N00129.AR.000956
NSB NEW LONDON
5090.3a

Work Plan
for
Basewide Groundwater Operable Unit Data Gap Investigation

Naval Submarine Base New London
Groton, Connecticut

Engineering Field Activity Northeast
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0841

October 2002

TETRA TECH NUS, INC.

REVISION 1
OCTOBER 2002

WORK PLAN
FOR
BASEWIDE GROUNDWATER OPERABLE UNIT
DATA GAP INVESTIGATION

NAVAL SUBMARINE BASE
NEW LONDON
GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Envineering Field Activity Northeast
Environmental Branch (Code EV2)
Naval Facilities Engineering Command
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0841

OCTOBER 2002

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ACRONYMS

BGOURI	Basewide Groundwater Operable Unit Remedial Investigation
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	contaminant of concern
COPC	compounds of potential concern
CTE	central tendency exposure
CTEDEP	Connecticut Department of Environmental Protection
CTO	Contract Task Order
DO	dissolved oxygen
DOD	Department of Defense
DOT	Department of Transportation
DPT	direct push technology
DRMO	Defense Reutilization and Marketing Office
ESQD	Explosive Safety Quantity Distance
FID	flame ionization detector
FOL	field operations leader
FS	Feasibility Study
FTMR	Field Task Modification Request
HASP	Health and Safety Plan
HDPE	high density polyethylene tubing
HHRA	human health risk assessment
HIs	hazard indices
HNO_3	nitric acid
IAS	Initial Assessment Study
ICR	incremental cancer risk
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic
IR	Installation Restoration
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
NAVD	North American Vertical Datum
NSB-NLON	Naval Submarine Base-New London
OBDA	Over Bank Disposal Area

PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPM	Remedial Project Manager
RSR	Remediation Standard Regulations
SASDA	Spent Acid Storage and Disposal Area
SOP	standard operating procedures
SPCS NAD	State plane coordinate system North American Datum
SVOC	semivolatile organic compound
TAL	target analyte list
TCE	trichloroethene
TCL	target compound list
TCLP	Toxicity Characteristic Leaching Procedure
TtNUS	Tetra Tech NUS, Inc.
USEPA	United States Environmental Protection Agency
VOC	volatile organics compounds
WP	work plan

1.0 INTRODUCTION

The Engineering Field Activity Northeast of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 0841 to Tetra Tech NUS, Inc. (TtNUS) under Comprehensive Long-Term Environmental Action Navy (CLEAN III contract) contract number N62467-94-D-0888. Under CTO 0841, TtNUS has prepared this work plan (WP) to perform additional field investigations at Site 3 [Area A Downstream Watercourse/Over Bank Disposal Area (OBDA)], Site 15 (Spent Acid Storage and Disposal Area), and Site 20 (Area A Weapons Center) at Naval Submarine Base-New London (NSB-NLON) in Groton, Connecticut to support completion of Feasibility Studies (FSs) for each of these sites.

The purpose of this WP is to describe the activities and procedures to be followed during the investigations at Sites 3, 15, and 20. Figure 1-1 shows the location of each of these sites with respect to each other and other Installation Restoration (IR) sites at NSB-NLON. The purpose of the investigations is to fill data gaps identified in the Basewide Groundwater Operable Unit Remedial Investigation (BGOURI) Report dated January, 2002, and to investigate one new source area discovered during a remedial action.

This WP was prepared to follow the intent of the United States Environmental Protection Agency's (USEPA) document titled Region I EPA-New England, Compendium of Quality Assurance Project Plan Guidance, dated October 1999 (USEPA, 1999), and the Department of Defense (DOD) guidance in the Handbook to Support the IR Program Statements of Work, Volume I – Remedial Investigation/Feasibility Studies (DOD, 1991). Because the intent of this WP is to fill data gaps of the previously performed BGOURI, the format of this WP differs from the formats presented in the references listed above.

Section 1.0 of the WP presents this introduction which includes the purpose of the WP. The remainder of Section 1.0 provides site descriptions, a summarization of available information (nature and extent of contamination, human health risks, and contaminant fate and transport at Sites 3, 15, and 20), a summary of data gaps, and project organization information. Section 2.0 details the scope of work to be conducted during the investigation. Section 3.0 provides guidance and procedures on conducting the field activities proposed in this WP. A Health and Safety Plan (HASP) (Appendix A), a Quality Assurance Project Plan (QAPP) (Appendix B), standard field forms (Appendix C), and standard operating procedures (SOPs) (Appendix D) are provided as appendices to this report.

1.1 SITE DESCRIPTION

1.1.1 Area A Downstream Watercourse / Over Bank Disposal Area (Site 3)

The Area A Downstream Watercourses receive surface water and groundwater recharge from the Area A Landfill, Area A Wetland, Torpedo Shops, and surrounding areas and conveys the surface and groundwater flows to the Thames River. The Area A Downstream Watercourses include North Lake and several small ponds (Upper Pond, Lower Pond, and OBDA Pond) and interconnected streams (Streams 1 through 6). The general configuration of the Area A Downstream Watercourses and adjacent areas is shown on Figure 1-2.

The primary water discharge point from the Area A Wetland to the Area A Downstream Watercourses is through four 24-inch diameter metal culvert pipes located within the dike that separates the Area A Wetland from the Area A Downstream Watercourses. The discharge from these culverts forms a small stream (Stream 4) that flows westward for approximately 200 feet into Upper Pond. Upper Pond discharges to Stream 3, which flows northward and then westward toward Triton Avenue (past the OBDANE, Site 14) to the entrance of the Torpedo Shops. At this location, it meets the drainage channel from the Torpedo Shops and forms Stream 5. Stream 5 flows westward along Triton Avenue through the Small Arms Range and under Shark Boulevard and eventually discharges to the Thames River at the Defense Reutilization and Marketing Office (DRMO) outfall. Upper Pond also has a discharge structure on the south side. A second pond (Lower Pond), northwest of Upper Pond, is a natural depression and is recharged by groundwater inflow. The outlet of the pond forms Stream 2, which enters a storm sewer and flows to the west around North Lake (TtNUS, 2002).

Groundwater discharges from the Area A Landfill to a small pond (the OBDA Pond) located at the base of the dike and the OBDA. Stream 1 flows from this pond westward toward North Lake, a recreational swimming area for Navy personnel. Under normal flow conditions, the stream enters a culvert that bypasses North Lake and discharges to a stream (Stream 6) below the outfall of the lake. Stream 6, which is formed by Stream 1, Stream 2, and the outflow of North Lake, flows westward under Shark Boulevard and through the golf course to the Thames River. North Lake is filled with potable water every year and drained at the end of the season. Surface water levels in North Lake do not appear to coincide with groundwater levels in adjacent monitoring wells, indicating little hydraulic connection between surface water of North Lake and the shallow groundwater (TtNUS, 2002).

Most of the area is within designated Explosive Safety Quantity Distance (ESQD) arcs of the Area A Weapons Center; therefore, further development is not planned for this area. Navy regulations prohibit construction of inhabited buildings or structures within these arcs and, although existing buildings operate under a waiver of these regulations.

A Proposed Plan and Record of Decision (ROD) were completed for this site; the ROD was signed in late 1997. A remedial design was completed for the soil and sediment at Site 3 in 1999, and the remedial action for Site 3 soil and sediment was completed during 1999 and 2000. During the remedial action, contaminated soil and sediment were dredged and hauled off site for disposal, and wetlands and waterways in the area were restored.

A previously unknown source of petroleum contamination was detected during the remedial action at Site 3. The source, found during the remediation of Stream 5, is located on the northern side of the stream just east of the Small Arms Range (see Figure 1-2). Petroleum product was discovered emanating from the northern side of the excavation. Upon further investigation, a small disposal area (i.e., drums, cable, etc.) was discovered upgradient of the location where petroleum was discovered. No additional investigation or remedial actions have been taken at this new source area.

The OBDA is located on the slope of the dike below and adjacent to the Area A Landfill. It is located on the southwestern end of the dike where the angle of the slope approaches 45 degrees. A small wetland exists at the base of the dike. The OBDA area was used as a disposal site after the earthen dike was constructed in 1957. The Initial Assessment Study (IAS) Report (NEESA, 1983) indicated that the material had been there for many years. The IAS Report also indicated that the materials were not covered and included 30 partially covered 200-gallon metal fuel tanks and scrap lumber. Atlantic personnel inspected the OBDA on September 30, 1988 and observed approximately 30 empty, unlabeled 200-gallon tanks, old creosote telephone poles, several empty unlabeled 55-gallon drums, and rolls of wire. Orange sediments were observed in the water discharging from the base of the dike embankment. All the debris from the OBDA area was removed and disposed off site as part of a time-critical removal action in 1997 (TtNUS, 2002).

1.1.2 Spent Acid Storage and Disposal Area (Site 15)

The Spent Acid Storage and Disposal Area (SASDA) was located in the Southern Region of NSB-NLON. It was centrally located between the southern sides of Buildings 409 and 410. At present, the site is being considered as a potential location for a multi-bay car wash (project in planning stages). The current condition of the site is a relatively flat area completely covered with concrete or bituminous pavement (Figure 1-3).

The IAS Report indicated that this area was used before and after World War II for the temporary storage of waste battery acid in a rubber-lined underground tank. The tank was reportedly 12 feet long by 4 feet wide by 4 feet high. The batteries were placed on a concrete pad next to the tank, where some acids occasionally leaked. No major spills were ever recorded. A 1951 aerial photograph shows that the area

around the tank was not paved. Acid from the batteries was stored in the tank and was subsequently pumped into a tank truck and disposed in the Area A Landfill (Site 2) (TtNUS, 2002).

The site was inspected and the outline of the top of the tank was found. The area was completely covered with concrete and only the top of the tank was visible. The tank had been filled in place with soil and capped with bituminous pavement.

A time-critical removal action was completed at the SASDA during the course of the Phase II Remedial Investigation (RI). The removal action, completed in January 1995, included removal of the tank, tank contents, contaminated pavement, and approximately 318 tons of lead-contaminated soil. Soil with lead concentrations in excess of 500 mg/kg or toxicity characteristic leachate procedure (TCLP) leachate results for lead in excess of 5.0 mg/L were removed by OHM Remediation Services Corporation, the Navy's Remedial Action Contractor (RAC). The excavated materials were transported off site and disposed in a Resource Conservation and Recovery Act (RCRA) landfill (Environmental Quality Company) in Bellville, Michigan. The excavation was backfilled with clean borrow material from an off-site location. The excavated area was covered with bituminous pavement.

The Navy, USEPA, and Connecticut Department of Environmental Protection (CTDEP) signed a No-Further-Action Source Control ROD for this site in 1997 (TtNUS, 2002).

1.1.3 Area A Weapons Center (Site 20)

Site 20, the Area A Weapons Center, consists of Building 524 and the weapons storage bunkers. The storage bunker area is divided into two portions (north and south areas) that were constructed at different times and are of different design. The site is located in the north central portion of NSB-NLON at the southeastern end of Triton Avenue, and is adjacent to and on the northwestern side of the Area A Wetland (TtNUS, 2002). The general configuration of the Area A Weapons Center site is shown in Figure 1-4.

The Area A Weapons Center (Building 524) is located near the top of a local topographic and bedrock high. Building 524 was constructed in 1990-1991. Portions of the site were blasted to remove bedrock to accommodate construction of the building. The weapons storage bunkers are located southeast and downhill of Building 524 and are adjacent to and at a slightly higher elevation than the Area A Wetland.

Prior to construction of the Area A Weapons Center, the site consisted of woodlands in the vicinity of Building 524. The bunker areas were part of the Area A Wetlands. Based on review of aerial photographs, the southern area of weapons storage bunkers was first evident in 1969. The northern area of weapons storage bunkers was first evident in February 1974 (TtNUS, 2002).

The site was inspected on September 11, 1992. The following information was obtained during the site inspection. Building 524 is used for administration, minor torpedo assembly, and storage of simulator torpedoes. No weapons production takes place in this building. Small quantities of chemicals and chemical waste generated by activities in this building are stored in 1- to 5-gallon containers in seven metal storage cabinets located on a paved area south of the building. Chemicals include cleaning and lubricating compounds, paints, and adhesives. Many of these materials are classified as corrosive or flammable materials. The waste storage and management practices appeared to be good.

The weapons storage bunkers are located southeast of Building 524. Liquid fuels present in the weapons storage bunkers include Otto fuel, JP-10, and TH Dimer (kerosene). The group of southern area bunkers has been reconstructed in the last 10 years. A major part of the reconstruction involved removal of structurally unsuitable soil from the site (TtNUS, 2002).

Routine maintenance and security improvements for the Area A Weapons Center include grouting and waterproofing of bunkers, repaving of roads, installation of culverts, and regrading associated with these activities.

A ROD was signed for the soil and sediment operable units associated with Site 20 in June 2000. A minor (200 cubic yards) soil removal action was completed in October 2001 to address polynuclear aromatic hydrocarbon (PAH) and metals contamination in soil and sediment. The remedial action was targeted towards mitigating direct contact exposures to soil and sediment.

The site is near the farthest upgrade end of NSB-NLON. There are no known contaminant sources existing upgradient of Site 20.

1.2 SUMMARY OF BGOURI RESULTS

This section summarizes the results of the BGOURI for Sites 3, 15, and 20. Further details on the BGOURI results for these sites, along with a summary of results from the Phase I RI (performed in 1992) and the Phase II RI (performed in 1997) which included these sites, are provided in the BGOURI report. As indicated in Section 1.1 remedial actions have been completed at Sites 3, 15, and 20 in the past. In 1999 and 2001 soils and sediments were removed from the Site 3 wetlands and waterways. In January of 1995, the underground storage tank, its contents, contaminated pavement and surrounding soils were removed from Site 15. Lastly in the fall of 2000, soils and sediments were removed from Site 20. Therefore, this section describes the extent of contamination as it relates to the groundwater and previously unknown areas of soil contamination (TtNUS, 2002).

1.2.1 Site 3

1.2.1.1 Nature and Extent of Contamination

During the BGOURI, several volatile organics compounds (VOCs) were identified as compounds of potential concern (COPCs) for groundwater, including chloroform, cis-1,2-dichloroethene (cis-1,2-DCE), trichloroethene (TCE), and vinyl chloride. The detections were disperse and generally low concentration, with the exceptions of cis-1,2-DCE (12.2 µg/L) and vinyl chloride (31.3 µg/L) in well 2DMW29S. None of the other VOC detections exceeded 10 µg/L in any of the monitoring wells sampled.

One semivolatile organic compound (SVOC), benzo(a)pyrene, was identified as a COPC based on a single positive detection in the monitoring wells sampled.

Trace levels of 4,4'-DDD and 4,4'-DDT were the only pesticides detected in groundwater from the overburden aquifer at Site 3. These compounds were only detected in the sample collected from monitoring well 2DMW30S, and high levels of total dissolved solids were measured in this well and are the likely cause of the detections of 4,4'-DDD and 4,4'-DDT.

Lastly, two inorganics, arsenic and thallium were identified as COPCs for groundwater based on the sampling results. There was only a single, low-concentration positive detection of arsenic and two detections of thallium (all less than 7 µg/L), indicating that metals contamination of groundwater is not a significant problem at Site 3 (TtNUS, 2001).

Figure 1-5 presents the BGOURI sampling locations for Site 3 and the detected contaminants of concern (COCs) in groundwater.

1.2.1.2 Contaminant Fate and Transport

TCE, cis-1,2-DCE, vinyl chloride, and chloroform are halogenated aliphatic hydrocarbons. Given the length of time since waste disposal activities were thought to occur and the mobility of these compounds, it is expected that the observed concentrations of these chemicals likely are indicative of steady-state or slowly declining concentrations within the groundwater. A preliminary evaluation of natural attenuation data (i.e., hydrogeologic, chemistry, and geochemical data) indicated that multiple minor sources of petroleum and chlorinated hydrocarbons are impacting the Area A Downstream groundwater and biodegradation and other natural attenuation processes are acting to reduce organic contaminants to relatively insignificant levels in the Area A Downstream. It is likely that monitored natural attenuation would be viable for the source area impacting 2DMW29S (TtNUS, 2002).

The only SVOC detected above screening levels in groundwater, benzo(a)pyrene, is a PAH. PAHs are generally considered relatively immobile in the environment. The single, low-level detection of benzo(a)pyrene is not considered to be indicative of a PAH problem in groundwater (TtNUS, 2002).

Arsenic and thallium were identified as COPCs in groundwater, based on a combined total of three, low-concentration detections. Metals are persistent in the environment but generally not very mobile, due to their low solubilities and affinities for binding to soil particles. The slightly acidic pH of the groundwater (as is characteristic of northern region groundwater) generally serves to enhance the mobility of metals. The low concentrations of metals detected and the lack of detectable levels over much of Area A Downstream indicate that metals contamination of groundwater is not a significant concern (TtNUS, 2002).

1.2.1.3 Summary of Human Health Risk Assessment

The following items summarize the human health risk assessment (HHRA) for Site 3 (TtNUS, 2002).

- The HHRA considered exposures to construction workers and future residents. Only exposures to groundwater were evaluated. For the construction worker, the only exposure pathway was dermal contact with groundwater. For the future resident, exposure pathways included ingestion, dermal contact, and inhalation.

- The maximum detected concentrations of chloroform, cis-1,2-DCE, TCE, vinyl chloride, benzo(a)pyrene, arsenic, and thallium exceeded their direct contact risk-based COPC screening levels and were retained for evaluation in the HHRA.

- The maximum detected concentration of arsenic exceeded its CTDEP screening criteria for protection of migration of groundwater to surface water.

- The maximum detected concentration of vinyl chloride exceeded its CTDEP screening criteria for the protection of migration from groundwater to indoor air.

- Incremental cancer risk (ICRs) and hazard indices (HIs) for construction workers exposed to groundwater at Site 3 were within USEPA and CTDEP acceptable levels.

- The ICR for future adult residents exposed to groundwater at Site 3 under the RME scenario exceeded USEPA's target risk range of 10^{-4} to 10^{-6} and CTDEP's acceptable risk level of 10^{-5} for cumulative exposures. Chemical-specific ICRs for arsenic, benzo(a)pyrene, TCE, and vinyl chloride exceeded CTDEP's target level of 1×10^{-6} for individual chemicals.

- The ICR for future adult residents exposed to groundwater at Site 3 under the central tendency exposure (CTE) scenario was within USEPA's target risk range of 10^{-4} to 10^{-6} but exceeded CTDEP's acceptable risk level of 10^{-5} for cumulative exposures. Chemical-specific ICRs for arsenic, benzo(a)pyrene, and vinyl chloride exceeded CTDEP's target level of 1×10^{-6} for individual chemicals.

- The HI for future adult residents exposed to groundwater at Site 3 exceeded USEPA's and CTDEP's acceptable level of 1.0 under the reasonable maximum exposure (RME) scenario. Thallium was the major contributor to the HI.

- The results of the human health risk assessment indicate that cancer risks and hazard indices exceed USEPA and CTDEP acceptable risk levels for future adult residents exposed to groundwater. Although the calculations were not performed, cancer risks and hazard indices for future child residents would also be expected to exceed USEPA and CTDEP acceptable levels.

- The maximum detected concentrations of chromium and manganese in groundwater exceeded their respective screening criteria but was within background levels, consequently chromium and manganese were not retained as COCs in the HHRA. ICRs and HIs for construction workers would have been within USEPA and CTDEP target levels if these compounds had been evaluated in the HHRA. HIs for adult residents exposed to manganese in groundwater would exceed the acceptable level of 1 if manganese were evaluated in the HHRA.

1.2.2 Sites 15

1.2.2.1 Nature and Extent of Contamination

During the BGOURI, TCE was the only VOC detected in the groundwater at Site 15. TCE was detected in 3 of 4 samples at concentrations ranging from 2.32 (15MW2S) to 16 µg/L (15MW3S). The maximum contaminant level (MCL) for TCE is 5 µg/L and the direct contact screening criterion is 1.6 µg/L. TCE was not detected in groundwater at this site during historical sampling events, and the source of the TCE is unknown. TCE was not detected in any Site 23 (Tank Farm) groundwater samples. Site 23 is located down-gradient of Site 15. Therefore, it does not appear that TCE is migrating to downgradient locations at significant concentrations (TtNUS, 2002).

Three SVOCs (anthracene, fluoranthene, and pyrene) were detected in Site 15 groundwater samples. None of these SVOCs were detected in groundwater samples collected during the Phase II RI. The PAHs were only detected in sample S15MW3S01. Concentrations of these PAHs were all under the applicable screening criteria (TtNUS, 2002).

Fifteen inorganics were detected in the groundwater samples collected from Site 15. Seven of the 15 detected metals were present in all four samples. Significant concentrations of metals were detected most frequently in samples S15MW1S01 and S15MW2S01. Cadmium, chromium, lead, nickel, silver, and zinc were detected at concentrations that exceeded screening criteria. Lead is the only common inorganic detected at significant levels during both the Phase II RI and BGOURI. Chromium and lead were detected in all four BGOURI samples. It is likely that residual contamination from the former SASDA is the source of several of the inorganics detected in groundwater (TtNUS, 2002).

Figure 1-6 presents the BGOURI sampling locations for Site 15 and the detected COCs in groundwater.

1.2.2.2 Contaminant Fate and Transport

The TCE detected in the groundwater at Site 15 may be the result of a spill event or a subsurface release that was solubilized by infiltrating precipitation. The most recent groundwater data collected at the site suggest that lateral transport of TCE is occurring since higher concentrations were found in downgradient wells; however, it is unclear if the former SASDA is the source of the contamination. In addition, TCE was not detected in any Site 23 (Tank Farm) groundwater sample; therefore, it does not appear that the TCE is migrating to downgradient locations at significant concentrations. The analytical results do not indicate that vertical migration of TCE in groundwater has occurred since neither TCE or other volatile organics were detected in the deep well in the Phase II RI or the BGOURI. It does not appear that appreciable biodegradation of TCE is occurring in the groundwater at Site 15 because no degradation products have been detected in on-site groundwater samples either in the BGOURI or the Phase II RI (TtNUS, 2002).

The BGOURI results show that the highest concentrations of metals tended to be in the shallow groundwater wells closest to the location of the former SASDA (i.e., wells 15MW1S and 15MW2S). The low pH (4.44) in the most upgradient well (15MW2S) and the generally acidic pH in two other shallow wells suggest that the metals cadmium, nickel, silver, and zinc will be present as cations and mobile. The combination of slightly acidic and generally oxidizing groundwater at Site 15 suggests chromium will be present as the Chromium (VI) chromate anion and thus more mobile than the metal cations. Silver was detected in one deep groundwater sample in the Phase II RI at a concentration of 1.2 µg/L, but it was detected in the three shallow wells sampled during the BGOURI at concentrations ranging from 79.1 to 615 µg/L. Although the monitoring well network is limited at Site 15, silver was not detected in any downgradient groundwater samples at Site 23. Therefore, it does not appear that silver is migrating to downgradient locations at significant concentrations. Based on the available data, it does not appear that soil contamination is the main source of the silver in groundwater. Lead was detected in groundwater at the site; the maximum concentration slightly exceeded screening levels. The concentrations of lead detected in the BGOURI (2.8 µg/L to 24.7 µg/L) are similar to those found in the Phase II RI (2.1 µg/L to 21.2 µg/L). Although lead is typically considered to be immobile, the presence of acidic conditions (low

pH) suggests that the lead is mobile. It is likely that, as these metals migrate from Site 15 toward and through the more reducing and more basic pH environment of Site 23 (Tank Farm), their mobility should decrease and they should precipitate out (TtNUS, 2002).

1.2.2.3 Human Health Risk Assessment

The following items summarize the HHRA for Site 15 (TtNUS, 2002):

- The HHRA for Site 15 considered exposures to construction workers and future adult residents. No soil samples were collected at Site 15; therefore, only exposures to groundwater were evaluated. Potential exposure pathways for groundwater included dermal contact for construction workers and incidental ingestion, dermal contact, and inhalation of volatile emissions for future adult residents.

- The maximum detected concentrations of TCE, cadmium, chromium, lead, nickel, and silver exceeded the direct contact risk-based COPC screening levels and was retained as COPCs for groundwater.

- Maximum detected concentrations of lead, silver, and zinc exceeded CTDEP's screening criteria for protection of migration of groundwater to surface water.

- The maximum detected concentrations of all chemicals in groundwater were less than the CTDEP criteria for migration from groundwater to indoor air.

- ICRs and HIs for construction workers exposed to groundwater at Site 15 were within USEPA and CTDEP acceptable levels.

- ICRs for future adult residents exposed to groundwater at Site 15 were less than or within USEPA's target risk range of 10^{-4} to 10^{-6} and CTDEP's acceptable risk level of 10^{-5} for cumulative exposures. The chemical-specific ICR for TCE exceeded CTDEP's target level of 1×10^{-6} for individual chemicals.

- HIs for future adult residents exposed to groundwater at Site 15 exceeded USEPA's and CTDEP's acceptable level of 1.0 under the RME scenario. Chromium and silver were the major contributors to the HI.

- The human health risk assessment results indicate that cancer risks for future adult residents exposed to groundwater were within EPA's acceptable cancer risk range, but exceeded CTDEP's acceptable risk levels. Hazard indices for future adult residents exposed to groundwater exceeded EPA's and CTDEP's acceptable levels. Even though the calculations were not performed, cancer

risks for future child residents would also be expected to be within EPA's acceptable cancer risk range but exceed CTDEP's acceptable risk levels and hazard indices would be expected to exceed EPA's and CTDEP's acceptable levels.

- The maximum detected concentration of lead in groundwater exceeded the Safe Drinking Water Act action level and CTDEP Remediation Standard Regulations (RSR) of 15 µg/L. The Integrated Exposure Uptake Biokinetic (IEUBK) model was used to evaluate exposures of lead in groundwater by hypothetical residential children. The IEUBK model indicated that no adverse effects are anticipated for hypothetical future child residents exposed to lead in groundwater at Site 15.

- The maximum detected concentration of manganese in groundwater exceeded its screening criteria but was within background levels, consequently manganese was not retained as a COC in the HHRA. HIs for adult residents exposed to manganese in groundwater would be equal to the acceptable level of 1 if manganese were evaluated in the HHRA.

1.2.3 Sites 20

1.2.3.1 Nature and Extent of Contamination

During the BGOURI, one VOC, TCE, was identified as a COPC for groundwater, due to two low-level detections (i.e., maximum of 5.02 µg/L). One detection was from an overburden monitoring well and the other was from a bedrock well.

The only SVOC COPC identified for Site 20 groundwater was benzo(a)pyrene. It was detected at a concentration of 0.05 µg/L in one overburden monitoring well. Metals identified as COPCs for Site 20 groundwater include antimony, arsenic, nickel, silver, thallium, and zinc. One or more metals were detected above background in three of the four wells sampled. The COPCs were only identified in samples taken from the overburden monitoring wells. Silver and arsenic had two detections each above screening criteria; the remaining metals had single detections each above their respective screening criteria. The metals exceedances did not follow any discernible pattern in regards to areal distribution (TtNUS, 2002).

Figure 1-7 presents the BGOURI sampling locations for Site 20 and the detected COCs in groundwater.

1.2.3.2 Contaminant Fate and Transport

One halogenated aliphatic (TCE) was identified as a COPC. Halogenated aliphatic hydrocarbons such as TCE are relatively water-soluble and have a low capacity for retention by soil organic carbon. The most

recent groundwater data collected at the site do not indicate significant lateral transport because TCE was detected in the more upgradient wells but not in the downgradient wells, and TCE was not detected in any downgradient wells in the Phase II RI (TtNUS, 2002).

The only SVOC identified as a COPC for Site 20 groundwater is benzo(a)pyrene, a high molecular weight PAH. PAHs have very low solubilities and low environmental mobility. In soil, PAHs are much more likely to bind to soil and be transported via mass transport mechanisms than go into solution. No PAHs were found in the bedrock well. The absence of these compounds at depth may be related to the fact that downward migration of PAHs from the surface is less likely because of their tendency to adhere to soil (TtNUS, 2002).

At Site 20, several metals were identified as COPCs for groundwater. Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. Factors that assist in predicting the mobility of metals are the soil/pore water pH, REDOX potential, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity. Based on the mobility of silver in comparison to the BGOURI-detected concentrations, it is likely that the silver detected at the site is bound to particulate matter (TtNUS, 2002).

1.2.3.3 Summary of Human Health Risk Assessment

The following is a summary of the results of the HHRA for Site 20 (TtNUS, 2002):

- The HHRA for Site 20 considered exposures to construction workers and future adult residents. No soil samples were collected at Site 20; therefore, only exposures to groundwater were evaluated. Potential exposure pathways included dermal contact with groundwater.

- The maximum detected concentrations of TCE, benzo(a)pyrene, antimony, arsenic, nickel, silver, and thallium exceeded the direct contact risk-based COC screening levels and were retained for evaluation in the HHRA.

- Maximum detected concentrations of arsenic, silver, and zinc exceeded CTDEP's screening criteria for protection of migration of groundwater to surface water.

- The maximum detected concentrations of all chemicals in groundwater were less than the CTDEP criteria for migration from groundwater to indoor air.

- ICRs and HIs for construction workers exposed to groundwater at Site 20 were within USEPA and CTDEP acceptable levels.

- The ICR for future adult residents exposed to groundwater at Site 20 under the RME scenario exceeded USEPA's target risk range of 10^{-4} to 10^{-6} and CTDEP's acceptable risk level of 10^{-5} for cumulative exposures. Chemical-specific ICRs for arsenic, benzo(a)pyrene, and TCE exceeded CTDEP's target level of 1×10^{-6} for individual chemicals. It should be noted that the maximum detected concentrations of benzo(a)pyrene and arsenic were less than their respective CTDEP RSRs for residential exposures.

- The ICR for future adult residents exposed to groundwater at Site 20 under the CTE scenario was within USEPA's target risk range of 10^{-4} to 10^{-6} but exceeded CTDEP's acceptable risk level of 10^{-5} for cumulative exposures. Chemical-specific ICRs for arsenic and benzo(a)pyrene exceeded CTDEP's target level of 1×10^{-6} for individual chemicals.

- The HI for future adult residents exposed to groundwater at Site 20 exceeded USEPA's and CTDEP's acceptable level of 1.0 under the RME scenario. Arsenic, silver, and thallium were the major contributors to the HI. It should be noted that the maximum detected concentrations of arsenic and thallium were less than their respective CTDEP RSRs for residential exposures.

- The results of the human health risk assessment indicate that cancer risks and hazard indices exceed USEPA and CTDEP acceptable risk levels for future adult residents exposed to groundwater. Even though the calculations ere not performed, cancer risks and hazard indices for future child residents would also be expected to exceed USEPA and CTDEP acceptable levels.

- The maximum detected concentration of manganese exceeded its direct contact screening criteria and the maximum detected concentration of copper exceeded its migration to surface water criteria, but were within background levels, consequently manganese and copper were not retained as COCs for groundwater in the HHRA. HIs for adult residents exposed to manganese in groundwater would exceed the acceptable level of 1 if manganese were evaluated in the HHRA.

1.3 IDENTIFICATION OF DATA GAPS

The following are the data gaps identified for Sites 3, 15, and 20 in the BGOURI. These data gaps will be addressed by the investigation outlined in this WP.

Site 3

- Newly identified source area needs to be investigated (nature and extent).

- Groundwater contamination nature and extent along with evaluation of degradation products needs to be investigated further at Site 3.

Site 15

- Completeness of the Site 15 1995 time-critical removal action has not been determined.
- Groundwater contamination nature and extent along with evaluation of degradation products needs to be investigated further at Site 15.

Site 20

- Groundwater contamination nature and extent along with evaluation of degradation products needs to be investigated further at Site 20.

1.4 PROJECT ORGANIZATION

Under the direction of the Navy Remedial Project Manager (RPM), TtNUS is responsible for the overall management, implementation, and inspection of this contract field activity. Navy personnel will actively support the investigation and will coordinate with personnel from TtNUS during field activities. The responsible organizations and personnel involved in the project are as follows:

EFANE	Mr. Mark Evans Remedial Project Manager (RPM) Naval Facilities Engineering Command Code 1823/ME 10 Industrial Highway, Mail Stop #82 Lester, PA 19113-2090 (610) 595-0567, ext. 162
NSB-NLON	Mr. Richard Conant Environmental Department Manager Environmental Department Building 166 Groton, CT 06349-4899 (860) 694-5176
Tetra Tech NUS, Inc.	Mr. John Trepanowski, P.E., Program Manager Mr. Corey Rich, P.E., Project Manager Mr. Paul Frank, Quality Assurance Manager Mr. Matthew M. Soltis, CIH, CSP, Health & Safety Manager Foster Plaza 7 661 Andersen Drive Pittsburgh, PA 15220 (412) 921-8984

USEPA	Ms. Kymberlee Keckler RPM USEPA Region I 1 Congress Street Suite 1100 (HBT) Boston, MA 02114-2023 (617) 918-1385
CTDEP	Mr. Mark Lewis RPM Connecticut Department of Environmental Protection Water Management Bureau Permitting, Enforcement and Remediation Division Federal Remediation Program 79 Elm Street Hartford, CT 06106-5127 (860) 424-3768

Figure 1-8 presents the project management organization chart for this project at NSB-NLON. The responsibilities for these individuals are as indicated in Section 1.6 of the BGOURI WP (TtNUS, 2001).

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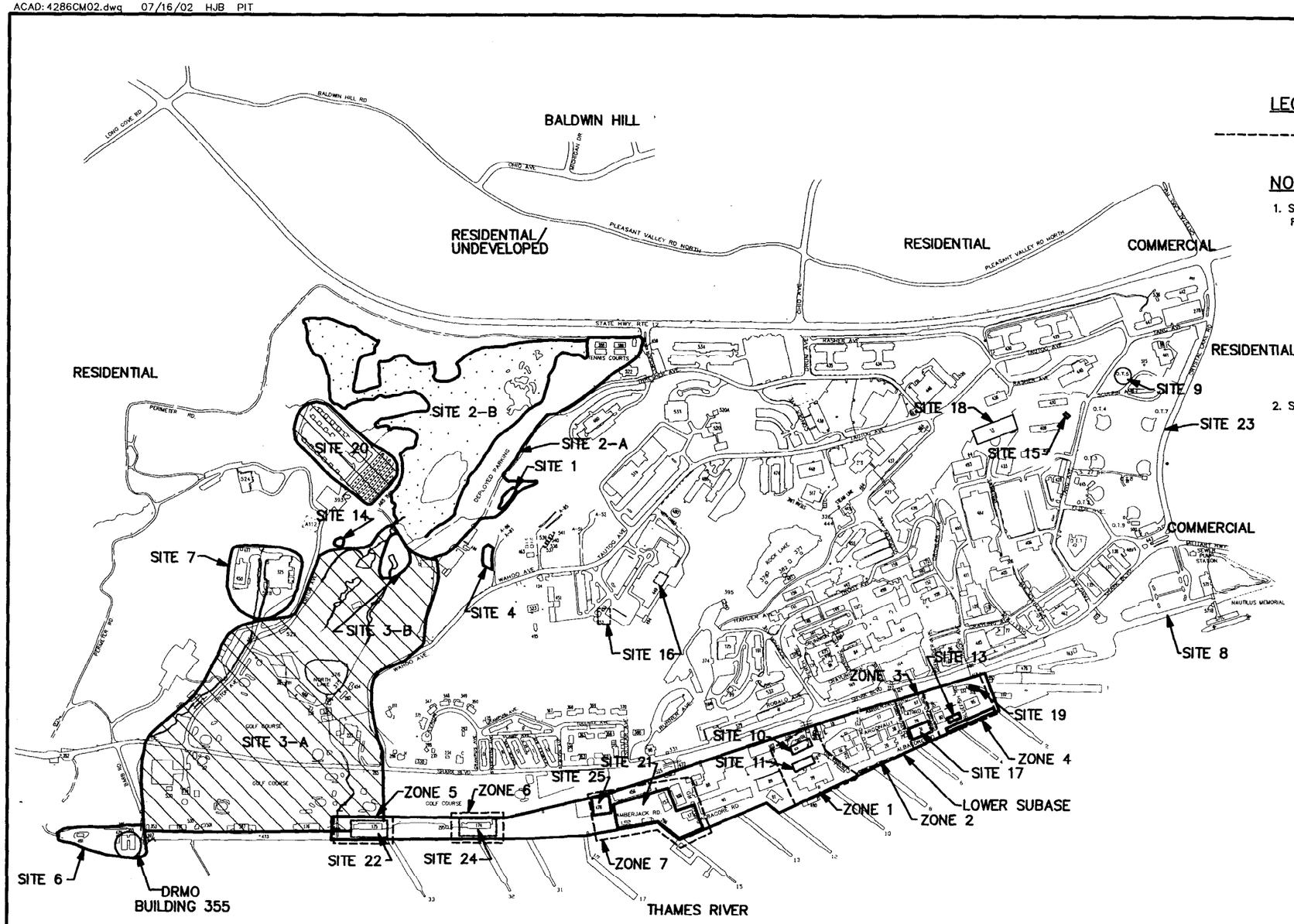

LEGEND:

-------- LOWER SUBASE REMEDIAL INVESTIGATION ZONE BOUNDARY

NOTES:

1. SITE AND STUDY AREA LOCATIONS WERE TAKEN FROM THE FOLLOWING REPORTS:
   - FEDERAL FACILITY AGREEMENT UNDER CERCLA 120, NAVAL SUBMARINE BASE, NEW LONDON, CONNECTICUT
   - FINAL INITIAL ASSESSMENT STUDY (ENVIRODYNE, MARCH 1983)
   - HYDROGEOLOGIC INVESTIGATION UNDERGROUND STORAGE TANKS OT-4, OT-7, OT-8, OT-9, AND 54-H (FUSS & O'NEILL, SEPTEMBER 1989)
   - PHASE I REMEDIAL INVESTIGATION (ATLANTIC, AUGUST 1992)
   - SITE CHARACTERIZATION REPORT FOR OT-10, BUILDING 325, AND BUILDING 89 (HNUS, APRIL 1995)
   - DRAFT FINAL SUPPLEMENT TO INITIAL ASSESSMENT STUDY (NAVAL FACILITIES ENGINEERING SERVICE CENTER, APRIL 1995)
   - REMOVAL SITE EVALUATION FOR QUAY WALL (HNUS, MAY 1995)
2. SITE AND STUDY AREA BOUNDRIES ARE APPROXIMATE.

SITE 1 – CONSTRUCTION BATTALION UNIT (CBU) DRUM STORAGE AREA
SITE 2 – (A) AREA A LANDFILL AND (B) AREA A WETLAND
SITE 3 – (A) AREA A DOWNSTREAM WATER COURSES AND (B) OVERBANK DISPOSAL AREA (OBDA)
SITE 4 – RUBBLE FILL AREA AT BUNKER A-86
SITE 6 – DEFENSE REUTILIZATION AND MARKETING OFFICE (DRMO)
SITE 7 – TORPEDO SHOPS
SITE 8 – GOSS COVE LANDFILL
SITE 9 – OILY WASTEWATER TANK (OT-5)
SITE 10 – LOWER SUBASE-FUEL STORAGE TANKS AND TANK 54-H
SITE 11 – LOWER SUBASE-POWER PLANT OIL TANKS
SITE 13 – LOWER SUBASE-BUILDING 79 WASTE OIL PIT
SITE 14 – OVERBANK DISPOSAL AREA NORTHEAST (OBDANE)
SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA (SASDA)
SITE 16 – HOSPITAL INCINERATORS
SITE 17 – HAZARDOUS MATERIALS/SOLVENT STORAGE AREA (BUILDING 31
SITE 18 – SOLVENT STORAGE AREA (BUILDING 33)
SITE 19 – SOLVENT STORAGE AREA (BUILDING 36)
SITE 20 – AREA A WEAPONS CENTER
SITE 21 – BERTH 16
SITE 22 – PIER 33
SITE 23 – FUEL FARM
SITE 24 – CENTRAL PAINT ACCUMULATION AREA (BUILDING 174)
SITE 25 – LOWER SUBASE-CLASSIFIED MATERIALS INCINERATOR

0 800 1600
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 7/9/02
CHECKED BY DATE 7/19/02
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

SITE LOCATION MAP
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 7/19/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-1
REV. 0

FORM CADD NO. TtNUS_BH.DGN – REV 0 – 1/20/98

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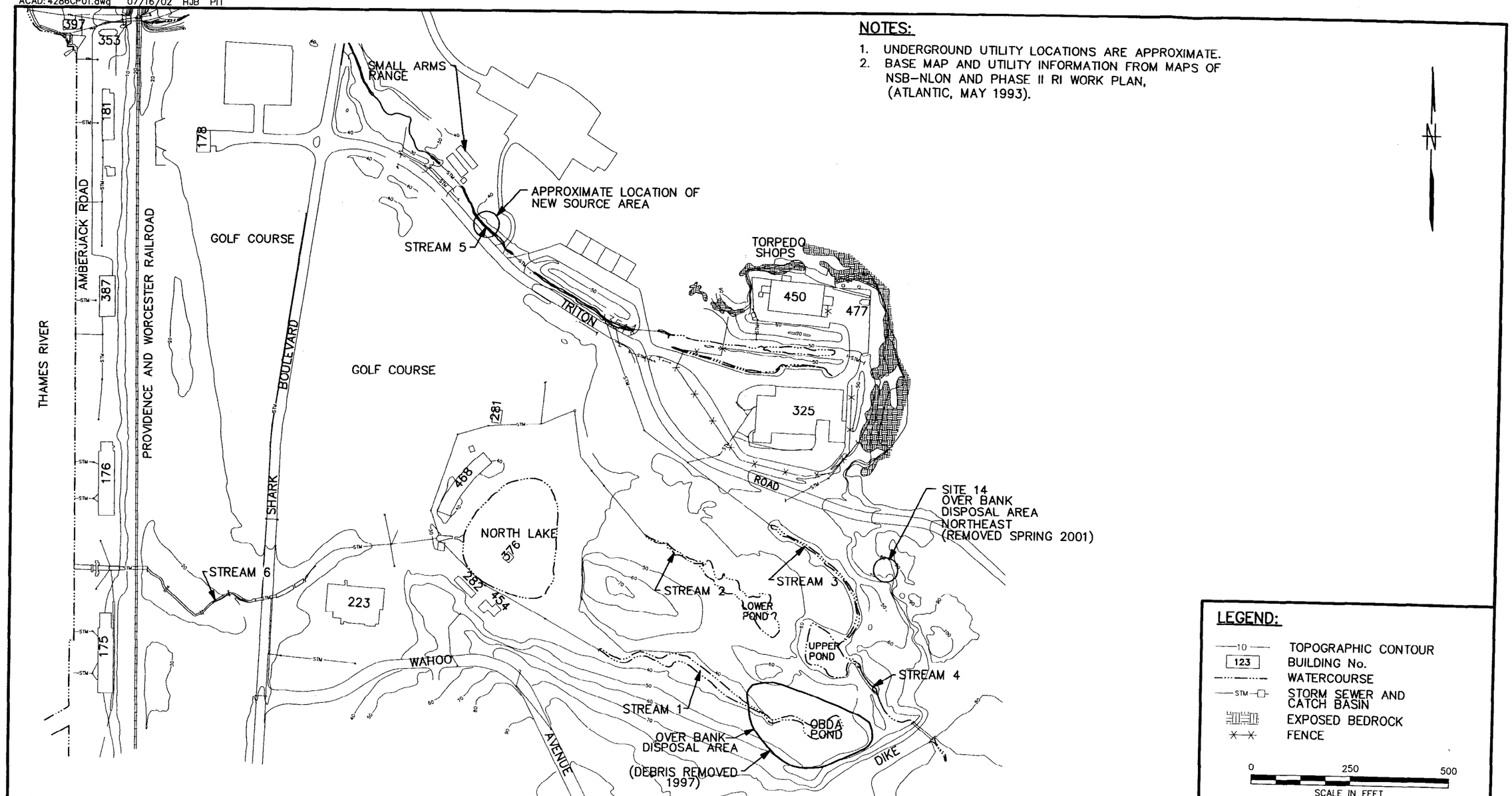


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

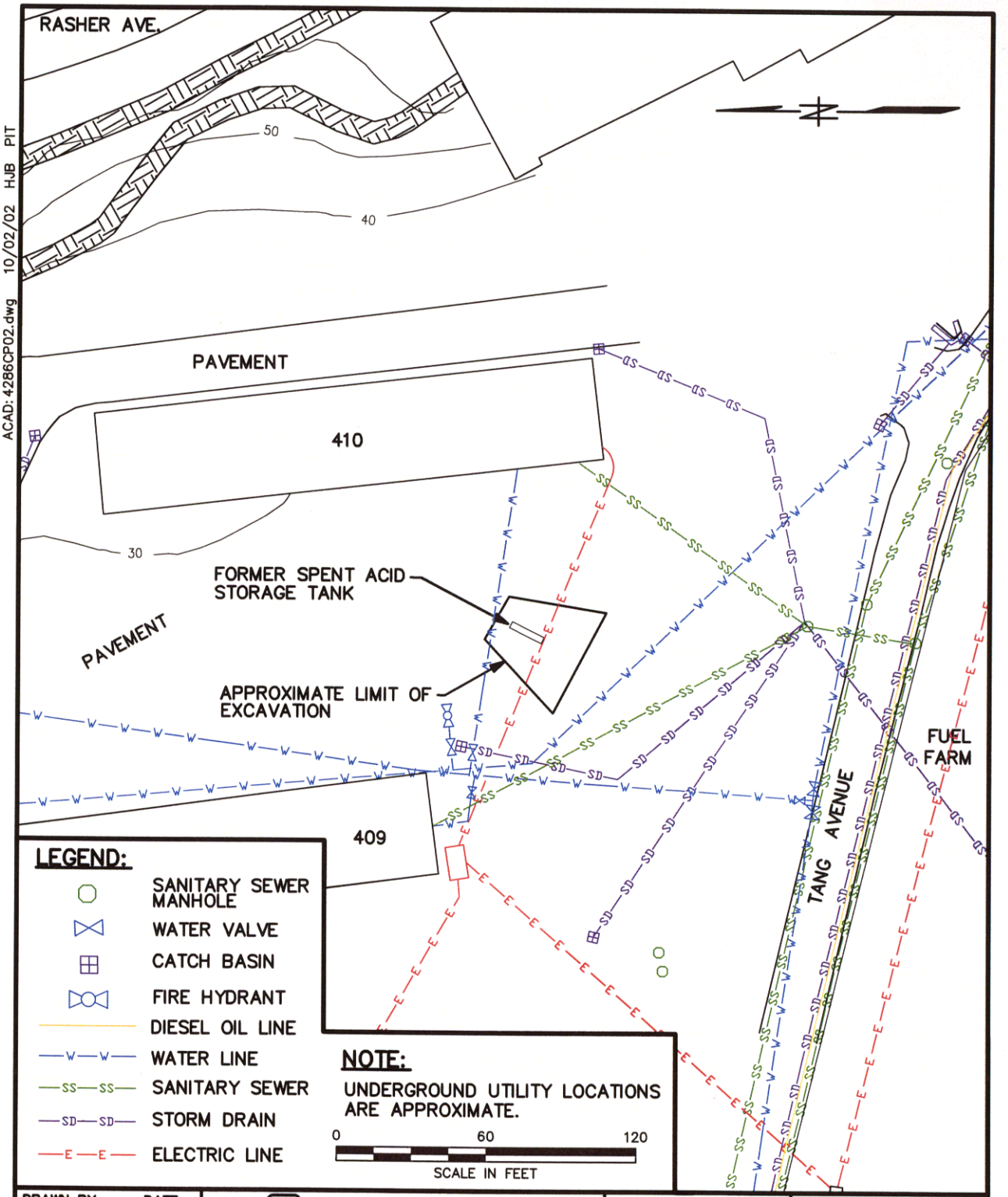
DRAWN BY HJB DATE 7/2/02
CHECKED BY DATE 7/19/02
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

SITE MAP
SITE 3-AREA A DOWNSTREAM WATERCOURSES/OBDA
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 7/19/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-2
REV. 0

FORM CADD NO. ttNUS_BH.DGN - REV 0 - 1/20/98



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DRAWN BY HJB DATE 10/2/02	Tetra Tech NUS, Inc.	CONTRACT NO. 2863	OWNER NO. 0841
CHECKED BY DATE	SITE MAP SITE 15–SPENT ACID STORAGE AND DISPOSAL AREA NSB–NLON GROTON, CONNECTICUT	APPROVED BY CAR	DATE 10/8/02
COST/SCHED–AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1–3	REV. 0

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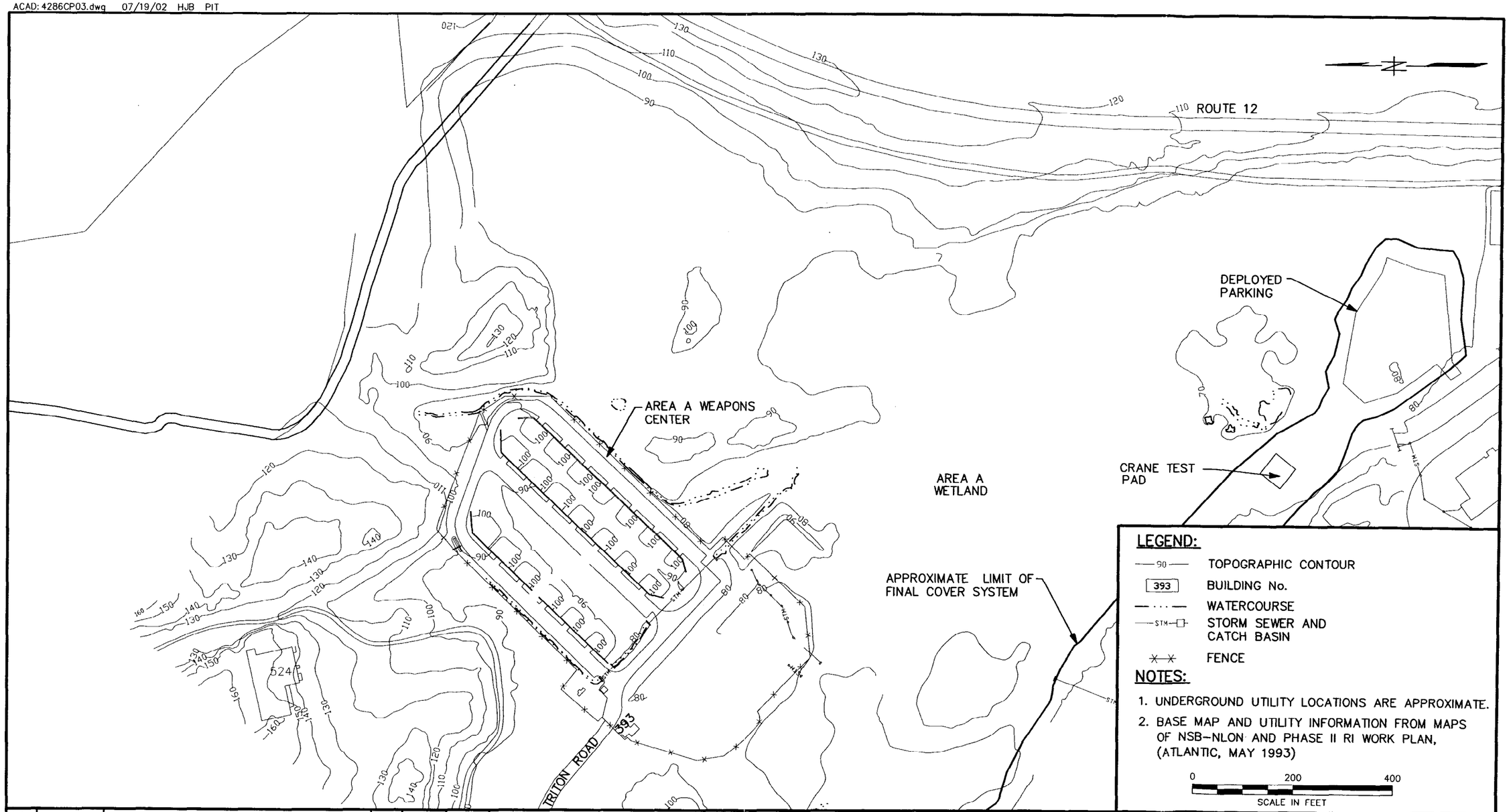


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

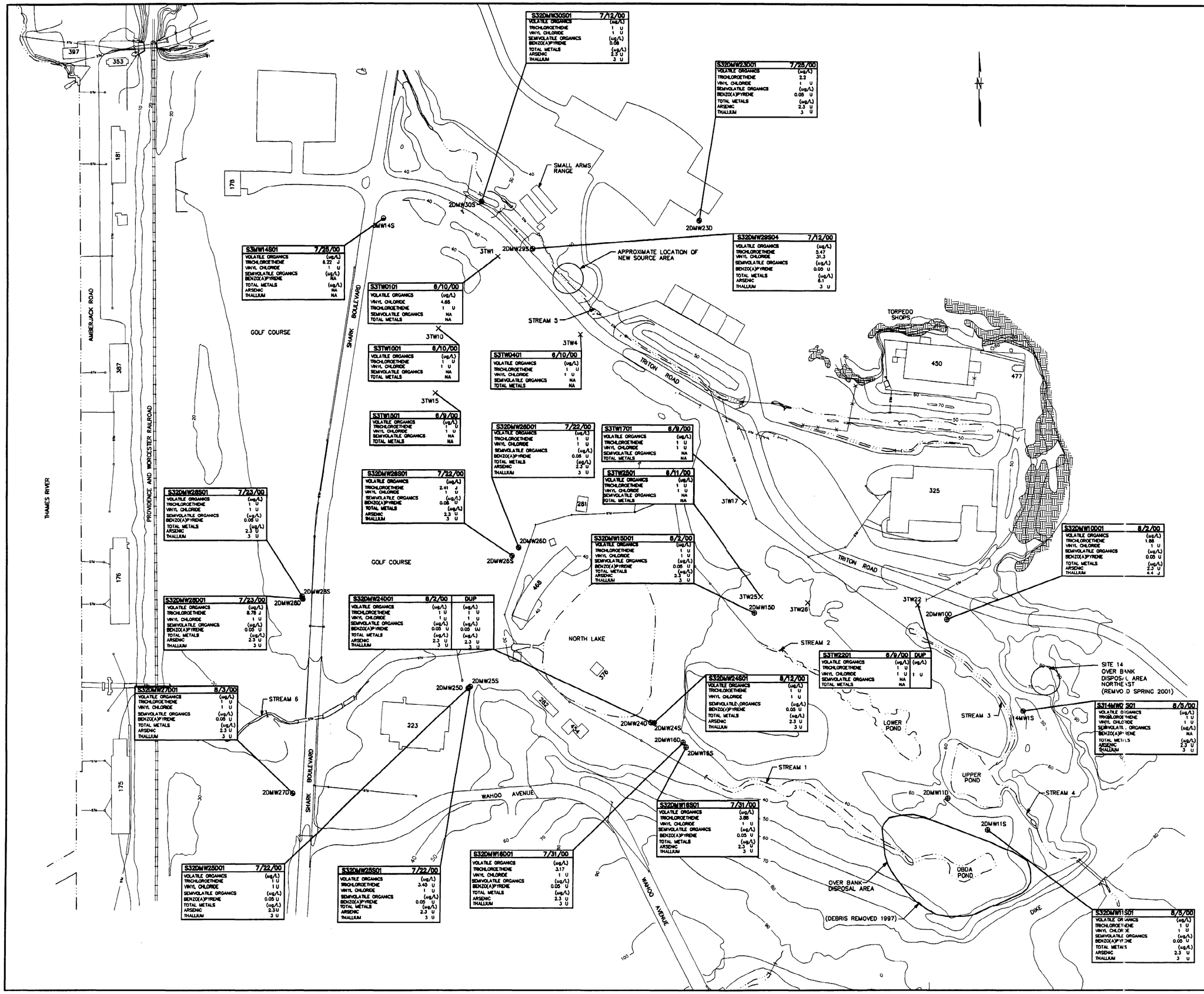
DRAWN BY HJP DATE 12/19/00
CHECKED BY DATE 7/19/02
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

SITE MAP
SITE 20-AREA A WEAPONS CENTER
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 7/19/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-4
REV. 0

FORM CADD NO. TtNUS_BH.DGN - REV 0 - 1/20/98



LEGEND:

× 3TW1	TEMPORARY WELL
⊕ 2DMW25D	PHASE I MONITORING WELL
⊕ 2DMW26D	PHASE II MONITORING WELL
⊕ 3MW14S	BGOURI MONITORING WELL
—10—	TOPOGRAPHIC CONTOUR
123	BUILDING No.
—·—·—	WATERCOURSE
—STM—□—	STORM SEWER AND CATCH BASIN
	EXPOSED BEDROCK
—×—×—	FENCE
U	UNDETECTED
J	ESTIMATED
NA	NOT ANALYZED
ug/L	MICROGRAMS PER LITER

NOTES:

1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN, (ATLANTIC, MAY 1993).

