06 C
1,2,3-Trichloropropene	96195	5.00E-03 H				X	30 N	18 N	6.8 N	10000 N	390 N		
1,1,2-Trichloro-1,2,2- trifluoroethane	76131	3.00E+01 I	8.57E+00 H			X	59000 N	31000 N	41000 N	1E+06 N	1000000 N	2400 S	3100 N
Tridiphane	58138082	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Triethylamine	121448		2.00E-03 I				73 N	7.3 N					
Trifluralin	1582098	7.50E-03 I		7.70E-03 I			8.7 C	0.81 C	0.41 C	740 C	83 C		
1,2,4-Trimethylbenzene	95636	5.00e-04 E				X	3 N	1.8 N	0.68 N	1000 N	39 N		
1,3,5-Trimethylbenzene	108678	4.00e-04 E				X	2.4 N	1.5 N	0.54 N	820 N	31 N	6.8 N	0.26 N
Trimethyl phosphate	512561			3.70E-02 H			1.8 C	0.17 C	0.085 C	150 C	17 C		
1,3,5-Trinitrobenzene	99354	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Trinitrophenylmethylnitramine	479458	1.00E-02 H					370 N	37 N	14 N	20000 N	780 N		
2,4,6-Trinitrotoluene	118967	5.00E-04 I		3.00E-02 I			2.2 C	0.21 C	0.11 C	190 C	21 C		
Uranium (soluble salts)	7440611	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Vanadium	7440622	7.00E-03 H					260 N	26 N	9.5 N	14000 N	550 N		
Vanadium pentoxide	1314621	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		
Vanadium sulfate	36907423	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Vernam	1929777	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Vinclozolin	50471448	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Vinyl acetate	108054	1.00E+00 H	5.71E-02 I				37000 N	210 N	1400 N	1E+06 N	78000 N	370 E	84 E
Vinyl bromide	593602		8.57E-04 I			X	5.2 N	3.1 N				2 N	0.018 N
Vinyl chloride	75014			1.90E+00 H	3.00E-01 H	X	0.019 C	0.021 C	0.0017 C	3 C	0.34 C	0.002 E	0.01 E
Warfarin	81812	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
m-Xyl[illegible]	108323	2.00E+00 H	2.00E-01 W			X	1400 N	730 N	2700 N	1E+06 N	160000 N	95[illegible]	240 N
o-Xyl[illegible]	95476	2.00E+00 H	2.00E-01 W			X	1400 N	730 N	2700 N	1E+06 N	160000 N	[illegible]	150 N

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p-Xylene	106423		8.57E-02 w			☒	520 N	310 N				1000 S	220 N
Xylene (mixed)	1330207	2.00E+00 I				☒	12000 N	7300 N	2700 N	1E+06 N	160000 N	320 E	74 E
Zinc	7440666	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N		42000 E
Zinc phosphide	1314847	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Zineb	12122677	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		