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Tetra Tech NUS, Inc. PITTSBURGH, PA. 15205
DSGN: SUPV: DR: HJP CH. ENG: CHK:
SUBMITTED BY: (FIRM NEWMEER) (TITLE) (DATE)
NORTHDIV HQ: Dist: HQ: PRC: DR:
OFFICER IN CHARGE APPROVED DATE

REV. DESCRIPTION PREP BY DATE APPRVD

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NORTHERN DIVISION LESTER, PA.
NAVAL BASE GROTON, CONNECTICUT
NAVAL SUBMARINE BASE, NEW LONDON
SEAL AREA
COCs IN GROUNDWATER
SITE 3 – AREA DOWNSTREAM WATERCOURSES/OBDA
NSB-NLON, GROTON, CONNECTICUT
APPROVED NORTHDIV FOR COMMANDER, NAVFAC DATE

SAT TO	DATE
CODE I.D. NO.	80091
SCALE :	
SPEC. NO. 04 -	
CONSTRN. CONTR. NO.	N62472- -C-
NAVFAC DRAWING NO.	
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1015 D04X

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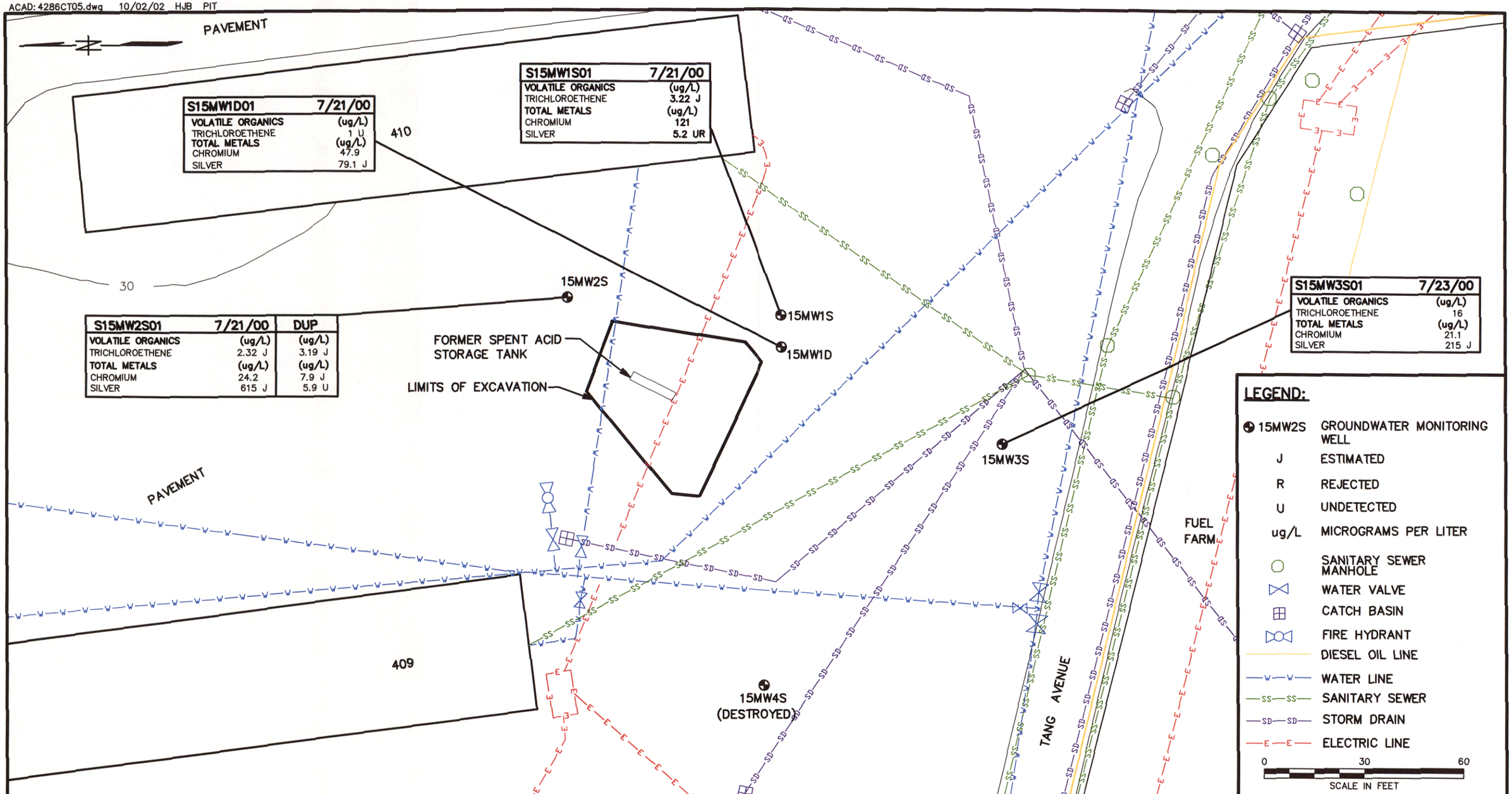

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 7/9/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

COCs IN GROUNDWATER
SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 10/8/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-6
REV. 0

FORM CADD NO. TtNUS_BH.DGN – REV 0 – 1/20/98

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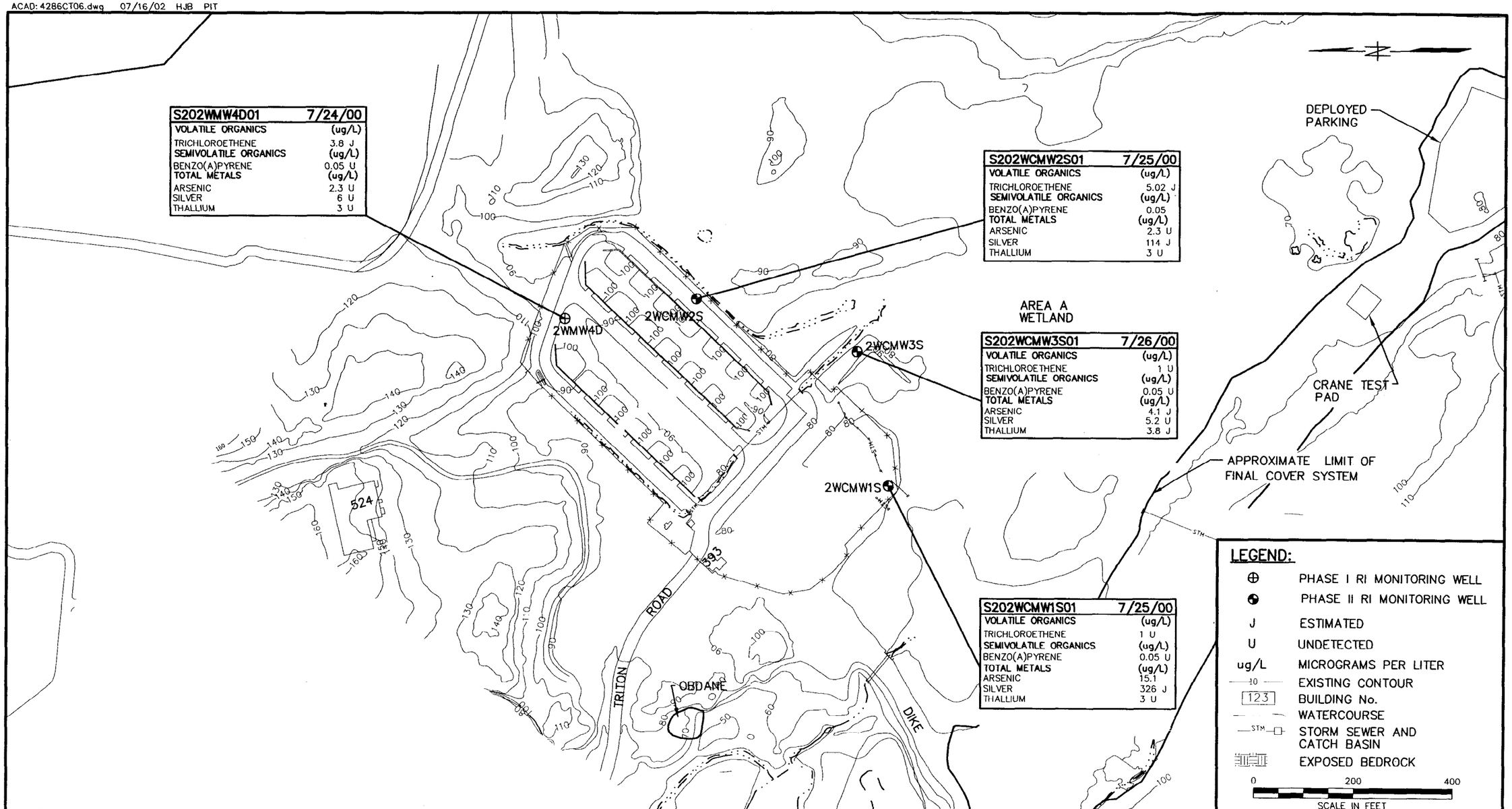


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 7/9/02
CHECKED BY DATE 7/19/02
COST/SCHED-AREA
SCALE AS NOTED

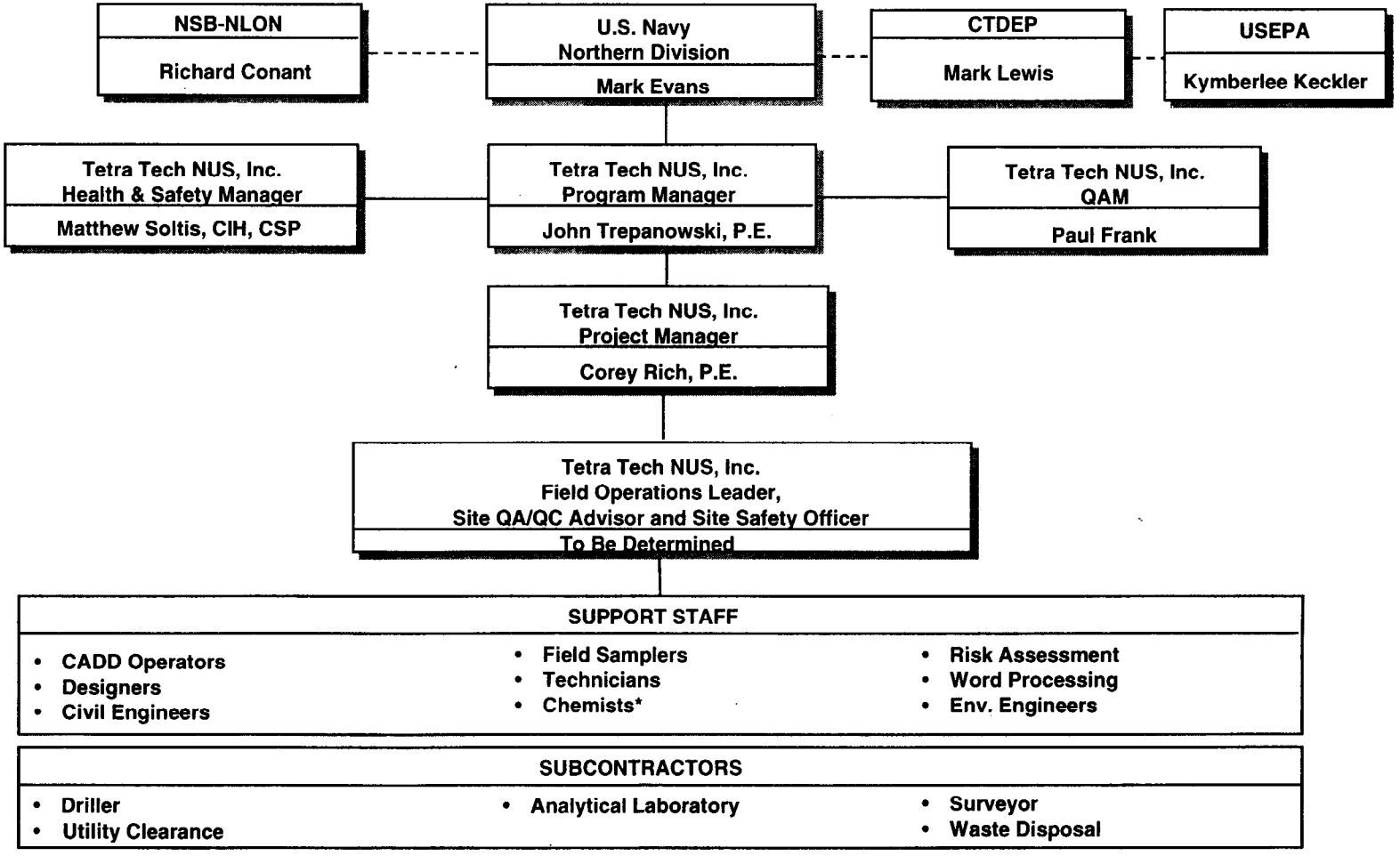
Tetra Tech NUS, Inc.

COCs IN GROUNDWATER
SITE 20-AREA A WEAPONS CENTER
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 7856
OWNER NO. 0312
APPROVED BY CAR
DATE 7/19/02
APPROVED BY
DATE
DRAWING NO. FIGURE 1-7
REV. 0

FORM CADD NO. T:NUS_BI.DGN - REV 0 - 1/20/98

FIGURE 1-8
ORGANIZATIONAL CHART
NSB-NLON, GROTON, CONNECTICUT



*Joe Samchuck (TtNUS) will be responsible for data validation.

2.0 SCOPE OF WORK

The field activities required to address the data gaps identified in Section 1.3 for Sites 3, 15, and 20 within NSB-NLON are provided in this section. Due to their locations, the results of historical investigations, and the previous remedial actions performed at these sites, the objectives of the proposed investigations at each site are different. The following subsections describe the objectives of the field investigation at each site along with the proposed investigative activities and rationale for those activities.

2.1 SITE 3 (AREA A DOWNSTREAM WATERCOURSE/OVER BANK DISPOSAL AREA)

2.1.1 Field Investigation Objectives

The objectives of the field investigation proposed for Site 3 include further definition of contamination degradation trends in groundwater and investigating the new source area located east of the Small Arms Range. The source area was identified during the 1999/2000 remedial action.

2.1.2 Field Activities

2.1.2.1 Further Define Contaminant Nature and Extent in Groundwater

The Human Health Risk Assessment completed for Site 3 groundwater analytical data, determined that TCE, vinyl chloride, benzo(a)pyrene, arsenic, and thallium are the COCs contributing to the unacceptable risks related to Site 3 groundwater. The locations where the COCs were detected are illustrated in Figure 1-5. The BGOURI also indicates the groundwater contamination nature and extent of the COCs and degradation product information at Site 3 has not yet been fully defined.

The hydrogeologic and groundwater analytical data from the BGOURI suggest that there are multiple minor sources of petroleum and chlorinated hydrocarbons impacting the Site 3 groundwater (TtNUS 2001). These potential source areas, as reported in the BGOURI, include the new disposal area discovered during the remediation of Stream 5, an unknown source located upgradient of monitoring well cluster 2DMW16S and 2DMW16D, a historic source located upgradient of 2DMW26S (most likely the leach fields located within the Torpedo Shops site), and separate minor sources in the vicinity or up-gradient of monitoring wells 2DMW10D, 2DMW28D, and 2DMW23D.

The identification of small source areas upgradient of monitoring wells 2DMW26S, 2DMW16S, 2DMW16D, and 2DMW10D is based on TCE detections in groundwater collected from monitoring wells 2DMW26S, 2DMW16S and 2DMW16D and a detection of thallium in monitoring well 2DMW10D. However, based on further evaluation of this groundwater analytical data, these minor source areas do

not warrant additional investigation. The TCE concentrations in wells 2DMW26S, 2DMW16S and 2DMW16D are all below the Federal MCL for TCE, and the thallium in well 2DMW10D is an isolated detection and there is no historic indication that thallium should be a concern for the groundwater in this portion of NSB-NLON. Therefore, the additional sample locations identified in this WP will be selected to provide further information on the potential small source areas in the vicinity of monitoring wells 2DMW28D, 2DMW23D, and the new source area discovered along Stream 5.

The existing groundwater wells selected for sampling during this data gap investigation include 2DMW23D, 2DMW28D, 2DMW29S, 2DMW30S, and 3MW14S. Monitoring well 2DMW23D will be sampled because it is the location of the only COC detection of benzo(a)pyrene, and it is the only existing well located upgradient of the new source area along Stream 5. Monitoring wells 2DMW29S, 2DMW30S, and 3MW14S will be sampled because of their proximity to the new source area along Stream 5 and because of the elevated detections of COCs during the BGOURI. Lastly, monitoring well 2DMW28D will be sampled because TCE was detected in this well above the Federal MCL.

The WP also proposes the installation of a bedrock well to replace monitoring well 3MW12D which was damaged during the 1999/2000 remedial action. This well is part of the groundwater monitoring well network for the Area A Landfill groundwater monitoring program. This well will be installed but sampled under the Area A Landfill monitoring program.

Because the data presented in the BGOURI represents groundwater conditions as of July 2000, the proposed additional samples will determine if the COC concentrations are increasing or decreasing in these wells. Likewise, the collection of groundwater elevation data will help to further determine the directions of groundwater flow and contaminant migration.

Therefore, to further evaluate the nature and extent of groundwater contamination and to evaluate degradation products at Site 3, this WP proposes;

- Collecting five groundwater samples from monitoring wells 2DMW28D, 3MW14S, 2DMW30S, 2DMW29S and 2DMW23D.

- Collecting groundwater level measurements from 20 groundwater monitoring wells identified on Figure 2-1.

The groundwater samples will be analyzed for TCL VOCs, TCL PAHs, and select metals (total and dissolved arsenic). The groundwater level measurements will include depth to groundwater, total well depth, and free-product thickness (if any). The location of the monitoring wells from which samples will

be collected and measurements made, are identified on Figure 2-1. Table 2-1 summarizes the parameters for which the Site 3 groundwater samples will be analyzed.

In addition to these items, while drillers and field crew are mobilized to Site 3, one bedrock monitoring well will be installed (replacement for 3MW12D destroyed during the 1999/2000 remedial action). The well will be drilled and installed using appropriate techniques (e.g., air rotary) and will be developed. However, the replacement well will not be sampled as part of this investigation. The location of the proposed monitoring well is identified on Figure 2-1.

2.1.2.2 Investigate New Source Area

Additional information is required to determine the source of the petroleum and chlorinated compounds detected in the groundwater wells located along Shark Boulevard and Triton Road at the northwestern end of Site 3. To determine the source of this contamination an evaluation of potential upgradient sources must be considered. Facilities located upgradient of these wells include the Small Arms Range, Torpedo Shops (Site 7), Area A Weapons Center (Site 20), and an unknown burial site discovered during the remediation of Site 3. During the remediation of Site 3 in 1999/2000, while excavating contaminated soils and sediments from Stream 5, the RAC discovered a disposal area to the east of the Small Arms Range and north of Stream 5. It was reported that petroleum product was seeping into the remediation excavation. The disposal area was not removed due to budgetary constraints during backfilling and restoration of Stream 5. Due to the types of compounds detected in the downgradient wells, the discovered disposal area will be the focus for determining the source of the groundwater contamination along the northwestern side of Site 3.

To evaluate the disposal area this WP proposes;

- Advancing four temporary monitoring wells using direct push technology (DPT) methods,
- Advance three soil borings using hand augers,
- Collecting groundwater samples from the four temporary wells,
- Collecting six surface soil samples from the locations of three of the four proposed temporary wells and the three soil borings,
- Collecting six subsurface soil samples, one from three of the four temporary monitoring wells and three from the soil borings [depths of subsurface soil samples will be determined by high

photoionization detector (PID)/flame ionization detector (FID) instrument readings (readings above background levels) as the borings are advanced].

- Collecting groundwater level measurements from the four temporary monitoring wells concurrent with the 20 monitoring wells shown on Figure 2-1.

The groundwater samples will be analyzed for target compound list (TCL) VOCs, TCL SVOCs, TCL pesticides/polychlorinated biphenyls (PCBs) and target analyte list (TAL) metals (total and filtered). Surface and subsurface soil samples will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and TAL metals. The groundwater level measurements will include depth to groundwater, total well depth, and free product thickness (if any). The proposed drilling and sampling locations are identified on Figure 2-2 and a summary of samples and analyses is provided in Table 2-1.

2.2 SITE 15 (SPENT ACID STORAGE AND DISPOSAL AREA)

2.2.1 Field Investigation Objectives

The objectives of the field investigation proposed for Site 15 include determining the extent of contaminants in groundwater and determining the extent, if any, of residual source material remaining following the 1995 time-critical removal action.

2.2.2 Field Activities

2.2.2.1 Determining Extent of Contamination in Groundwater

The groundwater analytical data from the BGOURI indicated that organic and inorganic contaminants were detected infrequently and at low concentrations in the groundwater at Site 15 and field measurements taken while sampling the Site 15 groundwater indicate low pH. From these infrequent detections, TCE, cadmium, chromium, lead, nickel, silver, and zinc were identified as COPCs. As a result of the Human Health Risk Assessment completed for Site 15 groundwater analytical data, it was determined that TCE, chromium, and silver contributed to the unacceptable risk related to the Site 15 groundwater. Comparing the analytical results for TCE, chromium, and silver, these COCs exceed their most strict screening criteria in monitoring wells 15MW1S (chromium only), 15MW1D (silver only), and 15MW3S (TCE and silver) (see Figure 1-6).

To further evaluate the TCE plume upgradient of Site 15 and the metals concentrations and low pH, this WP proposes;

- Advancing 3 temporary monitoring wells using DPT,
- Collecting groundwater samples from each of the three temporary well locations and from three existing groundwater monitoring well locations (15MW1S, 15MW2S, and 15MW3S),
- Collecting surface and subsurface soil samples from the three temporary well locations, and
- Collecting groundwater level measurements from 4 groundwater monitoring wells and 3 temporary monitoring wells.

The groundwater samples collected from the temporary wells will be analyzed for TCL VOCs and TAL metals (total and filtered). The groundwater samples collected from the existing monitoring wells will also be analyzed for the same parameters. Due to the low pH field measurements, the groundwater samples collected from the existing and temporary monitoring wells will be analyzed for acidity to determine the amount of neutralizing agent (such as caustic or lime) required when evaluating potential remedial technologies in the FS. The three surface soil samples and three subsurface soil samples collected from the temporary monitoring well locations will be analyzed for TCL VOCs and TAL metals. The locations of the subsurface soil samples will be determined by screening the soil removed from the boring with a PID or FID. The samples will be collected where PID or FID readings are highest. Lastly, the groundwater level measurements taken from each well will include depth to groundwater, total well depth, and free-product thickness (if any). Table 2-1 summarizes parameters for which the Site 15 samples will be analyzed. Figure 2-3 illustrates the locations of the proposed temporary monitoring wells, the locations of the existing wells to be included in the groundwater investigation, and the monitoring wells from which groundwater level measurements will be taken.

2.2.2.2 Evaluation of Soils Outside of Excavation Area

To evaluate soils beyond the extent of excavation during the 1995 time-critical removal action at Site 15 this work plan proposes advancing three soil borings and collecting six subsurface soil samples (i.e. two from each boring location). Since the site is paved, no surface soil samples can be collected at the site. The samples will be collected from unique intervals above the water table to provide an indication of the vertical distribution of contamination. The soil samples will be analyzed for TCL VOCs and TAL metals. Table 2-1 summarizes parameters for which the Site 15 soil samples will be analyzed. Figure 2-3 illustrates the locations of the proposed soil borings.

2.3 SITE 20 (AREA A WEAPONS CENTER)

2.3.1 Field Investigation Objectives

The objective of the field investigation proposed for Site 20 is to further define the nature and extent of groundwater contamination.

2.3.2 Field Activities

2.3.2.1 Further Define Contaminant Degradation Trends in Groundwater

The groundwater analytical data from the BGOURI indicate that organic and inorganic contaminants were detected infrequently and at low concentrations in the groundwater at Site 20. From these infrequent detections TCE, benzo(a)pyrene, antimony, arsenic, nickel, silver, thallium, and zinc were identified as COPCs. As a result of the Human Health Risk Assessment completed for Site 20 groundwater analytical data, it was determined that TCE, benzo(a)pyrene, arsenic, silver, and thallium contributed to the unacceptable risk related to the Site 20 groundwater. These COCs exceed their most strict screening criteria in monitoring wells 2WCMW1S (arsenic and silver), 2WCMW2S (TCE, benzo(a)pyrene, and silver), and 2WCMW3S (thallium only) (see Figure 1-7).

Further review of the analytical results from the BGOURI for Site 20 indicates the following:

- The maximum TCE detection at Site 20 equals 5.02 µg/L. This detection is considered a detection at the MCL (5 µg/L) and not a detection that exceeds the MCL. Therefore, TCE will not be further investigated as part of the data gap investigation.

- Arsenic exceeds its criteria in well 2WCMW1S. This well is located adjacent to the Area A Wetland where dredge spoils from the Thames River was placed. A review of the boring log for this well shows the presence of dredge spoils at the bottom of the boring. Data collected from wells completed in the dredge spoils (e.g., Area A groundwater monitoring well network) indicate the presence of arsenic in the groundwater samples is related to the dredge spoils and not site-specific contaminants. The other monitoring well that had an arsenic detection is 2WCMW3S. This well is also adjacent to Area A Wetland and was completed in dredge spoil, and therefore is also expected to be influenced by the dredge spoils. Therefore, arsenic is not believed to be site related and will not be further investigated as part of the data gap investigation.

- The thallium and benzo(a)pyrene detections are isolated detections and do not warrant further investigation.

Therefore, to further evaluate the groundwater conditions of Site 20, this WP proposes collecting a groundwater sample from monitoring wells 2WCMW1S and 2WCMW2S, and measuring groundwater levels in four groundwater monitoring wells. The groundwater sample collected from monitoring wells 2WCMW1S and 2WCMW2S will be analyzed for total and dissolved TAL metals. Table 2-1 summarizes parameters for which the Site 20 samples will be analyzed. Figure 2-4 illustrates the locations of monitoring wells 2WCMW1S and 2WCMW2S and the monitoring wells from which groundwater level measurements will be taken.

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TABLE 2-1

SUMMARY OF SAMPLES AND ANALYSES
SITES 3, 15, AND 20
BASEWIDE GROUNDWATER OPERABLE UNIT DATA GAP INVESTIGATION
NSB-NLON GROTON, CONNECTICUT
PAGE 1 OF 2

Sample Identification	Sample Location	Sample Type	Analysis					
			TCL VOCs	TCL SVOCs	TCL pesticides	TCL PCBs	Acidity	TAL metals [1]
SITE 3 (Further Define Contaminant Degradation Trends in Groundwater)								
S3GW2DMW28D02	2DMW28D	Groundwater	X	X[2]				X[3]
S3GW2DMW29S04	2DMW29S	Groundwater	X	X[2]				X[3]
S3GW2DMW30S02	2DMW30S	Groundwater	X	X[2]				X[3]
S3GW3MW14S02	3MW14S	Groundwater	X	X[2]				X[3]
S3GW2DMW23D02	2DMW23D	Groundwater	X	X[2]				X[3]
SITE 3 (Define the Origin of Contaminants in Downgradient Wells)								
S3GW3TW2701	3TW27	Groundwater	X	X	X	X		X
S3GW3TW2801	3TW28	Groundwater	X	X	X	X		X
S3GW3TW2901	3TW29	Groundwater	X	X	X	X		X
S3GW3TW3001	3TW30	Groundwater	X	X	X	X		X
S3SS3TW2701	3TW27	Surface Soil	X	X	X	X		X[4]
S3SS3TW2801	3TW28	Surface Soil	X	X	X	X		X[4]
S3SS3TW2901	3TW29	Surface Soil	X	X	X	X		X[4]
S3SB3TW2701	3TW27	Subsurface Soil	X	X	X	X		X[4]
S3SB3TW2801	3TW28	Subsurface Soil	X	X	X	X		X[4]
S3SB3TW2901	3TW29	Subsurface Soil	X	X	X	X		X[4]
S3SS3SB0101	3SB01	Surface Soil	X	X	X	X		X[4]
S3SS3SB0201	3SB02	Surface Soil	X	X	X	X		X[4]
S3SS3SB0301	3SB03	Surface Soil	X	X	X	X		X[4]
S3SB3SB0101	3SB01	Subsurface Soil	X	X	X	X		X[4]
S3SB3SB0201	3SB02	Subsurface Soil	X	X	X	X		X[4]
S3SB3SB0301	3SB03	Subsurface Soil	X	X	X	X		X[4]
SITE 15 (Evaluate Upgradient TCE Plume)								
S15GW15TW101	15TW1	Groundwater	X				X	X
S15GW15TW201	15TW2	Groundwater	X				X	X
S15GW15TW301	15TW3	Groundwater	X				X	X
S15GW15MW1S02	15MW1S	Groundwater	X				X	X
S15GW15MW2S02	15MW2S	Groundwater	X				X	X
S15GW15MW3S02	15MW3S	Groundwater	X				X	X
S15SS15TW101	15TW1	Surface Soil	X					X[4]
S15SS15TW201	15TW2	Surface Soil	X					X[4]
S15SS15TW301	15TW3	Surface Soil	X					X[4]

TABLE 2-1

SUMMARY OF SAMPLES AND ANALYSES
SITES 3, 15, AND 20
BASEWIDE GROUNDWATER OPERABLE UNIT DATA GAP INVESTIGATION
NSB-NLON GROTON, CONNECTICUT
PAGE 2 OF 2

Sample Identification	Sample Location	Sample Type	Analysis					
			TCL VOCs	TCL SVOCs	TCL pesticides	TCL PCBs	Acidity	TAL metals [1]
S15SB15TW101	15TW1	Subsurface Soil	X					X[4]
S15SB15TW201	15TW2	Subsurface Soil	X					X[4]
S15SB15TW301	15TW3	Subsurface Soil	X					X[4]
SITE 15 (Evaluate Soils Outside of Excavation Area)								
S15SB15SB101	15SB1	Subsurface Soil	X					X[4]
S15SB15SB102	15SB1	Subsurface Soil	X					X[4]
S15SB15SB201	15SB2	Subsurface Soil	X					X[4]
S15SB15SB202	15SB2	Subsurface Soil	X					X[4]
S15SB15SB301	15SB3	Subsurface Soil	X					X[4]
S15SB15SB302	15SB3	Subsurface Soil	X					X[4]
SITE 20 (Further Define Contaminant Degradation Trends in Groundwater)								
S20GW2WCMW1S02	2WCMW1S	Groundwater						X
S20GW2WCMW2S02	2WCMW2S	Groundwater						X
Quality Control Samples								
RB080802 [5]	NA	Aqueous	TBD	TBD	TBD	TBD	TBD	TBD
(Sample Number)-MS [6]	TBD	Aqueous or Solid	TBD	TBD	TBD	TBD	TBD	TBD
(Sample Number)-MSD [7]	TBD	Aqueous or Solid	TBD	TBD	TBD	TBD	TBD	TBD
FD080802-01 [8]	TBD	Aqueous or Solid	TBD	TBD	TBD	TBD	TBD	TBD

1 Two samples to be provided unless otherwise noted, one sample to be analyzed for total TAL metals and the other to be analyzed for filtered TAL metals.

2 Samples analyzed for PAH compounds only.

3 Samples analyzed for arsenic (total and dissolved) only.

4 Total TAL metals only.

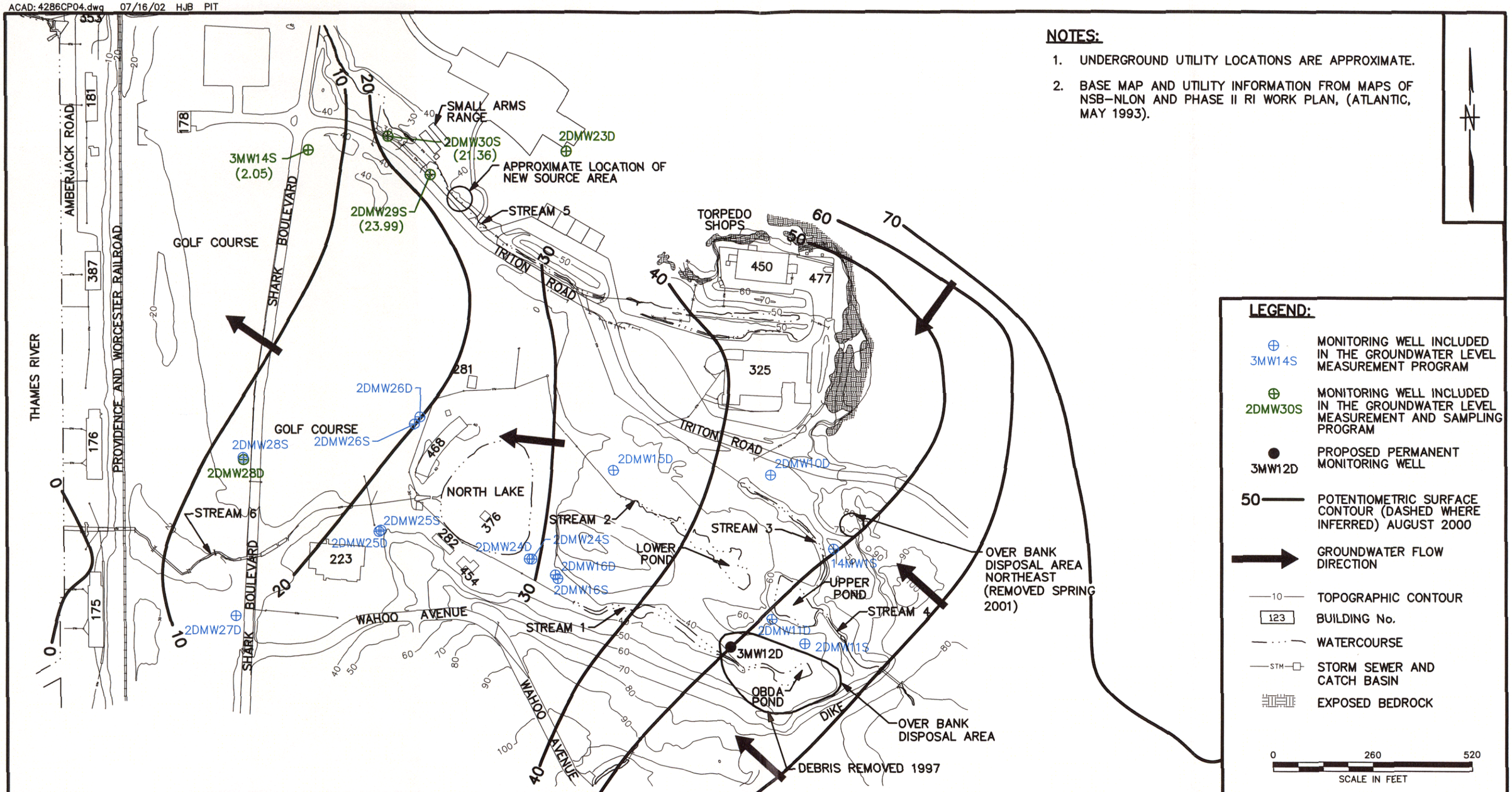
5 The 6-digit number represents the date on which the sample was collected (i.e. "080802" refers to August 8, 2002). In the event that disposable sampling equipment is used for the collection of environmental samples for the entire day, no rinse blank would be required for that day.

6 The "MS" indicates that sample contains extra volume of the indicated sample to run matrix spike analysis. MS samples are to be collected at a rate of 1 for every 20 environmental samples of the same matrix.

7 The "MSD" indicates that sample contains extra volume of the indicated sample to run matrix spike duplicate analysis. MSD samples are to be collected at the same rate as MS samples.

8 The "080802" indicates the date on which the duplicate sample was collected. The "01" provides the sequential number for days when multiple duplicates are collected. The sample for which the duplicate sample is a duplicate of, will be recorded in the field logbook and sample log sheet. Duplicate samples are to be collected at a rate of 1 for every 10 environmental samples of the same matrix.

ACAD: 4286CP04.dwg 07/16/02 HJB PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB	DATE 7/9/02	Tetra Tech NUS, Inc.	CONTRACT NO. 4286 / OWNER NO. 0841
CHECKED BY	DATE 7/19/02	SITE 3 PROPOSED GROUNDWATER LEVEL/ SAMPLING LOCATIONS NSB-NLON GROTON, CONNECTICUT	APPROVED BY CAR / DATE 7/19/02
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2-1 / REV. 0

FORM CADD NO. T4NUS_BH.DGN - REV 0 - 1/20/98

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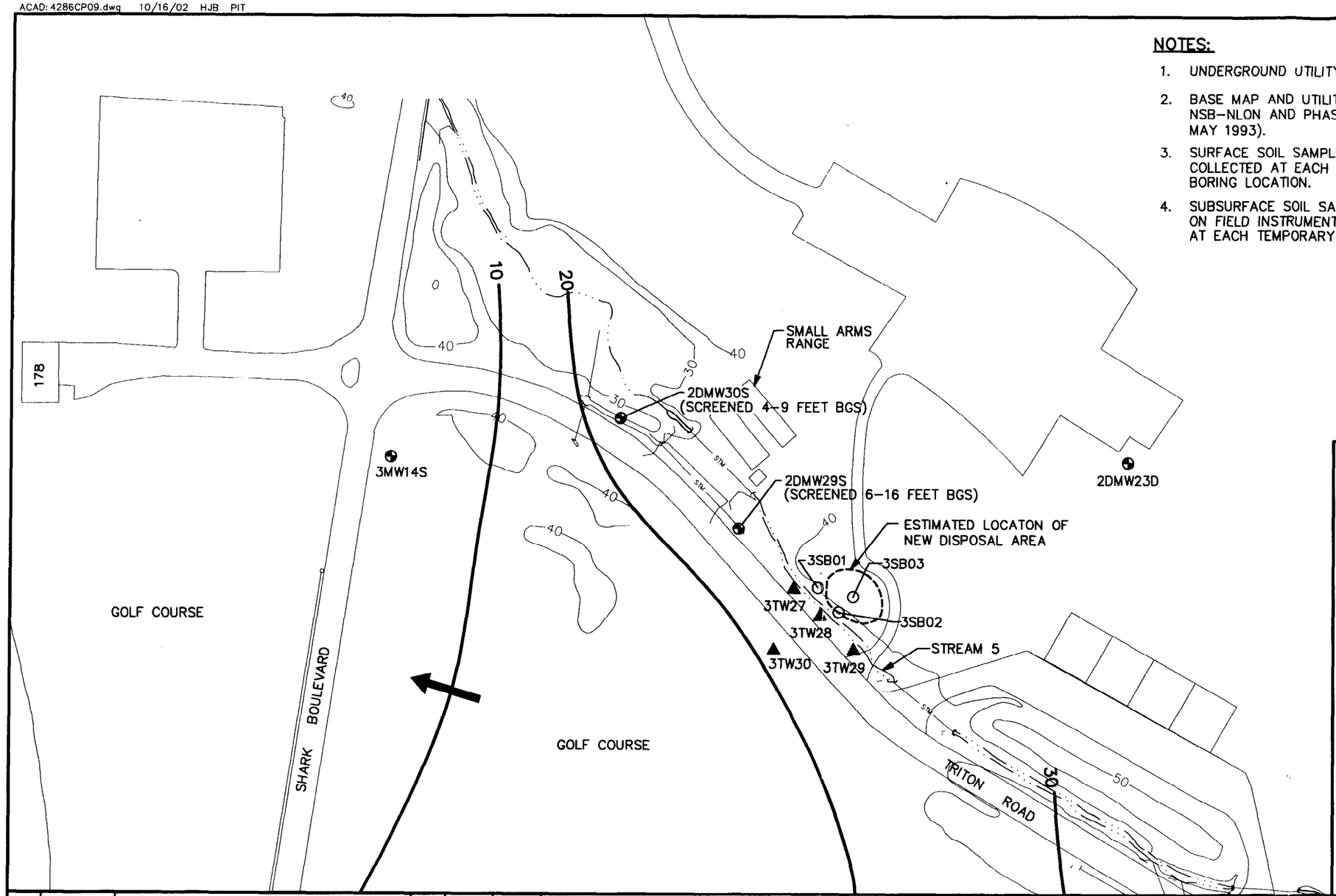


NOTES:

1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN, (ATLANTIC, MAY 1993).
3. SURFACE SOIL SAMPLES (0-1 FEET BGS) TO BE COLLECTED AT EACH TEMPORARY WELL AND SOIL BORING LOCATION.
4. SUBSURFACE SOIL SAMPLES (DEPTH DEPENDANT ON FIELD INSTRUMENT READINGS.) TO BE COLLECTED AT EACH TEMPORARY WELL AND SOIL BORING LOCATION.

LEGEND:

3MW14S	EXISTING MONITORING WELL LOCATION
3TW27	PROPOSED TEMPORARY WELL LOCATION
3SB01	PROPOSED SOIL BORING LOCATION
10	POTENTIOMETRIC SURFACE CONTOUR (DASHED WHERE INFERRED) AUGUST 2000
	GROUNDWATER FLOW DIRECTION
10	TOPOGRAPHIC CONTOUR
123	BUILDING NUMBER
	WATERCOURSE
STM	STORM SEWER AND CATCH BASIN

0 100 200
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 9/27/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

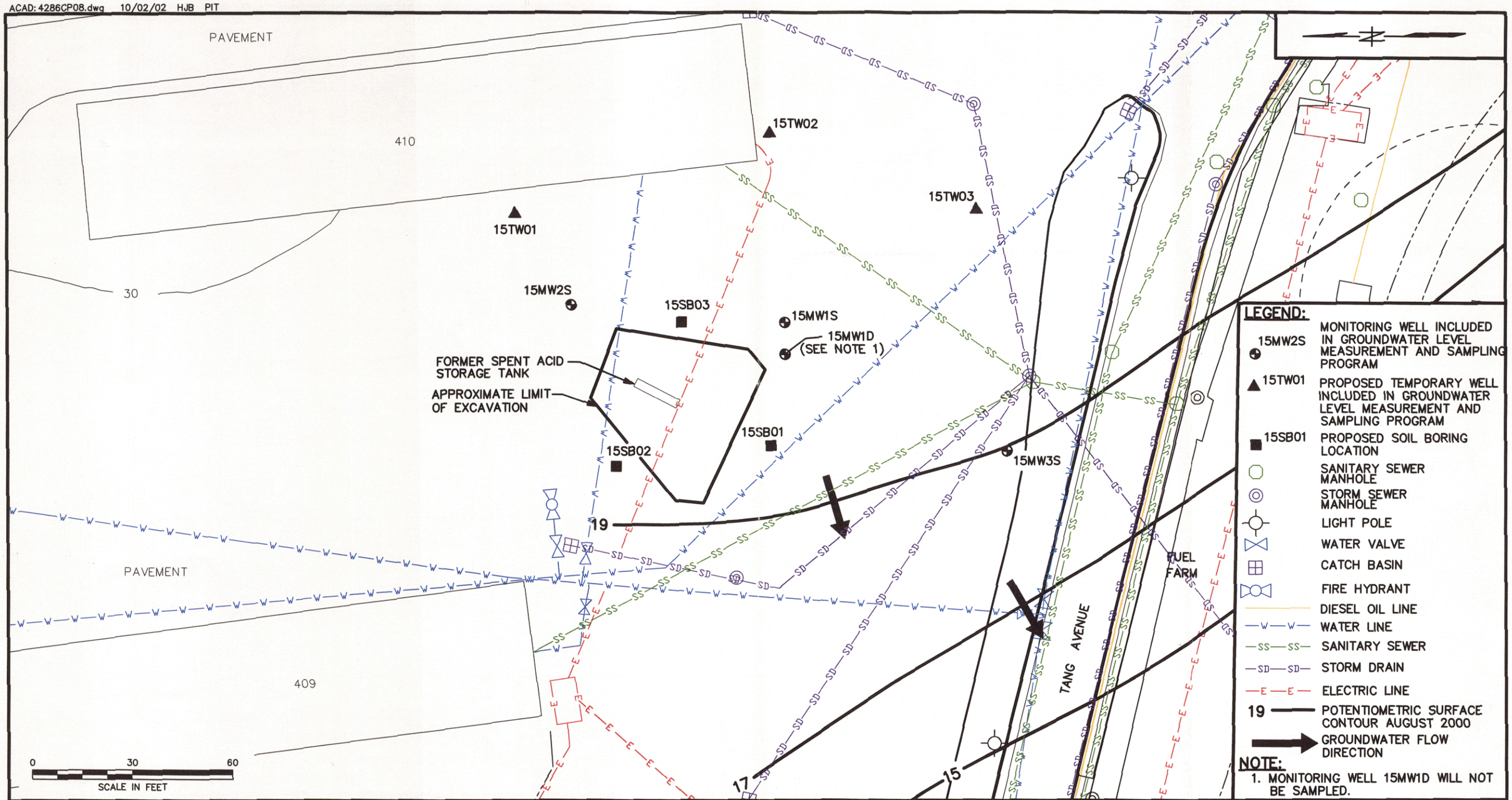
Tetra Tech NUS, Inc.

PROPOSED SAMPLING LOCATIONS
SITE 3 - NEW DISPOSAL AREA
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 10/16/02
APPROVED BY DATE
DRAWING NO. FIGURE 2-2
REV. 0

FORM CADD NO. TtNUS_BH.DGN - REV 0 - 1/20/98

ACAD: 4286CP08.dwg 10/02/02 HJB PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 9/26/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

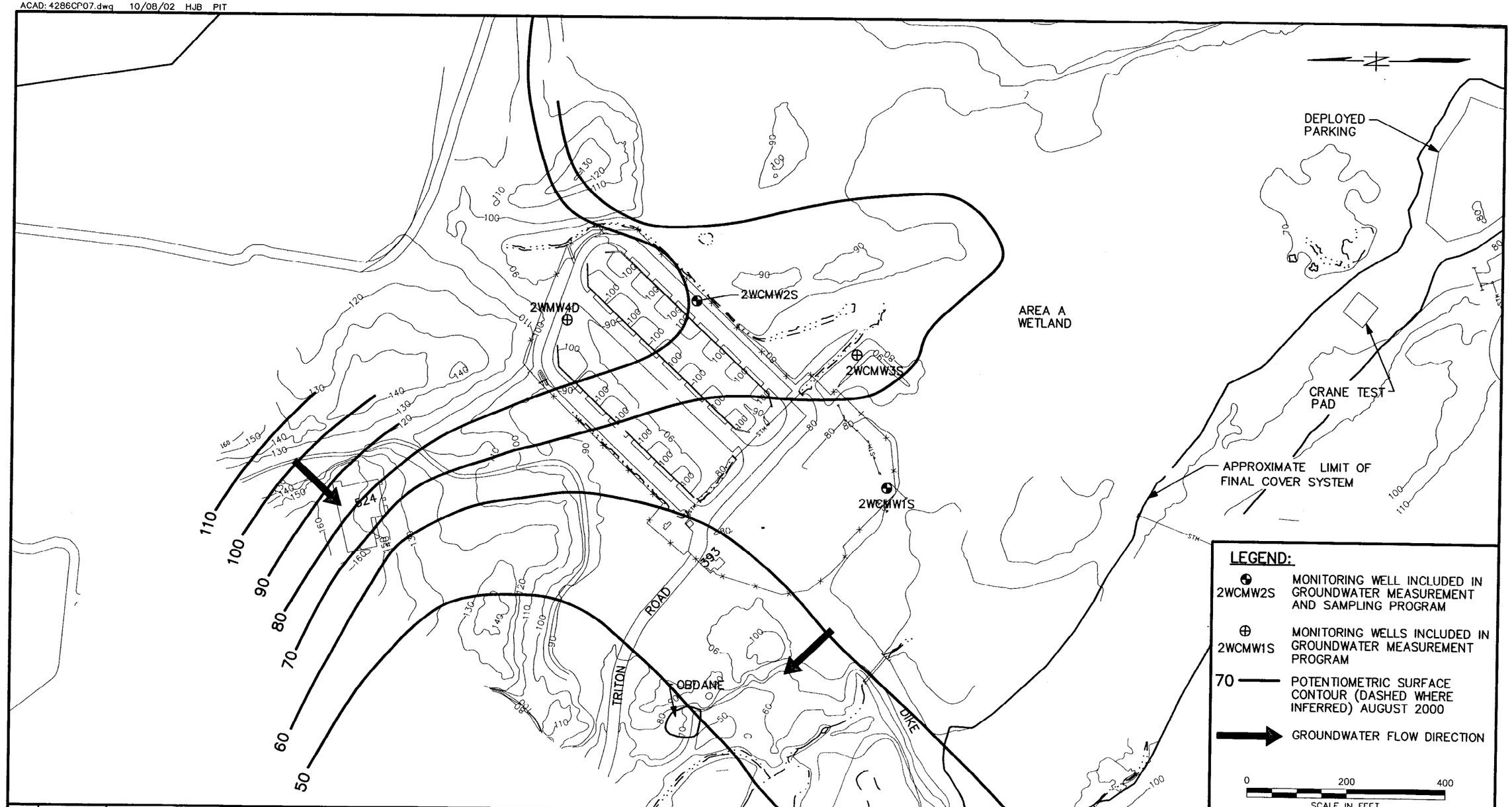
Tetra Tech NUS, Inc.

PROPOSED SAMPLE LOCATIONS
SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 10/7/02
APPROVED BY DATE
DRAWING NO. FIGURE 2-3
REV. 0

FORM CADD NO. T+NUS_BH.DGN - REV 0 - 1/20/98

ACAD: 4286CP07.dwg 10/08/02 HJB PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 7/10/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

PROPOSED SAMPLING LOCATIONS
SITE 20-AREA A WEAPONS CENTER
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO. 4286
OWNER NO. 0841
APPROVED BY CAR DATE 10/8/02
APPROVED BY DATE
DRAWING NO. FIGURE 2-4
REV. 0

FORM CADD NO. TtNUS_BH.DGN - REV 0 - 1/20/98

3.0 FIELD ACTIVITIES AND PROCEDURES

The Scope of Work for the field investigation includes the following tasks:

- Mobilization/Demobilization
- Temporary Groundwater Monitoring Well Installation
- Permanent Groundwater Monitoring Well Installation
- Monitoring Well Development
- Water Level Measurement Collection
- Groundwater Sampling and Analysis
- Soil Boring and Soil Sampling and Analysis
- Decontamination
- Investigation-Derived Waste Management
- Surveying
- Sample Handling
- Equipment Calibration and Maintenance
- Reporting and Documentation

The following paragraphs provide condensed scopes of work for the main tasks associated with this investigation. The subsections that follow describe the specific field methodologies that will be used to complete the individual tasks listed above.

3.1 MOBILIZATION/DEMOBILIZATION

Following approval of the WP, TtNUS will begin mobilization activities. These activities will include coordinating on-base utility clearances, subcontracted utility search services, mobilization of subcontractors, and mobilization of TtNUS staff and equipment. The field operations leader (FOL) will coordinate the mobilization activities for this project. The equipment required for field activities will be mobilized from the TtNUS Pittsburgh, Pennsylvania warehouse and other locations to the site by the FOL and the field crew. TtNUS personnel will submit proposed soil boring, temporary monitoring well and groundwater monitoring well location drawings to NSB-NLON Public Works for utility clearance purposes. These drawings will be submitted 2 weeks before staff and equipment are mobilized. The FOL will then mobilize to the site to mark the proposed boring locations with NSB-NLON personnel. The purpose of this mobilization will be to review each location for equipment access or logistic problems with on-going base activities. Subcontracted utility personnel will be mobilized to the site at this time to assist in clearing the boring locations. The FOL and NSB-NLON personnel will review and agree upon any locations that have to be moved due to access, utility, or logistic problems.

All field team members will review the WP, HASP (provided as Appendix A), and QAPP (provided as Appendix B) after utility clearance activities are completed. Prior to mobilization, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities. Site-specific health and safety training will be given to the field crew after they have mobilized to the site.

The FOL and crew will demobilize from the site after the field operations have been completed and transport all field equipment back to the appropriate locations.

3.2 TEMPORARY GROUNDWATER MONITORING WELL INSTALLATION

Temporary groundwater monitoring wells will be installed and sampled to determine the extent of contamination. Borings for installation of temporary monitoring wells will be advanced using DPT in accordance with TtNUS SOP SA-2.5 (Appendix D) and the following described methodology. A GeoProbe® or similar DPT will be used to advance 2-inch outside diameter Macro-Core® or similar sampler of 4-foot length to several feet below the local water table. For proper depth placement of the monitoring well screens, the depth to groundwater will be interpolated from water level measurements in existing permanent monitoring wells in the immediate vicinity and the depth to saturated soil from the Macro-Core® samples. If cobbles or thick gravel layers are encountered and prohibit advancement of the sampler using DPT or if open boreholes can not be maintained that allow installation of temporary monitoring wells, small diameter hollow-stem augers (2-3/4- to 3-1/4-inch inside diameter) or other appropriate drilling methods will be used to advance the boring to the required depth.

The Macro-Core® sampler will be removed from the borehole, and a temporary polyvinyl chloride (PVC) well will be installed. Prior to installing PVC screens and risers into the borehole, a wireline bailer will be used to remove suspended solids from the borehole. The PVC well screen (Schedule 40) used for the temporary well will have an outside diameter of 1-1/4 inches, and a slot size of either 0.006 inches or 0.01 inches depending on the particle size of the monitored interval, and a length of 10 feet. The well screen will be capped at the bottom. The screen will be installed across the water table (approximately 80 percent of the screen below the water table). PVC riser pipe (Schedule 40) will be attached to the screen to extend the well above grade. The screen and riser pipe will be flush jointed. A sand pack (No. 20 to No. 40 U.S. Standard sieve size or 00 Morie) will be installed in the annulus from 6-inches below the well screen, around the well screen, and up to 1 foot above the top of the screen, unless the formation collapses around the well screen. If a sand pack is installed, a bentonite seal (minimum 6-inch thickness) will be installed above the sand pack. Only 100 percent, certified pure, sodium bentonite will be used for well construction. The remaining annulus above the bentonite seal will remain open until the temporary well is removed and filled.

To abandon the temporary wells, the riser and screen will be withdrawn from the ground. If the borehole does not collapse after removal of the well, it will be grouted from the surface using a tremie pipe. The grout will be emplaced from the bottom of the hole to the surface and consist of a cement-bentonite slurry. If the borehole does partially collapse after removal of the well, the remaining portion of it will be backfilled with granular bentonite from the surface. The surface at each temporary well location will be restored to its original condition (vegetated, asphalt or concrete).

Boring logs will be maintained for each temporary well. The boring logs will record installation methods, depths of installation, abandonment details, and other pertinent information. A map of the monitoring well locations and appropriate data from the boring logs will also be recorded into the field logbook notes.

3.3 PERMANENT GROUNDWATER MONITORING WELL INSTALLATION

A bedrock monitoring well will be constructed of 6-inch diameter steel casing into bedrock plus PVC screen and riser in the monitored interval. The well will be cased through the overburden and sealed at the overburden-bedrock surface to prevent vertical contaminant migration into the bedrock from the overburden. PVC screen and riser will isolate the monitored interval from the shallower intervals.

A 10-inch diameter borehole and steel casing will be advanced through the overburden and at least 5 feet into competent bedrock using appropriate drilling methods. If borehole collapse occurs in the overburden during casing installation, mud rotary drilling methods may be used after all other methods have failed to advance the borehole into the bedrock. The drilling mud should not come into contact with the bedrock borehole to prevent impacting the bedrock groundwater quality.

The steel casing will be grouted in place with neat cement or cement-bentonite slurry using a tremie pipe raised from the bottom upward during pumping. The grout will be allowed to cure at least 24 hours before the well borehole is drilled. The well borehole will be 5-7/8-inch diameter and will be advanced using appropriate drilling methods to the first water bearing fracture with a greater than 1 gallon per minute flow rate or 10 feet into bedrock. If groundwater-producing fractures were not shown to occur in the first 10 feet of drilling the borehole will be allowed to naturally develop for 15 minutes. If groundwater enters the borehole in that period of time, a PVC monitoring well will be installed in the borehole, otherwise an additional ten feet of drilling will occur to explore for a water producing fracture. This process will continue until a productive fracture is encountered but no more than 30 feet into bedrock. A 10 foot or smaller screen length will be used to screen the productive fractures.

Lithology and drilling activities will be recorded on boring log sheets (Appendix C) for each monitoring well. Monitoring well construction sheets (Appendix C) will also be completed for each monitoring well.

3.4 MONITORING WELL DEVELOPMENT

Each newly installed temporary and permanent monitoring well will be developed a minimum of 12 hours and 24 hours, respectively, after installation is complete in accordance with TtNUS SOP GH-2.8 Section 5.4. The purpose of well development is to remove sediments from inside the casing and within the sand filter pack that surrounds the well screen. Well development information such as pH, conductivity, temperature, turbidity, and REDOX for each monitoring well will be recorded on well development sheets (Appendix C).

3.4.1 Temporary Monitoring Well Development

Each temporary well will be developed by repeatedly pumping the well, creating drawdown, then allowing the well to recover thus causing a surging effect. Development should not occur for a minimum of 12 hours after installation is complete. The purpose of well development is to remove sediments from inside the casing and within the sand pack which surrounds the well screen. Due to the diameter and volume of the proposed temporary wells, a peristaltic pump will be used to develop the wells. Each of the wells will be developed for approximately one-half hour. Other development techniques (e.g. surging with a surge block) may be required if the recommended over pumping technique is not adequate. Use of another development technique will be at the discretion of the FOL.

The water levels and free product thickness (if any) in the temporary wells will be allowed to stabilize for approximately 12 hours after development, depending on the permeability of the formation, before sampling. The temporary wells will be capped when left unattended to minimize the introduction of particles or contaminants into the well from the surface.

3.4.2 Permanent Monitoring Well Development

Each newly installed permanent monitoring well will be developed at least 24 hours after the installation is completed. The bedrock monitoring wells will be developed using surging. Development will proceed until the discharged water is visibly clear. The monitoring wells will be developed using a stainless-steel submersible or polypropylene Waterra pump equipped with a surge block gasket. Each monitoring well will be developed by repeatedly pumping the well, creating drawdown, then allowing the well to recover, thus causing a surging effect. Repeated pumping and recovery surge development will continue for a minimum of 1-hour per well location. Water-level elevation data will be collected periodically during the well development process to ensure that the well is not pumped dry and to obtain specific capacity data regarding the aquifer. Specific capacity data is useful in determining a well's potential yield and for estimating the hydraulic conductivity of an aquifer.

The water level and free product thickness (if any) in the monitoring wells will be allowed to stabilize for a minimum of 72 hours after development before sampling.

3.5 WATER LEVEL MEASURMENTS

Water-level and product thickness measurements (if present) will be obtained at each newly installed monitoring well and at all indicated existing monitoring well locations. Water-level and product thickness measurements will be taken simultaneously within a 24-hour period of consistent weather conditions. All water-level measurements will be taken using an electronic water-level meter. Water-level elevations will be recorded to within a 0.01-foot accuracy from a marked reference point at each location. Water levels will be recorded on a TtNUS water-level form (Appendix C).

If free product is encountered, two methods, an interface probe and a clear bailer, will be used to measure the thickness of free-phase product in a well. The measurements will be done under static conditions prior to any purging or removal of water or free-phase product from the monitoring well. The depth to the top and bottom of the free-phase product will be measured using a hydrocarbon interface probe. The interface probe will be used to detect free-phase product at both the surface of the water table and at the bottom of each well because some of the chlorinated solvents may have a specific gravity greater than 1. Interface probes (Keck, ORS, or Solinst brand meters) emit a single tone when the probe is in the free-phase product and an intermittent tone when the probe reaches water. A clear disposable bailer will be used to collect a free-phase product sample in order to confirm the interface probe measurement and to visually observe and describe the free-phase product. The bailed free-phase product shall be examined for thickness, layering, color, color gradation, coagulation, and apparent viscosity.

The interface probe shall be decontaminated between each well measurement to minimize cross-contamination. All measurements will be referenced to the top of the riser pipe. All appropriate measurements, observations, and calculations will be recorded in the field notebook and on the groundwater sample log sheets. Any bailed free-phase product will be placed into a temporary container in order to transport it, without spillage, to a designated on-site 55-gallon drum for temporary storage and subsequent disposal.

The condition of each existing groundwater monitoring well will be evaluated before wells are measured. The wells will be examined for damaged surface casings and concrete surface pads. Water-level measurements and monitoring well evaluations will be performed in accordance with procedures outlined in TtNUS SOP GH-1.2 (Appendix D).

A PID/FID will be used to monitor the presence of organic vapors in the well annulus. The organic vapor monitor will be calibrated daily in accordance with procedures outlined in Section 3.12

3.6 GROUNDWATER SAMPLING AND ANAYLSIS

The condition of each existing groundwater monitoring well will be evaluated before well purging and sampling begins. The wells will be examined for the presence of a silted screen, a damaged surface casing, or a damaged concrete surface pad. Monitoring well evaluations will be performed in accordance with procedures outlined in TtNUS SOP GH-1.2 (Appendix D). Groundwater monitoring wells will be purged immediately before sampling using low-flow purging methods. The methods shall be in accordance with USEPA Region I Low Stress Purging and Sampling Procedure for the Collection of Groundwater Sample from Monitoring Wells (US EPA Region I, 1996). The water-level elevation, free-product thickness and the depth of the water column will be measured before purging begins.

The wells will be purged using a peristaltic or submersible pump (depending on well) with dedicated high density polyethylene (HDPE) tubing lowered to the middle of the screen interval or to the middle of the remaining screen interval below the lowest depth of any free product. For temporary wells less than 2-inches in diameter, pharmaceutical-grade silicon tubing will be used in the rotaries of the peristaltic pump. All wells will be purged at a flow rate of 0.1 to 0.4 liters per minute.

Water quality parameters including pH, specific conductivity, temperature, dissolved oxygen (DO), REDOX potential, salinity, and turbidity will be measured at 5- to 10-minute intervals. All measurements except turbidity must be obtained using a flow-through cell. Transparent flow-through cells are preferred because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect field water quality parameters measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, the well will continue to be pumped while the cell is disconnected, cleaned, and then reconnected. The flow-through cell must be set up and operated in a way that prevents air bubble entrapment in the cell. Monitoring probes must be submerged in water at all times (USEPA, Region I, 1996, Appendix B).

Purging will be completed and sampling will begin when the following parameters have stabilized for three consecutive readings to within the following limits:

- pH to $\pm$ 0.1 units
- specific conductivity, 3 percent
- temperature, 3 percent
- DO, 10 percent

- REDOX, ± 10 millivolts
- turbidity, 10 percent for values greater than 5 NTU

The water level will not be allowed to draw down to the level of the pump intake. All purged water will be containerized.

Groundwater samples will be collected using the low-flow techniques described above. Samples will be transferred directly from the pump tubing to the container. Groundwater samples collected for dissolved metals analysis will be filtered in the field prior to preservation with nitric acid (HNO_3). VOC samples will be collected such that zero head space is present in the sample container once filled. Sample nomenclature and rationale are presented in Table 2-1. Bottle and sample preservation requirements are presented in Table 3-1.

The groundwater samples will be analyzed for a variety of parameters including TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, TAL metals (total and dissolved) and acidity. Water quality parameters such as DO, salinity, turbidity, pH, temperature, and REDOX will be measured using a flow-through cell and the appropriate instruments in the field.

Sampling chain-of-custody requirements are addressed in Section 3.11. All pertinent field data will be recorded on a TtNUS sample log sheet and in the field logbook. An example TtNUS sample log sheet and chain-of-custody form are included in Appendix C.

3.7 SOIL BORING AND SOIL SAMPLING AND ANALYSIS

With the exception of the three soil borings to be advanced in the new burial area of Site 3, which will be hand augured, temporary wells and soil borings will be completed using direct-push methods. A Geoprobe™ or other similar DPT will be used to collect shallow and deep soil samples while advancing soil borings and temporary wells. The purpose of using a Geoprobe™ or other similar technology is to generate less investigation-derived waste (IDW), minimize decontamination time, and minimize access space required relative to conventional drilling methods.

A concrete coring device will be concurrently mobilized to the site with the Geoprobe™ equipment. The coring device will cut concrete to minimize borehole drill time and to extend the life of the drill bit.

Continuous soil sampling will be performed from ground surface or from below the concrete or asphalt surface (if necessary) to the top of the water table using a Macro-Core® or similar sampler and in accordance with procedures outlined in TtNUS SOP SA-1.3 and SA-2.5 (Appendix D). Effort will be made to minimize residual asphalt from being included in the sampled material. The purpose of

continuous soil sampling is to identify potential zones of contamination, collect soil samples for field screening with a PID or FID, collect soil samples for laboratory analysis, and characterize the soil stratigraphy. Each sample will be monitored with a PID or FID meter. Results of the vapor monitoring will be recorded on TtNUS boring logs (Appendix C). Soil samples will be collected and logged in accordance with procedures outlined in TtNUS SOP SA-1.3 and GH-1.5 (Appendix D).

For the three soil borings advanced in the new disposal area at Site 3, the surface and subsurface samples will be collected using stainless steel hand augers. Due to the geology of the area, borings will be advanced to the extent possible at locations that appear to be free of large rocks (i.e., granite boulders). Surface and subsurface soil samples will be collected from the auger.

Surface and subsurface soil samples will be collected for laboratory analysis at Sites 3 and 15. The surface soil sample will be collected from a depth of 0 to 1 foot below ground surface or from the first foot of soil below pavement, and the subsurface soil sample will be collected from within a depth range that is from 1 foot bgs to the water table. The purpose of the surface soil sampling is to identify the presence of contaminant sources such as spills. The purpose of the subsurface sample is to delineate the extent of contaminated soils associated with past releases or spills.

At each drilling location surface soil samples will be collected for laboratory analysis. Subsurface soil samples will be selected for laboratory analysis based on the results of field screening with a PID or FID meter. A portion of each soil sample will be retained in a resealable bag for the screening. For the subsurface soils, the sample with the highest PID/FID readings will be retained for laboratory analysis. In the absence of PID/FID readings above background levels, the soil sample will be collected from the unsaturated soil just above the water table/unsaturated soil interface.

All borings will be backfilled with bentonite chips and patched with neat cement, cold-patch asphalt, or soil at grade to match the surrounding area. Care will be taken to return each location to its original condition after sampling. Each boring location will be revisited 24 hours after backfilling is completed to re-apply soil, cement grout, or cold-patch, if necessary.

All direct-push equipment will be steam cleaned prior to the start of the field investigation, decontaminated between each borehole to prevent cross-borehole contamination and steam cleaned prior to leaving the site, as discussed in Section 3.8.

3.8 DECONTAMINATION

The drilling and sampling equipment involved in the field sampling activities will be decontaminated upon arrival at the site, in between each borehole location, and at the completion of the sampling program as

per TtNUS SOP SA-7.1 (Appendix D). The sampling equipment may include split-spoon and Macro-Core® samplers, and a submersible or Waterra foot-valve pump. A centralized decontamination pad will be constructed at a Navy-approved location and will be used throughout the investigation.

The following sampling equipment decontamination sequence will be used:

1. Potable water rinse
2. Alconox or liquinox detergent wash
3. Potable water rinse
4. Pesticide-grade isopropanol rinse
5. Analyte-free water rinse
6. Air dry
7. Aluminum foil wrap if not used immediately

The drilling equipment will be steam cleaned before drilling operations begin, between each borehole location to minimize the potential for cross-contamination, and at the completion of the project. Steam cleaning will be performed with a portable steam cleaner supplied by the driller and municipal water supplied by NSB-NLON.

3.9 INVESTIGATION-DERIVED WASTE MANAGEMENT

It is anticipated that this investigation will generate four types of potentially contaminated residues:

- personal protective equipment (PPE)
- soil cuttings
- development and purge fluids
- equipment decontamination fluids

PPE - All PPE will be double bagged and placed in a designated dumpster.

Soil Cuttings - Soil cuttings will be placed in clean Department of Transportation (DOT)-approved 55-gallon steel drums. The drums will be labeled with the facility name, site number, and address; the type of contents; the boring or groundwater monitoring well identifier; the date the container was filled; and the name and phone number of the party responsible for disposal. NSB-NLON labels will be used for labeling the drums. The IDW disposal contractor will collect and analyze an appropriate number of soil samples from the drums at the completion of the field operations to determine the best disposal method. TtNUS will temporarily store the drums at a Navy-designated location.

Development and Purge Fluids - Purge and development fluids will be collected in 55 gallon, drums for temporary storage at a Navy-designated location prior to disposal. Each drum will be labeled with the facility's name and address, the type of contents, the groundwater monitoring well identifier, the date the drum was filled, and the name and phone number of the party responsible for disposal. NSB-NLON labels will be used for labeling the drums. The IDW disposal contractor will collect an appropriate number of liquid samples from the drums at the completion of the field operations and the results of the analyses will be used to determine the best method for disposal.

Equipment Decontamination Fluids - Equipment decontamination fluids will be containerized and handled in the same manner as development and purge fluids.

TtNUS will arrange for disposal of all IDW by a subcontractor. All IDW will be removed from the temporary storage location after receipt of analytical results. The TtNUS subcontractor will prepare waste manifests. The IDW will be considered the property of the Navy.

3.10 SURVEYING

The vertical and horizontal locations of soil borings and groundwater monitoring wells will be surveyed by a Connecticut-licensed professional surveyor. The third-order survey will be tied into the existing NSB-NLON Base Traverse and Monuments. The survey will be based on the Connecticut State Plane Coordinate System North American Datum (SPCS NAD) 1983 horizontal control and the North American Vertical Datum (NAVD) 1988 vertical control.

The monitoring wells shall be surveyed horizontally to the nearest 0.1 foot and vertically to the nearest 0.01 foot. At all well locations, the well casing elevation shall be surveyed at the designated reference point (e.g., where the uncapped PVC riser pipe is notched or marked). The elevation of the ground surface in the vicinity of the monitoring wells will also be measured.

3.11 SAMPLE HANDLING

Sample handling includes the field-related considerations concerning field sample documentation, nomenclature, packaging, shipping, and custody.

3.11.1 Field Sample Documentation

Sample documentation consists of the completion of Chain of Custody forms and matrix-specific sample logsheets. The FOL will maintain a bound weatherproof site logbook. All information related to sampling or field activities will be recorded in the site logbook and/or logsheets. This information will include, but is

not limited to, sample type, sample number, time, and date, weather conditions, method of sample collection, unusual events, field measurements, descriptions of any photographs taken, etc. Sample logsheets are sequentially numbered and placed in a sample logbook. Field documentation forms can be found in Appendix C.

All collected samples will be properly labeled with a sample label affixed to the sample container. The following information will be printed on the labels and tags prior to field activities:

- Project number (CTO 0841)
- Project location (NSB NLON)
- Sample identification
- Preservative
- Analysis to be performed
- Matrix type
- Laboratory name

Date, time, and sampler's initials will be completed in the field. Extra blank labels will be brought to the site for additional environmental samples not anticipated prior to mobilization.

3.11.2 Sample Nomenclature

Each sample collected will be assigned a unique sample tracking number. The sample tracking number generally follows TtNUS SOP CT-04 (Appendix D). The sample tracking number consists of up to 13 digits that identify the site, the sample media, the sample location, the Macro-Core® sampler or split-spoon number (soils only), and sampling round. All other pertinent information regarding sample identification will be recorded in the field logbooks. Sample numbers to be used for this project are provided in Table 2-1.

Soil Sample: S15SB00102??

S15 - Site 15
SB - Soil Boring
001 - Sampling Location
02 - Depth of sample (i.e., use 24 for a sample collected 2 to 4 feet bgs)
?? - The appropriate sequential number will be added for each location (i.e., if the selected well has been sampled two times during previous investigations this number will read 03 to represent the third sample collected for this location)

Groundwater Sample: S3GW3MW1?? (permanent well)

S3 - Site 3

GW - Groundwater

3MW1 - Existing well identification number

?? - The appropriate sequential number will be added for each location (i.e., if the selected well has been sampled two times during previous investigations this number will read 03 to represent the third sample collected for this location)

Groundwater Sample: S3GW3TW1?? (temporary well)

S3 – Site 3

GW - Groundwater

3TW1 – Temporary well identification number

?? - The appropriate sequential number will be added for each location (i.e., if the selected well has been sampled two times during previous investigations this number will read 03 to represent the third sample collected for this location)

For quality control samples the sample will be labeled to indicate whether the sample is a rinse blank or a matrix spike, a matrix spike duplicate, or an environmental duplicate sample. Rinse blanks will be labeled "RB080802", where the "080802" represents the date (August 8, 2002). Matrix spike and matrix spike duplicate samples will be labeled the same as an environmental sample, followed by "MS" for matrix spike and "MSD" for matrix spike duplicate. Lastly, an environmental duplicate sample will be labeled FD-080802-01, where the "080802" would indicate the day in which the duplicate was collected. The additional "01" would indicate a sequential number in the event that two or more duplicate samples are collected during the same day. This nomenclature will not allow the laboratory to know which sample the duplicate sample is a duplicate of. However the duplicate pair will be recorded in the field note book. and sample log sheet

3.11.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with TtNUS SOP SA-6.1 (Appendix D). The FOL will be responsible for completing the following forms:

- Sample Labels
- Chain-of-Custody Forms
- Chain-of-Custody Labels

- Shipping Labels for Coolers
- Express Mail Air Bills

The laboratory provides sample containers that are certified clean for the analytical parameter for which the sample is to be analyzed. All samples will be held, stored, and shipped at 4°C ± 2°C. This will be accomplished through refrigeration (used to hold samples prior to shipment) and/or ice.

3.11.4 Sample Custody

Custody of samples must be maintained and documented at all times as per TtNUS SOP SA-6.1 (Appendix D). Chain-of-custody begins with the collection of samples in the field. A sample chain-of custody record is provided in Appendix C. The FOL will be responsible for completion of the following forms:

- Sample labels
- Chain-of-custody forms
- Appropriate labels applied to shipping coolers
- Chain-of-custody seals
- Shipping bills

3.12 FIELD MEASUREMENTS, CALIBRATION, AND MAINTENANCE

Measurements recorded during field sampling operations include monitoring ambient air around the work-space area, screening soil samples, screening air quality within the well casing, and measuring groundwater quality parameters. The following instruments are anticipated to be used during the field activities:

- FID or PID
- YSI® 6820 with data logger (or similar device)
- Turbidity meter (LaMotte)
- Electronic water-level meter
- Interface probe

Field instruments will be calibrated in accordance with the manufacturer's recommendations. A field check will also be completed at the end of each day. Duplicate measurements of pH, specific conductance, temperature, and turbidity will be taken at a frequency of 1 in 10 samples and will be used to estimate the precision of the field analytical measurements.

All instrument calibrations will be recorded on an equipment calibration log sheet (Appendix C) as per TtNUS SOP SA-6.3 (Appendix D). During calibration, a maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts can be repaired or the instrument replaced.

In the event that an instrument does not meet performance specifications during operation, the instrument will be tagged out of service until the instrument is demonstrated to be performing within specifications. In the event that failed equipment cannot be repaired, the supplier of the equipment will be notified and an overnight carrier will ship replacement equipment to the site in order to minimize downtime.

3.13 REPORTING AND DOCUMENTATION

In addition to chain-of-custody records, certain standard forms will be completed to describe and document the samples. These forms shall include sample log sheets, boring logs, daily activity records, and logbooks. Each work team (i.e., sampling crew, well installation supervisor, etc.) shall maintain a bound, weatherproof notebook. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, and descriptions of photographs.

A bound, weatherproof logbook shall be maintained by the FOL. The requirements are outlined in TtNUS SOP SA-6.3 (Appendix D). This book will contain a summary of the day's activities and will reference the field notebooks when applicable. After the field activities are completed, the FOL shall submit all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, and daily activity logs to the project manager.

Field Task Modification Request (FTMR) forms are specific forms initiated when a change or deviation from procedures in the project planning documents occurs. The procedure for requesting and recording field changes follows:

- The FOL notifies the project manager of the need for the change.

- If necessary, the project manager discusses the change with the appropriate individuals [the Navy RPM, and TtNUS Quality Assurance Manager (QAM)]. Verbal approval or denial of the proposed change is given at this time.

- The FOL documents the change on an FTMR form and forwards the form to the project manager at the earliest convenient time (e.g., end of the workweek).

- The project manager signs the form and distributes copies to the Navy RPM, TtNUS QAM, FOL, and project file.

- A copy of the completed FTMR form is attached to the field copy of the affected document.

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TABLE 3-1

ANALYTICAL METHODS, BOTTLE REQUIREMENTS, PRESERVATIVE REQUIREMENTS, AND HOLDING TIMES NSB-NLON, GROTON, CONNECTICUT

Parameter	Sample Container[1]	Container Volume	Preservation[2]	Maximum Holding Time[3]	Analytical Methodology
GROUNDWATER					
TCL VOCs	Glass, black phenolic plastic screw cap, Teflon-lined septum	(2) 40 mL	Cool to 4 °C, dark HCL to pH < 2	14 days to analysis	OLC02.1
TCL SVOCs (minus PAHs)	Amber glass, Teflon-lined cap	1000 mL	Cool to 4 °C	7 days to extraction; 14 days to analysis	OLC02.1
Polyaromatic Hydrocarbons (PAHs)	Amber glass, Teflon-lined cap	1000 mL	Cool to 4 °C	7 days to extraction; 40 days to analysis	SW846 8310/8270C
TCL Pesticides/PCB	Amber glass, Teflon-lined cap	(2) 1000 mL	Cool to 4 °C	7 days to extraction; 14 days to analysis	OLC02.1
TAL Metals[4] (total and dissolved)	Polyethylene bottle, plastic cap, plastic liner	250 mL	HNO_3 to pH < 2	180 days to analysis; mercury 28 days to analysis	ILM04.1
Acidity	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4°C	14 days to analysis	USEPA 305.1
SOIL					
TCL VOCs	EnCore Sampler	(3) 5 g	Cool to 4 °C Lab to preserve via low level method	Lab to preserve within 48 hours of collection; Analysis must occur within 14 days of preservation.	SW846 8260B
TCL SVOCs (minus PAHs)	Glass, Teflon-lined cap	8 oz[5]	Cool to 4 °C, dark	14 days to extraction; 40 days to analysis	SW846 8270C
PAHs	Glass, Teflon-lined cap	8 oz.	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8310
TCL Pesticides	Glass, Teflon-lined cap	8 oz[5]	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8081A
TCL PCBs	Glass, Teflon-lined cap	8 oz[5]	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8082
TAL Metals	Glass, Teflon-lined cap	8 oz[5]	Cool to 4 °C	180 days to analysis; except mercury 28 days to analysis	ILM04.1

1 Container volume may vary based on laboratory.
2 HCL = Hydrochloric acid, NaOH = Sodium hydroxide, HNO_3 = Nitric acid, H_2SO_4 = Sulfuric acid.
3 All holding times are from date of collection.
4 Refer to Table 2-1 for a summary of the sample-specific metals analyses.
5 For soil samples, a single 8-ounce jar will provide sufficient sample volume for semivolatile organics, pesticides, PCBs, metals, and pH analyses.

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APPENDIX A

HEALTH AND SAFETY PLAN

Health and Safety Plan
for
Basewide Groundwater Operable Unit Data Gap Investigation

Naval Submarine Base - New London
Groton, Connecticut

Engineering Field Activity Northeast
Naval Facilities Engineering Command

Contract Number N62476-94-D-0888

Contract Task Order 0841

July 2002

HEALTH AND SAFETY PLAN
FOR
BASEWIDE GROUNDWATER
OPERABLE UNIT
DATA GAP INVESTIGATION

NAVAL SUBMARINE BASE – NEW LONDON
GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Environmental Branch, Code EV2
Naval Facilities Engineering Command
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1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been developed to provide practices and procedures for Tetra Tech NUS, Inc. (TtNUS) and subcontractor personnel engaged in activities associated with the Basewide Groundwater Operable Unit Data Gap Investigation at the Naval Submarine Base - New London (NSB-NLON), located in Groton, Connecticut. This HASP is being prepared for NSB-NLON as part of an overall effort conducted under Comprehensive Long-Term Environmental Action Navy (CLEAN III) administered through the U.S. Navy Engineering Field Activity Northeast Naval Facilities Engineering Command (NAVFAC), as defined under Contract Number N62476-94-D-0888. In addition to the HASP, a copy of the TtNUS Health and Safety Guidance Manual must be present at the site during the performance of site activities. The Guidance Manual provides supporting information pertaining to the HASP, as well as TtNUS Standard Operating Procedures (SOP's). Both documents must be present at the site to comply with the requirements stipulated in the Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response Standard or HAZWOPER).

This HASP has been developed using the latest available information regarding known or suspected chemical contaminants and potential physical hazards associated with the proposed work at the site. The HASP will be modified, if new information becomes available. All changes to the HASP will be made with the approval of the TtNUS Project Health and Safety Officer (PHSO) and the TtNUS Health and Safety Manager (HSM).

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for TtNUS and subcontractor employees engaged in onsite activities. Personnel assigned to these positions will exercise the primary responsibility for all onsite health and safety. These persons will be the primary point of contact for any questions regarding the safety and health procedures and the selected control measures that are to be implemented for onsite activities.

- The TtNUS PM is responsible for the overall direction of health and safety for this project.

- The PHSO is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  i. Providing information regarding site contaminants and physical hazards associated with the site.
  ii. Establishing air monitoring and decontamination procedures.
  iii. Assigning personal protective equipment based on task and potential hazards.

iv. Determining emergency response procedures and emergency contacts.
v. Stipulating training requirements and reviewing appropriate training and medical surveillance certificates.
vi. Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work.
vii. Modifying this HASP, as it becomes necessary.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed Site Safety Officer (SSO). The FOL manages field activities, executes the work plan, and enforces safety procedures as applicable to the work plan.

- The SSO supports site activities by advising the FOL on all aspects of health and safety on site. In this capacity the SSO:

i. Coordinates all health and safety activities with the FOL.
ii. Selects, applies, inspects, and maintains personal protective equipment.
iii. Establishes work zones and control points in areas of operation.
iv. Implements air monitoring program for onsite activities.
v. Verifies training and medical clearance of onsite personnel status in relation to site activities.
vi. Implements Hazard Communication, Respiratory Protection Programs, and other associated health and safety programs as they may apply to site activities.
vii. Coordinates emergency services.
viii. Provides site-specific training for all onsite personnel.
ix. Investigates all accidents and injuries (see Attachment I - Illness/Injury Reporting Procedure and Form)
x. Provides input to the PHSO regarding the need to modify this HASP, or applicable health and safety associated documents as per site-specific requirements.

Compliance with the requirements stipulated in this HASP is monitored by the SSO and coordinated through the TtNUS CLEAN HSM.

Note: In some cases one person may be designated responsibilities for more than one position. For example, at NSB-NLON the FOL may also be responsible for SSO duties. This action will be performed only as credentials, experience, and availability permits.

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Submarine Base - New London
Groton, Connecticut

Client Contact: Richard Conant
Phone Number: (860) 694-5176

Scheduled Activities: This activity will be divided into a multi-task operation, including the tasks of soil boring (drilling), and multi-media sampling. Further detail on these and other site tasks can be found in Section 4 of this HASP.

Dates of scheduled activities: Site activities will begin in August 2002 and will continue until completion.

Project Team:

TtNUS Management Personnel:	Discipline/Tasks Assigned:
Corey Rich, P.E.	Project Manager (PM)
TBD	Field Operations Leader (FOL)
TBD	Site Safety Officer (SSO)
Matthew M. Soltis, CIH, CSP	CLEAN Health and Safety Manager
Clyde J. Snyder	Project Health and Safety Officer (PHSO)

Other Potential TtNUS Project Personnel:

TBD	Field Geologist

Non-TtNUS Personnel Affiliation/Discipline/Tasks Assigned

TBD	Drilling subcontractor
TBD	Surveying subcontractor
TBD	IDW disposal
TBD	Utility Clearance Contractor

Hazard Assessments (for purposes of 29 CFR 1910.132) and HASP preparation have been conducted by:
Clyde J. Snyder

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section is part of a preplanning effort to direct and guide field personnel in the event of an emergency. All site activities will be coordinated with the client contact, Mr. Richard Conant. In the event of onsite emergencies that cannot be handled by onsite personnel, they will be evacuated to a safe place of refuge, and the appropriate emergency response agencies will be notified. Because a majority of potential emergency situations will require assistance from outside emergency responders, TtNUS and subcontractor personnel will not provide emergency response support for significant emergency events beyond responding to easily controlled minor incidents. The emergency response agencies listed in this plan are capable of providing the most effective response and are designated as the primary responders. These agencies are located within a reasonable distance from the area of operations, a factor that ensures adequate emergency response time. NSB-NLON contact Mr. Richard Conant will be notified anytime outside response agencies are contacted. This emergency action plan conforms to the requirements of OSHA Standard 29 CFR 1910.38(a), as allowed in OSHA 29 CFR 1910.120(l)(1)(ii).

TtNUS will, through necessary services, include initial response measures for incidents such as:

- Initial fire-fighting support and prevention
- Initial spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illness requiring only first-aid level support
- Provision of site control and security measures as necessary

2.2 PRE-EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, injury or illness resulting from exposure to chemical or physical hazards or fire are the most probable emergencies that can be encountered during site activities. To minimize and eliminate these potential emergency situations, pre-emergency planning activities associated with this project include the following. The SSO and/or the FOL are responsible for:

- Coordinating response actions with NSB-NLON Emergency Services personnel to ensure that TtNUS emergency action activities are compatible with existing facility emergency response procedures.
- Establishing and maintaining information at the project staging area (Support Zone) for easy access in the event of an emergency. This information includes the following:
  - Chemical Inventory (for substances used onsite), with Material Safety Data Sheets.

- Onsite personnel medical records (medical data sheets).
- A logbook identifying personnel onsite each day.
- Emergency notification phone numbers in all site vehicles

- Identifying a chain or command for emergency action.
- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.

It is the responsibility of the TtNUS FOL to ensure that this information is available and present at the site.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Foreseeable emergency situations that may be encountered during site activities will generally be recognizable by visual observation. A clear knowledge of the signs and symptoms of overexposure to contaminants of concern may alert personnel of the potential hazards concerning themselves or their fellow workers. These potential hazards, the activities with which they have been associated, and the recommended control methods are discussed in detail in Sections 5.0 and 6.0 of this document. Additionally, early recognition will be supported by periodic site surveys to eliminate any conditions that may predispose site personnel or properties to an emergency. The FOL and the SSO will constitute the site evaluation committee responsible for these periodic surveys. Site surveys will be conducted at least once a week during the initiation of this effort.

The above actions will provide early recognition for potential emergency situations. Should an incident take place, TtNUS will take defensive and offensive measures to control these situations. However, if the FOL and/or the SSO determine that an incident has progressed to a serious emergency situation, TtNUS will withdraw, and notify the appropriate response agencies.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by ensuring compliance with the HASP, the Health and Safety Guidance Manual, applicable OSHA regulations, and through periodic site surveys of work areas.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, all personnel will immediately stop activities and report to the FOL at the place of safe refuge. Safe places of refuge will be determined prior to commencement of site activities and will be conveyed to personnel as part of the daily safety meeting conducted each morning.

Upon reporting to the refuge location, personnel will remain there until directed otherwise by the TtNUS FOL. The FOL or the SSO will take a head count at this location to confirm the location of all site personnel. The site logbook will be used to take the head count. Places of refuge will ideally be selected which offer a point for communication purposes should this be required.

2.5 EVACUATION ROUTES AND PROCEDURES

Once an evacuation is initiated, personnel will proceed immediately to the designated place of refuge, unless doing so would further jeopardize the welfare of workers. In such event, personnel will proceed to a designated alternate location (to be identified) and remain there until further notification from the FOL. The use of these locations as assembly points provides communication and a direction point for emergency services, should they be needed.

Evacuation procedures will be discussed prior to the initiation of any work at the site. This shall include identifying primary and secondary evacuation routes and assembly points. Evacuation routes from the site are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) will influence the designation of evacuation routes. As a result, assembly points at NSB-NLON will be selected, and in the event of an emergency, field personnel will proceed to these points by the most direct route possible without further endangering themselves.

2.6 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Since TtNUS personnel will not always be working in the proximity of each other, hand signals, voice commands, air horns, and two-way radios (approved by NSB-NLON personnel) will comprise the mechanisms to alert site personnel of an emergency.

If an incident occurs, site personnel will initiate the following procedures:

- Initiate incident alerting procedures (if needed) verbally, by air horn, or using two-way radios.
- Evacuate non-essential personnel.
- Initiate incipient response procedures.
- Describe to the FOL (who will serve as the Incident Commander) what has occurred in as much detail as possible.

In the event that site personnel cannot control the incident through offensive and/or defensive measures, the FOL and/or the SSO will enact emergency notification procedure to secure additional outside assistance in the following manner:

- Contact Ext. 3333 from base phone (or 860/694-3333 from a conventional phone) to report the incident (see Table 2-1). Give the emergency operator the location of the emergency, the type of emergency, the number of injured, and a brief description of the incident. Stay on the phone and follow the instructions given by the operator. The operator will then notify and dispatch the proper emergency response agencies.

If an incident occurs at NSB-NLON outside of designated operating areas impacting field personnel, the following procedures are to be initiated:

- Initiate an evacuation (if needed) by voice commands, hand signals, air horns, or two-way radio.
- Call Navy On-Site Representative
- Proceed to the assembly points as directed by NSB-NLON personnel.

2.7 EMERGENCY CONTACTS

Prior to initiating field activities, all personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted where it is readily available to all site personnel. Facility maps should also be posted showing potential evacuation routes and designated meeting areas.

TABLE 2-1
EMERGENCY CONTACTS
NSB-NLON, GROTON, CONNECTICUT

CONTACT	PHONE NUMBER
Local NSB-NLON Fire Department and EMS	Ext. 3333 from base phone or (860) 694-3777
Lawrence & Memorial Hospital	(860) 442-0711
(Off-Base) Groton Police: Groton Fire Department:	911 911
Connecticut Poison Control Center	(800) 343-2722
Utility Emergencies (electric, gas, water and sewer) NSB-NLON Public Works:	(860) 694-4711
Connecticut Call Before Your Dig	(800) 922-4455
Site Contact Richard Conant	(860) 694-5176
NSB-NLON Security:	(860) 694-3444
Providence and Worcester Rail Road (PWRR) Dispatcher	(508) 755-4000 Ext. 400
TtNUS Project Manager Corey Rich, P.E.	(412) 921-8984
TtNUS Project Health and Safety Officer Clyde J. Snyder	(412) 921-8904
TtNUS CLEAN Health and Safety Manager Matthew M. Soltis, CIH, CSP	(412) 921-8912 (888) 627-3182 (pager)

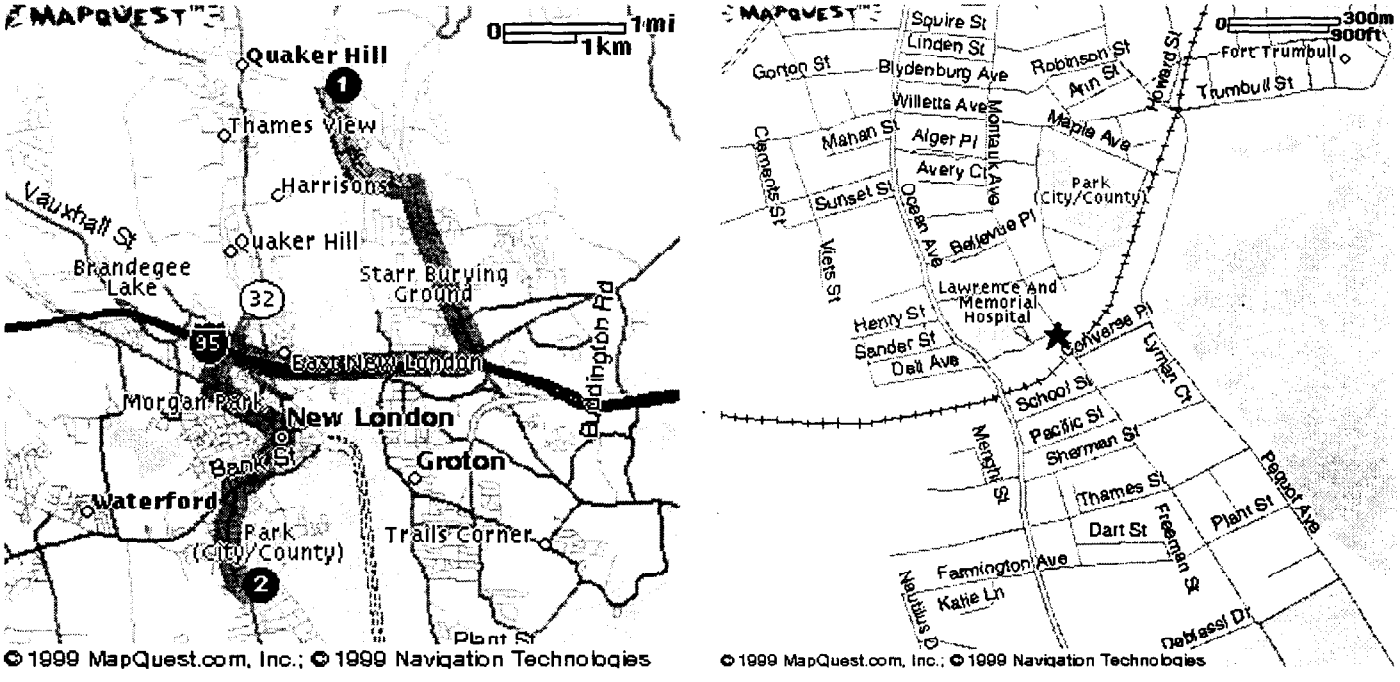
2.8 EMERGENCY ROUTE TO HOSPITAL

Lawrence and Memorial Hospital, 365 Montauk Ave., New London:

Exit the base and proceed South on Route 12 ❶. Exit onto I-95 South and take exit 82A. Proceed on the service road and continue until turning on Coleman Street. Travel on Coleman St. to the intersection of Coleman and Bank Streets. Turn right onto Bank Street and follow to the intersection of Ocean Avenue. Turn left onto Ocean Avenue and follow signs to the Hospital ❷.

FIGURE 2-1

ROUTE TO HOSPITAL



2.9 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will not be performed if the incident warrants immediate evacuation. However, it is unlikely that an incident would occur which would require workers to evacuate the site without first performing the necessary decontamination procedures.

TtNUS personnel will perform removal of personnel from emergency situations and may provide initial medical support for injury/illnesses requiring only "Basic First-Aid" level support. Basic First-Aid is considered treatment that can be rendered by a trained first aid provider at the injury location and not requiring follow-up treatment or examination by a physician (for example; minor cuts, bruises, stings, scrapes, and burns). Not included as Basic First-Aid are second or third degree burns, cuts, lacerations requiring stitches or butterfly bandaging, heat exhaustion, severe poisonous plant or insect bite reactions. Personnel providing medical assistance are required to be trained in First-Aid and in the requirements of OSHA's Bloodborne Pathogen Standard (29 CFR 1910.1030). Medical attention above Basic First-Aid will require assistance and support from the designated emergency response agencies. **If the emergency involves personnel exposures to chemicals, follow the steps provided in Figure 2-2.**

2.10 INJURY/ILLNESS REPORTING

If any TtNUS personnel are injured or develop an illness as a result of working on site, the TtNUS "Injury/Illness Procedure" (Attachment I) must be followed. Following this procedure is necessary for documenting all of the information obtained at the time of the incident. Also, as soon as possible Navy contact Richard Conant must be informed of any incident or accident that requires medical attention.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide information on the chemical, physical, and toxicological properties of the subject chemical(s) to medical service personnel.

FIGURE 2-2
EMERGENCY RESPONSE PROTOCOL

The purpose of this protocol is to provide guidance for the medical management of exposure situations.

In the event of a personnel exposure to a hazardous substance or agent:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the exposed person is a TtNUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. WorkCare physicians will monitor the care of the victim. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at 1-800-455-6155 (enter Ext. 109), or follow the voice prompt for after hours and weekend notification, and be prepared to provide:
- Any known information about the nature of the exposure.
- As much of the exposure history as was feasible to determine in the time allowed.
- Name and phone number of the medical facility to which the victim(s) has/have been taken.
- Name(s) of the exposed Tetra Tech NUS, Inc. employee(s).
- Name and phone number of an informed site officer who will be responsible for further investigations.
- Fax appropriate information (e.g., MSDS) to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) at 412-921-8912.
- Contact Corporate Human Resources Manager (Marilyn Duffy) at 412-921-8475.

As environmental data is gathered and the exposure scenario becomes more clearly defined, this information should be forwarded to WorkCare. WorkCare will compile the results of the data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident but deleting any personal or individual comments. This generalized summary will be accompanied by a personalized letter describing the individual's findings/results. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-2 (continued)

POTENTIAL EXPOSURE REPORT

Name: _____ Date of Exposure: _____

Social Security No.: _____ Age: _____ Sex: _____

Client Contact: _____ Phone No.: _____

Company Name: _____

I. Exposing Agent

Name of Product or Chemicals (if known): _____

_____

Characteristics (if the name is not known)

Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants

What was individual doing? _____

How long did individual work in area before signs/symptoms developed? _____

Was protective gear being used? If yes, what was the PPE? _____

Was their skin contact? _____

Was the exposing agent inhaled? _____

Were other persons exposed? If yes, did they experience symptoms? _____

III. Signs and Symptoms (check off appropriate symptoms)

Immediately With Exposure:

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

Delayed Symptoms:

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)

Improved: _____ Worsened: _____ Remained Unchanged: _____

V. Treatment of Symptoms (check off appropriate response)

None: _____ Self-Medicated: _____ Physician Treated: _____

3.0 SITE BACKGROUND

NSB-NLON is located in southern Connecticut, in the towns of Groton and Ledyard. NSB-NLON consists of approximately 547 acres of land and associated buildings, situated on the east bank of the Thames River, and is approximately six miles north of Long Island Sound. Location maps of NSB-NLON are included in the Work Plan for Basewide Groundwater Operable Unit Data Gap InvestigationNSB-NLON was established as an official Navy yard in July 1886. The site initially moored small craft and obsolete warships and was used as a coaling station for the Atlantic Fleet. The property was officially established as a permanent submarine base in 1916. The overall base facilities were expanded and a Submarine School training facility was established in 1917; the Submarine Medical Center was established in 1918. During World Wars I and II, NSB-NLON greatly expanded in size and in the number of buildings to support the submarine fleet. NSB-NLON currently provides a base command for naval submarine fleet activities in the Atlantic Ocean. In addition, NSB-NLON contains naval housing, submarine training facilities, military offices, medical facilities, and facilities for the maintenance, repair, and overhaul of submarines.

3.1 AREA A DOWNSTREAM WATERCOURSE / OVER BANK DISPOSAL AREA (SITE 3)

The Area A Downstream Watercourses receive surface water and groundwater recharge from the Area A Landfill, Area A Wetland, Torpedo Shops, and surrounding areas and conveys the surface and groundwater flows to the Thames River. The Area A Downstream Watercourses include North Lake and several small ponds (Upper Pond, Lower Pond, and OBDA Pond) and interconnected streams (Streams 1 through 6). Most of the area is within designated Explosive Safety Quantity Distance (ESQD) arcs of the Area A Weapons Center. A remedial design was completed for the soil and sediment at Site 3 in 1999, and the remedial action for Site 3 soil and sediment was completed in 1999 and 2000. During the remedial action, contaminated soil and sediment were dredged and hauled off site for disposal, and wetlands and waterways in the area were restored. A previously unknown source of petroleum contamination was detected during the remedial action at Site 3. The source, found during the remediation of Stream 5, is located on the northern side of the stream just east of the Small Arms Range. Petroleum product was discovered emanating from the northern side of the excavation. Upon further investigation, a small disposal area (i.e., drums, cable, etc.) was discovered upgradient of the location where petroleum was discovered.

The objectives of the field investigation proposed for Site 3 include further definition of contamination degradation trends in groundwater and investigating the new source area identified during the 1999/2000 remedial action located east of the Small Arms Range.

3.2 SPENT ACID STORAGE AND DISPOSAL AREA (SITE 15)

The Spent Acid Storage and Disposal Area (SASDA) was located in the Southern Region of NSB-NLON. It was centrally located between the southern sides of Buildings 409 and 410. The former site layout and historical sampling locations are shown on Figure 1-3. The site is a relatively flat area completely covered with concrete or bituminous pavement.

The IAS Report indicated that this area was used before and after World War II for the temporary storage of waste battery acid in a rubber-lined underground tank. The tank was reportedly 12 feet long by 4 feet wide by 4 feet high. The batteries were placed on a concrete pad next to the tank, where some acids occasionally leaked. No major spills were ever recorded. Atlantic personnel inspected the site and found the outline of the top of the tank. The area was completely covered with concrete and only the top of the tank was visible. The tank had been filled in place with soil and capped with bituminous pavement.

A time-critical removal action was completed at the SASDA during the course of the Phase II RI. The removal action, completed in January 1995, included removal of the tank, tank contents, contaminated pavement, and approximately 318 tons of lead-contaminated soil. The objectives of the field investigation proposed for Site 15 include evaluating the extent TCE and metals in the groundwater and determining the extent, if any, of source material remaining following the 1995 remedial action.

3.3 AREA A WEAPONS CENTER (SITE 20)

Site 20, the Area A Weapons Center, consists of Building 524 and the weapons storage bunkers. The storage bunker area is divided into two portions (north and south areas) that were constructed at different times and are of different design. The site is located in the north central portion of NSB-NLON at the southeastern end of Triton Avenue, and is adjacent to and on the northwestern side of the Area A Wetland.

The Area A Weapons Center (Building 524) is located near the top of a local topographic and bedrock high. Building 524 was constructed in 1990-1991. Portions of the site were blasted to remove bedrock to accommodate construction of the building. The weapons storage bunkers are located southeast and downhill of Building 524 and are adjacent to and at a slightly higher elevation than the Area A Wetland. Atlantic personnel inspected the Area Weapons Center on September 11, 1992. The following information was obtained during the site inspection. Building 524 is used for administration, minor torpedo assembly, and storage of simulator torpedoes. No weapons production takes place in this building. Small quantities of chemicals and chemical waste generated by activities in this building are stored in 1- to 5-gallon containers in seven metal storage cabinets located on a paved area south of the building. Chemicals include cleaning and lubricating compounds, paints, and adhesives. Many of these materials

are classified as corrosive or flammable materials. The waste storage and management practices appeared to be good.

Soil removal action was conducted and completed on October 20, 2001

The objective of the field investigation proposed for Site 20 is to further define groundwater contamination degradation trends.

4.0 SCOPE OF WORK

The following is a list of activities that are covered in this HASP for the contamination assessment to be conducted under CTO 0841.

- Mobilization/demobilization
- Soil boring activities using:
  - Air Rotary Drilling
  - Direct Push Technology
- Installation of Monitoring Wells
- Multi-Media Sampling
- Decontamination of sampling and heavy equipment
- IDW management

Any tasks to be conducted outside of the elements listed here will be considered a change in scope requiring modification of this document. The PM or a designated representative will submit all requested modifications to this document to the HSM.

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

Table 5-1 of this section serves as the primary portion of the site-specific HASP which identifies the tasks that are to be performed as part of the scope of work. This table will be modified and incorporated into this document as new or additional tasks are performed at the site. The anticipated hazards, recommended control measures, air-monitoring recommendations, required Personal Protective Equipment (PPE), and decontamination measures for each site task are discussed in detail. This table and the associated control measures shall be changed, if the scope of work, contaminants of concern, or other conditions change.

Through using the table, site personnel can determine which hazards are associated with each task and at each site, and what associated control measures are necessary to minimize potential exposure or injuries related to those hazards. The table also assists field team members in determining which PPE and decontamination procedures to use based on proper air monitoring techniques and site-specific conditions.

As discussed earlier, the Health and Safety Guidance Manual supports this table and HASP. The manual is designed to further explain supporting programs and elements for other site-specific aspects as required by regulatory requirements. The Guidance Manual should be referenced for additional information regarding air monitoring instrumentation, decontamination activities, emergency response, hazard assessments, hazard communication and hearing conservation programs, medical surveillance, PPE, respiratory protection, site control measures, standard work practices, and training requirements. Many of TtNUS' SOPs are also provided in this Guidance Manual.

Safe Work Permits issued for all Exclusion Zone activities (See Section 9.4 and Attachment IV) will use elements defined in Table 5-1 as the primary reference. The FOL or the SSO completing the Safe Work Permit will add additional site-specific information. In situations where the Safe Work Permit is more conservative than the direction provided in Table 5-1, the Safe Work Permit will be followed. As the project develops and more information is gained, the SSO will modify the Safe Work Permits to reflect this information.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific work practices identified on Table 5-1, follow these safe work practices when conducting work involving known and unknown site hazards. These safe work practices establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations.

- Refrain from eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. A thorough shower and washing must be conducted as soon as possible if excessive skin contamination occurs.
- Avoid contact with potentially contaminated substances by walking around puddles, pools, mud, or other such areas. Avoid, whenever possible, kneeling on the ground or leaning or sitting on equipment. Do not place monitoring equipment on potentially contaminated surfaces.
- Be familiar with and adhere to all instructions in the site-specific HASP.
- Be aware of the location of the nearest telephone and all emergency telephone numbers. See Section 2.0, Table 2-1.
- Attend briefings on anticipated hazards, equipment requirements, Safe Work Permits, emergency procedures, and communication methods before going on site.
- Plan and mark entrance, exit, and emergency escape routes. See Section 2.0.
- Rehearse unfamiliar operations prior to implementation.
- Use the "buddy system" whenever respiratory protection equipment is in use. Establish hand signals or other means of emergency communication in case two-way radio failure.
- Maintain visual contact with each other and with other on-site team members by remaining in close proximity in order to assist each other in case of emergency.
- Establish appropriate Safety Zones including Support, Contamination Reduction, and Exclusion Zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the Exclusion Zone). Non-essential vehicles and equipment should remain within the Support Zone.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the Site Safety Officer (SSO).
- Matches and lighters are restricted from entering in the Exclusion Zone or Contamination Reduction Zone.

- Observe coworkers for signs of toxic exposure and heat or cold stress.

- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 DRILLING SAFE WORK PRACTICES

The following Safe Work Practices are to be followed when working in or around Drill Rig Operations.

5.2.1 Before Drilling

- Identify all underground utilities and buried structures before drilling. Use the Utility Locating and Excavation Clearance Standard Operating Procedure provided in Attachment II.

- All drill rigs will be inspected by a Competent Person (the SSO or designee), prior to the acceptance of the equipment at the site and prior to the use of the equipment. All repairs or deficiencies identified will be corrected prior to use. The inspection will be accomplished using the Equipment Inspection Checklist provided in Attachment III. Inspection frequencies will be once every shift (either 5 or 10 day) or following repairs.

- The work area around the point of operation will be maintained to the extent possible to remove any trip hazards near or surrounding rotating equipment.

- The driller's helper will establish an equipment staging and laydown plan. The purpose of this is to keep the work area clear of clutter and slips, trips, and fall hazards. Mechanisms to secure heavy objects such as drill flights will be provided to avoid the collapse stacked equipment.

- All potentially contaminated tooling will be wrapped in polyethylene sheeting for storage and transport to the centrally located decontamination unit.

5.2.2 During Drilling

- Secure frayed or loose clothing, hair, and jewelry when working with rotating equipment.

- Minimize contact with contaminated tooling and environmental media.

- Support functions (sampling and screening stations) will be maintained a minimum distance from the drill rig of the height of the mast plus five feet to remove these activities from within physical hazard boundaries.

- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the drill rig.

- In order to minimize contact with potentially contaminated tooling and media and to minimize lifting hazards, multiple personnel should move auger flights and other heavy tooling.

- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone. Site visitors will be escorted at all times.

5.2.3 After Drilling

- All equipment used within the exclusion zone will undergo a complete decontamination and evaluation by the SSO to determined cleanliness prior to moving to the next location, exiting the site, or prior to down time for maintenance.

- All motorized equipment will be fueled prior to the commencement of the days activities. During fueling operations all equipment will be shutdown and bonded to the fuel provider.

- When not in use all drill rigs will be shutdown, emergency brakes set, and wheels chocked.

- All areas subjected to subsurface investigative methods will be restored to equal or better condition than original to remove any contamination brought to the surface and to remove any physical hazards. In situations where these hazards cannot be removed these areas will be barricaded to minimize the impact on field crews working in the area.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
NSB, NEW LONDON

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SSO require.)*	Decontamination Procedures
Mobilization/ Demobilization	***Chemical hazards:*** 1) Exposure to potential site contaminants is not anticipated during this activity. However, chemicals brought on site in support of field activities are to be identified, inventoried, accompanied by an appropriate MSDS, properly stored, and evaluated for purposes of hazard communication. ***Physical hazards:*** 2) Lifting (strain/muscle pulls) 3) Pinches and compressions 4) Slip, trips, and falls 5) Heavy equipment hazards (rotating equipment, hydraulic lines, etc.) 6) Vehicular and foot traffic 7) Ambient temperature extremes (heat stress) ***Natural hazards:*** 8) Insect/animal bites and stings	1) To eliminate potential chemical hazards associated with this task ensure the following: - A chemical inventory list must be generated and maintained for all chemicals brought on site (Complete Section 5.0 of the TtNUS Health and Safety Guidance Manual). - Material Safety Data Sheets must be available for all chemicals brought on site. - Materials are to be stored in accordance with recommended practices and according to compatibility (See MSDS for storage and compatibility recommendations). 2) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 3) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. 4) Preview work locations for unstable/uneven terrain. 5) All equipment will be - Inspected in accordance with OSHA, and manufacturer's design. - Operated by knowledgeable operators, and knowledgeable ground crew. 6) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - Heavy equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 7) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding cold/heat stress concerns is provided in Section 4 of the TtNUS Health and Safety Guidance Manual. 8) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Section 4 of the Health and Safety Guidance Manual.	Not required	Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Steel toe safety shoes - *Safety glasses* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV III) will be issued at the beginning of each task to address the work planned for that task. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	Not required

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
NSB, NEW LONDON

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SSO require.)*	Decontamination Procedures
Soil borings using DPT or Air Rotary Drilling techniques This task also includes monitoring well installation, development, and purging.	***Chemical hazards:*** 1) Site history and previous site investigations have determined the presence of various Volatile Organic Compounds (VOCs) specifically chlorinated organic compounds including: . trichloroethene, 1,2-dichloroethene, tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride. Additionally some metals have been detected in groundwater samples associated with these sites. However, none of these contaminants are anticipated to be present at airborne concentrations that would pose an inhalation hazard to site workers. Prevention of exposure through ingestion and contact can be minimized by following proper work practices (use of PPE, decontamination, and good personal hygiene practices such as washing hands before eating, drinking, etc.). None of the contaminants, are expected to be present in significant concentrations to present an inhalation hazard. Further information on these contaminants and other potential contaminants is presented in Table 6-1. 2) Transfer of contamination into clean areas or onto persons ***Physical hazards***: 3) Heavy equipment hazards (pinch/compression points, rotating equipment, hydraulic lines, etc.) 4) Noise in excess of 85 dBA 5) Energized systems (contact with underground or overhead utilities) 6) Lifting (strain/muscle pulls) 7) Slip, trips, and falls 8) Vehicular and foot traffic 9) Ambient temperature extremes (heat stress) ***Natural hazards:*** 10) Insect/animal bites and stings	1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). The generation of dusts should be minimized. If airborne dusts are observed, area wetting methods may be used. If area wetting methods are not feasible, termination of activities may be used to minimize exposure to excessive airborne dusts. 2) Decontaminate sampling equipment and supplies between boreholes and prior to leaving the site. 3) All equipment to be used will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturers design and documented as such using Equipment Inspection Sheet (see Attachment III of this HASP). - Operated by knowledgeable operators and ground crew. - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures. - Compressor shall be inspected using Equipment Inspection Sheet (See Attachment III) - All fittings, connections and hydraulic hoses must be secured in a manner that ensures safe operation In addition to the equipment considerations, the following standard operating procedures will be employed: - All personnel not directly supporting the soil boring or drilling operation will remain at least 25 feet from the point of operation. - All loose clothing/protective equipment will be secured to avoid possible entanglement. - Hand signals may be established prior to the commencement of soil boring or direct push activities. - A remote sampling device must be used to sample drill cuttings near rotating tools. - Work areas will be kept clear of clutter. - All personnel will be instructed in the location and operations of the emergency shut off device(s). This device will be tested initially (and then periodically) to insure its operational status (See Equipment Inspection Form Attachment III of this HASP) - Areas will be inspected prior to the movement of direct push rigs and support vehicles to mitigate physical hazards. This will be the responsibility of the FOL and/or SSO. 4) Hearing protection will be used during all drilling/DPT activities. 5) All utility clearances shall be obtained, in writing, prior to subsurface activities. Prior to any subsurface investigations, the locations of all underground utilities will be identified and marked.(See Attachment II Utility Clearance SOP) 6) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 7) Preview work locations for unstable/uneven terrain. 8) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 5 feet). - Secure all loose articles to avoid possible entanglement. - All heavy equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 9) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat stress concerns is provided in Section 4 of the TtNUS Health and Safety Guidance Manual. 10) Avoid potential nesting areas of biting/stinging insects and snakes. Use commercially available insect repellents. Wear appropriate clothing, including snake chaps where warranted. Tape ankle and wrists areas to prevent ticks and chiggers, etc. from attaching themselves to you skin. Wear light colored clothing so that biting insects can be easily visible and be removed. Follow directions as specified in Section 6.3 of this HASP and Section 4.0 of the Health and Safety Guidance Manual concerning natural hazards.	Direct reading instrument such as a Photoionization Detector (PID) with an 11.7 eV source (or higher) will be used as a general screening instrument to detect volatile organic compounds and to evaluate airborne concentrations of potential site contaminants: Source areas (sample locations, borings, etc.) will be monitored using a PID. Monitoring shall be performed periodically as the drill/DPT rig advances the bore hole. Any positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: Monitor the breathing zone of at-risk and downwind employees. Any sustained reading (greater than 1 minute in duration) above 1 part-per-million (ppm) in worker breathing zones requires site activities to be suspended and site personnel to report to an unaffected area. Work may only resume if airborne readings in worker breathing zone return to below 1 ppm. If readings do not subside, contact the PHSO for further guidance. Work performed in the presence of elevated readings in worker breathing zone will require colorimetric tube (Drager Tube) sampling using a vinyl chloride 0.5/b detector tube to verify that the contaminant of concern is not vinyl chloride. If vinyl chloride is detected site activities will be suspended. Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities (particularly when air rotary drilling is performed). Generation of dusts should be minimized to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be performed by observing work conditions for visible dust clouds. Potential exposure to contaminated dust will be controlled using dust curtains on rigs, water suppression, by avoiding dust plumes, or evacuating the operation or area until dust subsides.	All subsurface operations are to be initiated in Level D protection. Level D protection constitutes the following minimum protection: - Standard field attire (Sleeved shirt; long pants) - Steel toe safety shoes - Safety glasses - Hardhat - Nitrile gloves or leather gloves with surgical style inner gloves - Hearing protection during drilling or for other high noise areas as directed by the SSO. - Reflective vest for traffic areas - *Tyvek coveralls and disposable boot covers if surface contamination is present and if the potential exists for soiling work attire.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** - Will consist of a soap/water wash and rinse for reusable protective equipment (e.g., gloves). This function will take place at an area adjacent to the drilling operations bordering the support zone. This decontamination procedure for Level D protection will consist of - Equipment drop - Soap/water wash and rinse of reusable outer gloves, as applicable - Outer coveralls, boot covers, and/or outer glove removal - Removal, segregation, and disposal of non-reusable PPE in bags/containers provided - Wash hands and face, leave contamination reduction zone.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
NSB, NEW LONDON

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SSO require.)*	Decontamination Procedures
Multi-media sampling, including, surface, subsurface soil and groundwater sampling.	***Chemical hazards:*** 1) Site history and previous site investigations have determined the presence of various Volatile Organic Compounds (VOCs) specifically chlorinated organic compounds including: . trichloroethene, 1,2-dichloroethene, tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride. Additionally some metals have been detected in groundwater samples associated with these sites. However, none of these contaminants are anticipated to be present at airborne concentrations that would pose an inhalation hazard to site workers. Prevention of exposure through ingestion and contact can be minimized by following proper work practices (use of PPE, decontamination, and good personal hygiene practices such as washing hands before eating, drinking, etc.). None of the contaminants are expected to be present in significant concentrations to present an inhalation hazard. Further information on these contaminants and other potential contaminants is presented in Table 6-1. 2) Transfer of contamination into clean areas ***Physical hazards:*** 3) Noise in excess of 85 dBA 4) Lifting (strain/muscle pulls) 5) Pinches and compressions 6) Slip, trips, and falls 7) Ambient temperature extremes (heat stress) 8) Vehicular and foot traffic ***Natural hazards:*** 9) Insect/animal bites and stings	1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized. If airborne dusts are observed, area wetting methods may be used. If area wetting methods are not feasible, termination of activities may be used to minimize exposure to observed airborne dusts. 2) Establish the Exclusion Zone for this activity at 10 feet surrounding the well head and discharge collection container. Decontaminate sampling equipment that comes into contact with contaminated media between sampling locations and prior to leaving the site. 3) When sampling at the Air Rotary Drill/DPT rig use hearing protection. The use of hearing protection outside of 25 feet from the Air Rotary drill/DPT rig should be incorporated under the following condition: If you have to raise your voice to talk to someone who is within 2 feet of your location, hearing protection must be worn. 4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 5) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. - A remote sampling device must be used to sample drill cuttings near rotating tools. The equipment operator shall shutdown machinery if the sampler is near moving machinery parts. 6) Preview work locations for unstable/uneven terrain. 7) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding cold/heat stress concerns is provided in Section 4 of the TtNUS Health and Safety Guidance Manual. 8) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - All heavy equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 9) Avoid potential nesting areas of biting/stinging insects and snakes. Use commercially available insect repellents. Wear appropriate clothing, including snake chaps where warranted. Tape ankle and wrists areas to prevent ticks and chiggers, etc. from attaching themselves to you skin. Wear light colored clothing so that biting insects can be easily visible and be removed. Follow directions as specified in Section 6.3 of this HASP and Section 4.0 of the Health and Safety Guidance Manual concerning natural hazards.	Direct reading instrument such as PID with an 10.6 eV source (or higher) or FID will be used as a general screening instrument to detect volatile organic compounds and to evaluate airborne concentrations of potential site contaminants: Source areas (sample locations, borings, etc.) will be monitored using a PID or FID. Monitoring shall be performed periodically as the Air Rotary drill/DPT rig advances the bore hole. Any positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: Monitor the breathing zone of at-risk and downwind employees. Any sustained reading (greater than 1 minute in duration) above 1 ppm in worker breathing zones requires site activities to be suspended and site personnel to report to an unaffected area. Work may only resume if airborne readings in worker breathing zone return to below 1 ppm. If readings do not subside, contact the PHSO for further guidance. Work performed in the presence of elevated readings in worker breathing zone will require colorimetric tube (Drager Tube) sampling using a vinyl chloride 0.5/b detector tube to verify that the contaminant of concern is not vinyl chloride. If vinyl chloride is detected site activities will be suspended. Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Although sampling activities alone do not typically result in excessive dusts, related drilling activities (particularly air rotary drilling) have the potential to create dusts. Generation of dusts should be minimized to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be performed by observing work conditions for visible dust clouds. Potential exposure to contaminated dust will be controlled using water suppression, by avoiding dust plumes, or evacuating the operation area until dust subsides.	Level D protection will be utilized for the initiation of all sampling activities. Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Steel toe safety shoes - Safety glasses - Surgical style gloves (double-layered if necessary) - Reflective vest for high traffic areas - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Tyvek coveralls if surface contamination is present and if the potential for soiling work attire exists.* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each task to address the work planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a removal and disposal of non-reusable PPE (gloves, coveralls, etc., as applicable). The decon function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Outer coveralls, boot covers, and/or outer glove removal (as applicable) - Removal, segregation, and disposal of non-reusable PPE in bags/containers provided - Soap/water wash and rinse of reusable PPE (e.g., hardhat) if potentially contaminated - Wash hands and face, leave contamination reduction zone.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SSO require.)*	Decontamination Procedures
Decontamination of Sampling and Heavy Equipment	***Chemical hazards:*** 1) Site history and previous site investigations have determined the presence of various Volatile Organic Compounds (VOCs) specifically chlorinated organic compounds including: . trichloroethene, 1,2-dichloroethene, tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride. Additionally some metals have been detected in groundwater samples associated with these sites. However, none of these contaminants are anticipated to be present at airborne concentrations that would pose an inhalation hazard to site workers. Prevention of exposure through ingestion and contact can be minimized by following proper work practices (use of PPE, decontamination, and good personal hygiene practices such as washing hands before eating, drinking, etc.). None of the contaminants are expected to be present in significant concentrations to present an inhalation hazard. Further information on these contaminants and other potential contaminants is presented in Table 6-1. 2) Decontamination fluids - Liquinox (detergent), acetone or isopropanol ***Physical hazards:*** 3) Lifting (strain/muscle pulls) 4) Noise in excess of 85 dBA 5) Flying projectiles 6) Vehicular and foot traffic 7) Slips, trips, and falls 8) Ambient temperature extremes (heat stress)	1) and 2) Employ protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. Establish the exclusion zone for this activity at leas 25 feet surrounding the gross contamination wash and rinse as well as 25 feet surrounding the heavy equipment decontamination area. Obtain manufacturer's MSDS for any decontamination solvents used onsite. Use appropriate PPE as identified on MSDS. All chemicals used must be listed on the Chemical Inventory for the site, and site activities must be consistent with the Hazard Communication section of the Health and Safety Guidance Manual (Section 5). 3) Use multiple persons where necessary for lifting and handling sampling equipment for decontamination purposes. 4) Wear hearing protection when operating pressure washer. 5) Use eye and face protective equipment when operating pressure washer. All other personnel must be restricted from the area. 6) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 7) Preview work locations for unstable/uneven terrain. 8) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat stress concerns is provided in Section 4 of the TtNUS Health and Safety Guidance Manual.	Use visual observation, and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried.	For Heavy Equipment This applies to high pressure soap/water, steam cleaning wash and rinse procedures. Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Steel toe safety shoes - Chemical resistant boot covers - Nitrile outer gloves - Hard Hat - *PVC Rainsuits or PE or PVC coated Tyvek* - *Safety glasses underneath a splash shield* - *Hearing protection (plugs or muffs)* For sampling equipment (trowels, MacroCore Samplers, bailers, etc.), the following PPE is required Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Surgical outer gloves - Safety glasses In the event of overspray of chemical decontamination fluids employ PVC Rainsuits or PE or PVC coated Tyvek as necessary. **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for reusable outer protective equipment (boots, gloves, PVC splash suits, as applicable). The decon function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Soap/water wash and rinse of outer boots and gloves, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Disposable PPE will be removed and bagged. **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will have restricted access to exclusion zones, and have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. **Sampling Equipment Decontamination** Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan. MSDS for any decon solutions (Alconox, isopropanol, etc.) will be obtained and used to determine proper handling / disposal methods and protective measures (PPE, first-aid, etc.). All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving onsite and leaving the site. No equipment will be authorized access or exit without this evaluation.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
NSB, NEW LONDON

Tasks/Operation Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions or the FOL or SSO require.)	Decontamination Procedures
IDW management and moving IDW drums to storage areas	***Chemical hazards:*** 1) Site history and previous site investigations have determined the presence of various Volatile Organic Compounds (VOCs) specifically chlorinated organic compounds including: . trichloroethene, 1,2-dichloroethene, tetrachloroethane, 1,1,2-trichloroethane, vinyl chloride. Additionally some metals have been detected in groundwater samples associated with these sites. However, none of these contaminants are anticipated to be present at airborne concentrations that would pose an inhalation hazard to site workers. Prevention of exposure through ingestion and contact can be minimized by following proper work practices (use of PPE, decontamination, and good personal hygiene practices such as washing hands before eating, drinking, etc.). None of the contaminants are expected to be present in significant concentrations to present an inhalation hazard. Further information on these contaminants and other potential contaminants is presented in Table 6-1. 2) Transfer of contaminants to unaffected areas. ***Physical hazards:*** 3) Noise in excess of 85 dBA 4) Lifting (strain/muscle pulls) 5) Pinches and compressions 6) Slip, trips, and falls 7) Vehicular and foot traffic 8) Ambient temperature extremes (heat stress) ***Natural hazards:*** 9) Insect/animal bites and stings	1) Employ real-time monitoring instrumentation, action levels, and identify PPE to control exposures to potentially contaminated media (e.g. air, water, soils). 2) An Investigative Derived Waste (IDW) area will be constructed and barricaded. Only authorized personnel will be allowed access. Decontaminate all equipment and supplies, if they become contaminated, between locations and prior to leaving the site. 3) When working near heavy equipment, use hearing protection. 4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 5) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. 6) Preview work locations for unstable/uneven terrain. 7) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 8) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat stress concerns is provided in Section 4 of the TtNUS Health and Safety Guidance Manual. 9) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Section 4 of the Health and Safety Guidance Manual.	Direct reading instrument such as PID with an 10.6 eV source (or higher) will be used as a general screening instrument to detect volatile organic compounds and to evaluate airborne concentrations of potential site contaminants. Source areas (IDW containers/drums) will be monitored using a PID. Any positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: Monitor the breathing zone of at-risk and downwind employees. Any sustained reading (greater than 1 minute in duration) above 1 ppm in worker breathing zones requires site activities to be suspended and site personnel to report to an unaffected area. Work may only resume if airborne readings in worker breathing zone return to below 10 ppm. If readings do not subside, contact the PHSO for further guidance.	Level D protection will be utilized for the initiation of all sampling activities. Level D - (Minimum Requirements) - Standard field attire (long sleeve shirt; long pants) - If necessary, Nitrile or cotton/leather work gloves with surgical style inner gloves - Safety steel toe shoes - Safety glasses - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Tyvek coveralls and disposable boot covers if surface contamination is present and if the potential for soiling work attire exists.* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.* - *Work/rest regimen*	**Personnel Decontamination** will consist of a soap/water wash and rinse for reusable outer protective equipment (boots, gloves, PVC splash suits, as applicable). The decon function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Soap/water wash and rinse of outer boots and gloves, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Disposable PPE will be removed and bagged.
Geographical Survey and Utility Clearance	***Chemical hazards:*** Significant exposure to site contaminants is anticipated to be unlikely given the nature of this task. ***Physical hazards:*** 1) Slips, trips, and falls 2) Ambient temperature extremes (heat stress) ***Natural hazards:*** 3) Inclement weather 4) Insect/animal bites or stings, poisonous plants, etc.	1) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation, establish temporary means for traversing hazardous terrain (i.e., rope ladders, etc.) 2) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat stress is provided in Section 4 of the Health and Safety Guidance Manual. 3) Suspend or terminate operations until directed otherwise by SSO 4) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Section 4 of the Health and Safety Guidance Manual.	Air monitoring is not required given that volatile contaminants are not likely to be present during surveying activities.	Surveying activities shall be performed in Level D protection Level D Protection consists of the following: - Standard field dress including sleeved shirt and long pants - Safety shoes (Steel toe/shank) - *Safety glasses, hard hats (if working near machinery)* - *Snake chaps for heavily wooded area where encounters are likely.* - *Tyvek coveralls may be worn to provide additional protection against poisonous plants and insects, particularly ticks. Work gloves may be worn if desired.* - *Hearing protection* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each task to address the work planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** - A structured decontamination is not required as the likelihood of encountering contaminated media is considered remote. However, survey parties should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be employed to stop the transfer of these insects into vehicles, homes, and offices.

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical, physical, and natural hazards that are anticipated to be present during site activities. Table 6-1 provides information related to chemical constituents that have been identified by analysis or are suspected to be present at the site based on historical data. Specifically, toxicological information, exposure limits, symptoms of exposure, physical properties, and air monitoring and sampling data are discussed in the table.

6.1 CHEMICAL HAZARDS

The potential health hazards associated with NSB-NLON include inhalation, ingestion, and dermal contact of various contaminants that may be present in shallow and deep soils, and groundwater. Based on prior sampling activities at the sites, the following have been identified as the primary classes of contaminants present in soils and groundwater:

- Volatile Organic Compounds (VOC), specifically chlorinated organic compounds including: Trichloroethene, 1,2-dichloroethene, 1,1,2- trichloroethane, methyl chloride and vinyl chloride
- Metals including: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium compounds, cobalt, copper, lead, manganese, mercury, nickel, vanadium and zinc

Table 6-1 provides information on the toxicological, chemical, and physical properties of these substances. It is anticipated that the greatest potential for exposure to site contaminants is during intrusive activities (air rotary drilling/DPT activities, etc.). Exposure to these compounds is most likely to occur through ingestion and inhalation of contaminated soil or water, or hand-to-mouth contact during soil disturbance activities. For this reason, PPE and basic hygiene practices (washing face and hands before leaving site) will be extremely important. Inhalation exposure will be avoided by using appropriate PPE and engineering controls where necessary. Should this occur, however, personnel will immediately cease operations, retreat to a safe area, and await further guidance from the SSO.

6.2 PHYSICAL HAZARDS

The physical hazards that may be present during the performance of site activities are summarized below:

- Heavy equipment hazards (pinch/compression points, rotating equipment, etc.).
- Slips, trips, and falls
- Energized systems (contact with underground or overhead utilities)
- Lifting (strain/muscle pulls)

- Excavation collapse
- Sudden pressure release from cylinders/containers
- Noise in excess of 85 decibels (dBA)
- Flying projectiles
- Pinches and compressions
- Vehicular and foot traffic
- Contact with sharp objects (glass, metal, etc.)
- Ambient temperature extremes

These physical hazards are discussed in Table 5-1 as applicable to each site task. Further, many of these hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Specific discussions on some of these hazards are presented below.

6.2.1 Heavy Equipment Hazards (Pinch/compression points, rotating equipment, etc.)

Often the hazards associated with drilling operations are the most dangerous to be encountered during site activities. The SSO will thoroughly discuss safe drilling procedures during the pre-activities training session. All site personnel will sign the form in Figure 8-2 documenting that they received the training and understand the procedures. The following rules will apply to all drilling operations:

- Each rig must be equipped with emergency stop devices which will be tested daily to ensure that they are operational.

- Long handled shovels or equivalent shall be used to clear cuttings from the borehole and rotating equipment.

- The driller may not leave the controls when the augers are rotating.

6.2.2 Energized Systems (Contact with Underground or Overhead Utilities)

All subsurface activities must be conducted following the requirements of the TtNUS SOP for "Utility Locating and Excavation Clearance (HS-1.0)". A copy of this SOP is provided as Attachment II. Clearance of underground and overhead utilities for each sample location will be coordinated with NSB-NLON personnel. NSB-NLON Public Works is the point-of-contact for utilities clearance and can be reached at (860) 694-4711. Additionally, drilling operations will be conducted at a safe distance from overhead power lines as detailed in Attachment II. Whenever underground utilities are suspected to be close to subsurface sampling locations, the borehole will be advanced to a minimum of five (5) feet with a hand auger prior to

drilling. As built drawings may also be utilized for additional clarification. In certain cases, NSB-NLON personnel may need to de-energize electrical cables using facility lockout/tagout procedures to insure electrical hazards are eliminated.

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, and inclement weather are natural hazards that may be present given the location of activities to be conducted. In general, avoidance of areas of known infestation or growth will be the preferred exposure control for insects/animals and poisonous plants. Specific discussion on principle hazards of concern follows:

6.3.1 Insect/Animal Bites and Stings, Poisonous Plants, etc.

During warm months (spring through early fall), tick-borne Lyme Disease may pose a potential health hazard. The longer a disease carrying tick remains attached to the body, the greater the potential for contracting the disease. Wearing long sleeved shirts and long pants (tucked into boots). As well as performing frequent body checks will prevent long term attachment. Site first aid kits should be equipped with medical forceps and rubbing alcohol to assist in tick removal. For information regarding tick removal procedures, and symptoms of exposure, consult Section 4.0 of the Health and Safety Guidance Manual. Contact with poisonous plants and bites or stings from poisonous insects are other biological hazards that must be considered. Long pants (tucked into boots), and avoiding potential nesting areas will minimize the hazards of exposure. All site personnel who are allergic to stinging insects such as bees, wasps, and hornets must be particularly careful since severe illness and death may result from allergic reactions. As with any medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet and the FOL and SSO notified.

6.3.1.1 West Nile Virus

In the summer and fall of 1999, West Nile virus (WNV), which was responsible for 62 cases of serious illness and seven deaths, occurred in New York City and surrounding counties. Between 533 and 1,903 persons in an area surveyed in northern Queens (total population 46,220) were likely to have been exposed to WNV. In addition to the human cases, WNV infection was confirmed in hundreds of birds, mostly crows, as well as several horses and other domestic animals.

West Nile virus is transmitted primarily by the *Culex pipiens* mosquito, which feeds on both humans and birds. West Nile virus is new to the Western Hemisphere, and no one can say with any certainty whether the virus has run its course or if the cycle of infection will begin anew when mosquitoes emerge from hibernation. The recent reports of isolations of WNV from over wintering mosquitoes collected in Queens

and a hawk that died in February in Westchester County heighten concern that WNV will reemerge and pose a threat to human health beginning with mosquito activity this spring.

In Connecticut in 1999, WNV was isolated from *Aedes vexans* mosquitoes and *Culex pipiens* mosquitoes collected in the town of Greenwich on September 14. The isolates were found to be the same as virus isolated from the brain of a crow with encephalitis collected in the town of Westport on September 13. Virus isolations were made from 72 of 86 additional crows that died in Fairfield and New Haven Counties in September through October 29,1999, and from the brain of a Cooper's hawk. From September 23 through November 4, 1,040 crow deaths were reported from local health departments (35 towns in 6 of the 8 counties). Ninety percent (931) of the dead crow sightings were in Fairfield County. There were no confirmed human cases of illnesses in people in Connecticut due to WNV.

On September 25, 2000 the state announced the finding of a crow positive for West Nile Virus in the town of Manchester. However the State Mosquito Management Program temporarily suspended ground-level spraying for the control of mosquitoes in the state. When temperatures are below 50 degrees mosquito activity decreases, making ground level spraying less effective. Fall weather forecasts usually present unfavorable conditions; wind, rain and cooler evenings, which will effectively reduce current mosquito populations. The program will resume when weather conditions require.

6.3.1.2 Encephalitis

Encephalitis is an inflammation of the brain and can be caused by bacteria and viruses. West Nile virus is commonly found in Africa, West Asia, and the Middle East. It is closely related to St. Louis encephalitis virus found in the United States. The West Nile-like virus that has been found in New York is genetically related to West Nile virus, but because of genetic differences it may be a new subtype of West Nile virus.

The mosquito becomes infected by feeding on birds infected with the West Nile virus. Infected mosquitoes then transmit the West Nile virus to humans and animals when biting (or taking a blood-meal). West Nile encephalitis is NOT transmitted from person-to-person. There is no evidence that a person can get the virus from handling live or dead infected birds. However, avoid bare-handed contact when handling any dead animals, including dead birds. Ticks have not been implicated as vectors of West Nile-like virus.

Mild infections are common and include fever, headache, and body aches, often with skin rash and swollen lymph glands. More severe infection is marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, occasional convulsions, paralysis and, rarely death (especially in the elderly and very young). The incubation period of West Nile encephalitis is usually 3 to 12 days. There is no specific therapy or vaccine against West Nile encephalitis.

No cases have previously been reported in the U.S. prior to September 1999 (in New York). It is not known how long it has been in the U.S., but scientists believe the virus has probably been in the eastern U.S. for several months, possibly longer.

6.3.1.3 Precautions

- Limit outdoor activities during peak mosquito times – at dusk and dawn.
- Avoid standing water
- Wear long-sleeved shirts and long pants whenever you are outdoors.
- Apply insect repellent according to manufacturers instruction to exposed skin. An effective repellent will contain 20% to 30% DEET (N,N-diethyl-meta-toluamide). Avoid products containing more than 30% DEET.
- Spray clothing with repellents containing permethrin or DEET, mosquitoes may bite through thin clothing.

6.3.2 Inclement Weather

Many of the project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather (electrical storms, hurricanes, etc.) conditions arise, the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
1,2-Dichloroethene	540-59-0	PID: I.P. 9.65 eV, high response with PID and 10.2 eV lamp. FID: 50% response with FID.	Air sample using charcoal tube; and carbon disulfide desorption; Sampling and analytical protocol in accordance with OSHA Method #07; and NIOSH Method #1003.	OSHA; NIOSH; ACGIH: 200 ppm IDLH: 1000 ppm	Adequate- odor threshold 0.085-17 ppm. Use organic vapor/acid gas cartridges for exceedances above the TWA up to 1,000 ppm. >1,000 ppm should use pressure-demand supplied air respirator above exposure limits. **Recommended glove:** nitrile - 0.12 hrs; viton - 0.95 hrs	**Boiling Pt:** 117°F; 47°C **Melting Pt:** 7°F; -13.8°C **Solubility:** 0.4% **Flash Pt:** 36°F; 2.2°C **LEL/LFL:** 5.6% **UEL/UFL:** 12.8% **Vapor Density:** 2.0 **Vapor Pressure:** 180-260 mmHg **Specific Gravity:** 1.27 @ 90°F; 32°C **Incompatibilities:** Strong oxidizers, alkalis, potassium hydroxide, and copper. When heated to decomposition temperatures will emit toxic fumes of phosgene. **Appearance and Odor:** Colorless liquid with an acrid odor.	Overexposure may result in CNS depression with potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, liver, kidney, and lung damage.
Trichloroethene	79-01-6	PID: I.P. 9.45 eV, High response with PID and 10.2 eV lamp. FID: 70% Response with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol shall proceed in accordance with OSHA Method #07, or NIOSH Method #1022 or #1003.	OSHA: 50 ppm 200 ppm (Ceiling) ACGIH: 50 ppm 100 ppm STEL NIOSH: 25 ppm IDLH: 1000 ppm	Inadequate - Odor threshold 82 ppm. APRs with organic vapor/acid gas cartridges may be used for escape purposes. Exceedances over the exposure limits require the use of positive pressure-demand supplied air respirator. **Recommended gloves:** PV Alcohol unsupported >16.00 hrs; Silver shield >6.00 hrs; Teflon >24.00 hrs; or Viton >24.00 hrs; Nitrile (Useable time limit 0.5 hr, complete submersion for the nitrile selection)	**Boiling Pt:** 188°F; 86.7°C **Melting Pt:** -99°F; -73°C **Solubility:** 0.1% @ 77°F; 25°C **Flash Pt:** 90°F; 32°C **LEL/LFL:** 8% @ 77°F; 25°C **UEL/UFL:** 10.5 @ 77°F; 25°C **Vapor Density:** 4.53 **Vapor Pressure:** 100 mmHg @ 90°F; 32°C **Specific Gravity:** 1.46 **Incompatibilities:** Strong caustics and alkalis, chemically active metals (barium, lithium, sodium, magnesium, titanium, and beryllium) **Appearance and Odor:** Colorless liquid with a chloroform type odor. Combustible liquid, however, burns with difficulty.	Central nervous system effects including euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence. Damage to the liver, kidneys, heart, lungs, and skin have also been reported. Contact may result in irritation to the eyes, skin, and mucous membranes. Ingestion may result in GI disturbances including nausea, and vomiting NIOSH lists this substance a potential human carcinogen.
1,1,2- Trichloroethane	79-00-5	PID: I.P. 11.0 eV, relative response ratio unknown. FID: 85% response with FID.	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography-flame ionization detector; Sampling and analytical protocol in accordance with OSHA Method #07, or NIOSH Method #1003 Halogenated Hydrocarbons.	OSHA; NIOSH; ACGIH: 10 ppm (skin) IDLH: 100 ppm	No information was found concerning odor threshold limits. The use of air-purifying respirator with organic vapor cartridge for <100 ppm for escape purposes is permitted. Exceedances above 100 ppm will require the use of airline or SCBA combination units. **Recommended glove:** Butyl rubber,solvent dipped, unsupported - >5.78 hrs; PV alcohol - >8.00 hrs; Teflon - >24.00 hrs; Viton - <24.00 hrs	**Boiling Pt:** 237°F; 114°C **Melting Pt:** -31°F-35°C **Solubility:** 0.6% **Flash Pt:** Not available **LEL/LFL:** 6% **UEL/UFL:** 15.5% **Vapor Density:** Not available **Vapor Pressure:** 19 mmHg @ 68°F; 20°C **Specific Gravity:** 1.44 **Incompatibilities:** Acids, acid fumes, oxidizers, caustics, and chemically active metals such as aluminum, magnesium, sodium, potassium, etc. **Appearance and Odor:** Colorless liquid with a sweet chloroform-like odor.	Overexposure to this substance may cause irritation to the eyes, skin, and mucous membranes of the respiratory and gastrointestinal tract. CNS effects may include sleepiness, incoordination, depression similar to a narcotic. Chronic exposure may cause liver, kidney and lung damage. This substance has demonstrated carcinogenic potential in laboratory animals. Repeated or prolonged exposure may cause dermatitis.

TABLE 6-1
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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Methyl chloride (or chloromethane)	74-87-3	PID: I.P. 11.28 eV, High response with PID and 11.7 eV lamp. FID: 78% response with FID.	Air sample using charcoal or sorbent tube; methylene chloride desorption; gas chromatography-flame ionization detector; Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1001.	OSHA: 100 ppm, 200 ppm (Ceiling), 300 ppm (5-min max peak in any 3 hrs.) ACGIH: 50 ppm SKIN NIOSH: Lowest feasible concentration IDLH: 2000 ppm	Inadequate - Odor threshold 10 ppm or higher. Air purifying respirators are not recommended for use with methyl chloride. For situations requiring respiratory protection use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - (SCBA). **Recommended gloves:** Polyvinyl alcohol glove, unsupported 1-8 hrs	**Boiling Pt:** -12°F **Melting Pt:** -144°F **Solubility:** 0.5% **Flash Pt:** Not available (gas) **LEL/LFL:** 8.1% **UEL/UFL:** 17.4% **Vapor Density:** 1.8 **Vapor Pressure:** 4.8 ATM @ 68°F **Specific Gravity:** 0.92 **Incompatibilities:** Chemically active metals (i.e. aluminum, magnesium, potassium, and zinc); water **Appearance and Odor:** Colorless gas with a sweet odor that is not noticeable at dangerous concentrations.	Methyl chloride is a narcotic and may cause toxic encephalopathy. Severe but non-fatal poisoning in man is characterized by a latent period of several hours, followed by dizziness, nausea, vomiting, double vision, weakness, paralysis, convulsions, and coma; renal or hepatic damage and anemia also occur. Skin contact with pure methyl chloride may cause frostbite. Classified as a potential occupational carcinogen.
Vinyl chloride	75-01-4	PID: I.P. 9.99 eV, High response with PID and 10.2 eV lamp. FID: 40% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detection; Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1007, or OSHA Method #75.	OSHA: 1.0 ppm PEL 5.0 ppm (Ceiling) ACGIH: 5 ppm NIOSH: Lowest Feasible Concentration	Inadequate - Odor threshold 10-20 ppm. Gas Mask with a vinyl chloride Type N canister may be employed for concentrations up to 25 ppm. Canisters employed must have a minimum service life of 4-hrs. Exceedances over 25 ppm, must use a positive pressure demand, open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. **Recommended gloves:** Silver shield >6.00 hrs; Nitrile 5.70 hrs; or Viton 4.4 hrs	**Boiling Pt:** 7°F; -13.9°C **Melting Pt:** -256°F; -160°C **Solubility:** 0.1% @ 77°F; 25°C **Flash Pt:** 18°F; -8°C **LEL/LFL:** 3.6% **UEL/UFL:** 33% **Vapor Density:** 2.21 **Vapor Pressure:** 3.3 atm **Specific Gravity:** N.A. **Incompatibilities:** Oxidizers, copper, aluminum, peroxides, iron, steel, **Appearance and Odor:** Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations.	A severe skin, eye, and mucous membrane irritant(Liquid: frostbite). Narcotic effect causing weakness, abdominal pains, GI bleeding, and pallor skin or cyanosis. Chronic exposure has been linked to the formation of malignant tumors originating from blood lymphatic vessels in the liver (associated enlargement of the liver), and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH.
Aluminum	7429-90-5	Particulate form - unable to be detected by PID/FID.	Air sample using a cellulose ester membrane filter (particulate filter); atomic absorption (Method #7013) or ICP (Method #7300). Sampling and analytical protocol shall proceed in accordance with NIOSH Methods #7013 and #7300 as applicable.	OSHA: 15 mg/m^3 Total dust, 5 mg/m^3 Respirable fraction NIOSH: 10 mg/m^3 Total dust, 5 mg/m^3 Respirable fraction ACGIH: 10 mg/m^3	Particulate form - No identifiable warning properties to indicate presence and thereby detection. Employ air purifying respiratory protection suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** this is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 4452°F; 2450°C **Melting Pt:** 1220°F; 660°C **Solubility:** Insoluble **Flash Pt:** Nonflammable **LEL/LFL:** Nonflammable **UEL/UFL:** Nonflammable It should be noted that finely divided powders or dust when airborne becomes moderately flammable/explosive when exposed to heat, flame, or powerful oxidizers **Vapor Density:** Not available **Vapor Pressure:** 1 mm @ 2343°F; 1284°C **Specific Gravity:** 2.702 @ 77°F; 25°C **Incompatibles:** Acids, alkalis, oxidizers, halogens and halocarbons, alcohols **Appearance and odor:** silvery gray ductile, lustrous metal	Inhalation of finely divided powders or dusts may result in difficulty in breathing, coughing, and has been reported to cause pulmonary fibrosis. This malady known as "Shavers disease" is a form of benign pneumoconiosis.

TABLE 6-1
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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Antimony	7440-36-0	Particulate form - unable to be detected by PID/FID.	Air sample using particulate filter; acid desorption; atomic absorption spectrometry PeCam Sampling and analytical protocol shall proceed in accordance with NIOSH Method #261.	OSHA/NIOSH/ACGIH: 0.5 mg/m³ IDLH: 50 mg/m³	Metallic taste resulting from exposure. **Recommended Air Purifying Cartridges:** Protect from dusts, fumes, and mists use HEPA filters. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 2975°F; 1635°C **Melting Pt:** 1166°F; 630°C **Solubility:** Insoluble **Flash Pt:** Nonflammable **LEL/LFL:** Nonflammable **UEL/UFL:** Nonflammable NOTE: This substance is nonflammable but may present a moderate explosion hazard when airborne dusts of an adequate concentration are exposed to flames. **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 1627°F; 886° C **Specific Gravity:** 6.684 @ 77°F; 25°C **Incompatibles:** Acids, oxidizers, halogens **Appearance and odor:** silvery gray, lustrous metal	This substance is considered a poison by ingestion, irritating to the skin and mucous membranes causing inflammation to the nose,mouth, and throat. Chronic exposure may result in some forms of dermatitis. Ingestion may result in a metallic taste, vomiting, colic, and diarrhea. Chronic exposure may result in addition to those stated above indigestion, loss of appetite and weight, and diarrhea. Sores in the mouth along with a sore throat help distinguish this form of poisoning from other forms of metallic poisoning such as lead and arsenic. Inhalation at excessive concentrations may result in difficulty in breathing, headaches and a bloody discharge from the nose, and chemical pneumonitis.
Arsenic	7440-38-2	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; acid desorption; AAS detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7900.	OSHA: Organic compounds 0.5 mg/m³ Inorganic compounds 0.01 mg/m³ NIOSH: (Ceiling) 0.002 mg/m³ ACGIH: 0.01 mg/m³ IDLH: 5 mg/m³ as arsenic	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. This substance may be presented as a pesticide, therefore a cartridge suitable for pesticides (MSA-GMP). **Recommended Gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** sublimation @ 1134°F; 612°C **Melting Pt:** 1497°F; 814°C @ 36 atm **Solubility:** Insoluble in water;soluble in nitric acid **Flash Pt:** Nonflammable, however, airborne in the form of a dust this substance will support combustion **LEL/LFL:** Nonflammable **UEL/UFL:** Nonflammable **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 372°C (sublimes) **Specific Gravity:** 5.73 **Incompatibilities:** Oxidizers, halogens,zinc, lithium, azides, and acetylides **Appearance and odor:** Gray to black, brittle, crystalline, amorphous, odorless.	Overexposure to this substance through inhalation or ingestion may result in ulceration of the nasal septum, GI disturbances resulting in violent purging and vomiting, hoarse voice, sore throat, excessive salivation, peripheral neuropathy (numbness and burning sensations beginning at the extremities followed by motor weakness), respiratory irritation leading to possible pulmonary edema. Skin or eye contact may result in irritation, conjunctiva, dermatitis, and hyperpigmentation (darkening of the areas exposed) of the skin. This substance has been judged to be a Human carcinogen by NTP, and IARC.

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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Barium	7440-39-3 as Ba 10022-31-8 as Ba $(NO_3)_2$ 10361-37-2 as Ba Cl_2	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using particulate filter; water desorption; AAS detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7056.	OSHA; NIOSH; ACGIH: 0.5 mg/m³ IDLH: 50 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 2984°F 1640°C (decomposes) **Melting Pt:** 1337°F 725°C **Solubility:** Varies between compounds 9/38% **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 10 mmHg @ 1920°F 1049°C **Specific Gravity:** 3.5 **Incompatibilities:** Acids, oxidizers **Appearance and odor:** Silver to white, odorless	Overexposure to this substance results in the solubilization in the water or stomach acids. Symptoms include vomiting, colic, diarrhea (watery sometimes bloody), slow to irregular pulse, transient hypertension, convulsive tremors, and muscular paralysis resulting in stiffness immobility, leg cramps, twitching, and impairment of speech and swallowing. Overexposure to some compounds via inhalation may result in respiratory distress, dyspnea, and baritosis (a benign pneumoconiosis). Direct contact to the skin or eyes may result in irritation.
Beryllium	7440-41-7 as Be	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; acid desorption; AAS/GF detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7102.	OSHA: 0.002 mg/m³, (ceiling) 0.005 mg/m³ NIOSH: 0.0005 mg/m³ ACGIH: 0.002 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 5378°F; 2970°C **Melting Pt:** 2332°F; 1278°C **Solubility:** Insoluble **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 1.85 **Incompatibilities:** Halocarbons, strong oxidizers, acids and caustics **Appearance and odor:** gray to white hard light metal, brittle	Overexposure to this substance may result in respiratory symptoms including difficulty in breathing, coughing, rales, chest pain, possibly pulmonary edema, weakness, fatigue, headache, weight loss. Direct contact may result in irritant action on the skin (dermatitis), eyes (conjunctivae), and mucous membranes. This substance has been identified as a potential human carcinogen.
Cadmium	7440-43-9	Particulate Form - Unable to be easily detected by PID or FID.	Air sample using a mixed cellulose-ester filter / acid desorption and analysis by atomic absorption-flame. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300 or #7048.	OSHA: 2 µg/m³ (0.002 mg/m³) ACGIH: 0.01 mg/m³ (total particulate) 0.002 mg/m³ (respirable particulate) IDLH: 9 mg/m3 (as cd)	The use of an air purifying, full face-piece respirator with a high efficiency particulate air filter for concentrations up to 0.25 mg/m³. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 1412°F; 767°C **Melting Pt:** 610°F; 321°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 741°F; 394°C **Specific Gravity:** 8.65 @ 90°F; 32°C **Incompatibilities:** Strong oxidizers, elemental sulfur, selenium, tellurium, zinc, nitric acid, and hydrazoic acid **Appearance and Odor:** Metal: Silver-white, blue-tinged lustrous, odorless solid. Fume: yellow-brown, finely divided particulate dispersed in air.	Overexposure to this substance may result in irritation to the respiratory tract, dyspnea, tightness in the chest, coughing, possibly pulmonary edema. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Chronic exposure may result in damage to the lungs, kidneys and liver. This substance has been identified as a confirmed animal; potential human carcinogen by IARC and NTP.

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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Chromium Compounds	7440-47-3 (Element)	Not detectable by PID. Not detectable by FID.	Air sample using mixed cellulose - ester filter; acid desorption and analysis by atomic absorption. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7024.	OSHA & NIOSH: (Chromium II, III) 0.5 mg/m³ (Chromium VI) 0.1 mg/m³ (Ceiling) ACGIH: 0.5 mg/m³ (Chromium II, III compounds), 0.05 mg/m³ (Chromium VI compounds) IDLH: 30 mg/m³ (Chromium VI compounds)	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter for concentrations up to 0.1 mg/m³. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 4788°F; 2642°C **Melting Pt:** 3452°F; 1900°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 7.14 **Incompatibilities:** Strong oxidizers, peroxides, and alkalis **Appearance and Odor:** Appearance and odor vary depending upon the specific compound.	Health hazards are characterized normally through chronic exposure manifesting as histologic fibrosis of the lungs and ulceration of the nasal septum and skin. IARC, NTP and ACGIH list various chromium compounds as possessing carcinogenic properties.
Cobalt	7440-48-4 as Co	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; acid desorption; Atomic Absorption Spectrophotometry (AAS) detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7027.	OSHA; NIOSH; ACGIH: 0.05 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 5612°F; 3100°C **Melting Pt:** 2719°F; 1493°C **Solubility:** Insoluble in water; soluble in nitric acid **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 8.92 **Incompatibilities:** Strong oxidizers, and ammonium nitrate **Appearance and odor:** Silver-gray to black solid, odorless	Overexposure to this substance through ingestion may result in symptoms of nausea, and vomiting. Symptoms manifested through inhalation may include wheezing, coughing, dyspnea, increased by reduced pulmonary volume by nodular fibrosis. Direct contact may result in irritation leading to dermatitis of the skin. Irritation to the eyes may result largely from mechanical damage.
Copper and Copper Oxide	7440-50-8 (Cu) 1317-38-0 (CuO)	Substance is not volatile. Unable to be detected by PID or FID.	Air sample using a mixed cellulose ester filter; inductively coupled plasma/atomic emission spectroscopy. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300.	NIOSH; OSHA: 0.10 mg/m³ ACGIH: 0.2 mg/m³	The use of an air-purifying full-face respirator with a high efficiency particulate air filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 4703°F; 2595°C **Melting Pt:** 1981°F; 1083°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 8.94 **Incompatibilities:** Oxidizers, alkalis, sodium azide, acetylene, bromates, chlorates, iodates, and acids. **Appearance and Odor:** Metal: Reddish, lustrous malleable, odorless solid. Fume: Finely divided black particulate dispersed in air.	Irritation to the nose, throat, and respiratory tract. Metallic taste Discoloration of skin (potential dermatitis) and hair. Chronic exposure may result in dermatitis and damage to the liver and kidneys. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Ingestion may cause burning in the mouth, throat, and stomach. Metallic taste with colicky abdominal pain. Individuals with Wilson's disease are at greater risk of chronic exposure as a result of the bodies tendency to absorb and retain copper.

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SITES 3, 15, AND 20 NSB NEW LONDON

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Lead	7439-92-1	Particulate form - Unable to be detected by either PID or FID.	Air sample using a mixed cellulose ester filter; or HNO_3 or H_2O_2 desorption; or Atomic absorption detection. NIOSH Method #7082 or #7300.	OSHA: 0.05 mg/m³ ACGIH: 0.05 mg/m³ NIOSH: 0.10 mg/m³ IDLH: 100 mg/m³ as lead	The use of a air purifying, full-face respirator with high efficiency particulate air filter for up to 2.5 mg/m³. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 3164°F; 1740°C **Melting Pt:** 621°F; 327°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 11.34 **Incompatibilities:** Strong oxidizers, peroxides, sodium acetylide, zirconium, and acids **Appearance and Odor:** Metal: A heavy ductile, soft gray solid.	Overexposure to this substance via ingestion or inhalation may result in metallic taste in the mouth, dry throat, thirst, Gastrointestinal disorders (burning stomach pain, nausea, vomiting, possible diarrhea sometimes bloody or black, accompanied by severe bouts of colic), CNS effects (muscular weakness, pain, cramps, headaches, insomnia, depression, partial paralysis possibly coma and death. Extended exposure may result in damage to the kidneys, gingival lead line, brain, and anemia.
Manganese	7439-96-5 as Mn	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using particulate filter; acid desorption, ICP detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300.	OSHA: Ceiling 5 mg/m³ as a fume 1 mg/m³ NIOSH: 1 mg/m³ for dust and fume 3 mg/m³ as a STEL ACGIH: 5 mg/m³ for dust 1 mg/m³ for fume IDLH: 500 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 3452°F; 1900°C **Melting Pt:** 2300°F; 1260°C **Solubility:** Insoluble **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals. This substance is considered a combustible solid.) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 2358°F; 1292 °C **Specific Gravity:** 7.20 **Incompatibilities:** Strong oxidizers, halogens, and nitrates. Will react with water to produce hydrogen gas. **Appearance and odor:** Silvery solid or reddish-gray, odorless	Overexposure to this product may result in Central Nervous System and pulmonary effects by inhalation. Symptoms may include disturbances in gait and speech, sleepiness, mental confusion, stolid, masklike face, muscular twitching varying from tremors to coarse rhythmical movements of the extremities accompanied by cramps. Symptoms are described as postencephalitic Parkinsonism. Additionally dry throat, tightness in the chest, dyspnea, rales, flu-like symptoms low back pain, and vomiting.
Mercury	7439-97-6	Jerome Mercury Vapor Analyzer This substance is unable to be detected by PID/FID.	Air sample using Hydrar® sorbent tube; acid desorption; AA cold detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #6009.	OSHA; NIOSH; ACGIH: as alkyl compounds 0.01 mg/m³; STEL 0.03 mg/m³ IDLH: 10 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for Metallic mercury with HEPA filter. Preferably, with an end-of-service life indicator. **Recommended gloves:** Rubber gloves	**Boiling Pt:** 674°F; 356.9°C **Melting Pt:** -38°F; -38.89°C **Solubility:** Insoluble **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0.0012 mmHg @ 77°F; 25°C **Specific Gravity:** 13.6 **Incompatibilities:** Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper **Appearance and odor:** Silvery-white heavy mobile liquid, odorless	This substance is corrosive to all points of contact. Systemic symptoms include irritability, wakefulness, muscle weakness and tremors, increased reflexes, gingivitis, anorexia, headache, tinnitus, hypermobility, GI disturbances (nausea, vomiting), diarrhea (sometimes bloody), liver changes, dermatitis, and fever. Symptoms experienced via inhalation include to those above coughing, chest pain, dyspnea, bronchial pneumonitis, and excessive salivation.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
SITES 3, 15, AND 20 NSB NEW LONDON

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Nickel	7440-02-0	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using particulate filter; acid desorption; ICP detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300.	OSHA: as Ni metal and insoluble compounds 1 mg/m³ NIOSH: 0.015 mg/m³ ACGIH: 0.05 mg/m³ IDLH: 10 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This material is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 4946°F; 2730°C **Melting Pt:** 2651°F; 1455°C **Solubility:** Insoluble acid **Flash Pt:** Not available(Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 3290°F; 1810 °C **Specific Gravity:** 8.90 **Incompatibilities:** Strong acids, halogens, sulfur, wood and other combustibles, nickel nitrate, and oxidizers **Appearance and odor:** Silvery white, hard, malleable ductile metal, odorless	Symptoms of overexposure to this product may include headaches, vertigo, delirium, extreme weakness, GI disturbance and pain including nausea vomiting and diarrhea, coughing, hyperpnea, cyanosis, weakness, allergic dermatitis, nickel itch, pulmonary asthma, chest pains tightness, dyspnea, dry cough, and conjunctivitis. This substances has been identified as a Human carcinogen by NTP and IARC.
Vanadium Peroxide	7440-62-2 as V metal 1314-62-1 as vanadium pentoxide	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; tetrahydrofuran desorption; XRD detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300.	ACGIH: 0.05 mg/m3(Vanadium Peroxide) OSHA, NIOSH: 0.05 mg/m³ (Ceiling) BET -Vanadium in urine	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 3182 (Decomposes)°F; 1736°C **Melting Pt:** 1274°F; 690°C **Solubility:** Insoluble **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 3.36 **Incompatibilities:** Strong acids, lithium, oxidizers, chlorine **Appearance and odor:** Yellow orange powder	Symptoms of overexposure to this substance may include conjunctivitis, rhinitis, green tongue metallic taste, irritation to the respiratory tract, coughing, rales, dyspnea, bronchitis, bronchospasms, with asthma-like diseases in more severe cases, anemia, loss of skin pallor, and GI disturbances.
Zinc	7440-66-6	Particulate form - This substance is not detectable using a PID or FID.	Air sample using a particulate filter; acid desorption; AAS detection. Sampling and analytical protocol will proceed in accordance with NIOSH Method #7300.	OSHA: 10 mg/m³ Total dust, 5 mg/m³ Respirable fraction NIOSH: 5 mg/m³, 15 mg/m³ (Ceiling) ACGIH: 10 mg/m³	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 1666°F; 908°C **Melting Pt:** 788°F; 419.8°C **Solubility:** Insoluble **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 7.14 **Incompatibilities:** Strong acids, halogens, catalytic metals, combustibles, oxidizers, nitryl fluoride **Appearance and odor:** Bluish-white, lustrous metal, odorless	Inhalation of fumes may result in metal fume fever. This condition is characterized by metallic taste, dryness of the throat, coughing with generalized aching and flu-like symptoms. Effects through ingestion may include coughing, difficulty in breathing, and sweating. A human skin irritant. Irritation to the eyes may result from mechanical action.

7.0 AIR MONITORING

Some of the anticipated site contaminants are not volatile, and cannot be detected with the use of direct reading instruments (DRIs), specifically, the metals. Therefore DRI's will be used to screen source areas (boring and well head locations, etc.) and worker breathing zones for any detectable contaminants. Action Levels are listed in Table 5-1 as they may apply to a specific task or location. This approach (coupled with the use of PPE and the observance of the other control requirements presented in this HASP) will minimize the potential for personnel exposures to hazardous concentrations (known or unknown) of airborne contaminants. Additionally, the Health and Safety Guidance Manual, Section 1.0, contains detailed information regarding direct reading instrumentation, as well as general calibration procedures of various instruments.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas, while observing instrument action levels. Action levels are discussed in Table 5-1 as they may apply to a specific task or location.

7.1.1 Photoionization Detector or Flame Ionization Detector

In order to accurately monitor for any substances which may present an exposure hazard to site personnel, a Photoionization Detector (PID) with a lamp energy of 11.7 eV or higher or Flame Ionization Detector will be used. This instrument will be used to monitor potential source areas and to screen the breathing zones of employees during site activities.

Prior to the commencement of any field activities, the background levels of the site must be determined. Daily background readings will be taken in clean areas away from any potential contamination. These readings, any influencing conditions (i.e., weather, temperature, humidity) and site location must be documented in the field operations logbook or other site documentation (e.g., sample log sheet).

7.1.2 Hazard Monitoring Frequency

Table 5-1 presents the frequencies that hazard monitoring will be performed as well as the action levels which will initiate the use of elevated levels of protection. The SSO may decide to increases these frequencies based on instrument responses and site observations. The frequency at which monitoring is performed will not be reduced without the prior consent of the PHSO or HSM.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the TtNUS Equipment Manager. Operational checks and field calibration will be performed on all instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturer's recommendations (for example, the PID/FID must be field calibrated daily and an additional field calibration must be performed at the end of each day to determine any significant instrument drift). These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with the applicable manufacturer standard operating procedure (copies of which can be found in the Health & Safety Guidance Manual which will be maintained on site for reference). All calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that all of the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

FIGURE 7-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: _____ **PROJECT NO.:**_____

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section is included to specify health and safety training and medical surveillance requirements for both TtNUS and subcontractor personnel participating in site activities.

8.1.1 Requirements for TtNUS Personnel

All TtNUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the NSB-NLON facility. Additionally, TtNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training in the past 12 months before being cleared for site work. In addition, 8-hour supervisory training in accordance with 29 CFR 1910.120 (e)(4) will be required for site supervisory personnel.

Documentation of TtNUS introductory, supervisory, and refresher training as well as site-specific training will be maintained at the project. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.1.2 Requirements for Subcontractors

All TtNUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120 (e). Additionally, personnel who have had the introductory training more than 12 months ago, are required to have 8 hours of refresher training meeting the requirements of 29 CFR 1910.120 (e)(8) prior to performing field work at the NSB-NLON facility if required. TtNUS subcontractors must certify that each employee has had such training by sending TtNUS a letter, on company letterhead, containing the information in the example letter provided as in Figure 8-1 and by providing copies of certificates for all subcontractor personnel participating in site activities.

FIGURE 8-1
TRAINING LETTER

The following statements must be typed on company letterhead and signed by an officer of the company and accompanied by copies of personnel training certificates:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Corey Rich, P.E.
Tetra Tech NUS, Inc.
Task Order Manager
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: HAZWOPER Training for NSB-NLON, Groton, Connecticut

Dear Mr. Rich:

As an officer of XYZ Corporation, I hereby state that I am aware of the potential hazardous nature of the subject project. I also understand that it is our responsibility to comply with all applicable occupational safety and health regulations, including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through 1910 and Part 1926.

I also understand that Title 29 CFR 1910.120, entitled "Hazardous Waste Operations and Emergency Response," requires appropriate level of training for certain employees engaged in hazardous waste operations. In this regard, I hereby state that the following employees have had 40 hours of introductory hazardous waste site training or equivalent work experience as requested by 29 CFR 1910.120(e) and have had 8 hour of refresher training as applicable and as required by 29 CFR 1910.120(e)(8) and that site supervisory personnel have had training in accordance with 29 CFR 1910.120(e)(4).

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have any questions, please contact me at (555) 555-5555

Sincerely,

(Name and Title of Company Officer)

Enclosed: Training Certificates

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to all TtNUS employees and subcontractor personnel who will perform work on this project. Site-specific training will also be provided to all personnel (U.S. Department of Defense, EPA, etc.) who may enter the site to perform functions that may or may not be directly related to site operations. Site-Specific training will include:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits

Site-specific documentation will be established through the use of Figure 8-2. All site personnel and visitors must sign this document upon receiving site-specific training.

8.3 MEDICAL SURVEILLANCE

8.3.1 Medical Surveillance Requirements for TtNUS Personnel

All TtNUS personnel participating in project field activities will have had a physical examination meeting the requirements of TtNUS's medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained in the TtNUS Pittsburgh office and made available, as necessary.

FIGURE 8-2

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing remedial investigation activities at NSB-NLON, Groton, Connecticut, and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits

My signature below indicates that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction, and that the dates of my training and medical surveillance indicated below are accurate.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

8.3.2 Medical Surveillance Requirements for Subcontractors

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" provided in Figure 8-3 shall be used to satisfy this requirement, providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute "Subcontractor Medical Approval Form" (See Figure 8-3) with a letter, on company letterhead, containing all of the information in the example letter presented in Figure 8-4 of this HASP.

8.3.3 Requirements for All Field Personnel

Each field team member (including subcontractors) and visitors entering the Exclusion Zone(s) shall be required to complete and submit a copy of Medical Data Sheet found in the TtNUS Health and Safety Guidance Manual. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTIONS

Subcontractors who will not enter the Exclusion Zone during intrusive operations, and whose activities involve no potential for exposure to site contaminants, will not be required to meet the requirements for training/medical surveillance other than those stated for site-specific training (See Section 8.2).

FIGURE 8-3

SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name

Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f) and found to be medically:

   ( ) qualified to perform work at the NSB-NLON work site
   ( ) not qualified to perform work at the NSB-NLON work site

   and,

2. Undergone a physical examination as per OSHA 29 CFR 1910.134(b)(10) and found to be medically:

   ( ) qualified to wear respiratory protection
   ( ) not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

( ) A copy of OSHA Standard 29 CFR 1910.120 and appendices.
( ) A description of the employee's duties as they relate to the employee's exposures.
( ) A list of known/suspected contaminants and their concentrations (if known).
( ) A description of any personal protective equipment used or to be used.
( ) Information from previous medical examinations of the employee which is not readily available to the examining physician.

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 8-3
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

1. Results of the medical examination and tests (excluding finding or diagnoses unrelated to occupational exposure):

   _____
   _____
   _____

2. Any detected medical conditions that would place the employee at increased risk of material impairment of the employee's health:

   _____
   _____
   _____

3. Recommended limitations upon the employee's assigned work:

   _____
   _____
   _____

I have informed this participant of the results of this medical examination and any medical conditions that require further examination of treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the NSB-NLON work site, this participant

( ) may
( ) may not

perform his/her assigned task.

Physician's Signature _____

Address _____

Phone Number _____

NOTE: Copies of test results are maintained and available at:

_____
Address

FIGURE 8-4

MEDICAL SURVEILLANCE LETTER

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Corey Rich, P.E.
Tetra Tech NUS, Inc.
Task Order Manager
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: HAZWOPER Medical Surveillance for NSB-NLON, Groton, Connecticut

Dear Mr. Rich:

As an officer of XYZ Corporation, I hereby state that the persons listed below participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR) Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response. I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a license physician, to perform hazardous waste site work and to wear positive- and negative-pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at the NSB-NLON facility.

LIST OF FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have any questions, please contact me at (555) 555-5555

Sincerely,

(Name and Title of Company Officer)

9.0 SITE CONTROL

This section outlines the means by which TtNUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three-zone approach will be used during work at this site, including an Exclusion Zone, a Contamination Reduction Zone, and a Support Zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize potentials for the spread of contaminants and to protect individuals who are not cleared to enter the work areas.

9.1 EXCLUSION ZONE

The Exclusion Zone will be considered those areas of the site of known or suspected contamination. It is not anticipated that significant amounts of surface contamination are in the proposed work areas of this site. It is anticipated that this will remain so until/unless contaminants are brought to the surface by intrusive activities such as drilling. Furthermore, once such activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the Contamination Reduction Zone. Therefore, the Exclusion Zones for this project will be limited to those areas if the site where active work is being performed plus an established safety zone depending on the task, as follows:

- Soil boring – The boundary perimeter will be established by determining the height of the drill rig mast, plus five feet. For example, if the rig mast is 35 feet the Exclusion Zone would be a 40-foot boundary surrounding the point of operation.

- Surface/subsurface soils and bedrock – Five feet surrounding the sample collection point.

- Decontamination (heavy equipment – steam/pressure washers) – 35 feet surrounding the point of operation. Equipment decontamination will take place at a centralized location.

9.1.1 Exclusion Zone Clearance

A pre-startup site visit will be conducted by members of the field team in an effort to identify proposed subsurface investigation locations, conduct utility clearances, and provide up-front notices concerning scheduled activities within the facility. In all cases, no subsurface activities will proceed without utility clearance, and all activities must follow the TtNUS SOP for "Utility Locating and Excavation Clearance". In the event that a utility is struck during a subsurface investigative activity, the emergency numbers

provided in Table 2-1 will be notified. When base personnel are working within the proximity of this investigation, they will be moved or their operation temporarily discontinued to remove them from potential hazards associated with this operation.

9.2 CONTAMINATION REDUCTION ZONE

The Contamination Reduction Zone (CRZ) will be a buffer area between the Exclusion Zone and any area of the site where contamination is not suspected. This area will also serve as a focal point in supporting Exclusion Zone activities. This area will be delineated using barrier tape, cones, and postings to inform and direct facility personnel. Decontamination will be conducted at a central location. All equipment potentially contaminated will be bagged and taken to that location for decontamination.

9.3 SUPPORT ZONE

The Support Zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. In all cases, the Support Zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

9.4 SAFE WORK PERMITS

All Exclusion Zone work conducted in support of this project will be performed using Safe Work Permits to guide and direct field crews on a task by task basis. An example of the Safe Work Permit to be used is illustrated in Figure 9-1. Partially completed Permits for the work to be performed are included in Attachment IV. The daily meetings conducted at the site will further support these work permits. This effort will ensure all site-specific considerations and changing conditions are incorporated into the planning effort. All permits will require the signature of the FOL and SSO. Use of these permits will provide the communication line for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of protection and control measures. The work permit will take precedence over the HASP when more conservative measures are required based on specific site conditions.

FIGURE 9-1
SAFE WORK PERMIT

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope (To be filled in by person performing work)

I. Work limited to the following (description, area, equipment used): _____

II. Names: _____

III. Onsite Inspection conducted Yes No Initials of Inspector _____ _____
TtNUS NSB-NLON

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SKA-PAC SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☐

Modifications/Exceptions: _____

V. Chemicals of Concern | Action Level(s) | Response Measures

Chemicals of Concern	Action Level(s)	Response Measures

VI. Additional Safety Equipment/Procedures

Hardhat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☐ No
Chemical/splash goggles	☐ Yes	☐ No	Radio	☐ Yes	☐ No
Splash Shield	☐ Yes	☐ No	Barricades	☐ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type)	☐ Yes	☐ No
Steel toe/shank Workboots	☐ Yes	☐ No	Work/rest regimen	☐ Yes	☐ No

Modifications/Exceptions: _____

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	NA
Equipment drained/depressured	☐	☐
Equipment purged/cleaned	☐	☐
Isolation checklist completed	☐	☐
Electrical lockout required/field switch tested	☐	☐
Blinds/misalignments/blocks & bleeds in place	☐	☐
Hazardous materials on walls/behind liners considered	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☐ No
If yes, fill out appropriate section(s) on safety work permit addendum

X. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____
Job Completed by: _____ Date: _____

9.5 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by TtNUS
- Regulatory personnel (DOD, OSHA, DEP, etc.)
- Engineering Field Activity Northeast Navy Personnel
- Other authorized visitors

It is not anticipated that this operation will result in a large number of site visitors. However, as some visitors can reasonably be expected, the following requirements will be enforced:

- All site visitors will be routed to the FOL, who will sign them in to the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), who they represent, and purpose for the visit.

- All site visitors will be required to produce the necessary information supporting clearance onto the site. This includes information attesting to applicable training (40-hours of HAZWOPER training required for all Engineering Field Activity Northeast Navy personnel) and medical surveillance, as stipulated in Section 8 of this document. In addition, to enter the site's operational zones during planned activities, all visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this document.

NOTE: All site visitors will be escorted at all times while at the site.

Following this, the site visitor will be permitted to enter the site and applicable operational areas. All visitors are required to observe the protective equipment and site restrictions in effect at the area of their visit. Any and all visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause all onsite activities to be terminated until that visitor can be removed. Removal of unauthorized visitors will be accomplished with support from the NSB-NLON Contact, if necessary.

9.6 SITE SECURITY

Site security will be accomplished using TtNUS field personnel. TtNUS will retain complete control over active operational areas. As this activity takes place at Navy facilities open to public access and within a public parking area, the first line of security will take place using traffic/parking restrictions, Exclusion Zone

barriers, and any existing barriers at the sites to restrict the general public. The second line of security will take place at the work site referring interested parties to the FOL or designee. The FOL will serve as a focal point for all non-project interested parties, and serve as the final line of security and the primary enforcement contact.

9.7 SITE MAP

Once the areas of contamination, access routes, topography, and dispersion routes are determined, a site map will be generated and adjusted as site conditions change. When possible, these maps will be posted to illustrate up-to-date collection of contaminants and adjustment of zones and access points.

9.8 BUDDY SYSTEM

Personnel engaged in on-site activities will practice the "buddy system" to ensure the safety of all personnel involved in this operation.

9.9 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for all chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of all chemicals used on site will be developed using the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

9.10 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crews members will not be necessary. External communication will be accomplished by using the telephones at predetermined and approved locations. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities, the FOL will determine and arrange for telephone communications.

10.0 SPILL CONTAINMENT PROGRAM

10.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials (over 55-gallons) will be handled at any given time, or that any cylinders or containers will be unearthed, as part of this scope of work. It is also not anticipated that such spillage would constitute a danger to human health or the environment. However, as the job progresses, the potential may exist for accumulating Investigative Derived Wastes (IDW) such as decontamination fluids, soil cuttings, and purge and well development waters, in a central staging area. Once these fluids and other materials have been characterized, they can be removed from this area and properly disposed.

10.2 POTENTIAL SPILL AREAS

Potential spill areas will be periodically monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, limited areas are vulnerable to this hazard including:

- Resource deployment
- Waste transfer
- Central staging

It is anticipated that all IDW generated as a result of this scope of work will be containerized, labeled, and staged to await further analyses. The results of these analyses will determine the method of disposal.

10.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk-around by the personnel staging or disposing of drums or in the resource deployment area will be conducted during working hours to visually determine that storage vessels are not leaking. If a leak is detected, the contents will be transferred, using a hand pump, into a new vessel. The leak will be collected and contained using absorbents such as Oil-Dry, vermiculite, or sand, which are stored at the vulnerable areas in a conspicuously marked drum. This used material, too, will be containerized for disposal pending analysis. All inspections will be documented in the project logbook.

It is not anticipated that any cylinders or containers will be unearthed during site activities. Should a cylinder or container be uncovered, however, work will immediately be stopped and personnel will retreat to a safe area until directed by the FOL or SSO.

10.4 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed in the procedures for incipient spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and the SSO will serve as the Spill Response Coordinators for this operation, should the need arise.

10.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment that may be maintained (depending on anticipated need) at the staging areas at all times for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other non combustible absorbent (Oil-dry)
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Shovels, rakes, and brooms

10.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crewmembers will employ upon the detection of a spill or leak.

1. Notify the SSO or FOL immediately upon detection of a leak or spill. Activate emergency alerting procedures for that area to remove all non-essential personnel.

2. Employ the personal protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the container or raising the leak to the highest point in the vessel. Spread the absorbent material in the area of the spill, covering it completely.

3. Transfer the material to a new vessel; collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment and disposal options.

4. Re-containerize spills, including top cover impacted by the spill. Await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crew cannot handle. Should this occur, notification of the appropriate Emergency Response agencies will be carried out by the FOL or SSO in accordance with the procedures discussed in Section 2.0 of this HASP.

11.0 CONFINED-SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter any confined spaces (including test pits).** A confined space is defined as an area which has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS FOL shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for all chemicals brought on-site, including decon solution, fuels, sample preservations, calibration gases, etc.
- A full size OSHA Job Safety and Health Poster
- Training/Medical Surveillance Documentation Form (blank)
- Emergency Reference Form (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting these documents is not feasible, (such as no office trailer), these documents should be separated and immediately accessible.

Chemical Inventory Listing (posted) - This list represents all chemicals brought on-site, including decontamination solutions, sample preservations, fuel, etc.. This list should be posted in a central area.

Material Safety Data Sheets (MSDS) (maintained) - The MSDSs should also be in a central area accessible to all site personnel. These documents should match all the listings on the chemical inventory list for all substances employed on-site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - this poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaces, altered, or covered by other material.

Site Clearance (maintained) - This list is found within the training section of the HASP (See Figure 8-2). This list identifies all site personnel, dates of training (including site-specific training), and medical surveillance. The lists indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at all phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. a copy of this sheet or a wallet card will be given to all personnel to be carried on their person.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - this standard will be posted anytime hearing protection or other noise abatement procedures are employed.

Personnel Monitoring (maintained) - All results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

Placards and Labels (maintained) - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using DOT placards and acceptable (Hazard Communication 29 CFR 1910.1200(f)) labels.

The purpose, as stated above, is to allow site personnel quick access to this information. Variations concerning location and methods of presentation are acceptable, providing the objection is accomplished.

13.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action - Navy
CNS	Central Nervous System
CTO	Contract Task Order
CZR	Contamination Reduction Zone
DEP	Department of Environmental Protection (Connecticut)
DOD	United States Department of Defense
eV	electron Volts
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
IDLH	Immediate Dangerous to Life or Health
IDW	Investigative-Derived Wastes
MSDA	Material Safety Data Sheets
N/A	Not Available
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicity Program
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PPE	Personal Protective Equipment
PM	Project Manager
SOPs	Standard Operating Procedures
SSO	Site Safety Officer
TBD	To be determined
TLV	Threshold Limit Value
TWA	Time-Weighted Average
WP	Work Plan

ATTACHMENT I

INJURY/ILLNESS PROCEDURE AND REPORT FORM

CASE NO. _____

TETRA TECH NUS, INC.

INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

WHAT YOU SHOULD DO IF YOU ARE INJURED OR DEVELOP AN ILLNESS AS A RESULT OF YOUR EMPLOYMENT:

- If injury is minor, obtain appropriate first aid treatment.
- If injury or illness is severe or life threatening, obtain professional medical treatment at the nearest hospital emergency room.
- If incident involves a chemical exposure on a project work site, follow instructions in the Health & Safety Plan.
- Immediately report any injury or illness to your supervisor or office manager. In addition, you must contact your Human Resources representative, Marilyn Diethorn at (412) 921-8475, and the Corporate Health and Safety Manager, Matt Soltis at (412) 921-8912 within 24 hours. You will be required to complete an Injury/Illness Report (attached). You may also be required to participate in a more detailed investigation from the Health Sciences Department.
- If further medical treatment is needed, The Hartford Network Referral Unit will furnish a list of network providers customized to the location of the injured employee. These providers are to be used for treatment of Worker's Compensation injuries subject to the laws of the state in which you work. Please call Marilyn Diethorn at (412) 921-8475 for the number of the Referral Unit.

ADDITIONAL QUESTIONS REGARDING WORKER'S COMPENSATION:

Contact your local human resources representative, corporate health and safety coordinator, or Corporate Administration in Pasadena, California, at (626) 351-4664.

Worker's compensation is a state-mandated program that provides medical and disability benefits to employees who become disabled due to job related injury or illness. Tetra Tech, Inc. and its subsidiaries (Tetra Tech or Company) pay premiums on behalf of their employees. The type of injuries or illnesses covered and the amount of benefits paid are regulated by the state worker's compensation boards and vary from state to state. Corporate Administration in Pasadena is responsible for administering the Company's worker's compensation program. The following is a general explanation of worker's compensation provided in the event that you become injured or develop an illness as a result of your employment with Tetra Tech or any of its subsidiaries. Please be aware that the term used for worker's compensation varies from state to state.

WHO IS COVERED:

All employees of Tetra Tech, whether they are on a full-time, part-time or temporary status, working in an office or in the field, are entitled to worker's compensation benefits. All employees must follow the above injury/illness reporting procedures. Consultants, independent contractors, and employees of subcontractors are <u>not</u> covered by Tetra Tech's Worker's Compensation plan.

CASE NO. _____

WHAT IS COVERED:

If you are injured or develop an illness caused by your employment, worker's compensation benefits are available to you subject to the laws of the state you work in. Injuries do not have to be serious; even injuries treated by first aid practices are covered and must be reported. Please note that if you are working out-of-state and away from your home office, you are still eligible for worker's compensation benefits.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT

To: _____
Subsidiary Health and Safety Representative

cc: _____
Workers Compensation Administrator

Project name: _____

Project number: _____

Prepared by: _____

Position: _____

Office: _____

Telephone number: _____

Fax number: _____

Information Regarding Injured or Ill Employee

Name: _____

Home address: _____

_____

Home telephone number: _____

Occupation (regular job title): _____

Department: _____

Office: _____

Gender: M ☐ F ☐ No. of dependents: _____

Marital status: _____

Date of birth: _____

Social security number: _____

Date of Accident: _____

Time Employee Began Work: _____

Time of Accident: _____ a.m. ☐ p.m. ☐

☐ Check if time cannot be determined

Location of Incident

Street address: _____

City, state, and zip code: _____

County: _____

Was place of accident or exposure on employer's premises? Yes ☐ No ☐

Information About the Incident

What was the employee doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the employee was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from hand sprayer"; "Daily computer key-entry"

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor, worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time"

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

Information About the Incident (Continued)

What was the injury or illness? Describe the part(s) of the body affected and how it was affected. Be more specific than "hurt," "pain," or "sore." Examples "Strained back"; "Chemical burn, right hand"; "Carpal tunnel syndrome, left wrist"

Describe the Object or Substance that Directly Harmed the Employee: Examples: "Concrete floor"; "Chlorine"; "Radial arm saw." If this question does not apply to the incident, write "Not applicable."

Did the employee die? Yes ☐ No ☐ Date of death: _____

Was employee performing regular job duties? Yes ☐ No ☐

Was safety equipment provided? Yes ☐ No ☐ Was safety equipment used? Yes ☐ No ☐

Note: Attach any police reports or related diagrams to this report.

Witness (Attach additional sheets for other witnesses.)

Name: _____

Company: _____

Street address: _____

City: _____ State: _____ Zip code: _____

Telephone number: _____

Medical Treatment Required? ☐ Yes ☐ No ☐ First aid only

Name of physician or health care professional: _____

If treatment was provided away from the work site, provide the information below.

Facility name: _____

Street address: _____

City: _____ State: _____ Zip code: _____

Telephone number: _____

Was the employee treated in an emergency room? ☐ Yes ☐ No

Was the employee hospitalized over night as an in-patient? ☐ Yes ☐ No

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

Corrective Action(s) Taken by Unit Reporting the Accident:

Corrective Action Still to be Taken (by whom and when):

Name of Tetra Tech employee the injury or illness was first reported to: _____

Date of Report: _____ **Time of Report:** _____

I have reviewed this investigation report and agree, to the best of my recollection, with its contents.

_____ _____
Printed Name of Injured Employee Telephone Number

_____ _____
Signature of Injured Employee Date

The signatures provided below indicate that appropriate personnel have been notified of the incident.

Title	Printed Name	Signature	Telephone Number	Date
Office Manager				
Project Manager				
Site Safety Coordinator or Office Health and Safety Representative				

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

To Be Completed by the Subsidiary Health and Safety Representative

Classification of Incident:

☐ Injury ☐ Illness

Result of Incident:

☐ First aid only

☐ Days away from work

☐ Remained at work but incident resulted in job transfer or work restriction

☐ Incident involved days away and job transfer or work restriction

☐ Medical treatment only

No. of days away from work _____

Date employee left work _____

Date employee returned to work _____

No. of days placed on restriction or job transfer: _____

OSHA Recordable Case Number _____

To Be Completed by Human Resources

Social security number: _____

Date of hire: _____ Hire date for current job: _____

Wage information: $ _____ per ☐ Hour ☐ Day ☐ Week ☐ Month

Position at time of hire: _____

Current position: _____ Shift hours: _____

State in which employee was hired: _____

Status: ☐ Full-time ☐ Part-time Hours per week: _____ Days per week: _____

Temporary job end date: _____

To Be Completed during Report to Workers Compensation Carrier

Date reported: _____ Reported by: _____

Confirmation number: _____

Name of contact: _____

Field office of claims adjuster: _____

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

ATTACHMENT II

STANDARD OPERATING PROCEDURE FOR UTILITY LOCATING AND EXCAVATION CLEARANCE

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of the TtNUS Utility Locating and Clearance Policy. The TtNUS Utility Locating and Clearance Policy must be reviewed by anyone potentially involved with underground or overhead utility services.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence or absence of utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the development of detailed operating procedures. This guidance is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the geophysical methods may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure and the TtNUS Utility Locating and Clearance Policy.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP and the TtNUS Utility Locating and Clearance Policy. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy.

Site Personnel – Responsible for understanding and implementing this SOP and the TtNUS Utility Locating and Clearance Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. The following procedure must be followed prior to beginning any excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using such methods as passive and intrusive surveys, physical probing, or hand augering. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in many states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed with a hand auger or pole (tile probe) made of non-conductive material. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be

adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand-auger Surveys

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings must be hand-augered for all locations where there is a potential to impact buried utilities. The minimum hand-auger depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the

placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand-auger depths must be at least to the frost line depth plus two (2) feet, but never less than 4 feet below ground surface (bgs). For augering, the hole must be reamed by hand to at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand-auger. It is important to note that a post-hole digger must not be used in place of a hand-auger.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, tile probes may be used instead of or in addition to hand-augers. Tile probes must be performed to the same depth requirements as hand-augers. Depending upon the site conditions and intended probe usage, tile probes should be made of non-conductive material such as fiberglass.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the subsurface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

ALABAMA
Alabama Line Location (800) 292-8525

Tucson Blue Stake Center (800) 782-5348

Alaska
Locate Call Center of Alaska Inc. (800) 478-3121

Arizona
Arizona Blue Stake Inc. (800) 782-5348

Arkansas
Arkansas One Call System Inc. (800) 482-8998

California
Underground Service Alert North (800) 227-2600

Underground Service Alert South (800) 227-2600

Colorado
Utility Notification Center of Colorado
(800) 922-1987

Connecticut
Call Before You Dig (800) 922-4455

Delaware
Miss Utility of Delmarva
(800) 282-8555

District of Columbia
Miss Utility (800) 257-7777

Florida
Call Sunshine (800) 432-4770

Georgia
Utilities Protection Center Inc.
(800) 282-7411

Idaho
Palouse Empire Underground Coordinating Council
(800) 882-1974

Utilities Underground Location Center
(800) 424-5555

Kootenai Country Utility Coordinating Council
(800) 428-4950

Shoshone County One Call (800) 398-3285

Dig Line (800) 342-1585

One Call Concepts (800) 626-4950

Illinois
Julie Inc. (800) 892-0123

Digger (Chicago Utility Alert Network)
(312) 744-7000

Indiana
Indiana Underground Plant Protection Services
(800) 382-5544

Iowa
Underground Plant Location Service Inc.
(800) 292-8989

Kansas
Kansas One-Call Center (800) 344-7233

Kentucky
Kentucky Underground Protection Inc.
(800) 752-6007

Louisiana
Louisiana One Call (800) 272-3020

Maine
Dig Safe – Maine (800) 225-4977

Maryland
Miss Utility (800) 257-777

Miss Utility of Delmarva (800) 282-8555

Massachusetts
Dig Safe – Massachusetts (800) 322-4844

Michigan
Miss Dig System (800) 482-7171

Minnesota
Gopher State One Call (800) 252-1166

Mississippi
Mississippi One-Call System Inc. (800) 227-6477

Missouri
Missouri One Call System Inc. (800) 344-7483

Montana
Utilities Underground Location Center
(800) 424-5555

Montana One Call Center (800) 551-8344

Nebraska
Diggers Hotline of Nebraska (800) 331-5666

Nevada
Underground Service Alert North (800) 227-2600

New Hampshire
Dig Safe – New Hampshire (800) 225-4977

New Jersey
New Jersey One Call (800) 272-1000

New Mexico
New Mexico One Call System Inc.
(800) 321-ALERT

Las Cruces-Dona Utility Council (505) 526-0400

New York
Underground Facilities Protection Organization
(800) 962-7962

New York City: Long Island One Call Center
(800) 272-4480

North Carolina
The North Carolina One-Call Center Inc.
(800) 632-4949

North Dakota
Utilities Underground Location Center
(800) 795-0555

Ohio
Ohio Utilities Protection Service
(800) 362-2764

Oil & Gas Producers Underground Protection Service
(800) 925-0988

Oklahoma
Call Okie (800) 522-6543

Oregon
Utilities Underground Location Center
(800) 424-5555

Douglas Utilities Coordinating Council
(503) 673-6676

Josephine Utilities Coordinating Council
(503) 476-6676

Rogue Basin Utility Coordinating Council
(503) 779-6676

Utilities Notification Center
(800) 332-2344

Pennsylvania
Pennsylvania One Call System Inc.
(800) 242-1776

Rhode Island
Dig Safe – Rhode Island (800) 225-4977

South Carolina
Palmetto Utility Protection Service Inc.
(800) 922-0983

South Dakota
South Dakota One Call (800) 781-7474

Tennessee
Tennessee One-Call System (800) 351-1111

Texas
Texas One Call System (800) 245-4545

Texas Excavation Safety System (800) 344-8377

Lone Star Notification Center (800) 669-8344

Utah
Blue Stakes Location Center (800) 662-4111

Vermont
Dig Safe – Vermont (800) 225-4977

Virginia
Miss Utility of Virginia (800) 552-7001

Miss Utility (800) 257-7777

Miss Utility of Delmarva (800) 441-8355

Washington
Utilities Underground Location Center
(800) 424-5555

Grays Harbor & Pacific County
Utility Coordinating Council
(206) 535-3550

Utilities County of Cowlitz County
(360) 425-2506

Chelan-Douglas Utilities Coordinating Council
(509) 663-6111

Upper Yakima County
Underground Utilities Council
(800) 553-4344

Inland Empire Utility Coordinating Council
(509) 456-8000

Palouse Empire Utilities Coordinating Council
(800) 822-1974

Utilities Notification Center (800) 332-2344

West Virginia
Miss Utility of West Virginia Inc. (800) 245-4848

Wisconsin
Diggers Hotline Inc. (800) 242-8511

Wyoming
West Park Utility Coordinating Council
(307) 587-4800

Call-In Dig-In Safety Council (800) 300-9811

Fremont County Utility Coordinating Council
(800) 489-8023

Central Wyoming Utilities Coordinating Council
(800) 759-8035

Southwest Wyoming One Call (307) 362-8888

Carbon County Utility
Utility Coordinating Council (307) 324-6666

Albany County Utility Coordinating Council
(307) 742-3615

Southeast Wyoming Utilities Coordinating Council
(307) 638-6666

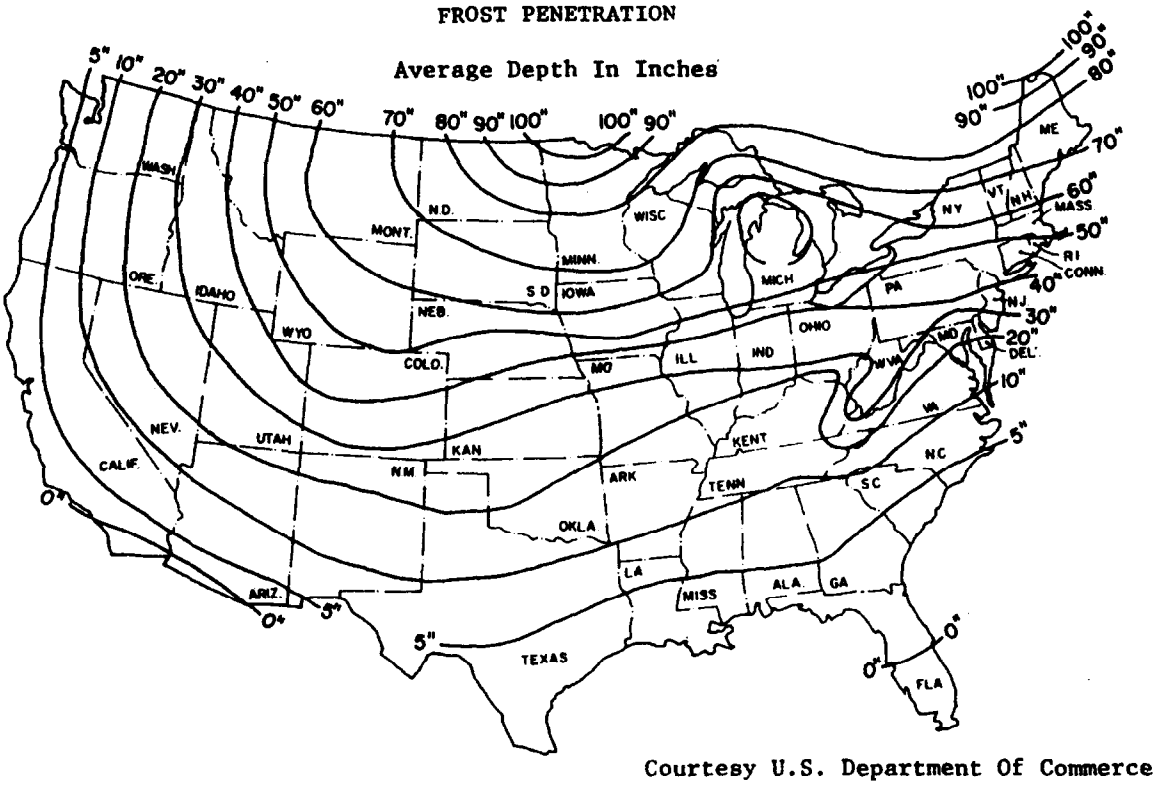
Wyoming One-Call
(800) 348-1030

Utilities Underground Location Center
(800) 454-5555

Converse County Utility Coordination Council
(800) 562-5561

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: _____ Project Name: _____

Project No.: _____ Completed By: _____

Location Name: _____ Work Date: _____

Excavation Method/Overhead Equipment: _____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name _____ Telephone: _____ Date: _____	yes no N/A
g)	State One-Call agency called? Caller: _____ Ticket Number: _____ Date: _____	yes no N/A
h)	Geophysical survey performed? Survey performed by: _____ Method: _____ Date: _____	yes no N/A
i)	Hand augering performed? Augering completed by: _____ Total depth: _____ feet Date: _____	yes no N/A
j)	Trench/excavation probed? Probing completed by: _____ Depth/frequency: _____ Date: _____	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _____	

3. Notes:

_____

_____

_____

Approval:

_____ _____

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

Connecticut One-Call

Note: This material has been prepared for use in Utility Contractor and Utility Claims Employee Training. For Legal Interpretations to be used in actual case settings, please consult your attorney or check with the Bar Association, in this state, for an appropriate referral to a qualified attorney.

DEPARTMENT OF PUBLIC UTILITY CONTROL
Excavation Near Underground Utility Facilities

Section 1: Section 16-345-1 through 16-345-7, inclusive, of the Regulations of Connecticut State Agencies are amended to read as follows:

Sec. 16-345-1. Definitions
(a) "Excavator" means a person, partnership, corporation or association, including a public utility or a person engaged as a contractor by a public utility or public agency, directly performing or engaged in the act of excavation, demolition or discharge of explosives.

(b) "Public agency" means the state or any political subdivision thereof, including any governmental agency.

(c) "Public utility" means the owner or operator of underground facilities for furnishing electric, gas, telephone, telegraph, communications and pipeline (whether for hire or not), sewage (including storm sewers, sanitary sewers and drainage systems, or parts thereof), water, community television antenna, steam, traffic signal, fire signal or similar service, including a municipal or other public owner or operator, but excluding facilities owned by the owner of a private residence for utility service solely for such residence, regardless of whether such owner or operator is otherwise subject to the jurisdiction of the Authority.(An "excavator" or "public agency" may also be a "public utility").

(d) "Central clearinghouse" means the single organization established by the public utilities pursuant to section 16-348 of the General Statutes for the purpose of receiving and giving notice of excavation activity within the state.

(e) "Excavation" means an operation for the purposes of movement or removal of earth, rock or other materials in or on the ground, or otherwise disturbing the subsurface of the earth, by the use of powered or mechanized equipment, including but not limited to digging, blasting, auguring, back filling, test boring, drilling, pile driving, grading, plowing-in, hammering, pulling-in, trenching, [and] tunneling, reclamation processes, and milling; excluding the movement of earth by tools manipulated only by human or animal power and the tilling of soil for agricultural purposes.

(f) " Demolition" means the wrecking, razing, rending, moving or removing of any structure.

(g) "Damage" includes but is not limited to the substantial weakening of structural or lateral support of a utility line, penetration or destruction of any utility line protective coating, housing or other protective device or the severance, partial or complete, of any utility line and "contact" includes, without limitation, the striking, scraping or denting, however slight, of any underground utility facility including any underground utility line protective coating, housing or other protective device, or any significant weakening or disturbance of the structural or lateral support of any underground utility facility.

(h) " Approximate location of underground facilities" means a strip of land not more than three feet wide or a strip of land extending no more than one and one-half feet on either side of the underground facilities.

(i) "Authority" means the Public Utilities Control Authority of the State of Connecticut.

(j) "At or Near" "means within the same subsection of a section in the standard grid system established or to be established pursuant to these regulations, when such term is used in connection with a proposed

excavation, discharge of explosives or demolition.

(k) "Standard grid system" means a grid system established or to be established by the central clearinghouse and approved by the Authority.

(l) "Facilities" means any wire, cable, pipe, vault, storage tank, transformer, or other similar property or equipment owned by public utilities for furnishing electric, gas, telephone, telegraph, communications and pipeline (whether for hire or not), sewage (including storm sewers, sanitary sewers and drainage systems, or parts thereof), water, community television antenna, steam, traffic signal, fire signal or similar service, regardless of whether such property or equipment is located on land owned by a person or public agency or whether it is located within an easement or right of way, but excluding such property or equipment owned by the owner of a private residence for utility service solely for such residence.

(m) "Registered" when used in connection with a public utility's facilities, includes such facilities known to the Authority and the central clearinghouse to the extent that the central clearinghouse has sufficient information to provide notification service as required by Section 16-345(d) of Chapter 293 of the General Statutes.

Sec. 16-345-2. Central clearinghouse
(a) Call Before You Dig, Inc. , a corporation established under the Connecticut Non-stock Corporation Act, membership in which corporation is open to all public utilities which file with it the information required by these regulations, shall be the central clearinghouse.

(b) The certificate or incorporation and Bylaws of the central clearinghouse shall be subject to the approval of the Authority.

(c) The central clearinghouse shall establish and submit to the Authority for its approval written operating procedures, which shall detail the days and hours during which the notification system will be in full operation, and which also shall include procedures for:

(1) receiving, handling and promptly dispatching messages, to public utilities and permit issuing public agencies described in Section 16-345-7 of these regulations,

(2) determining the size of the proposed excavation or demolition that may be included as one notification,

(3) advising the caller to contact individual public utilities which the caller suspects might be affected by emergency excavations, discharges of explosives or demolitions during non-operation hours,

(4) retaining record of all messages for a reasonable time period,

(5) establishing and maintaining a standard grid system,

(6) providing for the institution of advertisement and educational program to advise persons, public agencies and public utilities affected by Chapter 293 of The General Statures, of its terms and requirements; encouraging educational programs for the benefit of persons, public agencies and public utilities who excavate and the owners of underground utility facilities; and encouraging public and private agencies planning or undertaking construction project to require design engineers to obtain under ground utility information, identify such date on drawings, resolve facility conflicts with public utilities, and design projects to minimize adverse effects on facilities, and

(7) Such other provisions as the Authority shall deem necessary to carry out the objectives of chapter 293 of The General Statutes and the public safety.

(d) At least two months prior to the beginning of each fiscal year, the central clearinghouse shall propose to the Authority for approval an annual budget which shall:

(1) include billing rates that shall equitably allocate the costs of operating the notification system to those public utilities whose facilities are registered with the Authority, and

(2) be calculated so that the central clearinghouse shall neither make a profit nor suffer a loss, provided that if such a profit or less does occur during any year, the budget for the next year shall be adjusted accordingly.

(e) The central clearinghouse shall, from time to time, as the Authority may require, file with the Authority a current list of public utilities that participate in the central clearinghouse's service, which list shall include for each such public utility:

(1) the name and title of the public utility's employee or representative responsible for receiving notice of proposed excavations, discharges of explosives or demolitions,

(2) the business address of such employee,

(3) the normal hours and days of the week ("business hour") during which such employee may be contacted at the public utility.

(4) the "business hours" telephone number where such employee or representative may be reached

(5) an emergency telephone number to be used to contact such employee or representative during a non-business hours emergency, and

(6) such other information about each such public utility as the Authority shall deem necessary to carry out the objectives of Chapter 293 of the General Statues and the public safety.

(f) The central clearinghouse shall, from time to time , as the Authority may require, file with the Authority a list of the public utilities actually known to the central clearinghouse which have not filed with it the information required to be filed by the public utilities pursuant to these regulations.

(g) The central clearinghouse shall, from time to time as the Authority may require, file with the Authority, a summary list of all violations and damage reported to it pursuant to Section 16-345-3 (a) (3) and Section 16-345-3 (a) (4) of these regulations.

Sec. 16-345-3. Responsibilities of public utilities
(a) Each public utility shall:

(1) Maintain a current file, including new facilities, with the central clearinghouse containing the information listed in Section 16-345-2 (e) of these regulations and containing the locations, related to the standard grid system, of all its underground facilities within the State of Connecticut,

(2) Reimburse the central clearinghouse, in accordance with billing rates set by the Authority as part of the central clearinghouse's budget,

(3) Notify the central clearinghouse monthly of any excavation, discharge of explosives or demolition of which it is aware these regulations or Chapter 293 of the General Statutes. Additionally, each public utility shall file a report in January of each year indicating the number of damage incidents, by month, or that no such damage incidents occurred to its facilities, for the prior calendar year,

(4) Notify the central clearinghouse monthly of any damage to its facilities which resulted from, or which the public utility suspects resulted from, any excavation, discharge of explosive or demolition conducted by any other person or public agency,

(5) File with the central clearinghouses such other information which the central clearinghouse or the Authority shall deem necessary to carry out the objective of Chapter 293 of the General States and the public safety,

(6) Notify the central clearinghouse as soon as possible of any person or public agency whose actions of frequency of damage incidents indicates a situation that my require particular attention; provided however, that in deciding whether or not to make such a report, the public utility need not make or report any conclusion as to whether the reported condition or conditions represent a violation of any law or duty.

(7) Upon the exposure of previously unrecorded or inaccurately recorded facilities in the course of excavation or demolition activities and of which it has knowledge of such exposure, verify and modify existing records as necessary, and promptly make all necessary modifications, if needed, within the standard gird system maintained by the clearinghouse. The records shall be sufficiently detailed in order to allow the central clearinghouse to identify such previously unrecorded or inaccurately recorded facilities within its standard grid system, and

(8) Maintain records of all existing underground utility facility locations, including, without limitation, facilities abandoned in place and interconnections to all utility users.

(b) Each public utility shall:

(1) By the end of the second full day, (excluding Saturday, Sundays, and holidays) after the day of notification to the central clearinghouse of a proposed excavation, discharge of explosives or demolition at or near any of its facilities was received by the clearinghouse, or by the date on which excavation is scheduled to commence as reported in the notification to the central clearinghouse, whichever is later.

(A) In the event that it determines that it has underground facilities in the immediate vicinity of the specific site, mark the approximate location of such facilities using commercially available advanced proven techniques, methods and equipment appropriate to the circumstances, in accordance with Section 16-345-5 of these regulations, in such a manner that will enable the party giving such notice to establish the precise location of the underground facilities so marked, or if it is not practical to so mark the location of such facilities, identify the approximate location of such facilities in a manner mutually agreeable to the public utility and the party giving such notice. Any interconnections between facilities of the public utility and others, such as tees connecting mains to customer-owned facilities, shall be clearly marked and labeled by the utility providing service to the interconnection in accordance with Section 16-345-5 of these regulations, provided however, that such utility shall not be required to mark the location of customer owned facilities, except at the immediate location of the interconnection or tee. Whenever feasible, the public utility shall also provide information to the excavator as to any special requirements for excavation at or near its facilities including, without limitation, any special considerations regarding structural or lateral support or the use of heavy equipment over public utility facilities.

However, the public utility that has a standard and repeating layout and which is connected by facilities visible on the surface (such as certain storm sewers) need not mark out those standard and repeating facilities provided that maps indicating the approximate location are supplied to the person or public agency within the specified time limit. Facilities that are attached to a standard and repeating layout but do not conform to the standard and repeating layout shall be marked unless an alternate mutually agreeable location method is used.

(B) In the event that it determines that it has no underground facilities in the immediate vicinity of the specific site, make reasonable effort to so notify the excavator giving such notice and document such efforts, [and may] OR mark this information in accordance with section 16-345-5 of these regulations.

(3) Immediately upon receipt of notice that a proposed excavation or demolition without explosives is necessary to: (A) Correct an emergency involving danger to life, health or property or involving the interruption of the operation of a major industrial plan, or (B) assure the continuity of public utility service, dispatch personnel as soon as is reasonably possible to determine the effect of the excavation or

demolition on any facility it may have in the area; and if the excavation or demolition has not already occurred, to assist in establishing the location of such facilities.

(4) Upon receipt of notice that a proposed discharge of explosives is necessary immediately to correct an emergency involving an immediate and substantial danger of death or serious personal injury, dispatch personnel as soon as is reasonably possible to determine the effect of the discharge on any facility it may have in the area; and if the discharge has not already occurred, to assist in establishing the location of such facilities.

(5) Upon receipt of notice that contact involving its underground facilities has occurred, dispatch qualified personnel as soon thereafter as is reasonably possible to effect temporary or permanent repairs and to protect the public from any potential danger resulting from the contact to its facilities.

(c) A public utility may identify, in accordance with Section 16-345-5(k) of these regulations, the location of a facility connected to its facilities beyond the point of the interconnection or tee, but not owned or operated by the public utility, as a helpful guide to an excavator. Said identification shall not be deemed to impose any liability upon the public utility for [the accuracy] any inaccuracy [of] in said identification.

(d) Each public utility individually and through appropriate utility organizations, shall maintain a program designed to educate excavators in order to minimize the possibility of damage incidents to facilities and to minimize the potential detriment to public safety attendant with damage to underground facilities. Upon request by any excavator or any person, public agency or public utility planning an excavation, discharge of explosive or demolition, each public utility shall provide basic instruction concerning the hazards associated with its underground facilities and specific precautions necessary when working at or near those facilities.

(e) Each public utility shall attend all pre-construction meetings of which it has knowledge related to excavation, discharge of explosives or demolitions which might affect its facilities for the purpose of addressing special or particular issues related to public safety as well as others issues related to the proposed excavation, discharge or demolition.

(f) For all new underground facilities installed after January 1, 1989, [which is practicable] and for all repairs, replacements or modifications involving an exposure of existing underground facilities at least 100 feet longitudinally after January 1, 1989, of which the utility has knowledge of such exposure, the utility shall, where practicable, install a warning tape located above the facility, and keep appropriate records thereof. The minimum separation between the facility and the warning tape shall be 12 inches unless the depth, other underground facilities or other engineering considerations make the minimum separation unfeasible. The warning tape shall be durable, designed to withstand extended underground exposure, be of the color assigned to the type of facility for surface markings in Section 16-345-5(h) and durable imprinted with an appropriate warning or message.

Sec. 16-345-4. Responsibilities of excavators
(a) Any excavator responsible for excavating or discharging explosives at or near the location of public utility underground facilities or demolishing a structure containing any public utility facilities shall:

(1) Except as provided in Section 16-345-4 (a) (2) and Section 16-345-4 (a) (3) of these regulations, at least two full days, excluding Saturday, Sundays and holidays, but not more than thirty days before commencing such excavation, discharge of explosives or demolition at or near the location of such public utilities, notify the central clearinghouse of:

(A) The specific location of the site of the proposed excavation, discharge of explosives or demolition. Should field conditions or other circumstances require the excavation, discharge of explosives or demolition to be expanded outside the originally designated area established in accordance with Section 16-345-4c of these regulations, a separate notification shall be made and said notification shall be in accordance with the time requirements provided in section 16-345-4 (a) (I).

(B) The name address and telephone number of the entity giving the notice.

(C) The name address and telephone number of the excavator actually performing the proposed excavation discharge of explosives or demolition and the name address and telephone number of the person, public agency or public utility for whom the activity is being performed, except where the work is being performed by a public or municipal utility for the benefit of a utility customer, the customer's name, address and telephone number does not have to be provided.

(D) The date on which such proposed excavation, discharge of explosives or demolition will occur. The date shall be at least two full days, excluding Saturday, Sundays and holidays, after the notice is provided to the central clearinghouse, or after the area of proposed excavation, demolition or discharge of explosives is designated in accordance with Section 16-345-4 (d) whichever is later, but not more than thirty days after the notice has been provided to the central clearinghouse.

(E) The type of such proposed excavation, discharge of explosives or demolition.

(F) The method to be used to identify or designate the area of proposed excavation, discharge of explosives or demolition and the date by which the designation will be made, where the designation is not already shown on reconstruction plan.

(G) If it is an emergency, the basis for the emergency.

(H) Such other information as the central clearinghouse or the authority shall deem necessary to carry out the objectives of Chapter 293 of General Statutes and the public safety.

(2) In the event that an excavation or demolition without explosives is necessary to correct an emergency involving danger to life, health or property or the interruption of operation of a major industrial plant, or to assure the continuity of public utility service:

(A) immediately provide the notice required by Section 16-345-4 (a) (1) of these regulations to the central clearinghouse if it is during hours when the central clearinghouse is open for the purpose of determining the public utilities with facilities located at or near the site of the demolition unless the public utilities whose faculties may be affected are already known from a prior notification for excavation.

(B) immediately provide the notice required by Section w16-0345-4 (a) (1) of these regulations directly to the involved utilities, and

(C) notify the central clearinghouse by telephone of the emergency and response taken as soon as reasonably possible if such notice was not given immediately prior to the excavation or demolition.

(3) In the event that the use of explosives is necessary to correct an emergency involving an immediate and substantial danger of death or serious personal injury, immediately:

(A) provide the notice required by Section 16-345-4 (a) (1) of these regulations to the central clearinghouse if it is during hours when the central clearinghouse is open for the purpose of determining the public utilities with facilities located at or near the site of the discharge unless the affected public utilities are already known from a prior notification for excavation;

(B) immediately provide the information required by Section 16-345-4 (a) (1) of these regulations directly to the affected public utilities prior to discharge of the explosives; and

(C) provide notice directly to the central clearinghouse as soon as possible after the discharge if such notice was not given immediately prior to the discharge.

(4) Use prudent judgement in determining whether to proceed with the excavation, discharge of explosives or demolishing prior to the identification of any or all of the facilities in the event covered by

Section 16-345-4 (a) (2) and Section 16-345-4 (a) (3) of the regulations. In exercising such judgement, the excavator shall consider, among other things, the potential hazard to life and property while awaiting public utility personnel to locate the facilities having the greatest potential for detriment to the public safety and the potential hazards that could result from proceeding without having located the facilities and potential damage to those facilities.

(5) Exercise reasonable care when working in proximity to the underground facilities of any public utility. Reasonable care shall include, without limitation, the use of construction methods appropriate to ensure the integrity of existing utility facilities and their man-made temporary and permanent support including but not limited to adequate and proper shoring and proper backfill methods and techniques; the selection of equipment and explosives capable of performing the work with the minimum reasonable likelihood of disturbance to underground facilities; adequate supervisory personnel to ensure proper actions; proper understanding by the personnel on the job site of the authority of all parties involved in the activity so that prompt action can be taken in the event of unanticipated contact with underground facilities; adequate training of employees in executing their assignments to ensure protection of utility facilities and the public; maintaining necessary liaison with owners of underground facilities; sponsoring preplanning and pre-construction meetings as necessary, and complying with all applicable laws and regulations. If the excavator is utilizing trenchless excavation, the excavator shall, if such excavation is expected to cross or encroach within the approximate location of underground facilities either horizontally or vertically, prior to the crossing or encroaching, determine the precise location of such underground facilities expected to be so crossed or encroached.

(6) In the event that underground facilities of a public utility are likely to be expose by such excavating, discharging of explosives or demolishing, provide such support or protection, or both, as may be necessary to protect such facilities from damage. Where underground facilities containg combustible or hazardous fluids or gases (such as natural gas, propane, jet fuel or chlorine) are likely to be exposed or where the proposed excavation, discharge of explosives or demolition is to occur within the approximate location of such facilities or affecting such facilities, except for excavations performed in connection with the need to expose such underground facilities by the owner of such facilities, an excavator may use mechanical equipment solely for the purpose for removing the bituminous and concrete road surface. In such circumstances, other than for the removal of a bituminous or concrete road surface, an excavator, other than the owner exposing its own underground facilities, shall employ hand digging only.

(7) In the event that the excavator, after reasonable attempt, is unable to precisely locate the underground facilities after the approximate location of the underground facilities have been marked, the excavator must notify the public utility requesting such further assistance as may be needed to determine the precise location of the underground facility.

(8) Avoid the covering or removal of surface markings or stakes indicating underground facilities during construction activity prior to actually excavating, discharging explosives or demolishing in the vicinity for the located facilities.

(b) When any contact is done to any underground facility of a public utility, the excavator responsible for the operations causing such contact shall immediately and directly notify the public utility which owns or operates such facility of the contact, but such person, public agency or public utility shall not tamper with or attempt to repair such facility except to repair protective coatings when authorized by the owner of the facility.

(c) An excavation notice given pursuant to Section 16-345 (a) (1) of these regulations, shall expire at the end of thirty days from the date such notice is given to the clearinghouse. Whether or not an excavation, demolition or discharge of explosives has commenced pursuant to a valid notification at any time within the prior thirty days, if such activity has not been completed or is expected to last beyond the 30 day period, a renewal notice must by provided before the expiration of the thirty day period by the excavator. The renewal shall not be applicable for areas not designated in the prior notification. If excavation, demolition or discharge of explosives was not commenced pursuant to a valid notification at any time during the prior thirty day period following the date which the notice was originally given, notice shall be

given again in accordance with Section 16-345-4 (a) (1) of these regulations by the excavator. Where any excavation, discharge or demolition activity has remained dormant for a period of thirty days from the date of the last notice given pursuant to Section 16-345-4 (a) (1) of these regulations, an additional notice shall be given before commencing such activity by the excavator.

(d) The area of proposed excavation, discharge of explosives or demolition shall be designated by the excavator on such a manner as to enable the public utility or owner of underground facilities to know the approximate boundaries of the proposed excavation. The area shall be designated as follows:

(1) if the area of proposed excavation is less than 1000 feet longitudinally along an existing highway, only surface margin in accordance with Section 16-345-5 of these regulations may be used;

(2) if surface marking pursuant to Section 16-345-5 of these regulations are not used, designation must be by clear and appropriate markings on a plan map which was originally prepared by a licensed surveyor or competent employee of a public utility company or municipal utility and delivered to the public utility whose underground facilities may be affected, if the area is 1000 feet or more longitudinally on or adjacent to an existing highway and a preconstruction meeting is held by the person or public agency performing the excavation, discharge or demolition activity and all affected public utilities are notified of such meeting.

(3) the designation of the area shall include the maximum depth of excavation at a sufficient number of points to ensure an accurate profile unless detailed profile maps are provided. The depth information provided shall reasonably reflect the anticipated actual depth.

(e) When any contact is made with any underground facility a public utility, the excavator responsible for the operations causing such contact shall:

(1) Immediately and directly notify the public utility which owns or operates such facility of the contact, but such excavator shall not tamper with or attempt to repair such facility except to repair protective coating when authorized by the owner of the facility. The excavator performing the excavation, discharge of explosives or demolition shall use prudent judgement taking into account minimizing the potential detriment so public safety in determining whether to cease activities pending the arrival of qualified public utility personnel.

(2) When such contact includes the occurring of a serious electrical short circuit or the escaping of combustible or hazardous fluids or gases (such as natural gas, propane, jet fuel or chlorine) or any other event endangering the public, the excavator responsible for the excavation, demolition or discharge involved in such damage shall also alert all persons within the danger areas and take all feasible steps, including, where applicable, notifying police, fire and other emergency personnel, eliminating sources of ignition and evacuating employees and the general public from the affected area, but excluding tampering with or attempting to repair the damaged facility, to insure the public safety pending arrival of the appropriate public utility personnel.

(f) At all times when excavation, discharge or explosives or demolition are in progress there shall be a representative of the excavator present in overall charge of the operation who shall be knowledgeable reading the operation being performed and the legal name and address of the entity that is directly responsible for the performance of the operation. This person shall have satisfactory evidence that the notification requirement of these regulations have been met, such as the ticket number from the central clearinghouse on site at all times.

(g) Each person, or public agency involved in excavation, discharge of explosives and demolitions shall post a summary of the requirements of Sections 16-345-1 through 16-345-9 of these regulations in construction workplaces. Construction workplaces shall include, without limitation, offices of the entity performing the work in a location where persons directly involved in excavation, discharge of explosives and demolition frequent, field offices and similar locations.

(h) The representative of the excavator shall provide the legal name and address of the entity that is directly responsible for the performance of the excavation activity and shall provide satisfactory evidence to any entity, including a publicly agency or public utility requesting such information. Such representative shall also be an agent for service of notice or process in any matter related to compliance with these regulations.

(i) Except as provided in Section 16-345-4 (a) (3) of these regulations, explosives may not be discharged unless such discharge was disclosed in the original notification or upon six hours notice to all public utilities which have facilities at or near the proposed discharge location, including those that were previously indicated to have facilities at or near the proposed discharge but not in the immediate vicinity, except that on Saturday, Sundays and holidays, eight hour notice shall be provided.

Sec. 16-345-5. Surface markings (a) All surface markings and public utility locations stakings shall be made in accordance with this section.

(b) Surface markings shall consist of paint or equivalent material. The paint or material should have sufficient lasting properties so as to stand up to wear and tear of traffic; but should be sufficiently degradable so as not be permanent, unless the marking is intended to be permanent.

(c) Surface markings for the identification of the location of underground facilities shall be located preferably at the center line of the underground facility and at the outer limits of this proposed excavation, discharge or explosives or demolition activity.

(d) Where center-line marking is impractical, the location of the facility may be indicated by means of offset surface markings.

(e) Staking shall consist of the use of stakes made of wood or any other suitable material. The minimum sizes of a stake shall be one inch by one inch by twenty-four inches (1" x 1"x 24") (nominal size). Approximately one-fourth of the length of the stake shall be buried below the ground and the remainder of the stake shall be exposed above the ground in a upright position directly above facility. The top six (6) inches of the exposed portion of the stake shall be of the designated public utility color in accordance with Section 16-345-5 (h) of these regulations. The stake shall also be identified by one (1) inch minimum size letters in black color, having the designated public utility identification abbreviation, in accordance with Section 16-345-5 (I) of these regulations and the facility size, if applicable, on all four sides of the exposed portion of the stake. Such stakes shall be placed in an upright position directly above the facility and be exposed above the ground a minimum of eighteen (18) inches. The top of the stake shall be clearly marked with both the designated utility color and identification abbreviation in accordance with sections 16-345-5(h) and 16-345(i) of these regulations.

(f) In areas where surface marking cannot be utilized, or in areas where the use of stakes would be superior to surface markings, staking may be employed for locating facilities or for designating areas of proposed excavation, demolition or discharge of explosives. Stakes shall normally be located above the center line of the underground facility and at the outer limits of the proposed excavation, demolition or discharge of explosives activity. Stakes shall not be used for offset location unless surface marking or center line staking is inadequate or inappropriate.

(g) Surface markings or stakes shall be located at such appropriate intervals as is necessary to clearly indicate the location and course of the underground facility.

(h) With the exception of normal traffic control markings, all markings on public streets, sidewalks and right-of-way, and all surface marking and stakings of public utility locations and areas of proposed excavation, demolition or discharge of explosives shall be accordance with, and shall not conflict with, the following uniform color code.

YELLOW: Gas, oil petroleum products, steam, compressed air, compressed gases and all other hazardous materials except water.

RED: Electric power lines, electric power conduits and other electric power facilities.

ORANGE: Communication lines or cables, including but not limited to telephone, telegraph, fire signals, cable television, civil defense, data systems, electronic controls and other instrumentation.

BLUE: Water.

GREEN: Storm and sanitary sewers and drainage systems including force mains and other non-hazardous materials.

PURPLE: Radioactive materials.

WHITE: Proposed working area of excavation, discharge or explosive or demolition; survey markings.

BROWN: Other

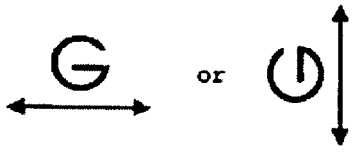
Unpainted stakes with [orange, red, or yellow flags] COLORED RIBBON: survey markings

(i) All surface marking and staking utilized for the location of underground facilities shall contain letter designations which clearly identify the type of facility so marked or staked. Such letters shall be legible and shall be used in accordance with the following.

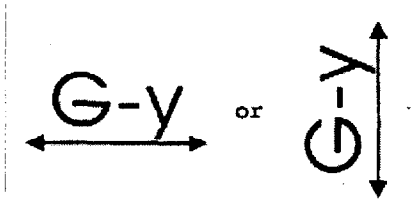
C-Communication facilities other than telephone company facilities.
CH- Chemicals.
CTV-Cable television.
E-Electric power.
FS-Fire signals.
G-Gas.
HPW-High-pressure water over 125 PSIG.
P-Petroleum.
PP-Petroleum products (naphtha, gasoline, kerosene and similar products).
S-Sewer.
ST-Steam.
T-Telephone company facilities.
TC- Traffic control signals.
W-Water.
O-All other facilities.

(j) All surface markings and staking shall be in accordance with the following. ("G" is represented below, but specific product identification use shall be in accordance with Section 16-345-5 (i) of these regulations.)

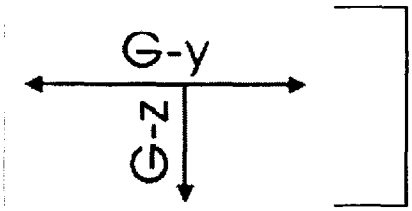
(1) Approximate location is a strip of land extending not more than one and one-half feet on either side of the markout line. The arrow indicated the direction of run. The length of the mark shall be approximately eighteen inches (18").



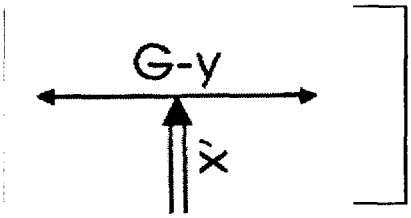
(2) Approximate location is a strip of land extending not more than one and one-half feet plus y/2 inches on either side of the markout line, where y is the size of the facility (e.g., y inch pipe, y inch conduit). The arrow indicated the direction of run. The length of the mark shall be approximately eighteen inches (18").



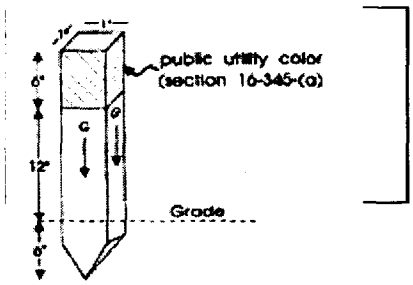
(3) A point where a facility tees off. y and z may or may not be present y and z are the size of he respective facilities (e.g., y inch pipe, z inch conduit).



(4) Offset mark for run of pipe where X' represents the distance, in feet, from the reference line to the underground facility. y may or may not be present. y is the size of the facility (e.g., y inch pipe , y inch conduit).

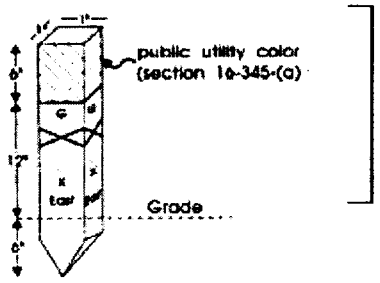


(5) Approximate location is a strip of land extending not more than one and one-half feet on either side of the line established by the series of stakes.

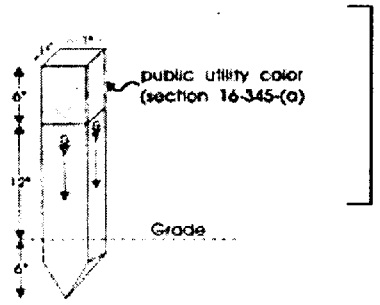


(6) Approximate location is as strip of land extending not more than one and one-half feet plus y/2 inches

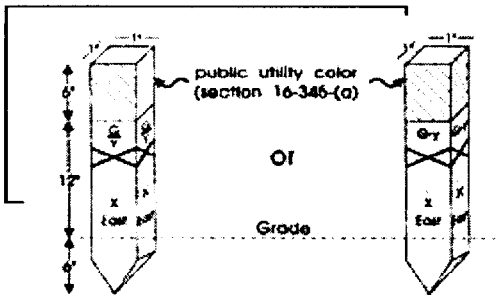
on either side of the line established by the series of stakes, where y is the size of the facility (e.g., y inch pipe, y inch conduit.)



(7) Approximate location is a strip of land extending not more than one and one-half feet on either side of, and X' in the direction indicated from the line established by the series of stakes.



(8) Approximate location is a strip of land extending not more than one and one-half feet plus y/2 inches on either side of, and X' in the direction (i.e., approximate compass direction) indicated from, the line established by the series of stakes, where y is the size of the facility (e.g., y inch pipe, y inch conduit).



(k) A public utility may in accordance with provisions of section 16-345-3(c), identify the location of a facility connected to its facility beyond the point of the interconnection or tee, but not owned or operated by the public utility as a helpful guide to an excavator in a similar manner to Section 16-345-5(a) through (j) of these regulations, except that surface markings shall be dotted or broken line instead of a solid line.

(l) A public utility may signify that it has no facilities in the immediate area of a proposed excavation, demolition or discharge of explosives by writing "no name of utility or commonly recognized abbreviation" in letters at least twelve inches high using the uniform color code as described in Section 16-345-5 (h) of these regulations.

Sec. 16-345-6. Permits to require compliance Any permit, except for advance construction permits, issued by a public agency for excavation, demolition or discharge of explosives shall require satisfactory evidence of compliance with Chapter 293 of the General Statutes and these regulation such as the central clearinghouse ticket number. The central clearinghouse may provide notification of each underground location request to each municipality's permit issuing department for proposed excavations within the municipality's jurisdiction.

Sec. 16-345-7. Compliance with local permit requirements
Except as provided in Section 16-345-6 of these regulations, these regulations shall not be construed to affect or impair local ordinances, charter or other provisions of law requiring permits to be obtained before excavating in a public highway or to demolish structures on private property, nor shall they be construed to grant to any person, excavator, or public agency any rights not specifically provided by Chapter 293 of the General Statutes and these regulations. A permit from a public agency shall not relieve any person from responsibility for complying with the provision of Chapter 293 of the General Statures and these regulations. The failure of any person who has been granted a permit to company with the provisions of Chapter 293 of the General Statures and these regulation shall not be deemed to impose any liability upon the public agency issuing the permit.

Sec. 16-345-8. Enforcement proceedings
(a) If the Department has reason to believe that a violation has occurred for which a civil penalty has been established for violations of Chapter 293 of the General Statues, as provided in Section 16-356 of the General Statues, or of any provision of these regulations, it may send to the violator by certified mail, return receipt requested, or by personal service, a notice which shall include:

(1) A reference to the section of the statute, regulation or order involved;

(2) A short and plain statement of the matters asserted or charged;

(3) A statement of the amount of the civil penalties proposed to be imposed after notice and opportunity for a hearing; and

(4) A statement of the party's right to a hearing.

(b) The person, public agency or public utility to whom the notice is addressed may, within 30 days from the date of receipt of the, notice, deliver to the Department written application for a hearing. If a hearing is requested, then after a hearing, and upon a finding that a violation has occurred, the Authority may issue a that order assessing a civil penalty under this section which is not greater than the penalty stated in the notice. If such a hearing is not so requested, or if such a request is later withdrawn, then the notice shall, on the first day after the expiration of such 30 day period or on the first day after the withdrawal of such request for hearing whichever is later, become a final order of the Authority and the matters asserted or charged in the notice shall be deemed admitted.

(c) All hearings under this section shall be conducted pursuant to Section 4-177 to 4-184 of the General Statues, inclusive. The final order of the Department assessing a civil penalty shall be subject to appeal under Section 4-183 of the General Statues. No challenge to a final order of the Department assessing a civil penalty pursuant to Section 16-345-9 of these regulations shall be allowed as to any issue which could have been raised by a timely request for a hearing pursuant to Section 16-345-8 (b) of these regulations. Any civil penalty authorized by this section shall become due and payable upon the final decision becoming a final order pursuant to Section 16-345-8 (b) of these regulations.

(d) A civil penalty assessed in a final order of the Department under this section may be enforced in the same manner as a judgment of the superior court. The final order shall be delivered to the respondent by personal service or by certified mail, return receipt requested.

Sec. 16-345-9 Assessment of civil penalties
(a) Any excavator, public agency or public utility which the Department finds to have violated any

provisions of Section 16-345-3, 16-345-4 or 16-345-5 of these regulations, or applicable sections of Chapter 293 of the General Statutes, may be fined, after notice and opportunity for a hearing as provided in Section 16-345-8. In such case, they shall forfeit and pay to the state a civil penalty in accordance with the following schedule of penalties:

(1) For violations which result in property damage, where the amount of property damage sustained is not greater than three-thousand dollars, a civil penalty not to exceed three-thousand dollar;

(2) For violations which result in property damage of more than three-thousand dollars, a civil penalty not to exceed five-thousand dollars;

(3) For a violation which results in personal injury or death, a civil penalty not to exceed ten-thousand dollars.

(b) In determining the amount of civil penalty to be assessed, the Department shall take into account the following criteria by way of aggravating and mitigating factors:

(1) The number of past violations within the prior two years of the date of the last violation,

(2) The degree of compliance with other requirement of Chapter 293 of the General Statutes, especially notification to the utility in the event of damage. In particular the department shall consider whether or not the violator has notified the utility pursuant to the provisions of Sections 16-345-4 (a) (1), 16-345-(a) (2) , 16-345-4 (b) (1), and 16-345-(b) (2),

(3) The "good faith "efforts of the violator to have complied with the statutes and regulations,

(4) The plans and procedures to insure compliance with the statutes and regulations in the future,

(5) The amount of damage caused to underground facilities.

(6) The degree of threat to the public safety, and degree of public safety, and degree of public inconvenience caused as a result of the violation,

(7) Whether the activity was performed in the course of business by a person or public agency regularly engaged in such activity.

(c) Where the Department has issued a penalty after a hearing, the Department shall specify the factors used in determining the penalty by way of mitigation or aggravation.

(d) Any excavator, public agency or public utility which the Department, finds has violated any of the provisions of Sections 16-345-3, 16-345-4 or 16-345-5 of these regulations, or applicable sections of Chapter 293 of the General Statutes, where there has not occurred any property damage or personal injury, may be fined, after notice and opportunity for a hearing as provided in Section 16-345-8 of these regulations. The fines shall, at a minimum, be according to the following schedule taking into account the number past violations:

One hundred ($100.00) dollars for a first violation, two hundred ($200.00) dollars for the second violation and three hundred ($300.00) dollars for a third violation and up to the statutory maximum thereafter.

(e) Where an excavator or public agency knowingly comes into contact with an underground facility during the course of excavation , demolition or discharge activity, and fails to notify the owner of the facility as soon as reasonably possible thereafter, the Department may impose a civil penalty, taking into account the amount of property damage or occurrence of personal injury or death, in accordance with the schedule of fines as stated in Section 16-345-9 (a) of these regulations.

Statement of purpose: To comply with the requirements of Public Act 87-71 to ensure compliance with

Chapter 293 of the General Statutes. These regulations are designed to protect the public safety by enumerating duties and responsibilities of persons, public agencies and public utilities with respect to excavating, discharging explosives or demolition in proximity to any public utility underground facility and extends the penalty provisions and procedures to cover those who violate any of the provisions of Chapter 293 or the regulations.

Be it known that the foregoing regulations are amended as hereinabove stated by the aforesaid agency pursuant to Sec. 16-6b of the General Statutes, and Public Act No. 87-71 of the Public Acts, after publication in the Connecticut Law Journal on September 22, 1987, of the notice of proposal to amend such regulations, and the holding of an advertised public hearing on the 4th day of November, 1987.

Wherefore, the forgoing regulations are hereby amended as hereinabove stated, effective when filed with the Secretary of the State. In Witness Whereof: April 6, 1988, Peter G. Boucher, Chairperson. Approved by the Attorney General as to legal sufficiency in accordance with Sec. 4-169, as amended, General Statutes: May 3, 1988.

Approved by the Legislative Regulation Review Committee in accordance with Sec. 4-170, as amended, of the General Statutes: October 18, 1988.

Two certified copies received and filed, and one such copy forwarded to the Commission on Official Legal Publications in accordance with Sec. 4-172, as amended, of the General Statues, Secretary of the State: October 25, 1988.

ATTACHMENT III

EQUIPMENT INSPECTION CHECKLIST

EQUIPMENT INSPECTION

COMPANY:_____ **UNIT NO.**_____

FREQUENCY: Inspect daily, document prior to use and as repairs are needed.

Inspection Date: ____/____/____ Time: _____ Equipment Type:_____
(e.g., bulldozer)

	Good	Need Repair	N/A
Tires or tracks	❒	❒	❒
Hoses and belts	❒	❒	❒
Cab, mirrors, safety glass	❒	❒	❒
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	❒	❒	❒
- Is the equipment equipped with audible back-up alarms and back-up lights?	❒	❒	❒
Horn and gauges	❒	❒	❒
Brake condition (dynamic, park, etc.)	❒	❒	❒
Fire extinguisher (Type/Rating -_____)	❒	❒	❒
Fluid Levels:			
- Engine oil	❒	❒	❒
- Transmission fluid	❒	❒	❒
- Brake fluid	❒	❒	❒
- Cooling system fluid	❒	❒	❒
- Windshield wipers	❒	❒	❒
- Hydraulic oil	❒	❒	❒
Oil leak/lube	❒	❒	❒
Coupling devices and connectors	❒	❒	❒
Exhaust system	❒	❒	❒
Blade/boom/ripper condition	❒	❒	❒
Accessways: Frame, hand holds, ladders, walkways (non-slip surfaces), guardrails?	❒	❒	❒
Power cable and/or hoist cable	❒	❒	❒
Steering (standard and emergency)	❒	❒	❒

Safety Guards:

	Yes	No
– Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?_____	❒	❒
– Hot pipes and surfaces exposed to accidental contact?_____	❒	❒
– All emergency shut offs have been identified and communicated to the field crew?_____	❒	❒
– Have emergency shutoffs been field tested? _____	❒	❒
– Results?_____	❒	❒
– Are any structural members bent, rusted, or otherwise show signs of damage?_____	❒	❒
– Are fueling cans used with this equipment approved type safety cans?_____	❒	❒

- Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use?_____ ❒ ❒

Portable Power Tools:

- Tools and Equipment in Safe Condition?_____ ❒ ❒
- Saw blades, grinding wheels free from recognizable defects (grinding wheels have been sounded)? ❒ ❒
- Portable electric tools properly grounded?_____ ❒ ❒
- Damage to electrical power cords?_____ ❒ ❒
- Blade guards in place?_____ ❒ ❒
- Components adjusted as per manufacturers recommendation?_____ ❒ ❒

Cleanliness:

- Overall condition (is the decontamination performed prior to arrival on-site considered acceptable)?_____
- Where was this equipment used prior to its arrival on site?_____
- Site Contaminants of concern at the previous site?_____
- Inside debris (coffee cups, soda cans, tools and equipment) blocking free access to foot controls?_____

Operator Qualifications (as applicable for all heavy equipment):

- Does the operator have proper licensing where applicable, (e.g., CDL)?_____
- Does the operator, understand the equipments operating instructions?_____
- Is the operator experienced with this equipment? _____
- Does the operator have emotional and/or physical limitations which would prevent him/her from performing this task in a safe manner?_____
- Is the operator 21 years of age or more?_____

Identification:

- Is a tagging system available, for positive identification, for tools removed from service?___

Additional Inspection Required Prior to Use On-Site

	Yes	No
- Does equipment emit noise levels above 90 decibels?	❒	❒
- If so, has an 8-hour noise dosimetry test been performed?	❒	❒

- Results of noise dosimetry:_____
- Defects and repairs needed:_____
- General Safety Condition: _____
- Operator or mechanic signature:_____

Approved for Use: ❒ Yes ❒ No

_____
Site Safety Officer Signature

ATTACHMENT IV

SAFE WORK PERMITS

SAFE WORK PERMIT FOR
IDW HANDLING, AND STAGING OF DRUMS
NSB NEW LONDON
CTO 0841

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): IDW management

II. Required Monitoring Instruments: FID/PID with 11.7eV (or higher) lamp detect presence of VOCs

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	Airline/SCBA	☐
SAR	☐	Bottle trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, hardhat, cotton/leather outer gloves with surgical-style inner gloves, impermeable boot covers.

V.

Chemicals of Concern	Action Level(s)	Response Measures
Potential site contaminants include VOCs, and metals,	Any sustained readings above 1 ppm in worker breathing zones for one minute.	Suspend site activities and retreat to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☐ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☐ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☒ Yes	☐ No	Gloves (Type - Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☐ No

Modifications/Exceptions: Tyvek coverall if there is a potential for soiling clothes.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☐	☒	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☐	☒	Assembly points	☒	☐

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Cleared and Established	☐	☐	☒
Physical Hazards Barricaded and Isolated	☐	☐	☒
Emergency Equipment Staged	☐	☐	☒

IX. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR
SOIL BORINGS
NAVAL SUBMARINE BASE NEW LONDON, GROTON, CONNECTICUT
CTO 0841

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Soil borings using air rotary and DPT techniques and associated tasks (monitoring well installations, soil and groundwater sampling).

II. Required Monitoring Instruments: FID or PID with a 11.7 eV lamp or higher

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SKA-PAC SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, and nitrile gloves or leather gloves with surgical-style inner gloves.

V.

Chemicals of Concern	Action Level(s)	Response Measures
Potential site contaminants include VOCs, and metals,	Any sustained readings above 1 ppm in worker breathing zones for one minute.	Suspend site activities and retreat to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Hearing protection during drilling activities. Reflective vests for high traffic areas. Tyvek coverall and impermeable boots if there is a potential for soiling work clothes.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	NA
Utility Locating and Excavation Clearance completed	☐	☒
Vehicle and Foot Traffic Routes Cleared and Established	☒	☐
Physical Hazards Barricaded and Isolated	☒	☐
Emergency Equipment Staged	☐	☒

IX. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Follow TtNUS SOP "Utility Locating and Excavation Clearance". Minimize generation of airborne dusts.

Permit Issued by: _____ Permit Accepted by: _____

Job Completed by: _____ Date: _____

SAFE WORK PERMIT FOR
DECONTAMINATION ACTIVITIES
NAVAL SUBMARINE BASE NEW LONDON, GROTON, CONNECTICUT

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Decontamination of sampling equipment and machinery (i.e., drill rigs, augers, DPT) . Brushes and spray bottles will be used to decon small sampling equipment. Pressure washers or steam cleaning units will be used to decon the augers and Drill/DPT Rigs.

II. Required Monitoring Instrument(s): FID or PID with at least 11.7 eV lamp source (used to screen equipment)

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirements include sleeved shirt and long pants, safety glasses, safety footwear, and nitrile gloves. When using pressure washers, steam cleaners field crews will wear hearing protection, and face shields.

VI.

Chemicals of Concern	Action Level(s)	Response Measures
Site contaminants include VOCs, and metals,	Any sustained readings above 1 ppm for one minute in worker breathing zones.	Suspend site activities and report to an unaffected area.

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☒ Yes	☐ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type - Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: PVC rain suits or PE or PVC coated Tyvek for protection against splashes and overspray. Chemical resistant boot covers if excessive liquids are generated or to protected footwear.

VIII.

Procedure review with permit acceptors	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☒	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☐	☒	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☒	☐	Assembly points	☒	☐

IX.

Equipment Preparation	Yes	NA
Utility Locating and Excavation Clearance completed	☐	☒
Vehicle and Foot Traffic Routes Cleared and Established	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐
Emergency Equipment Staged	☐	☐

X. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XI. Special instructions, precautions: Other chemical hazards include decontamination fluids such as isopropyl alcohol, etc. To minimize the potential for exposure, site personnel will use PPE and prevent contact with potentially contaminated equipment. Refer to the manufacturer's MSDS regarding PPE, handling, storage, and first-aid measures related to decontamination fluids.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR
MOBILIZATION AND DEMOBILIZATION ACTIVITIES
NAVAL SUBMARINE BASE, NEW LONDON, GROTON CONNECTICUT
CTO 0841

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Mobilization and demobilization activities

II. Required Monitoring Instruments: None

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety glasses and safety footwear. Hard hats and hearing protection will be worn when working near operating equipment.

VI.

Chemicals of Concern	Action Level(s)	Response Measures
None anticipated given the nature of surveying activities and limited contact w/ media.		

VII. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☒ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type -_____)	☐ Yes	☒ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall to protect against natrual hazards (e.g., ticks). If working in areas where snakes are a threat, wear snake chaps to protect against bites.

VIII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

	Yes	NA
Utility Locating and Excavation Clearance completed	☒	☐
Vehicle and Foot Traffic Routes Cleared and Established	☒	☐
Physical Hazards Barricaded and Isolated	☐	☒
Emergency Equipment Staged	☐	☒

X. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XI. Special instructions, precautions: Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Avoid potential nesting areas. Wear light colored clothing so that ticks and other biting insects can be easily visible and can be removed. Inspect clothing and body for ticks. Minimize contact with potentially contaminated media. Suspend site activities in the event of inclement weather

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR
MULTI-MEDIA SAMPLING
NAVAL SUBMARINE BASE NEW LONDON, GROTON, CONNECTICUT
CTO 0841

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Multi-media sampling including Surface, subsurface soils and groundwater

II. Required Monitoring Instrument(s): FID or PID with a 11.6 eV lamp source or higher

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, surgical style gloves, and safety glasses. Hard hats and hearing protection will be worn when working near operating equipment or when required by the SSO. Reflective vests will be worn for high traffic areas.

V. Chemicals of Concern	Action Level(s)	Response Measures
Site contaminants include VOCs and Metals,	Any sustained readings above 10 ppm in worker breathing zones for one minute.	Suspend site activities and retreat to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Tyvek coverall if there is a potential for soiling work cloths. SSO may dictate double-layering gloves. Hearing protection when working in close proximity of the drill rig or any noise source.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☒	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☐	☒	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☐	☒	Assembly points	☒	☐

VIII. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

IX. Additional Permits required (Hot work, confined space entry, excavation etc.) ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____

Job Completed by: _____ Date: _____

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

Quality Assurance Project Plan Addendum

for

Basewide Groundwater Operable Unit Data Gap Investigation

Naval Submarine Base
New London
Groton, Connecticut

Engineering Field Activity Northeast
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0841

July 2002

070204/P

QUALITY ASSURANCE PROJECT PLAN ADDENDUM
FOR
BASEWIDE GROUNDWATER OPERABLE UNIT
DATA GAP INVESTIGATION

NAVAL SUBMARINE BASE
NEW LONDON
GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Environmental Branch Code 18
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
Tetra Tech NUS, Inc.
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406-1433

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0841

JULY 2002

PREPARED UNDER DIRECTION OF:

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PITTSBURGH, PENNSYLVANIA

APPROVED BY:

PAUL V. FRANK
QUALITY ASSURANCE MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

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ACRONYMS

AWQC	Ambient Water Quality Criteria
B&RE	Brown & Root Environmental
BGOU	Base-wide Groundwater Operable Unit
BGS	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COC	Chain of Custody
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Cancer Slope Factor
CTDEP	Connecticut Department of Environmental Protection
CTE	Central Tendency Exposure
CTO	Contract Task Order
DGI	Data Gap Investigation
EGIS	Environmental Geographic Information System
ESQD	Explosive Safety Quantity Distance
FFA	Federal Facilities Agreement
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Request
G-RAM	General Radioactive Material
GIS	Geographic Information System
GMP	Groundwater Monitoring Plan
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSA	Hollow Stem Auger
HSWA	Hazardous and Solid Waste Amendments
IAS	Initial Assessment Study
ID	Inside Diameter
IDW	Investigation Derived Waste
IRA	Interim Remedial Action

IR	Installation Restoration
LIMS	Laboratory Information Management System
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
msl	mean sea level
NCP	National Contingency Plan
NNPP	Naval Nuclear Propulsion Program
NPL	National Priorities List
NSB-NLON	Naval Submarine Base New London
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAB	Restoration Advisory Board
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
REDOX	Oxidation-Reduction Potential
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SASDA	Spent Acid Storage and Disposal Area
SCS	Soil Conservation Service
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SOW	Statement of Work
SQL	Sample Quantitation Limit
SSL	Soil Screening Level

SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WP	Work Plan

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared by Tetra Tech NUS (TtNUS) on behalf of the United States Navy Engineering Division Activity Northeast Naval Facilities Engineering Command and the Naval Submarine Base New London (NSB-NLON), Groton, Connecticut, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-94-D-0888, Contract Task Order (CTO) 841. This QAPP, along with the Health and Safety Plan (HASP) are provided as attachments to the Work Plan (WP) constitute the planning documents for the Basewide Groundwater Operable Unit (BGOU) Data Gap Investigation (DGI) to be performed at NSB-NLON.

This QAPP presents the organization, objectives, planned activities, and specific Quality Assurance/Quality Control (QA/QC) procedures associated with the WP for this BGOU DGI. Specific protocols for sampling, sample handling and storage, chain-of-custody, and laboratory and field analyses are described within this document. All QA/QC procedures are structured in accordance with applicable technical standards, the Naval Facilities Engineering Service Center (NFESC) guidance document "Navy Installation Restoration Laboratory Quality Assurance Guide (February 1996), and United States Environmental Protection Agency (USEPA) Region I and Connecticut Department of Environmental Protection (CTDEP) requirements, regulations, guidance, and technical standards.

1.2 FACILITY DESCRIPTION

A description of NSB-NLON, including its location, size and borders, site conditions, natural and manmade features, are presented in the BGOU Remedial Investigaion Report (TtNUS 2001). Descriptions of sites included in this investigation are provided in Section 1.1 of the WP.

1.3 PROJECT OBJECTIVES

This section discusses the overall project objectives, the anticipated target parameters and intended data uses for both field and laboratory analytical data.

1.3.1 Overall Project Objectives

The overall objectives of the work will be to perform further investigation and characterization of the soil and groundwater at NSB-NLON Sites 3, 15, and 20. Project objectives are discussed in more detail in Section 2 of the WP.

1.3.2 Project Target Parameters and Intended Data Uses

This section discusses the field and laboratory analytical information to be generated during the course of the investigation. Field parameters and intended data uses are discussed in Section 1.3.2.1. Laboratory parameters and intended data uses are discussed in Section 1.3.2.2.

1.3.2.1 Field Parameters

Field parameters will include those parameters associated with the completion of soil borings, installation and development of monitoring wells, and sampling and analysis of soil and groundwater. All field measurements will be completed using simple field instrumentation or field test kits.

Field measurements of total volatile organic compounds will be completed using a Photoionization Detector (PID) or Flame Ionization Detector (FID). These measurements will be used to determine appropriate subsurface sample horizons to be submitted for laboratory analysis and for safety monitoring to determine breathing zone conditions for site workers.

Field measurements of dissolved oxygen, oxidation-reduction potential (REDOX), temperature, salinity, specific conductance, and turbidity will be completed for all groundwater samples. These measurements will be used to support monitoring well development and purging of stagnant water from well casings. Specific conductance and pH will also be measured and used as general indicators of water quality. Turbidity will be measured using a LaMonte Turbidity meter. The other parameters will be measured using a meter with a flow-through cell.

Further details regarding field sampling and analysis methods are provided in Section 3.12 of the WP.

1.3.2.2 Laboratory Parameters

The analytical methods to be used for analysis of the NSB-NLON samples have been selected based on existing analytical data from previous investigations. The suite of analyses for NSB-NLON BGOU DGI includes Target Compound List (TCL) volatiles, TCL semivolatiles (minus PAHs), TCL pesticides, TCL polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAHs); Target Analyte List (TAL) metals; and acidity. The Contract Laboratory Program (CLP) Low-Concentration Statement of Work (SOW) OLC02.1 will be utilized for analysis of TCL volatiles, TCL semivolatiles, and TCL pesticide/PCBs, CLP SOW ILM04.1 for analysis of metals, and SW-846 Method 8310 for PAHs in groundwater samples, whereas only SW-846 methodology will be used for these same parameters for the analysis of soil samples.

The aforementioned parameters will be used to evaluate the nature and extent of contamination, to evaluate contaminant migration pathways and link source areas to potential receptors, and to support decision making via human health risk assessment. An additional laboratory parameter, which will be used in conjunction with the field parameters previously discussed to evaluate metals mobility in the groundwater, includes acidity. Tables 1-1 through 1-5 provide a summary of all target analytes and associated Contract Required Detection Limits (CRDLs)/Contract Required Quantitation Limits (CRQLs)/Practical Quantitation Limits (PQLs). Analytical methods are further discussed in Section 7.0 of this QAPP.

1.4 SAMPLE NETWORK DESIGN AND RATIONALE

The sample network design and rationale is discussed in detail in Section 2 of the WP. Figures displaying all proposed sampling locations are also provided in Section 2.0 of the WP.

1.5 PROJECT SCHEDULE

The project schedule will be determined upon approval of this QAPP and the WP.

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TABLE 1-1

ANALYTICAL DETECTION LIMITS - TCL LOW-CONCENTRATION ORGANICS GROUNDWATER SAMPLES NSB-NLON, GROTON, CONNECTICUT PAGE 1 OF 4

Parameter	CRQL [1] Groundwater Samples (µg/L)
VOLATILE ORGANIC COMPOUNDS	
Acetone	5
Benzene	1
Bromochloromethane	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	1
2-Butanone	5
Carbon disulfide	1
Carbon tetrachloride	1
Chlorobenzene	1
Chloroethane	1
Chloroform	1
Chloromethane	1
Dibromochloromethane	1
1,2-Dibromo-3-chloropropane	1
1,2-Dibromoethane	1
1,2-Dichlorobenzene	1
1,3-Dichlorobenzene	1
1,4-Dichlorobenzene	1
1,1-Dichloroethane	1
1,2-Dichloroethane	1
1,1-Dichloroethene	1
cis-1,2-Dichloroethene	1
trans-1,2-Dichloroethene	1
1,2-Dichloropropane	1
cis-1,3-Dichloropropene	1
trans-1,3-Dichloropropene	1
Ethylbenzene	1
2-Hexanone	5
4-Methyl-2-pentanone	5
Methylene chloride	2
Styrene	1
1,1,2,2-Tetrachloroethane	1
1,1,1-Trichloroethane	1
1,1,2-Trichloroethane	1
Trichloroethene	1
Tetrachloroethene	1
Toluene	1
Vinyl chloride	1
Xylenes (total)	1

TABLE 1-1

ANALYTICAL DETECTION LIMITS - TCL LOW-CONCENTRATION ORGANICS GROUNDWATER SAMPLES NSB-NLON, GROTON, CONNECTICUT PAGE 2 OF 4

Parameter	CRQL[1] Groundwater Samples (µg/L)
SEMIVOLATILE ORGANIC COMPOUNDS	
Acenaphthene	(2)
Acenaphthylene	(2)
Anthracene	(2)
Benzo(a)anthracene	(2)
Benzo(a)pyrene	(2)
Benzo(b)fluoranthene	(2)
Benzo(g,h,i)perylene	(2)
Benzo(k)fluoranthene	(2)
Bis(2-chloroethoxy)methane	5
Bis(2-chloroethyl)ether	5
Bis(2-ethylhexyl)phthalate	5
4-Bromophenyl-phenylether	5
Butylbenzylphthalate	5
Carbazole	5
4-Chloro-3-methylphenol	5
4-Chloroaniline	5
2-Chloronaphthalene	5
2-Chlorophenol	5
4-Chlorophenyl-phenylether	5
Chrysene	(2)
Dibenz(a,h)anthracene	(2)
Dibenzofuran	5
3,3'-Dichlorobenzidine	5
Diethylphthalate	5
Di-n-butylphthalate	5
Di-n-octylphthalate	5
4,6-Dinitro-2-methylphenol	20
2,4-Dinitrophenol	20
2,4-Dinitrotoluene	5
2,4-Dichlorophenol	5

TABLE 1-1

ANALYTICAL DETECTION LIMITS - TCL LOW-CONCENTRATION ORGANICS GROUNDWATER SAMPLES NSB-NLON, GROTON, CONNECTICUT PAGE 3 OF 4

Parameter	CRQL[1] Groundwater Samples (µg/L)
Dimethylphthalate	5
2,4-Dimethylphenol	5
2,6-Dinitrotoluene	5
Fluoranthene	(2)
Fluorene	(2)
Hexachlorobenzene	5
Hexachlorobutadiene	5
Hexachlorocyclopentadiene	5
Hexachloroethane	5
Indeno(1,2,3-cd)pyrene	(2)
Isophorone	5
2-Methylnaphthalene	(2)
2-Methylphenol	5
4-Methylphenol	5
Naphthalene	(2)
2-Nitroaniline	20
3-Nitroaniline	20
4-Nitroaniline	20
Nitrobenzene	5
2-Nitrophenol	5
4-Nitrophenol	20
N-nitroso-di-n-propylamine	5
N-nitrosodiphenylamine	5
2,2'-Oxybis(1-chloropropane)	5
Pentachlorophenol	20
Phenanthrene	(2)
Phenol	5
Pyrene	(2)
2,4,5-Trichlorophenol	5
2,4,6-Trichlorophenol	20

TABLE 1-1

ANALYTICAL DETECTION LIMITS - TCL LOW-CONCENTRATION ORGANICS GROUNDWATER SAMPLES NSB-NLON, GROTON, CONNECTICUT PAGE 4 OF 4

Parameter	CRQL[1] Groundwater Samples (µg/L)
Pesticides/PCBs	
Aldrin	0.01
alpha-BHC	0.01
alpha-Chlordane	0.01
beta-BHC	0.01
4,4'-DDE	0.02
4,4'-DDD	0.02
4,4'-DDT	0.02
delta-BHC	0.01
Dieldrin	0.02
Endosulfan I	0.01
Endosulfan II	0.02
Endosulfan sulfate	0.02
Endrin	0.02
Endrin aldehyde	0.02
Endrin ketone	0.02
gamma-BHC (Lindane)	0.01
gamma-Chlordane	0.01
Heptachlor	0.01
Heptachlor epoxide	0.01
Methoxychlor	0.1
Toxaphene	1.0
Aroclor-1016	0.2
Aroclor-1221	0.4
Aroclor-1232	0.2
Aroclor-1242	0.2
Aroclor-1248	0.2
Aroclor-1254	0.2
Aroclor-1260	0.2

1 CRQL Contract Required Quantitation Limit; as specified in the CLP SOW OLC02.1.
2 Due to low detection limit requirements, these PAH compounds will be analyzed using SW-846 8310. See Table 1-4.

TABLE 1-2

ANALYTICAL DETECTION LIMITS - TCL ORGANICS
SOIL SAMPLES
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Parameter Volatile Organic Compounds	PQL[1] Soil Samples (µg/kg)
Acetone	5
Benzene	5
Bromodichloromethane	5
Bromoform	5
Bromomethane	5
2-Butanone	5
Carbon disulfide	5
Carbon tetrachloride	5
Chlorobenzene	5
Chloroethane	5
Chloroform	5
Chloromethane	5
Dibromochloromethane	5
1,1-Dichloroethane	5
1,2-Dichloroethane	5
1,1-Dichloroethene	5
1,2-Dichloroethene (total)	5
1,2-Dichloropropane	5
cis-1,3-Dichloropropene	5
trans-1,3-Dichloropropene	5
Ethylbenzene	5
2-Hexanone	5
4-Methyl-2-pentanone	5
Methylene chloride	5
Styrene	5
1,1,2,2-Tetrachloroethane	5
1,1,1-Trichloroethane	5
1,1,2-Trichloroethane	5
Trichloroethene	5
Tetrachloroethene	5
Toluene	5
Vinyl chloride	5
Xylenes (total)	5

TABLE 1-2

ANALYTICAL DETECTION LIMITS - TCL ORGANICS
SOIL SAMPLES
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4

Parameter Semivolatile Organic Compounds	PQL[1] Soil Samples (µg/kg)
Acenaphthene	(2)
Acenaphthylene	(2)
Anthracene	(2)
Benzo(a)anthracene	(2)
Benzo(a)pyrene	(2)
Benzo(b)fluoranthene	(2)
Benzo(g,h,i)perylene	(2)
Benzo(k)fluoranthene	(2)
Bis(2-chloroethoxy)methane	167
Bis(2-chloroethyl)ether	167
Bis(2-ethylhexyl)phthalate	167
4-Bromophenyl-phenylether	167
Butylbenzylphthalate	167
Carbazole	330
4-Chloro-3-methylphenol	167
4-Chloroaniline	167
2-Chloronaphthalene	167
2-Chlorophenol	167
4-Chlorophenyl-phenylether	167
Chrysene	(2)
Dibenz(a,h)anthracene	(2)
Dibenzofuran	330
3,3'-Dichlorobenzidine	167
Diethylphthalate	167
Di-n-butylphthalate	167
Di-n-octylphthalate	167
4,6-Dinitro-2-methylphenol	167
2,4-Dinitrophenol	167
2,4-Dinitrotoluene	167
1,2-Dichlorobenzene	167
1,3-Dichlorobenzene	167
1,4-Dichlorobenzene	167
2,4-Dichlorophenol	167

TABLE 1-2

ANALYTICAL DETECTION LIMITS - TCL ORGANICS
SOIL SAMPLES
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Parameter Semivolatile Organic Compounds	PQL[1] Soil Samples (µg/kg)
Dimethylphthalate	167
2,4-Dimethylphenol	167
2,6-Dinitrotoluene	167
Fluoranthene	(2)
Fluorene	(2)
Hexachlorobenzene	167
Hexachlorobutadiene	167
Hexachlorocyclopentadiene	167
Hexachloroethane	167
Indeno(1,2,3-cd)pyrene	(2)
Isophorone	167
2-Methylnaphthalene	(2)
2-Methylphenol	167
4-Methylphenol	167
Naphthalene	(2)
2-Nitroaniline	167
3-Nitroaniline	167
4-Nitroaniline	167
Nitrobenzene	167
2-Nitrophenol	167
4-Nitrophenol	167
N-nitroso-di-n-propylamine	167
N-nitrosodiphenylamine	167
2,2'-Oxybis(1-chloropropane)	167
Pentachlorophenol	167
Phenanthrene	(2)
Phenol	167
Pyrene	(2)
1,2,4-Trichlorobenzene	167
2,4,5-Trichlorophenol	167
2,4,6-Trichlorophenol	167

TABLE 1-2

**ANALYTICAL DETECTION LIMITS - TCL ORGANICS
SOIL SAMPLES
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 4**

Parameter	PQL[1] Soil Samples (µg/kg)
Pesticides/PCBs	
Aldrin	1.65
alpha-BHC	1.65
alpha-Chlordane	16.5
beta-BHC	1.65
4,4'-DDE	1.65
4,4'-DDD	1.65
4,4'-DDT	1.65
delta-BHC	1.65
Dieldrin	1.65
Endosulfan I	1.65
Endosulfan II	1.65
Endosulfan sulfate	1.65
Endrin	1.65
Endrin aldehyde	1.65
Endrin ketone	1.65
gamma-BHC (Lindane)	1.65
gamma-Chlordane	16.5
Heptachlor	1.65
Heptachlor epoxide	1.65
Methoxychlor	1.65
Toxaphene	66
Aroclor-1016	16.5
Aroclor-1221	16.5
Aroclor-1232	16.5
Aroclor-1242	16.5
Aroclor-1248	16.5
Aroclor-1254	16.5
Aroclor-1260	16.5

1 PQL Typical Practical Quantitation Limit; actual PQL may vary based on the laboratory.
2 Due to low detection limit requirements, these PAH compounds will be analyzed using SW-846 8310. See Table 1-4.

TABLE 1-3

**ANALYTICAL DETECTION LIMITS - TAL METALS
NSB-NLON, GROTON, CONNECTICUT**

Parameter	CRDL[1]	
	Groundwater Samples (µg/L)	Soil Samples (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	4	2
Barium	200	40
Beryllium	5	1
Cadmium	5	1
Calcium	5000	1000
Chromium (total)	10	2
Cobalt	50	10
Copper	25	5
Iron	100	20
Lead	3	0.6
Magnesium	5000	1000
Manganese	15	3
Mercury	0.2	0.1
Nickel	40	8
Potassium	5000	1000
Selenium	5	1
Silver	10	2
Sodium	5000	1000
Thallium	10	2
Vanadium	50	10
Zinc	20	4

1 CRDL Contract Required Detection Limit; as specified in the CLP SOW ILM04.1 Trace ICP.

TABLE 1-4

ANALYTICAL DETECTION LIMITS – POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) NSB-NLON, GROTON, CONNECTICUT

Parameter	PQL [1]	
	Groundwater Samples (µg/L)	Soil Samples (µg/kg)
Acenaphthene	1.0	33
Acenaphthylene	1.0	33
Anthracene	2.0	5
Benzo(a)anthracene	0.10	5
Benzo(a)pyrene	0.10	5
Benzo(b)fluoranthene	0.10	5
Benzo(g,h,i)perylene	0.10	5
Benzo(k)fluoranthene	0.05	5
Chrysene	0.10	5
Dibenz(a,h)anthracene	0.1	5
Fluoranthene	0.1	5
Fluorene	1.0	5
Indeno(1,2,3-cd)pyrene	0.1	5
2-Methylnaphthalene	2.0	33
Naphthalene	2.0	33
Phenanthrene	1.0	5
Pyrene	0.1	5

1 PQL Typical Practical Quantitation Limit; actual PQL may vary based on the laboratory.

TABLE 1-5

ANALYTICAL DETECTION LIMITS – MISCELLANEOUS PARAMETERS NSB-NLON, GROTON, CONNECTICUT

Parameter	PQL[1]	
	Groundwater Samples (mg/L)	Soil Samples (mg/kg)
Acidity	NA[3]	NR[2]

1 PQL Typical Practical Quantitation Limit; actual PQL may vary based on the laboratory.
2 Analysis not required.
3 Not Applicable.

2.0 PROJECT ORGANIZATION

The project organization for the Base-wide Groundwater OU DGI is discussed in Section 1.4 of the WP.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for this project is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results, which are legally defensible in a court of law. Intended data uses are described in Section 1.3.2 of this QAPP. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, data reporting, internal quality control, audits, preventive maintenance of field and laboratory equipment, and corrective action are described in other sections of this QAPP.

The precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are discussed in the remainder of this section. Specific routine procedures used to assess the quantitative parameters (precision, accuracy, and completeness) are provided in Section 12.0.

3.1 PRECISION

3.1.1 Definition

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for samples under similar conditions. The equation for determining precision is provided in Section 12.2.

3.1.2 Field Precision Objectives

Field duplicate precision monitors the consistency with which environmental samples were obtained and analyzed. Field duplicate results for solid matrix samples are considered to be precise if the relative percent difference (RPD) is less than or equal to 50 percent. Field duplicate results for aqueous matrix samples are considered to be precise if the RPD is less than or equal to 30 percent. Field precision is assessed through the collection and measurement of field duplicates at a rate of: 1 duplicate per 10 environmental samples of like matrix.

3.1.3 Laboratory Precision Objectives

Laboratory precision QC samples are analyzed at a frequency of 5 percent (i.e., one quality control sample per 20 environmental samples). Laboratory precision is measured via comparison of calculated RPD values and precision control limits specified in the analytical method or by the laboratory's QA/QC program.

With the exception of low-concentration organic analyses (TCL volatiles, semivolatiles, and pesticides/PCBs), precision for organic analyses (TCL volatiles, TCL semivolatiles, TCL pesticides, TCL PCBs, and PAHs via SW-846 methods) will be measured via the RPDs for matrix spike/matrix spike duplicate (MS/MSD) samples. Although the CLP SOW for low-concentration TCL volatile, semivolatile, and pesticide/PCB analysis does not require a specific QC sample to monitor precision, the calibration requirements of the method (i.e., specific limits of precision for the calibration standards) do ensure that a sufficient level of precision is achieved. (Calibration is further discussed in Section 6.0.) Precision for TAL metals analysis will be measured via RPDs for laboratory duplicates and the precision control limits are presented in Table 3-1. Internal laboratory control limits for precision, which are typically set at three times the standard deviation of a series of RPDs, will be used for evaluation of precision for all non-CLP methodology.

3.2 ACCURACY

3.2.1 Definition

Accuracy is the degree of agreement between an observed value and an accepted reference value. The equation for determining accuracy is provided in Section 12.1.

3.2.2 Field Accuracy Objectives

Accuracy in the field is assessed through the use of rinsate and trip blanks and is ensured through the adherence to all sample handling, preservation, and holding time requirements. Accuracy and precision requirements for field measurements are ensured through calibration as discussed in Section 6.0.

3.2.3 Laboratory Accuracy Objectives

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

Accuracy for organic analysis will be measured via the %Rs for surrogate spikes, MS/MSDs, and/or LCSs. Accuracy for TAL metals analysis will be measured via %Rs for MSs and LCSs. Table 3-2 presents the accuracy control limits for LCS and surrogate spikes for TCL low concentration organics (via CLP SOW OLC02.1). Tables 3-3 and 3-4 presents accuracy control limits for MS %Rs and LCS %Rs, respectively, for TAL metals (via CLP SOW ILM04.1). Accuracy for the remaining parameters (volatiles, semivolatiles, pesticides, PCBs, and PAHs via SW-846 methods; will typically be measured via %Rs for MSs and/or LCSs. Internal laboratory control limits for accuracy, which are typically set at three times the standard deviation of a series of %R values, will be used for evaluation of accuracy for all non-CLP methods.

3.3 COMPLETENESS

Completeness is a measure of the amount of usable, valid analytical data obtained, compared to the amount expected to be obtained. Completeness is typically expressed as a percentage. The equation for completeness is presented in Section 12.3.

The ideal objective for completeness is 100 percent (i.e., every sample planned to be collected is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed), errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination), or strong matrix effects can become apparent (e.g., extremely low matrix spike recovery).

These instances result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. If critical data points are lost, resampling and/or reanalysis may be required.

As further discussed in Section 9.2, 100 percent of the laboratory data for the NSB-NLON Basewide Groundwater OU RI will be validated in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (October 1999), and Inorganic Data Review (February 1994), Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, (June 1988 modified February 1999), and Region I EPA New England Data Validation Functional Guidelines to Evaluating Environmental Analyses (December 1996). Data rejected as a result of the validation process will be treated as unusable data.

3.4 REPRESENTATIVENESS

3.4.1 Definition

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

3.4.2 Measures to Ensure Representativeness of Field Data

Representativeness is dependent upon the proper design of the sampling program. It will be satisfied by ensuring that the sampling procedures are followed and that proper sampling techniques are used. The rationale of the sampling network is discussed in detail in Section 1.3 of the WP/SAP.

3.4.3 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory data is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing duplicate samples.

3.5 COMPARABILITY

3.5.1 Definition

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized sampling and analysis methods, and data reporting formats (including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis). Additionally, consideration is given to seasonal conditions and other environmental variations that could influence data results.

3.5.2 Measures to Ensure Comparability of Field Data

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the SAP is followed and that proper sampling techniques are used. It is also dependent on recording field measurements using the correct units. Field measurement units are further discussed in Section 9.1.1.

3.5.3 Measures to Ensure Comparability of Laboratory Data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current state and Federal standards and guidelines. Laboratory measurement units are further discussed in Section 9.1.2.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Trip blank, rinsate blank, ambient condition blank, source water blank, method blank, field and laboratory duplicate, laboratory control, and matrix spike samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs. In addition, field duplicate measurements will be completed for all field parameters.

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

Field duplicates are either two samples collected independently at a sampling location (e.g., surface water), or a single sample homogenized and split into two portions. [When volatile organic compounds (VOCs) are to be analyzed, the VOC sample aliquots are containerized first to avoid loss of constituents, then the remaining sample matrix is homogenized.] Field duplicates are collected and analyzed for all chemical constituents to measure the precision of the sampling and analysis methods employed. The level of the QC effort will be one field duplicate for every 10 or fewer investigative samples.

Trip blanks and ambient condition blanks, consisting of distilled water, will be submitted to the laboratory to provide the means to assess the quality of the data resulting from the field sampling program. Ambient blanks are not collected using the same sampling equipment as the field samples, but are collected while at the field sampling site by placing distilled water directly into the same type of container, preserved and stored in the same manner, as the field samples. Ambient blank samples are analyzed to check for background contamination at the facility (e.g., vapors, dust, or exhaust fumes that are part of normal operations at the site) which may cause sample contamination. The exposure of the ambient blank to ambient conditions should be similar to the ambient exposure of the field samples. Ambient blanks will be collected based on conditions at the time of sampling at the discretion of the Field Operations Leader (FOL), with a minimum of one ambient blank being collected during the investigation.

Trip blanks only pertain to samples collected for VOC analysis. Trip blanks are used to assess the potential for contamination of samples to be analyzed for VOCs by contaminant migration into sample containers during sample shipment and storage. Trip blanks are prepared by the laboratory prior to the sampling event, shipped to the site with the sample containers, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment with other VOC samples and sent for analysis. There should be one trip blank included in each sample shipping container that contains samples for VOC analysis. At no time after trip blank preparation are their sample containers opened before they reach the laboratory.

Source water blanks consist of the potable water used for decontamination of sampling equipment. These blanks are used to determine if the potable water may be contributing to sample contamination. Source water blanks will be collected at a rate of one blank per each potable water source.

Equipment rinsate blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and prior to use. At least one equipment blank will be collected per day, per matrix. If pre-cleaned, dedicated, or disposable sampling equipment is used, one rinsate blank per type of equipment used must be collected as a "batch blank." Rinsate blanks are analyzed for the same chemical constituents as the associated environmental samples.

Method blank samples are generated within the laboratory and used to assess contamination resulting from laboratory procedures. Laboratory duplicate samples are analyzed for inorganic parameters to check for sampling and analytical reproducibility. MSs provide information about the effect of the sample matrix on the digestion and measurement methodology. All MSs for organic analyses are performed in duplicate and, as previously defined, are referred to as MS/MSD samples.

MS/MSD samples are investigative samples. Soil MS/MSD samples require no extra volume for VOCs or extractable organics. However, aqueous MS/MSD samples must be collected at triple the volume for VOCs and extractable organics. One MS/MSD sample will be collected/designated for every 20 or fewer investigative samples per sample matrix (i.e., groundwater, soil, surface water, sediment).

The level of QC effort provided by the laboratory for the TCL and TAL parameters to be tested will be equivalent to the level of QC effort specified under the USEPA Contract Laboratory Program. The level of QC effort for testing of TCL organics (volatiles, semivolatiles, pesticides, PCBs), and PAHs will conform to the applicable SW-846 test methods or CLP SOW for low-concentration organics (OLC02.1). The level of QC effort for testing of metals will conform to the CLP SOW for TAL metals (ILM04.0). The level of QC

effort for testing the remaining parameters will conform to the appropriate analytical methods, as specified in Tables 7-1 and 7-2 of this QAPP.

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TABLE 3-1

**PRECISION CONTROL LIMITS (RPDs)[1]
LABORATORY DUPLICATE SAMPLES
METALS ANALYSIS VIA ILM04.1[2]
NSB-NLON, GROTON, CONNECTICUT**

Chemical	Aqueous Samples[3]	Solid Samples[4]
TAL METALS		
Aluminum	20	35
Antimony	20	35
Arsenic	20	35
Barium	20	35
Beryllium	20	35
Cadmium	20	35
Calcium	20	35
Chromium (total)	20	35
Cobalt	20	35
Copper	20	35
Iron	20	35
Lead	20	35
Magnesium	20	35
Manganese	20	35
Mercury	20	35
Nickel	20	35
Potassium	20	35
Selenium	20	35
Silver	20	35
Sodium	20	35
Thallium	20	35
Tin	20	35
Vanadium	20	35
Zinc	20	35

1 RPD - Relative Percent Difference as described in Section 12.0.
2 USEPA CLP. Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, ILM04.1.
3 For aqueous sample results less than 5X CRDL, a control limit of ±CRDL is used.
4 For solid sample results less than 5X CRDL, a control limit of ±2X CRDL is used.

TABLE 3-2

ACCURACY CONTROL LIMITS (%R)[1]
LABORATORY CONTROL SAMPLE AND SURROGATE SPIKE
LOW-CONCENTRATION VOLATILE, SEMIVOLATILE, AND PESTICIDE/PCB
ORGANIC ANALYSIS VIA OLC02.1[2]
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Chemical	Aqueous Samples
LABORATORY CONTROL SAMPLE	
TCL Volatiles	
Vinyl chloride	60-140
1,2-Dichloroethane	60-140
Carbon tetrachloride	60-140
1,2-Dichloropropane	60-140
Trichloroethene	60-140
1,1,2-Trichloroethane	60-140
Benzene	60-140
cis-1,3-Dichloropropene	60-140
Bromoform	60-140
Tetrachloroethene	60-140
1,2-Dibromoethane	60-140
1,4-Dichlorobenzene	60-140
TCL Semivolatiles	
Phenol	40-120
2-Chlorophenol	50-110
4-Chloroaniline	10-120
2,4,6-Trichlorophenol	40-120
Bis(2-chloroethyl)ether	50-110
N-nitroso-di-propylamine	30-110
Hexachloroethane	20-110
Isophorone	50-110
2,4-Dinitrotoluene	30-120
Diethylphthalate	50-120
N-nitrosodiphenylamine	30-110
Hexachlorobenzene	40-120
TCL Pesticides/PCBs	
Gamma-BHC	50-120
Heptachlor epoxide	50-150
Dieldrin	30-130
4,4;-DDE	50-150
Endrin	50-120
Endosulfan sulfate	50-120
Gamma-chlordane	30-130

TABLE 3-2
ACCURACY CONTROL LIMITS (%R)[1]
LABORATORY CONTROL SAMPLE AND SURROGATE SPIKE
LOW-CONCENTRATION VOLATILE, SEMIVOLATILE, AND PESTICIDE/PCB
ORGANIC ANALYSIS VIA OLC02.1[2]
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Chemical	Aqueous Samples
SURROGATE SPIKE	
TCL Volatiles	
Bromoflourobenzene	80-120
TCL Semivolatiles	
Nitrobenzene-d5	23-120
2-Fluorbiphenyl	30-115
Terphenyl-d14	18-140
Phenol-d5	12-115
2-Fluorophenol	15-121
2,4,6-Tribromophenol	15-130
TCL Pesticides/PCBs	
Tetrachloro-m-xylene	30-150
Decachlorobiphenyl	30-150

1 %R - Percent Recovery as described in Section 12.0.
2 USEPA CLP, 1996. Superfund Analytical Methods for Low Concentration Water for Organics Analysis, 2/96, OLC02.1.

TABLE 3-3

ACCURACY CONTROL LIMITS (%R)[1]
MATRIX SPIKE SAMPLES
METALS ANALYSIS VIA ILM04.1[2]
NSB-NLON, GROTON, CONNECTICUT

Chemical	Aqueous Samples	Solid Samples
TAL METALS		
Aluminum	75-125	NS[3]
Antimony	75-125	75-125
Arsenic	75-125	75-125
Barium	75-125	75-125
Beryllium	75-125	75-125
Cadmium	75-125	75-125
Calcium	NS	NS
Chromium (total)	75-125	75-125
Cobalt	75-125	75-125
Copper	75-125	75-125
Iron	75-125	NS
Lead	75-125	75-125
Magnesium	NS	NS
Manganese	75-125	75-125
Mercury	75-125	75-125
Nickel	75-125	75-125
Potassium	NS	NS
Selenium	75-125	75-125
Silver	75-125	75-125
Sodium	NS	NS
Thallium	75-125	75-125
Tin	75-125	75-125
Vanadium	75-125	75-125
Zinc	75-125	75-125

1 %R - Percent Recovery as described in Section 12.0.
2 USEPA CLP. Statement of work for Inorganics Analysis, Multi-Media, Multi-Concentration, ILM04.1.
3 No spike required.

TABLE 3-4

ACCURACY CONTROL LIMITS (%R)[1]
LABORATORY CONTROL SAMPLES
METALS ANALYSIS VIA ILM04.1[2]
NSB-NLON, GROTON, CONNECTICUT

Chemical	Aqueous Samples	Solid Samples
TAL METALS		
Aluminum	80-120	TBD[3]
Antimony	80-120[4]	TBD
Arsenic	80-120	TBD
Barium	80-120	TBD
Beryllium	80-120	TBD
Cadmium	80-120	TBD
Calcium	80-120	TBD
Chromium	80-120	TBD
Cobalt	80-120	TBD
Copper	80-120	TBD
Iron	80-120	TBD
Lead	80-120	TBD
Magnesium	80-120	TBD
Manganese	80-120	TBD
Mercury	NA[5]	TBD
Nickel	80-120	TBD
Potassium	80-120	TBD
Selenium	80-120	TBD
Silver	80-120[4]	TBD
Sodium	80-120	TBD
Thallium	80-120	TBD
Tin	80-120	TBD
Vanadium	80-120	TBD
Zinc	80-120	TBD

1 %R - Percent Recovery as described in Section 12.0.
2 USEPA CLP, 1996. Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration, ILM04.1.
3 TBD - To Be Determined at time of analysis based on USEPA LCS lot number.
4 Advisory limits only.
5 NA - Not Applicable.

4.0 SAMPLING PROCEDURES

Field sampling procedures and related field investigation tasks for the BGOU DGI are discussed in detail in the following sections of the WP.

- Mobilization and demobilization - Section 3.1
- Investigation methodologies and techniques – Sections 3.2-3.7
- Groundwater monitoring well sampling - Sections 3.2 and 3.3
- Decontamination - Section 3.8
- Investigation derived waste - Section 3.9
- Surveying - Section 3.10
- Sample handling procedures – Section 3.11
- Sample identification system nomenclature - Section 3.11.2
- Sample packaging and shipping - Section 3.11.3
- Sample Custody – Section 3.11.4
- Field Measurements, Calibration, and Maintenance - Section 3.12
- Recordkeeping - Section 3.13

Standard Operating Procedures (SOPs) regarding sampling, recordkeeping, and field investigation tasks are included in Appendix D of the WP.

5.0 CUSTODY PROCEDURES

Refer to Section 5.0 of the RI QAPP (TtNUS, 2000).

6.0 CALIBRATION PROCEDURES AND FREQUENCY

Refer to Section 6.0 of the RI QAPP (TtNUS, 2000).

7.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Samples will be subjected to field and laboratory parameter measurement as necessary based on the sample location under investigation. The analytical program for environmental samples collected at each anticipated location is provided in Table 2-1 of the WP.

Chemical/physical parameters to be measured using field instrumentation include volatile organics as methane equivalents (breathing zone air and soil vapors); temperature, specific conductance, pH, turbidity dissolved oxygen, and salinity (groundwater samples); and REDOX potential (groundwater samples). Measurement of field parameters and calibration of field instruments are discussed in Section 3.12 of the WP.

All groundwater and soil samples collected for fixed-laboratory analysis during NSB-NLON BGOU DGI will be analyzed by a NFESC-approved laboratory. All groundwater samples will be analyzed for low-concentration TCL organics analysis in accordance with the Superfund Analytical Methods for Low Concentration Water for Organics Analysis (OLC02.1). All soil samples will be analyzed for TCL organics in accordance with the analytical procedures set forth in "Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846)". All soil and groundwater samples will be analyzed for TAL metals in accordance with the CLP analytical procedures set forth in the USEPA SOW for Inorganics Analysis (ILM04.1). Non-CLP methods will be used for quantitation of the remaining parameters. Tables 7-1 and 7-2 provide a summary of the laboratory analytical methods for the NSB-NLON BGOU DGI.

A complete list of the target compounds/analytes, Contract Required Quantitation Limits (CRQLs), Contract Required Detection Limits (CRDLs), and estimated PQLs is provided in Section 1.3.2.2 of this QAPP. Data generated through use of CLP protocols will be reported to the CRQL for organics analysis and the CRDL for inorganics analysis. Analytes that are positively identified and that can be quantitated at concentrations below the CRQL/CRDL will be reported as specified in the appropriate CLP SOW. All environmental data generated through use of non-CLP methods will be reported to the analyte's PQL as per the analytical method and these may vary from laboratory to laboratory. An analyte's PQL is an expression of the method detection limit with consideration given to required adjustments to ensure that the precision and accuracy requirements of the method are attainable. The PQLs provided in the tables in Section 1.3.2.2 are estimated since these values may vary based on the laboratory.

All solid sample results will be reported on a dry-weight basis. Percent solids determination will be based on CLP or SW-846 protocols, respectively. Quantitation and detection limits will also be adjusted, as necessary, based on dilutions and sample volume.

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TABLE 7-1

SUMMARY OF ORGANIC AND INORGANIC ANALYTICAL PROCEDURES GROUNDWATER SAMPLES NSB-NLON, GROTON, CONNECTICUT

Analytical Parameter	Analytical Method
TCL Volatile Organics - Low Concentration	OLC02.1[1]
TCL Semivolatile Organics (minus PAHs)	OLC02.1[1]
TCL Pesticides/PCBs	OLC02.1[1]
TAL Metals	ILM04.1[2]
TCL PAHs	SW-846 8310 / 8270C [3]
Acidity	USEPA 305.1[4]

1 USEPA CLP, 2001. Superfund Analytical Methods for Low Concentration Water for Organics Analysis, OLC02.1.

2 USEPA CLP. Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, ILM04.0.

3 USEPA, June 1997. Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, 3rd ed., up to and including Update III.

4 USEPA, 1983. Methods for Chemical Analysis of Water and Wastes.

TABLE 7-2

SUMMARY OF ORGANIC AND INORGANIC ANALYTICAL PROCEDURES
SOIL SAMPLES
NSB-NLON, GROTON, CONNECTICUT

Analytical Parameter/Procedure	Method
TCL Volatile Organics (low level preservation)	SW-846[1] 5035/8260B
TCL Semivolatile Organics (minus PAHs)	SW-846 8270C
TCL Pesticides	SW-846 8081A
TCL PCBs	SW-846 8082
TCL PAHs	SW-846 8310
TAL Metals	ILM04.1[2]

1 USEPA, June 1997. Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, 3rd ed., up to and including Update III.

2 USEPA CLP. Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, ILM04.0.

8.0 INTERNAL QUALITY CONTROL CHECKS

Refer to Section 8.0 of the RI QAPP (TtNUS, 2000).

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

Refer to Section 9.0 of the RI QAPP (TtNUS, 2000) with the following exceptions.

- "Divalent Iron – mg/L" will be omitted from Section 9.1.1.
- "Acidity – mg/L" will be added to Section 9.1.1.
- Dioxin/Furans, Perchlorate, TOC, alkalinity, hardness, chloride, nitrate, sulfate, sulfide, ammonia, methane, bulk density, pH, porosity, TOC, and SPLP references will be omitted from Section 9.1.2.

10.0 PERFORMANCE AND SYSTEM AUDITS

Refer to Section 10.0 of the RI QAPP (TtNUS, 2000).

11.0 PREVENTIVE MAINTENANCE PROCEDURES

Refer to Section 11.0 of the RI QAPP (TtNUS, 2000).

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Refer to Section 12.0 of the RI QAPP (TtNUS, 2000).

13.0 CORRECTIVE ACTION

Refer to Section 13.0 of the RI QAPP (TtNUS, 2000).

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Refer to Section 14.0 of the RI QAPP (TtNUS, 2000).

REFERENCE

TtNUS, 2000. Basewide Groundwater Operable Unit Remedial Investigation Work Plan. Naval Submarine Base New London. Groton, CT. May 2000.

APPENDIX C

FIELD FORMS

- Boring Log
- Well Construction Diagram
- Well Development Form
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Low Flow Purge Data sheet
- Soil and Sediment Sample Log Sheet
- Equipment Calibration Log
- Chain of Custody Record

BORING LOG

Tetra Tech NUS, Inc.

Page ___ of ___

PROJECT NAME/No.: _____ BORING NO.: _____
GEOLOGIST: _____ DATE START: _____
DRILLER/Co.: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

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

* When rock coring, enter rock brokeness.

Background (ppm): _____

Remarks: _____

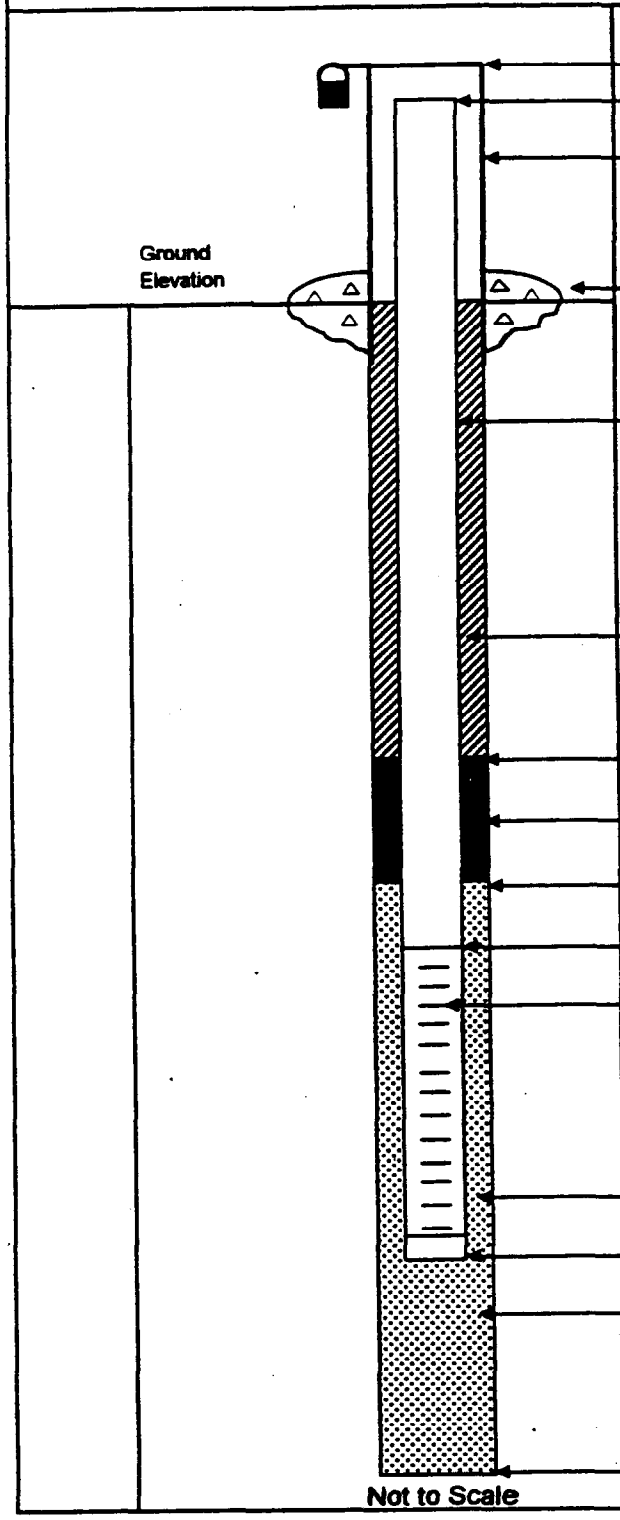
Converted to Well: Yes _____ No _____ Well I.D. #: _____

Tetra Tech NUS, Inc.

WELL No.: _____

MONITORING WELL SHEET

PROJECT:	_____	DRILLING Co.:	_____	BORING No.:	_____
PROJECT No.:	_____	DRILLER:	_____	DATE COMPLETED:	_____
SITE:	_____	DRILLING METHOD:	_____	GROUND ELEVATION:	_____
GEOLOGIST:	_____	DEV. METHOD:	_____	ELEVATION DATUM:	_____



Elevation / Height of Top of Surface Casing: _____ / _____

Elevation / Height of Top of Riser: _____ / _____

I.D. of Surface Casing: _____

Type of Surface Casing: _____

Type of Surface Seal: _____

I.D. of Riser: _____

Type of Riser: _____

Borehole Diameter: _____

Type of Backfill: _____

Elevation / Depth of Seal: _____ / _____

Type of Backfill: _____

Elevation / Depth of Top of Filter Pack: _____ / _____

Elevation / Depth of Top of Screen: _____ / _____

Type of Screen: _____

Slot Size x Length: _____

I.D. of Screen: _____

Type of Filter Pack: _____

Elevation / Depth of Bottom of Screen: _____ / _____

Elevation / Depth of Bottom of Filter Pack: _____ / _____

Type of Backfill Below Well: _____

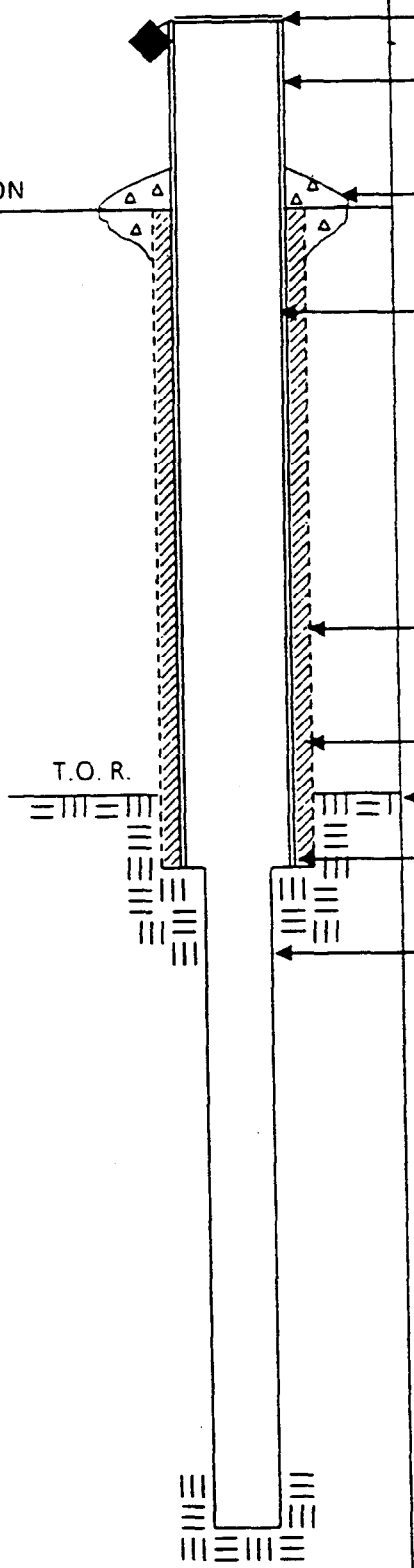
Elevation / Total Depth of Borehole: _____ / _____

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: _____ / _____

Tetra Tech NUS, Inc.

WELL DEVELOPMENT DATA SHEET

PROJECT: _____ WELL No.: _____

PROJECT No.: _____ DATE INSTALLED: _____

SITE: _____ DATE DEVELOPED: _____

PROJECT GEOLOGIST: _____ DRILLING Co.: _____

WELL DATA

WELL MATERIAL: ☐ PVC ☐ STAINLESS STEEL ☐ OTHER: _____

TOTAL DEPTH: _____ feet (TOC / bgs) CASING ID: _____ inches

STATIC WATER LEVEL: _____ feet (TOC / bgs) SCREEN LENGTH: _____ feet

CASING VOLUME _____ (gal. / L) BOREHOLE DIA.: _____ inches

PURGE DATA

START TIME: _____ (hr.) METHOD: _____

STOP TIME: _____ (hr.) PUMP TYPE: _____

Time	Cumulative Volume (gal. / L)	Pumping Rate (gpm / Lpm)	Water Level (ft. / m.)	Water Meter Type: pH	Sp. Cond. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/L)	Remarks (Color/Odor)

TOTAL PURGE VOLUME: (gal. / L) TOTAL PURGE TIME: (min. / hrs.

NOTE: All depth measurements to nearest 0.01 foot.

COMMENTS/CALCULATIONS:

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project: _____ Site: _____

Project No.: _____ Personnel: _____

Temperature: _____ Date: _____

Precipitation: _____ Level Indicator Type: _____

Tide: _____ Serial Number: _____

Well/Piezometer Number	Time	(A) Elevation of Reference Point (feet)*	(B) Water Level Indicator Reading (feet)*	=(A)-(B) Groundwater Elevation (feet)*	Total Well Depth (feet)*	Tidally Influenced	Comme

* Measurements to the nearest 0.01 foot.

Tetra Tech NUS, Inc. GROUNDWATER SAMPLE LOG SHEET

Project / Site: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

[ ] Monitoring Well

[ ] Domestic Well

[ ] Other: _____

Sampler: _____

SAMPLING DATA

Date: / Time:	Color	pH	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/L	Salinity ppt	Eh mV
Method:								

PURGE DATA

Date:	See Attached Low Flow Purge Data Sheet for Purge Data
Method:	
Monitor Reading (ppm):	
Well Casing Diameter: Well Casing Material:	
Total Well Depth (TD):	
Static Water Level (WL):	
One Casing Volume(gal/L):	
Start Purge (hrs):	
End Purge (hrs):	
Total Purge Time (min):	
Total Vol. Purged (gal/L):	

SAMPLE COLLECTION INFORMATION

Analysis	Preservative	Container Requirements	Laboratory	Collected
TCL VOLATILES (LOW-LEVEL)		X	Ceimic Corp.	
TCL SEMIVOLATILES		X	Ceimic Corp.	
TCL PEST/PCBs		X	Ceimic Corp.	
TCL PAH		X	Ceimic Corp.	
TAL METALS (TOTAL)	HNO3	X	Katahdin Analytical	
TAL METALS (FILTERED)	HNO3	X	Katahdin Analytical	

OBSERVATIONS / NOTES

LAB INFO

LAB: _____

COC #: _____

LAB: _____

COC #: _____

Check If Collected:

☐ MS / MSD ☐ DUPLICATE / ID No.:

Signature(s):

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

Well No.: _____

PROJECT: _____ DATE: _____
PROJECT NUMBER: _____ WEATHER: _____
SITE: _____ PERSONNEL: _____

Well Screen Depth: _____ / _____ ft.
Initial Water Level: _____ @ _____ hrs.
Pump Type/Material: _____
Pump Intake Depth: _____
Tide Cycle: ☐ High @ _____ ☐ Low @ _____ ☐ Not Affected
Total Purge Volume= _____ (gal / L)
Total Purge Time= _____ (min)

Time	Water Level feet below TOC	Volume mL	Flow Rate mL/min	Pump Settings	Temp °C	pH	Sp Cond mS/cm	DO mg/L	Turbidity NTU	Salinity ppt	Eh mV	Comments

Water Quality Meter (S/N): _____
Control Box Type (S/N): _____
Notes: _____

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

MONITORING INSTRUMENT CALIBRATION LOG

PROJECT NAME: _____ INSTRUMENT/MANUFACTURER: _____

PROJECT NUMBER: _____ MODEL NUMBER: _____

SITE NAME: _____ SERIAL/RENTAL ID NUMBER: _____

DATE	TIME	CALIBRATION BY	CALIBRATION STANDARD				REMARKS/ COMMENTS
			Span Gas	Concentration	Lot Number	Exp. Date	

01026

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:	

APPENDIX D

STANDARD OPERATING PROCEDURES

D-1	CT-04	Sample Nomenclature
D-2	GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement
D-3	GH-1.5	Borehole and Sampling Logging
D-4	GH-2.7	Groundwater Monitoring Well Installation
D-5	SA-1.3	Soil Sampling
D-6	SA-2.5	Direct Push Technology (Geoprobe®/Hydropunch™)
D-7	SA-6.1	Non-Radiological Sample Handling
D-8	SA-6.3	Field Documentation
D-9	SA-7.1	Decontamination of Field Equipment and Waste Handling

APPENDIX D-1

CT-04 SAMPLE NOMENCLATURE

TABLE OF CONTENTS

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2.0 SCOPE **2**

3.0 GLOSSARY **2**

4.0 RESPONSIBILITIES **2**

5.0 PROCEDURES **3**

5.1 INTRODUCTION 3
5.2 SAMPLE NUMBER FIELD REQUIREMENTS 3
5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS 4

1.0 PURPOSE

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

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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

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

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

5.0 PROCEDURES

5.1 Introduction

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

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

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

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

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

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

Site Type Location Depth Round

5.2 Sample Number Field Requirements

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

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

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

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

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

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

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

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

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

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

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

Sample Type - Examples of sample types are as follows:

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

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

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

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

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

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

Location - Examples of the location field are as follows:

A01 - Grid node A1
001 - Monitoring Well 1

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

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

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

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

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

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

5.4 Example Sample Numbers

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

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

APPENDIX D-2

GH-1.2 EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of any electrical cable and its connections.
- The presence of a survey mark on the well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) and combustible gas meter to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present, the well be should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an

established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, chalked tape or electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a float recorder or pressure transducer. When conditions in the well limit readings (i.e., turbulence in the water surface or limited access through small diameter tubing), less precise, but appropriate methods such as the air line or capillary tubing methods can be used (see subsequent SOP section for discussion of these devices).

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A):

   - Well number.
   - Water level (to the nearest 0.01 foot; 0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
   - Time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

5.3.4 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time-consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape, and added to the band reading to obtain the depth to water.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen

horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft). Another disadvantage includes the introduction of air into a monitoring well. This may not be acceptable to achieve specific project objectives.

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel systems. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this

purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment A). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID (e.g., HNu) or FID (e.g., OVA) and combustible gas meters shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

ATTACHMENT A
EXAMPLE GROUNDWATER LEVEL MESUREMENT SHEET

GROUNDWATER LEVEL MEASUREMENT SHEET

Page ___ of ___

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

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

*Measurements to nearest 0.01 foot.

Signature(s): _____

APPENDIX D-3

GH-1.5 BOREHOLE AND SAMPLING LOGGING

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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 on site, 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 hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

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

FIGURE 1

BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	PID/FID Reading (ppm): Sample 1/2	PID/FID Reading (ppm): Borehole**	PID/FID Reading (ppm): Driller 1/2**

* When rock coring, enter rock brokeness.

** Include monitor reading in 5 foot intervals @ borehole. Increase reading frequency if elevated response read.

Drilling Area Background (ppm): ____

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size					FINE-GRAINED SOILS More Than Half of Material is SMALLER Than			
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights			GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size			
						DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)
GRAVELS (50%(+)+ 1/4" Ø	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle size	GW	Well graded gravels, gravel-sand mixtures, little or no fines	SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Medium to High	None to Very Slow	Medium
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures		Slight to Medium	Slow	Slight
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures	SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium
SANDS 50%(+)+ 1/4" Ø	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle size	SW	Well graded sand, gravelly sands, little or no fines		High to Very High	None	High
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines		Medium to High	None to Very Slow	Slight to Medium
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures	HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture		
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures				

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

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	
Very Soft	Less than 0.25	0 to 2	Easily penetrate
Soft	0.25 to 0.50	2 to 4	Easily penetrate
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetr
Stiff	1.0 to 2.0	8 to 15	Readily indent
Very Stiff	2.0 to 4.0	15 to 30	Readily indent
Hard	More than 4.0	Over 30	Indented with

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be Gouged	Breaks (one blow), crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Breaks (one blow), sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Breaks considerably (several blows), sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

S-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample

O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

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

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

Z - Other Core Sizes, Specify in Remarks

12/10

12/10

WATER LEVELS

▽ W.L. Initial Level w/Date & Depth

▽ W.L. Stabilized Level w/Date & Depth

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 Figure 1 (Continued).
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 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-1.3. 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, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

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 shown in Figure 2.

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
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. 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 with difficulty by thumbnail

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 Figure 3.

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

FIGURE 3

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)

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. 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. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very 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. 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 types 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. Figure 4 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 hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4

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

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 (see Figure 3) 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 brokenness 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-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot 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 (calcareous, 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 inches 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 preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring 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 either on the back of the boring log or on a separate sheet, 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 at 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 on 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.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB - SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55

BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ORG.	5	0	0	0
C 0800	2.0	9/10				TO BLK	ROCK FR: TR BRICKS		ODOR				
							(FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 C		5/7	2.9/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	–	–
0810	6.0	9/8					GRAVEL		NAT. MATL. TOOK SAMPLE				
	•			7'▽ ±					SB01-0406 FOR ANALYSIS				
	8.0			8.0									
S-3 C		6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0
0820	10.0	17/16					TR. F. GRAVEL		HIT WATER: 7'±				
	12.0			12.0									
S-4 C		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	–	–
0830	14.0	5/8											
	15.0			15.0					AUGER REF @ 15'				
				LIGHT 16	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
									LO ∠ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±				
							SILTSTONE		SET TEMP 6" CAS TO 15.5				
4.8/5.0	②		5.0/5.0						SET 2" @ PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 R16, 4¼" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min. RUN ② = 15 min

Converted to Well: Yes ✓ No ____ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant 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/Or: 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 the terms angular, subangular, subrounded, or 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 Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently 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 Figure 5) in columns 6 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 brokenness 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 Figure 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.

APPENDIX D-4

GH-2.8 GROUNDWATER MONITORING WELL INSTALLATION

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. 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 determined during the project planning phases of the investigation, and any required permits must 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 screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

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 representative of the level to which water will rise in a well cased to the screened aquifer.

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 capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater 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 when installing a monitoring well or piezometer:

- 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 engineer's 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 installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well 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 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, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from 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 investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval 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 depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant 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 the water-bearing zone. The well diameter desired depends 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 (and possibly other) 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 (5 feet or less) are usually required where flow lines are not horizontal, (i.e., 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. 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 bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the 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), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a 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 (for installation of high capacity pumps); 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". 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 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 presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice 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, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials 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 required 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 a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of 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. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

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 annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. 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 site 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 No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

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 medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. 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 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent 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 installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used 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, extending to the surface. The grout effectively seals the remaining borehole annulus 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 upward, to prevent bridging, and to provide a better seal. In shallow 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 one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

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/chips or cement grout. A short (1- to 2-foot) 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 typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. 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 (flush-mounted) 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, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is 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

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

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 engineer's rule to ensure proper 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, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly 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. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

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. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and 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.

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 aquifers. 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 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter 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. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into 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. 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 removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section 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 manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

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 small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

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) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field 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).

5.4.1 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.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls 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.

5.4.3 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 introducing air into the formation and 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 of the well is subsequently done using the air lift method.

5.4.4 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 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or 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 (see Attachments to SOP SA-6.3) shall be completed, ensuring 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. 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 (single- or double-cased), as a cased well in bedrock, 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 an 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 or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	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
Mineral Acid/ High Solids Content	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)

Potentially-Deteriorating Substance	Type of Casing Material								
	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 Content	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

* Trademark of DuPont

Source: Barcelona et al., 1983

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 are not critical.
Weight	Relatively heavier.	Light-weight; 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 hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings – pipes should be threaded or pressure fitted. Should be steam cleaned when 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.

APPENDIX D-5

SA-1.3 SOIL SAMPLING

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A SPLIT-SPOON SAMPLER 17
B REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING 18

1.0 PURPOSE

This procedure discusses the methods used to collect surface, near surface, and subsurface soil samples. Additionally, it describes the method for sampling of test pits and trenches to determine subsurface soil and rock conditions, and recover small-volume or bulk samples.

2.0 SCOPE

This procedure is applicable to the collection of surface, near surface and subsurface soils for laboratory testing, which are exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites.

3.0 GLOSSARY

Composite Sample - A composite sample exists as a combination of more than one sample at various locations and/or depths and times, which is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples are not to be collected for volatile organics analysis.

Grab Sample - One sample collected at one location and at one specific time.

Non-Volatile Sample - A non-volatile sample includes all other chemical parameters (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

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 a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

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-barrel sampler is typically 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-barrel samplers commonly range in size from 2-inch OD to 3-1/2 inch OD. The larger sizes are commonly used when a larger volume of sample material is required.

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher excavator, or bulldozer).

Confined Space - As stipulated in 29 CFR 1910.146, a confined space means a space that: 1) is large enough and so configured that an employee can bodily enter and perform assigned work; 2) has limited or restricted means for entry or exit (for example tanks, vessels, silos, storage bins, hoppers, vaults, and pits, and excavations are spaces that may have limited means of entry.); and 3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for determining sampling objectives, as well as, the field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches, and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring and excavation activities, and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - The FOL is responsible for finalizing the location of surface, near surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits and trenches, and for adherence to OSHA regulations during these operations.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of soil samples and the completion of all required paperwork (i.e., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms).

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

5.0 PROCEDURES

5.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they have migrated into the water table, and can establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during the sampling operations, particularly noting the location, depth, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. As a result, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be obtained from published soil

surveys available through the U.S. Geological Surveys and other government or farm agencies. It is the intent of this procedure to present the most commonly employed soil sampling methods used at hazardous waste sites.

5.2 Soil Sample Collection

5.2.1 Procedure for Collecting Soil Samples for Volatile Organic Compounds

The above described traditional sampling techniques, used for the collection of soil samples for volatile organic analysis, have recently been evaluated by the scientific community and determined to be ineffective in producing accurate results (biased low) due to the loss of volatile organics in the sampling stages and microbial degradation of aromatic volatiles. One of the newly adopted sampling procedures for collecting soil samples includes the field preservation of samples with methanol or sodium bisulfate to minimize volatilization and biodegradation. These preservation methods may be performed either in the field or laboratory, depending on the sampling methodology employed.

Soil samples to be preserved by the laboratory are currently being performed using method SW-846, 5035. Laboratories are currently performing low level analyses (sodium bisulfate preservation) and high level analyses (methanol preservation) depending on the end users needs.

It should be noted that a major disadvantage of the methanol preservation method is that the laboratory reporting limits will be higher than conventional testing. The reporting levels using the new method for most analytes are 0.5 µg/g for GC/MS and 0.05 µg/g for GC methods.

The alternative preservation method for collecting soil samples is with sodium bisulfate. This method is more complex to perform in the field and therefore is not preferred for field crews. It should also be noted that currently, not all laboratories have the capabilities to perform this analysis. The advantage to this method is that the reporting limits (0.001 µg/g for GC/PID or GC/ELCD, or 0.010 for GC/MS) are lower than those described above.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

5.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organics that are to be preserved at the laboratory will be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample will be obtained using a reusable sampling handle provided with the EnCore™ sampler. The sample is collected by pushing the EnCore™ sampler directly into the soil, ensuring that the sampler is packed tight with soil, leaving zero headspace. Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives.

Once the sample is collected, it should be placed on ice immediately and shipped to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

If the lower detection limits are necessary, an option would be to collect several EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) method and medium-level (methanol preservation) method.

Methanol Preservation (Medium Level):

Soil samples to be preserved in the field with methanol will utilize 40-60 mL glass vials with septum lids. Each sample bottle will be filled with 25 mL of demonstrated analyte-free purge and trap grade methanol. Bottles may be prespiked with methanol in the laboratory or prepared in the field.

Soil will be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol preserved sample bottle. Calibration of the scale should be performed prior to use and intermittently throughout the day according to the manufacturers requirements.

The sample should be collected by pulling the plunger back and inserting the syringe into the soil to be sampled. The top several inches of soil should be removed before collecting the sample. Approximately 10 grams $\pm$2g (8-12 grams) of soil should be collected. The sample should be weighed and adjusted until obtaining the required amount of sample. The sample weight should be recorded to the nearest 0.01 gram in the field logbook and/or sample log sheet. The soil should then be extruded into the methanol preserved sample bottle taking care not to contact the sample container with the syringe. The threads of the bottle and cap must be free of soil particles.

After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

Samples to be preserved using the sodium bisulfate method are to be prepared as follows:

Add 1 gram of sodium bisulfate to 5 mL of laboratory grade deionized water in a 40-60 mL glass vial with septum lid. Bottles may be prespiked in the laboratory or prepared in the field. The soil sample should be collected in a manner as described above and added to the sample container. The sample should be weighed to nearest 0.01 gram as described above and recorded in field logbook or sample log sheet.

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soils containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode.

When preparing samples using the sodium bisulfate preservation method, duplicate samples must be collected using the methanol preservation method on a one for one sample basis. The reason for this is because it is necessary for the laboratory to perform both the low level and medium level analyses. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

If the lower detection limits are necessary, an option to field preserving with sodium bisulfate would be to collect 3 EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.2 Procedure for Collecting Non-Volatile Soil Samples

Non-volatile soil samples may be collected as either grab or composite samples. The non-volatile soil sample is thoroughly mixed in a stainless steel or disposable, inert plastic tray, using a stainless steel trowel or other approved tool, then transferred into the appropriate sample container(s). Head space is permitted in a non-volatile soil sample container to allow for sample expansion.

5.2.3 Procedure for Collecting Undisturbed Soil Samples (ASTM D1587-83)

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) will be employed. The following method will be used:

1. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Use of any side-discharge bits is permitted.

3. 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 into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. 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're 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 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.

5. Upon removal of the sampling 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. Clean filler must be placed in voids at either end of the tube prior to sealing with wax. Place plastic caps on the ends of the sample tube, tape the caps in place, and dip the ends in wax.

6. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label. Mark the "up" direction on the side of the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms (see SOP SA-6.3). 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 Dennison 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 need for acquiring an undisturbed sample.

5.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples (most commonly collected to a depth of 6 inches) for subsequent analysis is by use of a stainless steel trowel. Surface soils are considered 0-12 inches bgs.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Real-time air monitoring instrument (e.g., PID, FID, etc.).
- Latex gloves.
- Required Personal Protective Equipment (PPE).
- Required paperwork.
- Required decontamination equipment.
- Required sample container(s).
- Wooden stakes or pin flags.
- Sealable polyethylene bags (i.e., Ziploc® baggies).
- Heavy duty cooler.
- Ice (if required) double-bagged in sealable polyethylene bags.
- Chain-of-custody records and custody seals.

When acquiring surface soil samples, the following procedure shall be used:

1. Carefully remove vegetation, roots, twigs, litter, etc., to expose an adequate soil surface area to accommodate sample volume requirements.

2. Using a decontaminated stainless steel trowel, follow the procedure cited in Section 5.2.1 for collecting a volatile soil sample. Surface soil samples for volatile organic analysis should be collected from 6-12 inches bgs only.

3. Thoroughly mix (in-situ) a sufficient amount of soil to fill the remaining sample containers and transfer the sample into those containers utilizing the same stainless steel trowel employed above. Cap and securely tighten all sample containers.

4. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.

5. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

5.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6-18 inches) can be accomplished with tools such as shovels and stainless steel or pre-cleaned disposable trowels.

The following equipment is necessary to collect near surface soil samples:

- Clean shovel.
- The equipment listed under Section 5.3 of this procedure.
- Hand auger.

To obtain near-surface soil samples, the following protocol shall be observed:

1. With a clean shovel, make a series of vertical cuts to the depth required in the soil to form a square approximately 1 foot by 1 foot.

2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

3. Follow steps 2 through 5 listed under Section 5.3 of this procedure.

5.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of all stainless steel bucket bits (i.e., cylinders 6-1/2" long, and 2-3/4", 3-1/4", and 4" in diameter), a series of extension rods (available in 2', 3', 4' and 5' lengths), and a cross handle. A larger diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then withdrawn. In turn, the larger diameter bit is replaced with a smaller diameter bit, lowered down the hole, and slowly turned into the soil at the completion depth (approximately 6"). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil both from the surface, or to depths in excess of 12 feet. However, the presence of rock layers and the collapse of the borehole normally contribute to its limiting factors.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes).
- Stainless steel mixing bowls.
- The equipment listed under Section 5.3 of this procedure.

To obtain soil samples using a hand auger, the following procedure shall be followed:

1. Attach a properly decontaminated bucket bit to a clean extension rod and further attach the cross handle to the extension rod.

2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).

3. Begin augering (periodically removing accumulated soils from the bucket bit) and add additional rod extensions as necessary. Also, note (in a field notebook or on standardized data sheets) any changes in the color, texture or odor of the soil.

4. After reaching the desired depth, slowly and carefully withdraw the apparatus from the borehole.

5. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is commonly smaller in diameter than the bucket bit employed to initiate the borehole.

6. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

7. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

8. Discard the top of the core (approximately 1"), which represents any loose material collected by the bucket bit before penetrating the sample material.

9. Fill volatile sample container(s), using a properly decontaminated stainless steel trowel, with sample material directly from the bucket bit. Refer to Section 5.2.1 of this procedure.

10. Utilizing the above trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl and thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

11. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.6 Subsurface Soil Sampling With a Split-Barrel Sampler (ASTM D1586-84)

Split-barrel (split-spoon) samplers consist of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment A). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-lb. or larger casing driver.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (O.D. 2 inches, I.D. 1-3/8 inches, either 20 inches or 26 inches long); Larger O.D. samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed under Section 5.3 of this procedure.

The following steps shall be followed to obtain split-barrel samples:

1. Remove the drive head and nosepiece, and open the sampler to reveal the soil sample. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.). Carefully separate the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.

2. Collect the volatile sample from the center of the core where elevated readings occurred. If no elevated readings where encountered the sample material should still be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact). Refer to Section 5.2.1 of this procedure.

3. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl. Thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

4. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.7 Subsurface Sol Sampling Using Direct Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using direct push technology (DPT). DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

5.8 Excavation and Sampling of Test Pits and Trenches

5.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise which control the method of excavation. No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is still required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. Any entry may constitute a Confined Space and must be done in conformance with all applicable regulations. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, 29 CFR 1910.134, AND 29 CFR 1910.146.

Excavations are generally not practical where a depth of more than about 15 feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

5.8.2 Test Pit and Trench Excavation

These procedures describe the methods for excavating and logging test pits and trenches excavated to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented as described in SOP SA-6.3.

Test pits and trenches may be excavated by hand or by power equipment to permit detailed description of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration.
- The space required for efficient excavation.
- The chemicals of concern.
- The economics and efficiency of available equipment.

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, gives a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area, and spoils pile will be predicated based on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

As mentioned previously, no personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is still required, Occupational Safety and Health Administration (OSHA) requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry). It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

5.8.3 Sampling in Test Pits and Trenches

5.8.3.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made as described in SOP SA-6.3. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable Health and Safety and OSHA requirements have been met.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information would include soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples, which can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

5.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottleware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.

- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps and right angle adapter for conduit (see Attachment B).

5.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.7.3.4.

- Excavate trench or pit in several depth increments. After each increment, the operator will wait while the sampler inspects the test pit from grade level to decide if conditions are appropriate for sampling. (Monitoring of volatiles by the SSO will also be used to evaluate the need for sampling.) Practical depth increments range from 2 to 4 feet.

- The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

- Any fluid phase or groundwater seepage is encountered in the test pit.

- Any drums, other potential waste containers, obstructions or utility lines are encountered.

- Distinct changes of material are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending upon the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Remove loose material to the greatest extent possible with backhoe.

- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or SSO then approaches the bucket and monitors its contents with a photoionization or flame ionization detector. The sample is collected from the center of the bucket or pile and placed in sample containers using a decontaminated stainless steel trowel or spatula.

- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

- Using the remote sampler shown in Attachment B, samples can be taken at the desired depth from the side wall or bottom of the pit. The face of the pit/trench shall first be scraped (using a long-

handled shovel or hoe) to remove the smeared zone that has contacted the backhoe bucket. The sample shall then be collected directly into the sample jar, by scraping with the jar edge, eliminating the need to utilize samplers and minimizing the likelihood of cross-contamination. The sample jar is then capped, removed from the assembly, and packaged for shipment.

- Complete documentation as described in SOP SA-6.3.

5.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soils or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There is no practical alternative means of obtaining such data.
- The Site Safety Officer and Competent Person determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).
- A Company-designated Competent Person determines that the pit/trench is stable or is made stable (by grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements must be strictly observed.

If these conditions are satisfied, one person will enter the pit/trench. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit, usually Level B. He/she will be affixed to a safety rope and continuously monitored while in the pit.

A second individual will be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon. As an added precaution, it is advisable to keep the backhoe bucket in the test pit when personnel are working below grade. Such personnel can either stand in or near the bucket while performing sample operations. In the event of a cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 5.7.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., open tube samplers), which can be pushed or driven into the floor of the test pit.

- Suitable driving (i.e., a sledge hammer) or pushing (i.e., the backhoe bucket) equipment which is used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soils in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification, while larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 5.7.3.4 of this procedure must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry of the test pit, the requirements in Section 5.7.3.4 of this procedure must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SOP SA-6.3.

5.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL.

If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

5.9 Records

The appropriate sample log sheet (see SOP SA-6.3; Field Documentation) must be completed by the site geologist/sampler. All soil sampling locations must be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see SOP SA-6.3; Field Documentation) shall contain a sketch of pit conditions. In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Date of boring and excavation.
- Approximate surface elevation.
- Total depth of boring and excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.

6.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

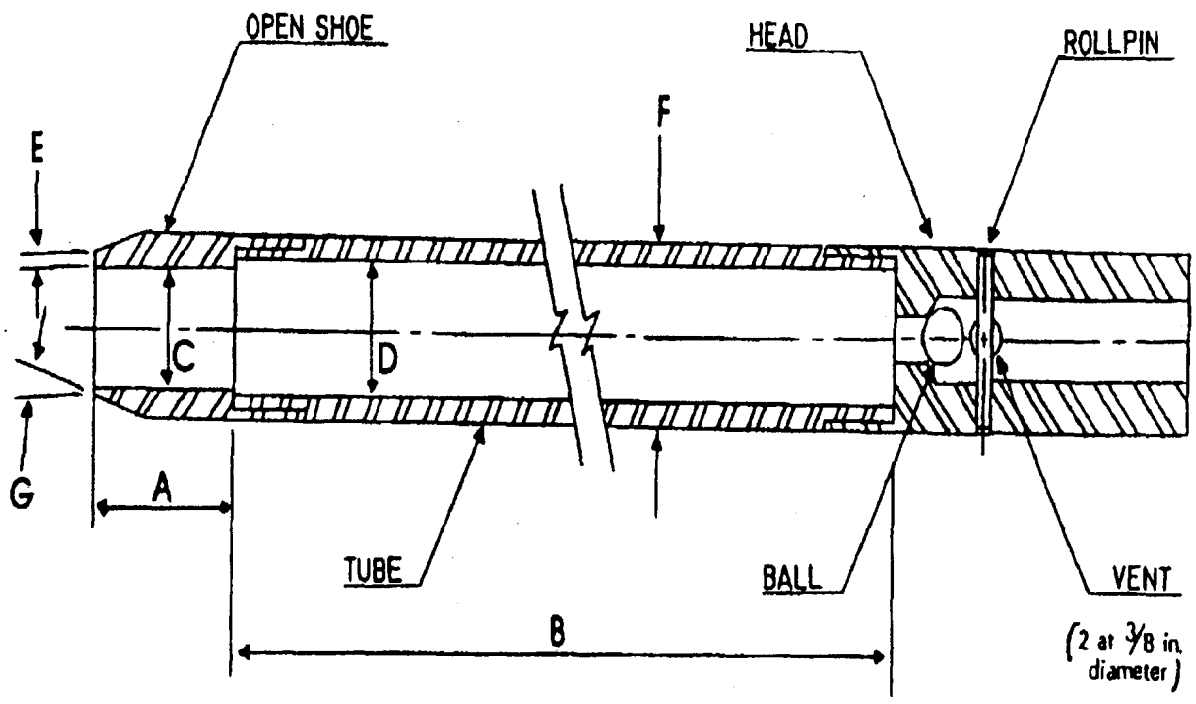
NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

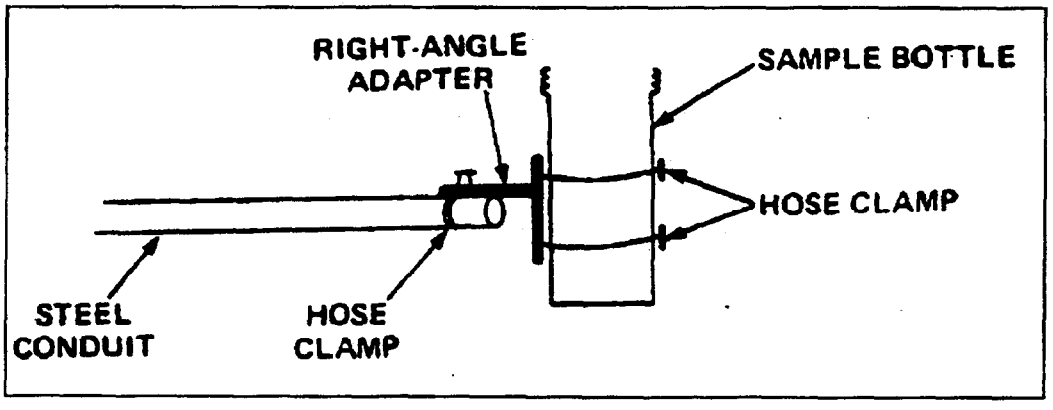
ATTACHMENT A
SPLIT-SPOON SAMPLER



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT B
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



APPENDIX D-6

SA-2.5 DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. 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

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), but the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with battery/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.

- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity ($\pm$10 percent), the well may be sampled.

- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with battery/electric-operated equipment (e.g., jack hammer).

- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: _____

III. Field Crew: _____

IV. *On-site Inspection conducted* ☐ Yes ☐ No *Initials of Inspector* _____ TtNUS _____

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required
- Level D ☒ Level B ☐
- Level C ☐ Level A ☐
- Detailed on Reverse

Respiratory equipment required
- Full face APR ☐
- Half face APR ☐
- SKA-PAC SAR ☐
- Skid Rig ☐
- Escape Pack ☐
- SCBA ☐
- Bottle Trailer ☐
- None ☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern | Action Level(s) | Response Measures

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☒ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - _____)	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/warming regimen	☐ Yes	☐ No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. *Procedure review with permit acceptors*

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒	Emergency alarms	☐	☐
Daily tail gate meetings	☒	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation	☐ Yes	☐ No
Physical hazards removed or blockaded	☐ Yes	☐ No
Site control boundaries demarcated/signage	☐ Yes	☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No

If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: _____ Permit Accepted by: _____

APPENDIX D-7

SA-6.1 NON-RADIOLOGICAL SAMPLE HANDLING

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-6.1	Page 1 of 24
		Effective Date 03/00	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject NON-RADIOLOGICAL SAMPLE HANDLING		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

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 off site for chemical analysis.
- Provides instruction for sample packaging and shipping in accordance with current U.S. Department of Transportation (DOT) and International Air Transportation Association (IATA) regulations. IATA regulates transportation of hazardous materials by air (which is the mode of transportation used for shipping nearly all samples derived during TtNUS projects).

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (ÿ261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (ÿ261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

ORM - Other regulated material (see DOT 49 CFR 173.144).

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

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, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

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 a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although 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 (certain biological samples only).

5.2.1 Overview

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 be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. 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, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. 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 transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental and hazardous material samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough noncombustible, absorbent, cushioning materials such as vermiculite (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), double-bag ice in Ziploc baggies and place around sample container shoulders, and on top of absorbent packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

5.4.2 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.

NOTE: Packaging and shipping of hazardous materials can only be performed by personnel who have participated in the TtNUS training course "Shipping Hazardous Materials" (or equivalent training approved by Health Sciences).

5.4.2.1 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) or the IATA List of Dangerous Goods Table (IATA Dangerous Goods Regulations). DOT Guide for shippers can be found in Attachment D of this document.

To determine the proper shipping name, use the following steps to help locate the shipping name on the Hazardous Materials Table, DOT 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 listed as tetrachloroethylene (listed 172.101). It may be useful to consult Health Sciences or 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. 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 use the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

If you have any doubt regarding the proper shipping name, contact Health Sciences in Pittsburgh, Pennsylvania for assistance.

5.4.2.2 Unknown Substances

For samples of hazardous substances that are not listed on the Hazardous Materials Table, or are of unknown content, the shipper is required to:

1. Determine that the substance is not forbidden for shipment. Items forbidden include explosives (solid and liquid), substances liable to produce a dangerous evolution of heat or gas, and listed "unusual" compounds (which TtNUS fortunately does not typically handle). If the substance is in any way atypical of routine shipments, contact Health Sciences for further information on determining if the substance is forbidden.

2. Classify the substance by assessing whether it is anticipated to exhibit any unusual physical properties as defined by DOT (flammability, explosivity, etc.). If the substance has more than one hazard, follow the hazardous materials classification scheme identified in Attachment C of this SOP.

3. Use the generic or "n.o.s." proper shipping name that most accurately describes the article or substance. There are two types of general proper shipping names:

   - Generic, e.g., Alcohols, n.o.s. *
   - Hazard description, e.g., Flammable liquid, n.o.s.*

   Generic or n.o.s. proper shipping names marked with an "*" require the addition of the technical name in parenthesis () immediately following the proper shipping name. For example, most of our instrument calibration gases are not listed by name and must be declared under the most accurately descriptive name, which is "Compressed Gas, n.o.s. (Mixture Nitrogen and Oxygen)".

The correct shipping classification for an unknown sample is therefore selected through a process of elimination as described above (and detailed in 49 CFR 172.101(c)(11). By using the provisions in this paragraph, the proper shipping name and description will be determined. A step-by-step guide is provided by the DOT and can be found in Attachment D of this SOP. Again, if you have any doubt regarding the proper shipping name, contact Health Sciences for assistance.

5.4.3 Packaging and Shipping of Samples Classified as Flammable Liquid (or Solid)

5.4.3.1 Packaging

Applying the word "flammable" to a sample does not necessarily mean that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations and classification schemes. The DOT defines flammable liquids as substances with a flash point less than 140°F (60°C). For shipping purposes, liquids with a flash point exceeding 95°F (35°C) need not be considered as flammable liquids if they are miscible solutions and have a water content of more than 90% by weight. For solutions classified as flammable liquids:

1. Containerize sample as required (see Attachments A and B). To prevent leakage, fill container no more than 90 percent full. Seal lid with teflon tape or wire.

2. Complete sample label and attach securely to sample container.

3. Seal container and place in 2-mil-thick (or thicker) polyethylene bag (e.g., Ziploc baggie), one sample per bag. Position sample identification label so that it can be read through bag. Seal bag.

4. For soil jars, place sealed bag inside metal can (available from laboratory or laboratory supplier) 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 5.3.4.2, below. Single 1-gallon bottles do not need to be placed in metal cans.

5. Place one or more metal cans (or a single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans (or bottle) with noncombustible, absorbent cushioning materials for stability during transport. The absorbent material should be able to absorb the entire contents of the container. Mark container as indicated in Paragraph 2 below.

5.4.3.2 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.
   - Proper shipping name from the hazardous materials table (DOT Regulation CFR 49 172.101). Example: "Flammable Liquid, n.o.s. (with the technical name in parentheses).

2. Determine packing group. The packing group must be included on the shipping papers in the description section. Packaging groups are classified as follows:

   Group I. Most Hazardous
   Group II. Medium Hazard
   Group III. Least Hazardous

   The packing group will be listed in the hazardous materials table, column 5.

3. Place the following information on outside shipping container per the instructions provided in the "Shipping Hazardous Materials" course:

   - Proper shipping name
   - UN or NA number
   - Proper label(s)
   - Addressee and sender

For flammable liquids, the following are the proper labels to be placed on the outside shipping container:

- DOT "Flammable liquid" label
- Package orientation label (arrows pointing upward) on at least two opposite sides of the package
- "Cargo Aircraft Only" label if shipping more than 30L of flammable liquids in the package.

5.4.3.3 Shipping Papers

Principally because of limitations in sample holding times, TtNUS almost exclusively uses air transportation to ship hazardous materials and other environmental samples. The "Dangerous Goods Airbill" is the shipping paper used to document the information associated with the shipment. As identified previously, only personnel who have participated in "Shipping Hazardous Materials" training (or equivalent course) are authorized to prepare hazardous materials for shipment - including preparation of associated shipping papers. Included in this training are instructions on what specific information is to be provided on the Airbill for hazardous materials typically shipped by TtNUS. Refer to the training course Student Manual or contact Health Sciences for this information.

The properly executed Chain-of-Custody Report must be included in the container. Use custody seals.

Using the Airbill of our common carrier (i.e., Federal Express) as an example, the following instructions apply to the information to be provided under "Transport Details", "Nature and Quantity of Dangerous Goods", and other associated fields.

a) Transport Details

- Select "Passenger and Cargo" or "Cargo Aircraft Only" (This is based on the type and quantity of dangerous goods you are shipping). X-out the non-applicable selection.
- Airport of Departure - Enter the full name of the airport or city of departure.
- Airport of Destination - Enter the full name of the airport or city of destination.

b) Shipment Type – Delete the option that does not apply (Non-Radioactive/Radioactive)

c) Nature and Quantity of Dangerous Goods

1. Dangerous Goods Identification

   - Proper Shipping Name - List the proper shipping name (this is the name as it appears on the List of Dangerous Goods Table and NOT the product or trade name), and if applicable, the technical name in parenthesis.
   - Class or Division - List the class or division number and, if applicable, compatibility group.
   - UN or ID No - List the UN or I.D. number, preceded with "UN" or "I.D." This selection may change when shipping in accordance with 49 CFR regulations that permit the shipment under NA (North American Continental Shipments) designations for certain substances.
   - Packing Group – List the appropriate packing group, if applicable. This is the level of anticipated hazard of the shipment. It does not apply for all shipments. When no information is available, leave the space blank.
   - Subsidiary Risk – List the class or division number of the subsidiary risk, if applicable. The subsidiary risk is any additional hazard beyond the most significant (or primary) hazard. This information is obtained from the List of Dangerous Goods Table.

2. Quantity and Type of Packaging – List the number of packages, the type of package, and the net quantity in each package. The type of packaging you are shipping the hazardous material in is presented first, followed by the amount (Kg, L, etc.). For example, "1 fiberboard box X 2 Kg". When no outer packaging is identified, the packaging selected must provide limited protection of the inner packaging by securing and cushioning during shipment. NOTE: Always use the package that the hazardous material was shipped to the site in. If it is not available, contact the Health Sciences Department in Pittsburgh for further instruction.

3. Packing Instructions – Enter the Packing Instruction number. These instructions are provided in Section 5 of the IATA Dangerous Goods Regulations. They provide the exact type of packaging required by the industry for various hazard classes. When no addition packaging considerations are given, the shipper may use their best judgment for the shipment of an identified substance and/or article.

4. Authorization – List the words " Limited Quantity," if applicable; list any special provision(s) or approval(s) if applicable. This section provides for exceptions to this transportation regulation and the conditions for those exceptions.

d) Additional handling Information - Enter any required special handling information.

e) Prepared for Air Transport according to: Check the ICAO/IATA box.

f) Emergency Telephone Number - Enter the 24-hour emergency contact number. This number is required of all US Origin or Destination Shipments. List the number for InfoTRAC (1-800-535-5053). InfoTRAC is a company retained by TtNUS to provide 24-Hour Emergency Hotline service for dangerous goods shipment. This company has MSDSs for the substances routinely shipped by TtNUS. They provide information to FedEx or any other emergency responders, should situations arise with one of our shipments. In addition, they have telephone numbers of certain Tetra Tech NUS Health Science Department personnel in the Pittsburgh Office in the event of an emergency.

g) Name/Title of the Signatory - Enter name and job title (Field Operations Leader, Geologist, Health & Safety Specialist, etc.)

h) Place and date - Enter the city and date of shipment

i) Signature - Sign the form (must be a complete signature). All alterations must be signed with the same signature used to sign the declaration.

5.4.3.4 Transportation

1. The majority of unknown hazardous substance samples will be classified as flammable liquids. The samples will be transported by rented or common carrier truck, railroad, or express overnight package services. Do not transport samples on any passenger-carrying air transport system, even if the system has cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that carry only cargo. If unsure of what mode of transportation to use, consult Health Sciences.[1]

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 followed.

3. Use the hazardous materials shipping check list (Attachment E) as a guidance to ensure that all sample-handling requirements are satisfied.

4. In some cases, various materials may react if they break during shipment. To determine if you are shipping such materials, refer to the DOT compatibility chart in Attachment F.

5.5 Shipment of Lithium Batteries

Monitoring well data are analyzed using either the Hermit SE 1000 or the Hermit SE 2000 environmental data logger. These instruments are typically powered by lithium batteries in sufficient quantity to make the unit subject to hazardous material shipping requirements. The DOT determined that lithium batteries are to be shipped using the following information:

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1 Note: If you are unsure as how to ship the sample (hazardous or environmental sample), contact Health Sciences so that a decision can be made as to the proper shipping practices. The DOT and IATA penalties for improper shipment of a hazardous material are stringent and may include a prison term for intentional violations.

- Product Designation
  - Hermit SE 1000
  - Hermit SE 2000

- Proper Shipping Name
  - Lithium batteries, contained in equipment, UN3091

- UN No - UN-3091

- Classification or Division
  - Class 9

Shipment of equipment containing lithium batteries must be accompanied by shipping papers completed as indicated in Attachment G. The instrument will be shipped by Federal Express as a Hazardous Material. Place the instrument in the same container in which it was received. This container or case is a DOT-approved shipping container. For Federal Express procedures to ship hazardous materials, call 1-800-238-5355, extension 922-1666. In most cases, the return shipping papers and DOT labels will be shipped to you from the company warehouse or the vendor. An example of the types of labels used for shipment and the wording are shown in Attachment G. These labels will be attached to the outside container and include all the information noted under Section 5.4.3.2. Instead of the Flammable Liquid information, however, the following will be presented with the following wording:

- Lithium Batteries Contained in Equipment
  - UN-3091

- DOT Miscellaneous Hazardous Materials (Class 9) label

- "Cargo Aircraft Only" label

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

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.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration			Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER						
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		Wide-mouth glass with teflon liner	2 x 4 oz.	Cool to 4°C	14 days
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	7 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube – 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/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 - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	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; 0.6 g 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
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	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 & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
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 (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	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

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
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], [12]	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]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & 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 (PAHs)[11],[14]	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
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G); generally 1L.
(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°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, 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 periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made 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 7 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 7 days before extraction and for 40 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-diphenylthydrazine 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% $Na_2S_2O_3$.

ATTACHMENT C

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2a)

1. Radioactive material (except a limited quantity)
2. Division 2.3, Poisonous Gases
3. Division 2.1, Flammable Gas
4. Division 2.2, Nonflammable gas
5. Division 6.1, Poisonous Liquids, Packing Group 1 (poison by inhalation only)
6. Division 4.2, Pyrophoric Material
7. Division 4.1, Self-Reactive Material
8. Class 3, Flammable Liquids*
9. Class 8, Corrosive Material
10. Division 4.1, Flammable Solid*
11. Division 4.2, Spontaneously Combustible Materials*
12. Division 4.3, Dangerous When Wet Materials*
13. Division 5.1, Oxidizers*
14. Division 6.1, Poisonous Liquids or Solids (other than Packing Group 1)*
15. Combustible liquid
16. Class 9, Miscellaneous Hazardous Materials

* If a material has or meets the criteria for more than one hazard class, use the precedence of hazardous table on the following page for Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1. The following table ranks those materials that meet the definition of Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1.

ATTACHMENT C (Continued)

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2a)

Class	Packing Group	4.2	4.3	5.1 I[a]	5.1 II[a]	5.1 III[a]	6.1 I (Dermal)	6.1 I (Oral)	6.1 II	6.1 III	8 I (Liquid)	8 I (Solid)	8 II (Liquid)	8 II (Solid)	8 III (Liquid)	8 III (Solid)
3	I						3	3	3	3	3	[c]	3	[c]	3	[c]
3	II						3	3	3	3	8	[c]	3	[c]	3	[c]
3	III						6.1	6.1	6.1	3[d]	8	[c]	8	[c]	3	[c]
4.1	II[b]	4.2	4.3	5.1	4.1	4.1	6.1	6.1	4.1	4.1	[c]	8	[c]	4.1	[c]	4.1
4.1	III[b]	4.2	4.3	5.1	4.1	4.1	6.1	6.1	6.1	4.1	[c]	8	[c]	8	[c]	4.1
4.2	II		4.3	5.1	4.2	4.2	6.1	6.1	4.2	4.2	[c]	8	[c]	4.2	[c]	4.2
4.2	III		4.3	5.1	4.2	4.2	6.1	6.1	6.1	4.2	[c]	8	[c]	8	[c]	4.2
4.3	I			5.1	4.3	4.3	6.1	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
4.3	II			5.1	4.3	4.3	6.1	4.3	4.3	4.3	8	8	8	4.3	4.3	4.3
4.3	III			5.1	4.3	4.3	6.1	6.1	6.1	4.3	8	8	8	8	4.3	4.3
5.1	I[a]						5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
5.1	II[a]						6.1	5.1	5.1	5.1	8	8	8	5.1	5.1	5.1
5.1	III[a]						6.1	6.1	6.1	5.1	8	8	8	8	5.1	5.1
6.1	I, Dermal										8	6.1	6.1	6.1	6.1	6.1
6.1	I, Oral										8	6.1	6.1	6.1	6.1	6.1
6.1	II, Inhalation										8	6.1	6.1	6.1	6.1	6.1
6.1	II, Dermal										8	6.1	8	6.1	6.1	6.1
6.1	II, Oral										8	8	8	6.1	6.1	6.1
6.1	III										8	8	8	8	8	8

(a) There are at present no established criteria for determining Packing Groups for liquids in Division 5.1. At present, the degree of hazard is to be assessed by analogy with listed substances, allocating the substances to Packing Group I, Great; Group II, Medium; or Group III, Minor Danger.

(b) Substances of Division 4.1 other than self-reactive substances.

(c) Denotes an impossible combination.

(d) For pesticides only, where a material has the hazards of Class 3, Packing Group III, and Division 6.1, Packing Group III, the primary hazard is Division 6.1, Packing Group III.

ATTACHMENT D

GUIDE FOR HAZARDOUS MATERIALS SHIPPERS

USE OF GUIDE - This guide is presented as an aid to shippers of hazardous materials. It does not contain or refer to all of the DOT requirements for shipping hazardous materials. For specific details, refer to all of the DOT requirements for shipping hazardous materials, as provided in the Code of Federal Regulations (CFR), Title 49, Transportation, Parts 100-199.

The following is offered as a step-by-step procedure to aid in compliance with the applicable DOT regulations.

STEP 1 - DETERMINE THE PROPER SHIPPING NAME. The shipper must determine the proper shipping name of the materials as listed in the Hazardous Materials Table, 49 CFR 172.101, Column (2).

STEP 2 - DETERMINE THE HAZARD CLASS OR CLASSES.

a. Refer to the Table, 49 CFR 172.101, Column (3), and locate the hazard class of the material.
b. If more than one class is shown for the proper shipping name, determine the proper class by definition.
c. If the materials have more than one hazard, classify the material based on the order of hazards in 49 CFR 173.2.

STEP 3 - SELECT THE PROPER IDENTIFICATION NUMBERS.

a. Refer to the Table, 49 CFR 172.101, Column (3a), and select the Identification Number (ID) that corresponds to the proper shipping name and hazard class.
b. Enter the ID number(s) on the shipping papers and display them, as required, on packagings, placards and/or orange panels.

STEP 4 - DETERMINE THE MODE(S) OF TRANSPORT TO ULTIMATE DESTINATION.

a. As a shipper, you must assure yourself that the shipment complies with various modal requirements.
b. The modal requirements may affect the following: (1) Packaging; (2) Quantity per Package; (3) Marking; (4) Labeling; (5) Shipping Papers; and (6) Certification.

STEP 5 - SELECT THE PROPER LABEL(S) AND APPLY AS REQUIRED.

a. Refer to the Table, 49 CFR 172.101, Column (4) for required labels.
b. For details on labeling refer to (1) Additional Labels, 49 CFR 172.402; (2) Placement of Labels, 49 CFR 172.406; (3) Packagings (Mixed or Consolidated), 49 CFR 172.404(a) and (h); (4) Packages Containing Samples, 49 CFR 172.402(h); (5) Radioactive Materials, 49 CFR 172.403; and (6) Authorized Label Modifications, 49 CFR 172.405.

STEP 6 - DETERMINE AND SELECT THE PROPER PACKAGES.

a. Refer to the Table, 49 CFR 172.101, Column (5a) for exceptions and Column (5b) for specification packagings. Consider the following when selecting an authorized package: Quantity per Package; Cushioning Material, if required; Proper Closure and Reinforcement; Proper Pressure; Outage; etc., as required.
b. If packaged by a prior shipper, make sure the packaging is correct and in proper condition for transportation.

ATTACHMENT D (Continued)
GUIDE FOR HAZARDOUS MATERIALS SHIPPERS

STEP 7 - MARK THE PACKAGING (INCLUDING OVERPACKS).

a. Apply the required markings (49 CFR 172.300); Proper shipping name and ID number, when required (49 CFR 172.301); Name and address of Consignee or Consignor (49 CFR 172.306).
b. For details and other required markings, see 49 CFR 172.300 through 172.338.

STEP 8 - PREPARE THE SHIPPING PAPERS.

a. The basic requirements for preparing shipping papers include Proper Shipping Name; Hazard Class; ID Number; Total Quantity; Shipper's Certification; and Emergency Response Telephone Number.
b. Make all entries on the shipping papers using the information required and in proper sequence (49 CFR 172.202).

STEP 9 - CERTIFICATION.

a. Each shipper must certify by printing (manually or mechanically) on the shipping papers that the materials being offered for shipment are properly classified, described, packaged, marked and labeled, and in proper condition for transportation according to the applicable DOT Regulations (49 CFR 172.202).

STEP 10 - LOADING, BLOCKING, AND BRACING. When hazardous materials are loaded into the transport vehicle or freight container, each package must be loaded, blocked, and braced in accordance with the requirements for mode of transport.

a. If the shipper loads the freight container or transport vehicle, the shipper is responsible for the proper loading, blocking, and bracing of the materials.
b. If the carrier does the loading, the carrier is responsible.

STEP 11 - DETERMINE THE PROPER PLACARD(S). Each person who offers hazardous materials for transportation must determine that the placarding requirements have been met.

a. For Highway, unless the vehicle is already correctly placarded, the shipper must provide the required placard(s) and required ID number(s) (49 CFR 172.506).
b. For Rail, if loaded by the shipper, the shipper must placard the rail car if placards are required (49 CFR 172.508).
c. For Air and Water shipments, the shipper has the responsibility to apply the proper placards.

STEP 12 - HAZARDOUS WASTE/HAZARDOUS SUBSTANCE.

a. If the material is classed as a hazardous waste or hazardous substance, most of the above steps will be applicable.
b. Pertinent Environmental Protection Agency regulations are found in the Code of Federal Regulations, Title 40, Part 262.

As a final check and before offering the shipment for transportation, visually inspect the shipment. The shipper should ensure that emergency response information is on the vehicle for transportation of hazardous materials.

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Revised March 1995.

ATTACHMENT E

HAZARDOUS MATERIALS SHIPPING CHECK LIST

PACKAGING

1. Check DOT 173.24 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 for 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 that 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. Check that certification is signed by shipper.
8. 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 F
DOT SEGREGATION AND SEPARATON CHART

Class or Division	Notes	1.1-1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3 gas Zone A*	2.3 gas Zone B*	3	4.1	4.2	4.3	5.1	5.2	6.1 liquids PG-I Zone A*	7	8 liquids only
Explosives... 1.1 and 1.2	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Explosives..... 1.3		*	*	*	*	*	X		X	X	X		X	X	X	X	X		X
Explosives..... 1.4		*	*	*	*	*	O		O	O	O		O				O		O
Very insensitive explosives..... 1.5	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Extremely insensitive explosives..... 1.6		*	*	*	*	*													
Flammable gases 2.1		X	X	O	X				X	O							O	O	
Non-toxic, non-flammable gases 2.2		X			X														
Poisonous gas - Zone A** 2.3		X	X	O	X		X				X	X	X	X	X	X			X
Poisonous gas - Zone B** 2.3		X	X	O	X		O				O	O	O	O	O	O			O
Flammable liquids..... 3		X	X	O	X				X	O					O		X		
Flammable solids..... 4.1		X			X				X	O							X		O
Spontaneously combustible materials 4.2		X	X	O	X				X	O							X		X
Dangerous-when-wet materials 4.3		X	X		X				X	O							X		O
Oxidizers..... 5.1	A	X	X		X				X	O	O						X		O
Organic peroxides.... 5.2		X	X		X				X	O							X		O
Poisonous liquids PG I - Zone A** 6.1		X	X	O	X		O				X	X	X	X	X	X			X
Radioactive materials . 7		X			X		O												
Corrosive liquids 8		X	X	O	X				X	O		O	X	O	O	O	X		

No entry means that the materials are compatible (have no restrictions).

X These materials may not be loaded, transported, or stored together in the same vehicle or facility.
O The materials may not be loaded, transported, or stored together in the same vehicle or facility unless they are separated for 4 feet on all sides.
* Check the explosives compatibility chart in 49 CFR 179.848(f).
A Ammonium nitrate fertilizers may be stored with Division 1.1 materials.
** Denotes inhalation hazardous for poisons; consult field team leader or project manager if you encounter a material in this class
1 before shipment.

ATTACHMENT G
LITHIUM BATTERY SHIPPING PAPERS

3224637861

Two completed and signed copies of this Declaration must be handed to the operator.

WARNING

Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for: *(delete non applicable)*

[redacted] | CARGO AIRCRAFT ONLY

Airport of Departure

Airport of Destination: 19CYS

Shipment type: *(delete non-applicable)*

NON-RADIOACTIVE | [redacted]

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification						
Proper Shipping Name	Class or Division	UN or ID No.	Subsidiary Risk	Quantity and type of packing	Packing Inst.	Authorization
LITHIUM BATTERIES CONTAINED IN EQUIPMENT	9	UN3091		1 PLASTIC BOX X 55 GRAMS	912 II	PER CA-9206009

Additional Handling Information

1 HERMIT SERIES DATALOGGER X 55 GRAMS (11 GRAMS/CELL)

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.

Name/Title of Signatory

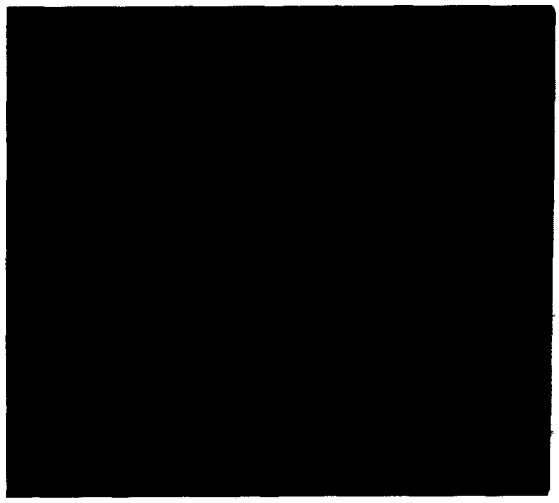
Place and Date

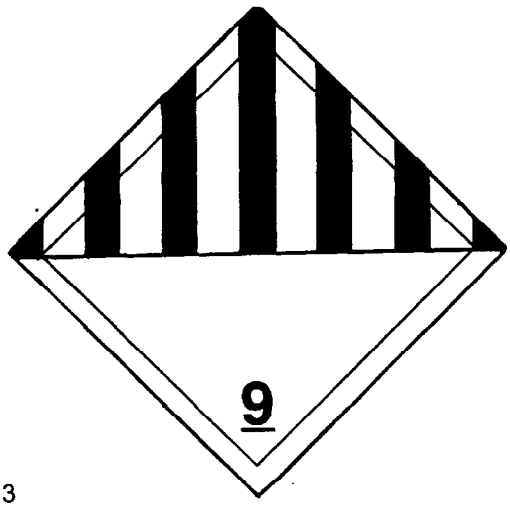
Signature *(see warning above)*

Emergency Telephone Number (Required for US Origin or Destination Shipments)
800-535-5053

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

ATTACHMENT G (CONTINUED)
LITHIUM BATTERY SHIPPING PAPERS





3

LITHIUM BATTERIES CONTAINED IN EQUIPMENT.
UN-3091.
SHIPPED UNDER CA-9206009

APPENDIX D-8

SA-6.3 FIELD DOCUMENTATION

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1.0 PURPOSE

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

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

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

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

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

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

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

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

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

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

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook 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/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. 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. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Field Notebooks

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

5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Table of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client

approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

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

5.3.1.2 Sample Label

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

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager, while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

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

5.3.1.5 Field Analytical Log Sheets for Geochemical Parameters

Field Analytical Log Sheets (Attachment B-8) are used to record geochemical and/or natural attenuation field test results. Attachments B-8 (3-page form) should be used when applicable.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

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

5.3.2.2 Data Sheet for Pumping Test

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

5.3.2.3 Packer Test Report Form

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

5.3.2.4 Summary Log of Boring

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

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions.

5.3.2.6 Test Pit Log

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

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance (Attachment C-11) should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record (Attachment C-12) should be used as the project directs to document all well development activities.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

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

5.4 Field Reports

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

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

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

5.4.1.2 Responsibilities

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

5.4.1.3 Submittal and Approval

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

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required. Attachment F is an example of a Field Trip Summary Report form.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment B-8	FIELD ANALYTICAL LOG SHEET
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-9	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-10	EXAMPLE TEST PIT LOG
Attachment C-11	MONITORING WELL MATERIALS CERTIFICATE OF CONFORMANCE
Attachment C-12	MONITORING WELL DEVELOPMENT RECORD
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

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

ACTIVITIES:

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

_____

Field Operations Leader

ATTACHMENT B-1

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: / Time: / Method:	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

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

ATTACHMENT B-2

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date:								
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-3

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-4

Tetra Tech NUS, Inc.

CONTAINER SAMPLE & INSPECTION SHEET

Page____ of ____

Project Site Name: _____
Project Number: _____
Site Identification: _____
Container Number(s): _____
Sample Type: 0 Grab
0 Composite

Sample ID No. _____
Sampled By: _____
C.O.C. No. _____
Concentration: 0 High
0 Medium
0 Low

CONTAINER SOURCE	CONTAINER DESCRIPTION
DRUM: 0 Bung Top 0 Lever Lock 0 Bolted Ring 0 Other _____	**COLOR:** _____ **CONDITION:** _____
TANK: 0 Plastic 0 Metal 0 Other _____	**MARKINGS:** _____ **VOL. OF CONTENTS:** _____
OTHER: _____	**OTHER:** _____

CONTAINER DISPOSITION	CONTENTS DESCRIPTION
SAMPLED: _____ **OPENED BUT NOT SAMPLED:** Reason _____ **NOT OPENED:** Reason _____	**SINGLE PHASED:** _____ **MULTIPHASE :** Layer 1 / Layer 2 / Layer 3 Phase (Sol. or Liq.) _____ _____ _____ Color _____ _____ _____ Viscosity L, M or H L, M or H L, M orH % of Total Volume _____ _____ _____
MONITOR READING:	**SAMPLE and /or INSPECTION DATE & TIME:** _____HRS. **METHOD:**_____
SAMPLER(S) and / or INSPECTOR(S) SIGNATURE:	**ANALYSIS:**

ATTACHMENT B-5

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:		
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:	Laboratory:		

ATTACHMENT B-6

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE ____ OF _____

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER AND PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER	CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS									COMMENTS

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY			1. RECEIVED BY		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

3/99
FORM NO. TtNUS-001

ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

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

ATTACHMENT B-8

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): _____

SAMPLING DATA:

Date: / Time: / Method:	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv):_____ Electrode Make & Model:_____

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier		Concentration
_____	x 0.01	=	mg/L
_____	x 0.02	=	mg/L

CHEMetrics: _____mg/L

Notes:

Alkalinity:

Analysis Time: _____

Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range: _____mg/L) Filtered: ☐

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier		Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	_____ & _____	x 0.1	=	mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	_____ & _____	x 0.4	=	mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	_____ & _____	x 1.0	=	mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	_____ & _____	x 2.0	=	mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	_____ & _____	x 5.0	=	mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	_____ & _____	x 10.0	=	mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:_____ Digits Required: 1st.:_____ 2nd.:_____ 3rd.:_____

Carbon Dioxide:

Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count			Concentration
_____	x 0.1	=	mg/L
_____	x 0.2	=	mg/L
_____	x 1.0	=	mg/L
_____	x 2.0	=	mg/L

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:_____ Digits Required: 1st.:_____ 2nd.:_____ 3rd.:_____

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Sulfide (S^{2-}):

Equipment: DR-700 DR-8 __ HS-WR Color Wheel Other: _____ Analysis Time: _____

Program/Module: 610nm 93

Concentration: _____ mg/L Filtered: ☐

Notes: _____

Sulfate (SO_4^{2-}):

Equipment: DR-700 DR-8 __ Other: _____ Analysis Time: _____

Program/Module: 91

Concentration: _____ mg/L Filtered: ☐

Standard Solution: ☐ Results: _____

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Nitrite (NO_2^--N):

Analysis Time: _____

Equipment: DR-700 DR-8 __ Other: _____ Filtered: ☐

Program/Module: 60

Concentration: _____ mg/L Reagent Blank Correction: ☐

Standard Solution: ☐ Results: ☐

Notes: _____

Nitrate (NO_3^--N):

Analysis Time: _____

Equipment: DR-700 DR-8 __ Other: _____ Filtered: ☐

Program/Module: 55

Concentration: _____ mg/L

Nitrite Interference Treatment: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 __ HACH MN-5 Other: _____ Analysis Time: _____

Program/Module: 525nm 41

Concentration: _____ mg/L Filtered: ☐

Digestion: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Ferrous Iron (Fe^{2+}):

Equipment: DR-700 DR-8 __ IR-18C Color Wheel Other: _____ Analysis Time: _____

Program/Module: 500nm 33

Concentration: _____ mg/L Filtered: ☐

Notes: _____

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: _____ Analysis Time: _____

Concentration: _____ mg/L Exceeded 5.0 mg/L range on color chart: ☐

Notes: _____

QA/QC Checklist:

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

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

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ___ of ___

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

Tetra Tech NUS, Inc.

PUMPING TEST DATA SHEET

PROJECT NAME: _____ PUMPING WELL NUMBER: _____
PROJECT NUMBER: _____ MEASURED WELL NUMBER: _____

[ ] PUMPING TEST [ ] STEP DRAW DOWN TEST

DATE(s): MONITORING POINT:
MEASUREMENT METHOD: DEPTH CORRECTION (ft):
TEST NUMBER: *PUMP SETTING (Ft. below monitoring point):*
STATIC WATER LEVEL (ft): DISTANCE FROM PUMPING WELL (ft):
PERSONNEL:
REMARKS:

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

NOTE: All measurements to nearest 0.01 foot measured from top of well riser pipe unless otherwise noted.

ATTACHMENT C-3

ATTACHMENT C-3

PACKER TEST REPORT FORM

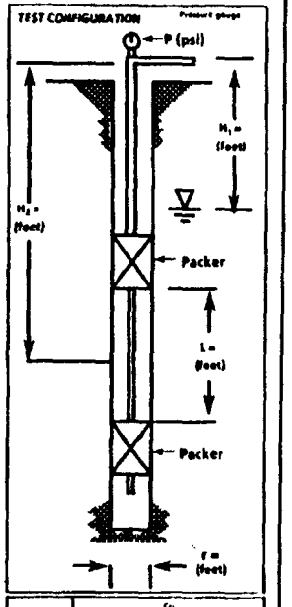
PROJECT: _____ PROJECT NO.: _____ TEST NO: _____ PAGE ____ OF ____

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

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

Flow Test					Calculated Results							
Pressure, P (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(ft) = 2.31 (psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp Q/H	K (cm/sec) = 9.67 x 10⁻⁷ K (ft/yr)

TEST CONFIGURATION



Length of Test Section in feet, L	Cp (Standard Bit Size)			
	EX (1.5")	AX (1.875")	BX (2.31")	NX (3")
1	31,000	20,500	25,000	21,700
2	19,400	16,100	14,000	15,700
5	9,000	9,200	8,000	6,800
8	6,800	6,500	5,400	5,200
10	5,700	5,400	4,400	4,900
15	4,100	3,800	3,800	3,600
20	3,000	2,900	2,800	2,800

CP = (1/(2 x L)) ln(L/r) (70.315 5)
7.48 Gallons = 1 Ft³
1 psi = 2.31 ft head
Remarks: _____

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

ATTACHMENT C-4

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

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

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area _____
Background (ppm): [ ]

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

ATTACHMENT C4 (Continued)

LEGEND
SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

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

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

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

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

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

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily 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)			ROCK BROKENESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

5-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

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

Q-NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▽ 12.6' Initial Level w/Date & Depth

12/16

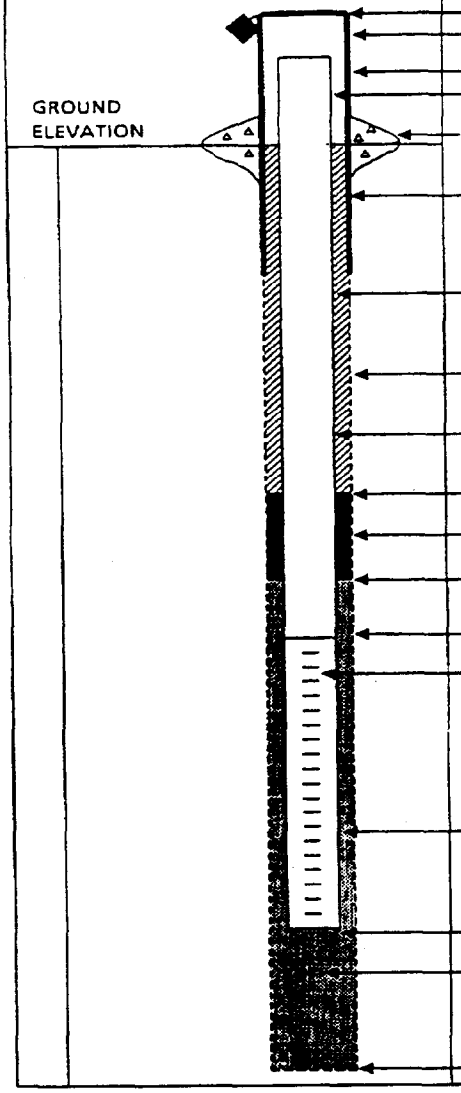
ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ / _____

TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ / _____

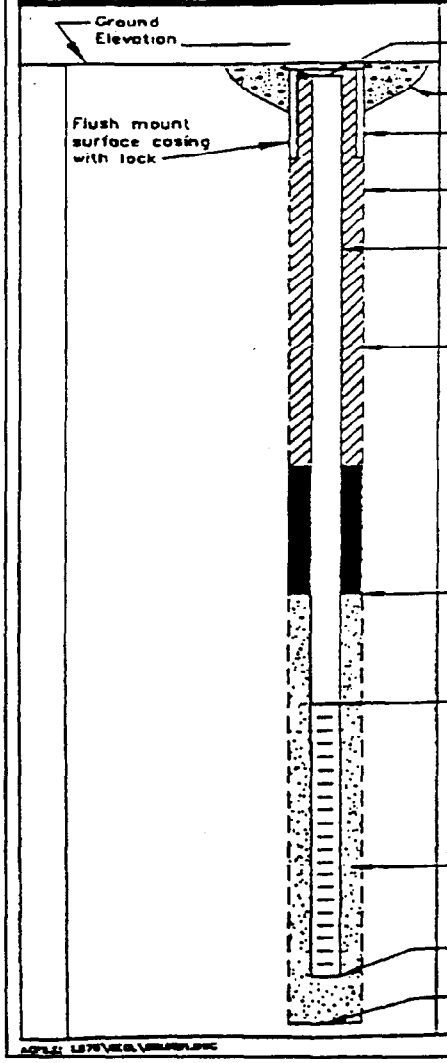
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: _____

MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

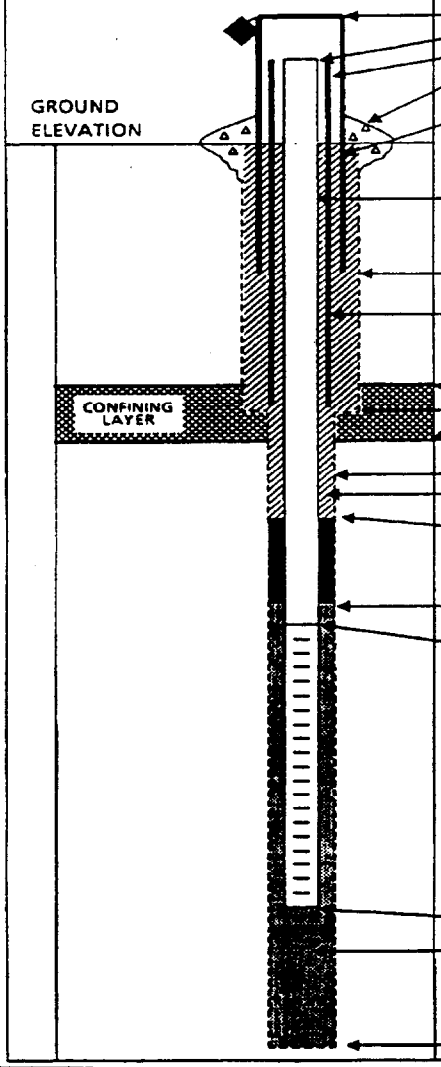
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

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

BOREHOLE DIAMETER: _____

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

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

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

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

DEPTH TOP OF SAND PACK: _____

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

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

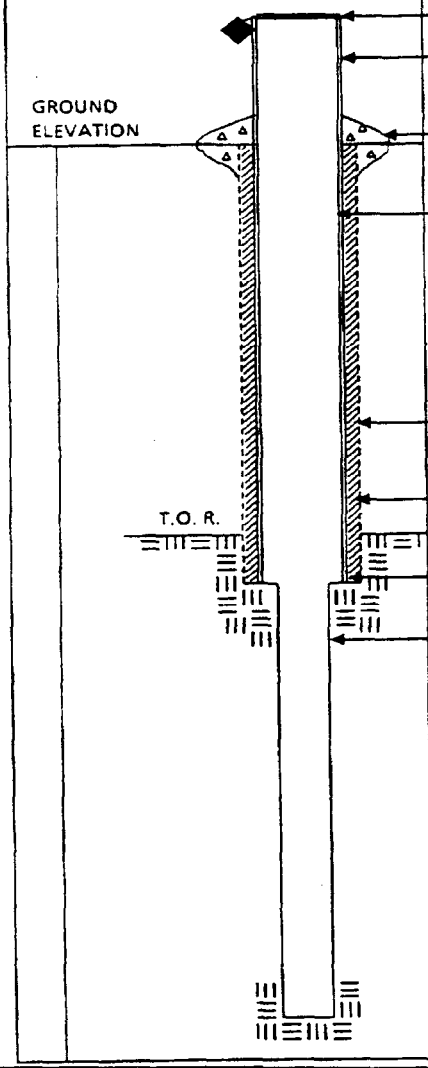
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

_____

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

_____

_____

ELEVATION / DEPTH OF HOLE: _____

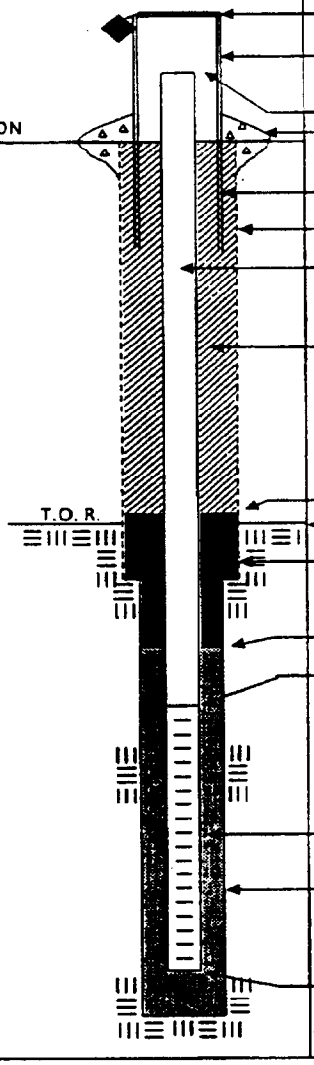
ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: ____/____

ELEVATION / DEPTH TOP OF BEDROCK: ____/____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: ____/____

ELEVATION / DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: ____/____

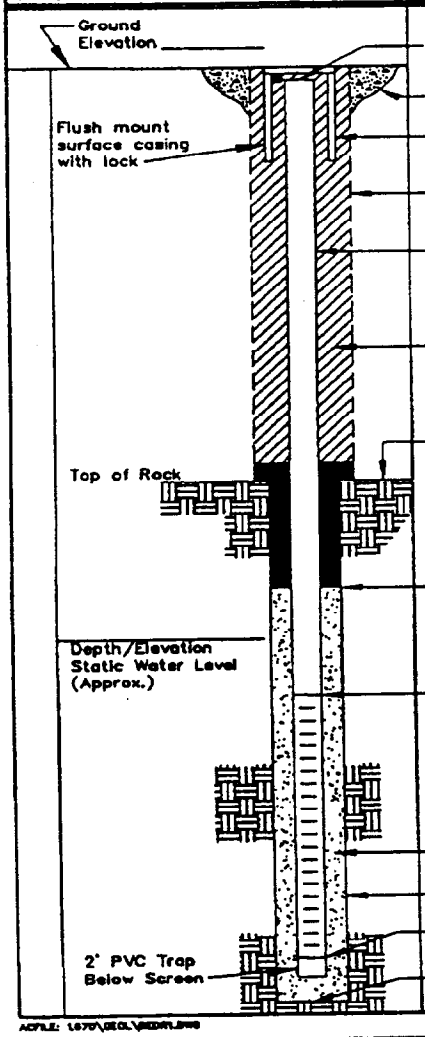
ELEVATION / DEPTH BOTTOM OF HOLE: ____/____

ATTACHMENT C-9
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: _____ LOCATION: _____ DRILLER: _____
PROJECT NO.: _____ BORING: _____ DRILLING METHOD: _____
ELEVATION: _____ DATE: _____ DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____



ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
TYPE OF PROTECTIVE CASING: _____
I.D. OF PROTECTIVE CASING: _____
DIAMETER OF HOLE: _____
TYPE OF RISER PIPE: _____
RISER PIPE I.D.: _____
TYPE OF BACKFILL/SEAL: _____
_____
DEPTH/ELEVATION TOP OF BEDROCK: _____ / _____
DEPTH/ELEVATION TOP OF SAND: _____ / _____
DEPTH/ELEVATION TOP OF SCREEN: _____ / _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____
DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____
DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____
BACKFILL MATERIAL BELOW SAND: _____

ACFILE: 1670\GEOL\BEDRFL.DWG

ATTACHMENT C-10
EXAMPLE TEST PIT LOG

TEST PIT LOG

Tetra Tech NUS, Inc.

PROJECT: _____ TEST PIT NO.:
PROJECT NO _____ DATE: _____
LOCATION: _____
FIELD GEOLOGIST: _____

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

Test Pit Cross Section and / or Plan View

REMARKS _____

PHOTO LOG _____ TEST PIT _____

PAGE ____ OF ____

ATTACHMENT C-11
EXAMPLE CERTIFICATE OF CONFORMANCE

MONITORING WELL MATERIALS
CERTIFICATE OF CONFORMANCE

Well Designation: _____ Site Geologist: _____
Site Name: _____ Drilling Company: _____
Date Installed: _____ Driller: _____
Project Name: _____ Project Number: _____

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

Signature of Site Geologist: _____

ATTACHMENT C-12
EXAMPLE MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ____

Site: _____ Depth to Bottom (ft.): _____ Project Name: _____
Well: _____ Static Water Level Before (ft.): _____ Project Number: _____
Date Installed: _____ Static Water Level After (ft.): _____ Site Geologist: _____
Date Developed _____ Screen Length (ft.) _____ Drilling Co: _____
Dev. Method _____ Specific Capacity _____
Pump Type: _____ Casing ID (in.). _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____

SITE NAME: _____

PROJECT No.: _____

INSTRUMENT NAME/MODEL: _____

MANUFACTURER: _____

SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT E

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: _____ **PROJECT NUMBER:** _____

CLIENT: _____ **LOCATION:** _____

DATE: _____ **ARRIVAL TIME:** _____

Tt NUS PERSONNEL: _____ **DEPARTURE TIME:** _____

CONTRACTOR: _____ **DRILLER:** _____

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

COMMENTS: _____

APPROVED BY:

_____ _____

Tt NUS REPRESENTATIVE DRILLER

DATE: _____

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

MONDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

TUESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

WEDNESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

APPENDIX D-9

SA-7.1 DECONTAMINATION OF FIELD EQUIPMENT AND WASTE HANDLING

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A TWO TYPES OF MUD PITS USED IN WELL DRILLING 9

1.0 PURPOSE

The purpose of this procedure is to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure addresses drilling equipment and monitoring well materials decontamination, as well as chemical sampling and field analytical equipment decontamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Deionized Water - Deionized (analyte free) water is tap water that has been treated by passing through a standard deionizing resin column. Deionized water should contain no detectable heavy metals or other inorganic compounds at or above the analytical detection limits for the project.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

5.0 PROCEDURES

To ensure that analytical chemical results reflect actual contaminant concentrations present at sampling locations, the various drilling equipment and chemical sampling and analytical equipment used to acquire the environment sample must be properly decontaminated. Decontamination minimizes the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

5.1 Drilling Equipment

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 samples. 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. Where the drilling rig is set to perform multiple borings at a single area of concern, the steam-cleaning of the drilling rig itself may be waived with proper approval. Downhole equipment, however, must always be steam-cleaned between borings. Where PVC well casings are to be installed, decontamination is not required if the manufacturer provides these casings in factory-sealed, protective, plastic sleeves (so long as the protective packaging is not compromised until immediately before use).

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-ground tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases 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. Alternately, a lined sloped pad with a collection pump installed at the lower end may be permissible. The location of the steam cleaning area shall be onsite in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating drilling 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.

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, as practicable. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

Error! Bookmark not defined.**5.2 Sampling Equipment**

5.2.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points through the use of a common bailer or its attached line is high unless strict procedures for decontamination are followed. For this reason, it is preferable 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 must be followed.

Before the initial sampling and after each successive sampling point, the bailer must be decontaminated. The following steps are to be performed when sampling for organic contaminants. Note: contract-specific requirements may permit alternative procedures.

- 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 is heavily contaminated with heavy or extremely viscous compounds)
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Pesticide-grade isopropanol (unless otherwise required)
- Pesticide-grade hexane rinse**
- Copious distilled/Deionized water rinse
- Air dry

If sampling for volatile organic compounds (VOCs) only, the nitric acid, isopropanol, and hexane rinses may be omitted. Only reagent grade or purer solvents are to be used for decontamination. When solvents are used, the bailer must be thoroughly dry before using to acquire the next sample.

In general, specially purchased pre-cleaned disposable sampling equipment is not decontaminated (nor is an equipment rinsate blank collected) so long as the supplier has provided certification of cleanliness. If decontamination is performed on several bailers at once (i.e., in batches), bailers not immediately used may be completely wrapped in aluminum foil (shiny-side toward equipment) and stored for future use. When batch decontamination is performed, one equipment rinsate is generally collected from one of the bailers belonging to the batch before it is used for sampling.

It is recommended that clean, dedicated braided nylon or polypropylene line be employed with each bailer use.

5.2.2 Sampling Pumps

Most sampling pumps are 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 prior to initial use and after each use.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except that 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. For peristaltic pumps, the tubing is replaced rather than cleaned.

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 (especially phthalate esters) into the water being sampled or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (listed in order of preference).

---

* 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.

** If sampling for pesticides, PCBs, or fuels.

Whenever possible, dedicated hoses should be used. It is preferable that these types of pumps not be used for sampling, only for purging.

5.2.3 Filtering Equipment

On occasion, the sampling plan may require acquisition of filtered groundwater samples. Field-filtering is addressed in SOP SA-6.1 and should be conducted as soon after sample acquisition as possible. 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 or replaced before each use.

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.)

5.2.4 Other Sampling Equipment

Field tools such as trowels and mixing bowls are to be decontaminated in the same manner as described above.

5.3 Field Analytical Equipment

5.3.1 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

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.

5.3.2 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 (e.g., dissolved oxygen probes). 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 is self-cleaning when exposure to uncontaminated air is allowed and the housing can be wiped clean with paper-towels or cloth wetted with alcohol.

5.4 Waste Handling

For the purposes of these procedures, contaminated materials are defined as any byproducts of field activities that are suspected or known to be contaminated with hazardous substances. These byproducts

include such materials as decontamination solutions, disposable equipment, drilling muds, well-development fluids, and spill-contaminated materials and Personal Protection Equipment (PPE).

The procedures for obtaining permits for investigations of sites containing hazardous substances are not clearly defined at present. In the absence of a clear directive to the contrary by the EPA and the states, it must be assumed that hazardous wastes generated during field activities will require compliance with Federal agency requirements for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. This procedure exclusively describes the technical methods used to control contaminated materials.

The plan documents for site activities must include a description of control procedures for contaminated materials. This planning strategy must assess the type of contamination, estimate the amounts that would be produced, describe containment equipment and procedures, and delineate storage or disposal methods. As a general policy, it is wise to select investigation methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials can be dangerous and expensive. Until sample analysis is complete, it is assumed that all produced materials are suspected of contamination from hazardous chemicals and require containment.

5.5 Sources of Contaminated Materials and Containment Methods

5.5.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. Larger equipment such as backhoes and tractors must be decontaminated in an area provided with an impermeable liner and a liquid collection system. A decontamination area for large equipment could consist of a bermed concrete pad with a floor drain leading to a buried holding tank.

5.5.2 Disposable Equipment

Disposable equipment that could become contaminated during use typically includes PPE, rubber gloves, boots, broken sample containers, and cleaning-wipes. These items are small and can easily be contained in 55-gallon drums with lids. These containers should be closed at the end of each work day and upon project completion to provide secure containment until disposed.

5.5.3 Drilling Muds and Well-Development Fluids

Drilling muds and well-development fluids are materials that may be used in groundwater monitoring well installations. Their proper use could result in the surface accumulation of contaminated liquids and muds that require containment. The volumes of drilling muds and well-development fluids used depend on well diameter and depth, groundwater characteristics, and geologic formations. There are no simple mathematical formulas available for accurately predicting these volumes. It is best to rely on the experience of reputable well drillers familiar with local conditions and the well installation techniques selected. These individuals should be able to estimate the sizes (or number) of containment structures required. Since guesswork is involved, it is recommended that an slight excess of the estimated amount of containers required will be available.

Drilling muds are mixed and stored in what is commonly referred to as a mud pit. This mud pit consists of a suction section from which drilling mud is withdrawn and pumped through hoses, down the drill pipe to the bit, and back up the hole to the settling section of the mud pit. In the settling section, the mud's velocity is reduced by a screen and several flow-restriction devices, thereby allowing the well cuttings to settle out of the mud/fluid.

The mud pit may be either portable above-ground tanks commonly made of steel (which is preferred) or stationary in-ground pits as depicted in Attachment A. The above-ground tanks have a major advantage over the in-ground pits because the above-ground tanks isolate the natural soils from the contaminated fluids within the drilling system. These tanks are also portable and can usually be cleaned easily.

As the well is drilled, the cuttings that accumulate in the settling section must be removed. This is best done by shoveling them into drums or other similar containers. When the drilling is complete, the contents of the above-ground tank are likewise shoveled or pumped into drums, and the tank is cleaned and made available for its next use.

If in-ground pits are used, they should not extend into the natural water table. They should also be lined with a bentonite-cement mixture followed by a layer of flexible impermeable material such as plastic sheeting. Of course, to maintain its impermeable seal, the lining material used would have to be nonreactive with the wastes. An advantage of the in-ground pits is that well cuttings do not necessarily have to be removed periodically during drilling because the pit can be made deep enough to contain them. Depending on site conditions, the in-ground pit may have to be totally excavated and refilled with uncontaminated natural soils when the drilling operation is complete.

When the above-ground tank or the in-ground pit is used, a reserve tank or pit should be located at the site as a backup system for leaks, spills, and overflows. In either case, surface drainage should be such that any excess fluid could be controlled within the immediate area of the drill site.

The containment procedure for well-development fluids is similar to that for drilling muds. The volume and weight of contaminated fluid will be determined by the method used for development. When a new well is pumped or bailed to produce clear water, substantially less volume and weight of fluid result than when backwashing or high-velocity jetting is used.

5.5.4 Spill-Contaminated Materials

A spill is always possible when containers of liquids are opened or moved. Contaminated sorbents and soils resulting from spills must be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable structures. In some cases, onsite containment may not be feasible and immediate transport to an approved disposal site will be required.

5.6 Disposal of Contaminated Materials

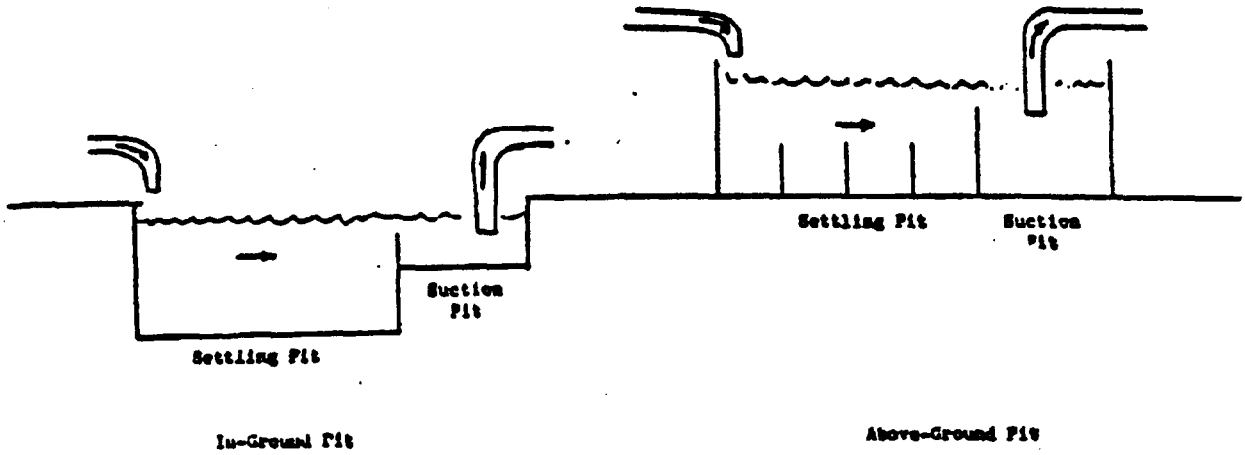
Actual disposal techniques for contaminated materials are the same as those for any hazardous substance, that is, incineration, landfilling, treatment, and so on. The problem centers around the assignment of responsibility for disposal. The responsibility must be determined and agreed upon by all involved parties before the field work starts. If the site owner or manager was involved in activities that precipitated the investigation, it seems reasonable to encourage his acceptance of the disposal obligation. In instances where a responsible party cannot be identified, this responsibility may fall on the public agency or private organization investigating the site.

Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable

onsite disposal structure is expected, contaminated materials generated during the investigation should be stored at the site for disposal with other site materials. In this case, the initial containment structures should be evaluated for use as long-term storage structures. Also, other site conditions such as drainage control, security, and soil type must be considered so that proper storage is provided. If onsite storage is expected, then the containment structures should be specifically designed for that purpose.

6.0 REFERENCES

Brown & Root Environmental: Standard Operating Procedure No. 4.33, Control of Contaminated Material.

ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING