

**Work Plan and Sampling
and Analysis Plan**
for
**Basewide Groundwater Operable Unit
Remedial Investigation**
**Naval Submarine Base
New London**
Groton, Connecticut



**Northern Division
Naval Facilities Engineering Command**
Contract Number N62472-90-D-1298
Contract Task Order 0312

June 1999



TETRA TECHNUS, INC.

**WORK PLAN AND SAMPLING AND ANALYSIS PLAN
FOR
BASEWIDE GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION**

**NAVAL SUBMARINE BASE, NEW LONDON
GROTON, CONNECTICUT**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

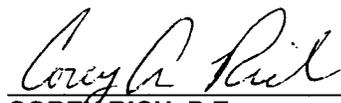
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ACRONYMS AND ABBREVIATIONS

AS	Air Sparging
ASTM	American Society for Testing and Materials
Atlantic	Atlantic Environmental Services, Inc.
AWQC	Ambient Water Quality Criteria
B&RE	Brown & Root Environmental
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
COD	Chemical Oxygen Demand
CSF	Cancer Slope Factor
CTDEP	Connecticut Department of Environmental Protection
CTE	Central Tendency Exposure
CTO	Contract Task Order
DO	Dissolved Oxygen
DOD	Department of Defense
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Office
ECTran	Excel-Crystal Ball Transport
EDSR	Existing Data Summary Report
EGIS	Environmental Geographic Information System
ESQD	Explosive Safety Quantity Distance
FFA	Federal Facilities Agreement
FID	Flame Ionization Detector
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
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	Incremental Lifetime Cancer Risk
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
IR	Installation Restoration
LIMS	Laboratory Information Management System
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
msl	mean sea level
NAD	North American Datum
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NNPP	Naval Nuclear Propulsion Program
NOAEL	No Observed Adverse Effect Level
NORTHDIV	Northern Division
NPL	National Priorities List
NSB-NLON	Naval Submarine Base-New London
OBDA	Over Bank Disposal Area
OBDA NE	Over Bank Disposal Area Northeast
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PCE	Tetrachloroethene
PPE	Personal Protective Equipment
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
RSR	Remediation Standard Regulations
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
SECWA	Southeastern Connecticut Water Authority
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCS	State Plane Coordinate System
SPLP	Synthetic Precipitation Leaching Procedure
SQL	Sample Quantitation Limit
SSL	Soil Screening Level
SSO	Site Safety Officer
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEF	Toxicity Equivalence Factor

TSS	Total Suspended Solids
TtNUS	Tetra Tech NUS, Inc.
TOC	Total Organic Carbon
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WP	Work Plan
WPCA	Water Pollution Control Authority

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has prepared this Work Plan (WP) and Sampling and Analysis Plan (SAP) for the Basewide Groundwater Operable Unit (OU) Remedial Investigation (RI) at the Naval Submarine Base - New London (NSB-NLON), Groton, Connecticut. These planning documents were prepared by TtNUS for the U.S. Department of the Navy (Navy) Northern Division (NORTHDIV) under Contract Task Order (CTO) 0312 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract number N62472-90-D-1298.

These planning documents are an outgrowth of the May 1999 final Existing Data Summary Report (EDSR) that was completed for this project (TtNUS, 1999g). The WP is designed to define the technical and management approach for the project. The WP discusses project objectives, scope, background information, rationale, management techniques, community relations planning, and schedule. The SAP is designed to provide direction for field and laboratory staff to ensure that specific procedures are properly implemented in a safe and scientifically defensible manner. Together, the WP and SAP provide a logical rationale for the RI approach based on existing regional and site-specific information.

The WP is presented in a format modified from United States Environmental Protection Agency (USEPA) guidance for conducting remedial investigations and feasibility studies (RI/FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA, 1988). The WP is also consistent with Department of Defense (DOD) guidance in the Handbook to Support the Installation Restoration (IR) Program Statements of Work (SOW), Volume I - Remedial Investigation/Feasibility Studies (RI/FS) (DOD, 1991).

The WP is presented in Section 1.0 of this report and consists of 10 subsections, which include this Introduction; Background, Objectives, and Scope; Description of Site Conditions; Site Descriptions; Project Rationale; Risk Assessment, Project Management and Organization; Community Relations; Data Deliverables and Management; and Project Schedule. The SAP, Section 2.0, consists of 16 subsections. Tables and figures are located at the end of the respective sections. Appendices to this report include the following: Field Forms (Appendix A); Standard Operating Procedures (SOPs) (Appendix B); Quality Assurance Project Plan (QAPP) (Appendix C); Health and Safety Plan (HASP) (Appendix D); and USEPA and Connecticut Department of Environmental Protection (CTDEP) Criteria (Appendix E).

1.1 BACKGROUND, OBJECTIVES, AND SCOPE

On August 28, 1991, NSB-NLON was placed on the National Priorities List (NPL) by USEPA pursuant to CERCLA and the Superfund Amendments and Reauthorization Act (SARA) of 1986. The NPL is a list of uncontrolled or abandoned hazardous waste sites identified by USEPA as requiring priority remedial actions.

In January 1995, the Navy, USEPA, and the State of Connecticut signed the USEPA Federal Facilities Agreement (FFA) for NSB-NLON (USEPA, 1995a). The agreement is used to ensure that environmental impacts associated with past and present activities at NSB-NLON are thoroughly investigated and that the appropriate remedial actions are implemented to protect human health and the environment. In addition, the FFA establishes a procedural framework and timetable for developing, implementing, and monitoring appropriate responses at NSB-NLON, in accordance with CERCLA (and SARA), the National Contingency Plan (NCP), the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments (HSWA) of 1984, Executive Order 12580, and applicable state laws.

Two RIs have been completed at NSB-NLON that included data collection and analysis at most of the sites covered by the Basewide Groundwater OU. Atlantic Environmental Services, Inc. (Atlantic) performed a Phase I RI in 1992, and Brown & Root Environmental (B&RE) completed a Phase II RI in 1997. The findings of these RIs and other investigations conducted at the sites included in the Basewide Groundwater OU are summarized in the final EDSR prepared and submitted by TtNUS on behalf of the Navy in May 1999.

The EDSR summarizes the data collected from previous and on-going investigations at the sites included in the Basewide Groundwater OU. It also describes the 13 sites to be investigated and evaluated during this RI. The EDSR was used as the basis for developing the scope of this RI. The purpose of project scoping was to analyze existing data to establish the physical characteristics of the site, determine the need for additional data, and develop an approach to collect the data.

The objectives of this RI, based on the summary and recommendations of the final EDSR, are as follows:

- Further characterize the nature and extent of contamination and hydrogeologic conditions within the aquifers at the sites
- Further characterize the nature and extent of contamination within the soil at several sites
- Perform preliminary investigations at two sites

- Determine background groundwater conditions
- Determine human health risks associated with each site
- Identify and evaluate the factors affecting organic and inorganic contaminant migration
- Provide data pertinent to identifying potential site-specific remedial alternatives (e.g., natural attenuation)

The data collected during this RI and data collected from previous investigations will be used to complete these objectives.

The scope of the RI described in this WP includes the following tasks:

- Prepare planning documents (WP, SAP, QAPP, and HASP)
- Complete necessary field work
- Manage and validate project data
- Evaluate and interpret project data
- Prepare the RI report
- Manage the project

1.2 DESCRIPTION OF SITE CONDITIONS

NSB-NLON is located in southeastern Connecticut in the towns of Ledyard and Groton. Figure 1-1 shows the location of the base. NSB-NLON is situated on the east bank of the Thames River, approximately 6 miles north of Long Island Sound. It is bordered on the east by Connecticut Route 12, on the south by Crystal Lake Road, and on the west by the Thames River. The northern border is a low ridge that trends approximately east-southeast from the Thames River to Baldwin Hill.

NSB-NLON currently provides base command for submarine activities in the Atlantic Ocean. It also provides housing for Navy personnel and their families and supports submarine training facilities, military offices, medical facilities, and facilities for submarine maintenance, repair, and overhaul.

The Basewide Groundwater OU RI covers essentially all of NSB-NLON, except for a long narrow strip of land that is adjacent to the Thames River and runs the entire length of the west side of the base (see Drawing 1). IR Program sites located in this excluded strip include the Defense Reutilization and

Marketing Office (DRMO) and the Lower Subbase. The remaining portion of NSB-NLON included in this investigation is bordered on the east by Connecticut Route 12, on the south by Crystal Lake Road and Goss Cove, and on the north by a low ridge that trends approximately east-southeast from the Thames River to Baldwin Hill.

1.2.1 Regional Boundaries

The EDSR identified three separate regions within NSB-NLON: the Northern, Central, and Southern Regions. The three regions were delineated to encompass specific sites and to focus the preparation of the EDSR and RI. Site-specific hydrogeologic information was also used to delineate the regions. Regional boundaries were generally chosen so that contamination from one region would not migrate into another. The three regions are shown on Drawing 2.

1.2.2 Topography and Surface Features for NSB-NLON

Four bedrock highs form the topographic upland areas at the NSB-NLON and the surrounding area. East of the facility, Baldwin Hill reaches an elevation of 245 feet above mean sea level (msl). In the northern, central, and southern regions of the facility, the bedrock highs reach elevations that also exceed 200 feet above msl. These bedrock highs have a northwest-southeast trend, which is consistent with the regional strike and other bedrock features in the region (USGS, 1967). The western edge of the facility borders the Thames River.

At NSB-NLON, the bedrock highs slope downward to two small, west-trending valleys. Bedrock outcrops are prevalent along steep topographic slopes. In addition to the large bedrock highs, several small sub-ridges are visible as bedrock outcrops at the facility. Two primary sub-ridges include one east of the Defense Reutilization and Marketing Office (DRMO) and one northeast of the Goss Cove Landfill.

The two valleys between the bedrock highs are characterized as wetlands and poorly drained stream valleys. The valleys slope gently to the Thames River. In the northern valley, the ground elevation ranges from approximately 80 feet in the eastern portion to near sea level along the Thames River. The eastern (upper) portion of this valley contains the Area A Wetland, which drains through an earthen dike into the Area A Downstream Watercourses. The ground surface drops steeply across the dike to 30 to 40 feet below the elevation of the wetland. Historically, the ground surface decreased more uniformly toward the Thames River (USGS, 1960). Construction of the dike and subsequent filling of the wetland area with dredge spoils from the Thames River caused the steep drop in the ground elevation.

In the southern valley, the ground elevation slopes mildly from approximately 50 feet in the eastern portion to near sea level along the Thames River. Historically, there was a topographic depression at the former Crystal Lake between Tang Avenue and Crystal Lake Road. The topographic depression has been filled. Filling has also occurred along the Thames River, and the historical shoreline has been extended.

Currently, NSB-NLON consists of over 300 buildings on 547 acres of land (Atlantic, 1992). The density of buildings is high along the central bedrock high, in the southern valley, and along the Thames River. In the northern valley are streams, a wetland, and a golf course. The northern bedrock high is not heavily developed except along the southern face at the Area A Weapons Center and the Torpedo Shops. The top and northern faces of the northern ridge are wooded, undeveloped areas.

1.2.3 Groundwater Classification and Quality at NSB-NLON

1.2.3.1 Groundwater Classification

The CTDEP previously classified the groundwater beneath the central and southern regions of NSB-NLON as GB/GA. Due to the industrial nature of the site, it was unlikely that groundwater at NSB-NLON would be used as a potable water source. Therefore, based upon the availability of potable water and the proximity of the facility to the tidally influenced Thames River, the Navy applied to CTDEP to have all groundwater beneath NSB-NLON reclassified as GB. The GB classification indicates that the area has been used for long-term intense industrial or commercial development and the groundwater is not used as a drinking water source. Remediation standards for GB areas are typically lower than those for GA areas. The Navy submitted a reclassification application to CTDEP on August 12, 1996. A public hearing was conducted on the issue on December 13, 1996, and formal notification from the CTDEP regarding successful reclassification was received on March 5, 1997. As a result, the groundwater for all of NSB-NLON, except for a small portion of the site north of Perimeter Road, is now classified as GB. This small northern portion, which is not part of the area covered by the Basewide Groundwater OU RI, remains classified as GA.

1.2.3.2 Groundwater Quality

For the State of Connecticut, the United States Geological Survey (USGS) National Water Summary (USGS, 1986) reports that ". . . groundwater beneath more than 90 percent of the land in the state is considered to be suitable for drinking without treatment. . . ." However, saltwater intrusion impacts groundwater in coastal areas. Also, groundwater is hard to very hard in 70 percent of the wells in the state's carbonate rock aquifer, 40 percent of the wells in the state's sedimentary rock aquifer, and 15

percent of the wells in the stratified drift and crystalline bedrock aquifers. NSB-NLON is characterized as being located in the stratified drift and crystalline bedrock aquifers of the state. The USGS report also states that "large concentrations of iron (as large as 40,000 µg/L) and manganese (as large as 14,000 µg/L) are a common natural groundwater-quality problem in Connecticut."

The Groton Water Department supplies potable water to NSB-NLON. The primary source of the Groton water supply is surface water reservoirs, which are supplemented with wells. The water supplies are located within the Poquonock River Watershed, located east of NSB-NLON, and not within the NSB-NLON watershed. Groundwater and surface water at NSB-NLON are not used for drinking water. Although, there are several irrigation wells on site at the golf course, located on the western side of both the Northern and Central Regions of NSB-NLON, they have not been used for several years.

Well water users in the vicinity of NSB-NLON include the Groton Water Department, the Southeastern Connecticut Water Authority (SECWA), the town of Ledyard, and a limited number of residences adjacent to the base. Several active, private groundwater supply wells are located north (near Sleepy Hollow and along Long Cove Road and Military Highway) and northeast (along Route 12 near the trailer park) of the Northern Region of NSB-NLON.

SECWA uses groundwater to provide potable water to residents in areas north, east, and northwest of NSB-NLON. Analysis of groundwater samples collected in 1991 and 1994 from 16 SECWA divisions detected barium, sodium, chloride, fluoride, sulfate, nitrates, and nitrites.

The town of Ledyard also uses groundwater to provide potable water to its residents. The Ledyard Water Pollution Control Authority (WPCA) monitors groundwater constituents. Analysis for iron and manganese in samples collected during July and August 1995 indicated that iron concentrations ranged from 2,170 µg/L to 2,780 µg/L and manganese concentrations ranged from 1,100 µg/L to 1,400 µg/L.

Homes on Route 12 adjacent to the northeastern portion of NSB-NLON have private drinking water wells, as do homes to the north on Sleepy Hollow Road, Long Cove Road, and Military Highway. The quality of groundwater in these areas was measured by Atlantic and is summarized in the Off-Site Residential Well Water Data Evaluation Report (Atlantic, 1994e). Manganese concentrations measured in these residential wells ranged from less than 0.7 µg/L to 2,130 µg/L, and iron concentrations ranged from less than 4.8 µg/L to 21,800 µg/L. Two trailer parks near the site have wells classified as public water supply wells. The Colonel Ledyard Mobile Home Park, located on Sleepy Hollow Road adjacent to the North Gate, has a well that supplies between 15 and 20 families. The Grandview Trailer Park, located at the intersection of Long Cove Road and Route 12, has two water supply wells.

1.2.4 Soil Characteristics for NSB-NLON

The United States Department of Agriculture Soil Conservation Service (SCS) has mapped the soils of NSB-NLON (SCS, 1983). According to the SCS report, soils at NSB-NLON have moderate to moderately high permeability. Available water capacity is moderate to low. In general, the soils are well drained, and runoff is rapid. The pH of the soils indicates that they are strongly to moderately acidic, and the erosion hazard is severe.

Native soils across the facility consist of dark, fine, sandy loam (Hollis and Charlton soils). Stones, boulders, and bedrock outcrops are prevalent on hills and ridges (the Hollis-Charlton-Rock Complex). The Hinkley Loam has been identified in the far northwestern portion of the facility. The soil is associated with stream terraces and outwash plains and consists of dark, gravelly and sandy loam. Native materials along the Thames River were most likely of this type.

Altered soils at NSB-NLON have been classified as either Urdothents-Urban land or Urban land. The Urdothents-Urban land is defined as excessively to moderately drained soils that have been disturbed by cutting and filling. This type of soil is located in the northern portion of NSB-NLON in the Area A Downstream Watercourses and along the Thames River. Urban land is defined as areas where more than 85 percent of the surface is covered by streets, parking lots, and buildings. Urban land has been mapped in the southern portion of NSB-NLON and along the Thames River.

1.2.5 Geology at NSB-NLON

NSB-NLON is situated in the Eastern Uplands region of Connecticut. The area has irregular hills of exposed bedrock and poorly drained, uneven valleys. The bedrock consists of metamorphosed rocks of sedimentary and igneous origin. The bedrock has been faulted and folded. A major east-west-trending fault (The Honey Hill Fault) is located approximately 6 miles north of NSB-NLON. The fault does not intersect the facility.

Detailed descriptions of the regional geology are provided in the Phase I RI Report (Atlantic, 1992) and the Initial Assessment Study Report (IAS) (NEESA, 1983). The following subsections summarize the geologic setting of NSB-NLON and describe the bedrock surface and structure.

1.2.5.1 Geologic Setting

According to the USGS bedrock map (USGS, 1967), the NSB-NLON facility is underlain by five different formations: Alaskite Gneiss, Granitic Gneiss, Mamacoke Formation, Plainfield Formation, and Westerly Granite. The Alaskite Gneiss and Granitic Gneiss are orange-pink to light gray, medium-grained granitic

gneisses. The Mamacoke Formation is light to dark gray, medium-grained biotite-quartz-feldspar gneiss. The Plainfield Formation is dark green hornblende-biotite-quartz-plagioclase gneiss. The Westerly Granite is gray, fine- to medium-grained equigranular granite.

Most of the surficial deposits in the area are unconsolidated glacial materials that were deposited during the Pleistocene Age. There are two types of glacial deposits at the facility, stratified drift and glacial till. Stratified drift consists of sorted silt, sand, and gravel that were deposited by meltwater streams. Stratified drift is located on terraces of the Thames River and is mapped along the western portion of the facility (USGS, 1960). Glacial till consists of a dense, heterogeneous mixture of clay, silt, sand, and rock fragments as large as boulders. Glacial till is exposed on most of the bedrock highs and most likely underlies outwash materials in the valleys. The thickness varies considerably, but averages less than 10 feet.

The remainder of the surficial deposits is the product of post-glacial river/floodplain processes and man-made modifications. Quaternary alluvium that consists of sand, silt, and gravel has been mapped in the area of the Area A Wetland (USGS, 1960). Artificial and natural fill are prevalent at the sites being investigated.

1.2.5.2 Bedrock Surface and Structure

The eastern edge of the facility is bordered by a bedrock high known as Baldwin Hill. The bedrock along this hill slopes toward the facility. There are three bedrock highs along the Northern, Central, and Southern Regions of the facility. At higher elevations (greater than 120 feet), these hills mimic the topographic surface. The depth to bedrock at wells 4MW1S through 4MW4S along the central hill, and well 2WMW1D along the eastern hill, is less than 10 feet. At the top of the central hill, depths to bedrock of 2 and 7 feet were measured in wells 2LMW36B and 2LMW35B, respectively. For other bedrock highs where no data were available, a depth to bedrock of 10 to 15 feet was assumed.

In the two nearly east-west-trending valleys between the bedrock highs, the bedrock surface continues to decrease along slopes similar to the hills, and the topographic surface flattens. In the northern valley, the bedrock surface decreases to a general elevation of 30 feet. The overburden thickness is typically 20 to 30 feet; however, it is thicker in the eastern portion of the valley in the vicinity of the Area A Wetland. Three oblong-shaped bedrock highs protrude within the valley. On these hills, the depth to bedrock is less than 10 feet. The southern valley is broader; the bedrock elevation decreases to below msl, and the overburden thickens to greater than 50 feet. There is one bedrock outcrop northeast of the Goss Cove Landfill along Shark Boulevard. The depth to bedrock is 12 feet at the Goss Cove Landfill, as determined from boring logs for well cluster 8MW2.

Of the five types of bedrock, only the biotite-quartz-feldspar gneiss of the Mamacoke Formation and the Granitic Gneiss were identified during drilling, as documented in the boring logs for site-specific investigations. The Mamacoke Formation was identified at the Construction Battalion Unit (CBU) Drum Storage Area, Area A Landfill, Area A Downstream Watercourses, Rubble Fill Area at Bunker A86, Over Bank Disposal Area (OBDA), Torpedo Shops, Over Bank Disposal Area Northeast (OBDANE), Spent Acid Storage and Disposal Area (SASDA), and Goss Cove Landfill. The Granitic Gneiss was identified at the Area A Weapons Center. Both formations were identified within the Area A Wetland and the DRMO. The bedrock surface was not encountered at the Lower Subase.

1.2.6 Hydrogeology at NSB-NLON

This section summarizes hydrogeologic conditions at NSB-NLON. Brief discussions of aquifer characteristics, groundwater flow, and tidal and seasonal influences on groundwater flow are provided below.

1.2.6.1 Aquifer Characteristics

During the Phase II RI, which was completed by B&RE in 1995, slug tests were performed on seven wells. The data were analyzed, and values of hydraulic conductivity were estimated using the Bouwer and Rice Method (Bouwer and Rice, 1976). Calculated hydraulic conductivity values ranged from 0.07 to 20.3 feet/day ($2.47\text{E-}5$ to $7.16\text{E-}3$ cm/sec). The highest value is from a well screened in loose sand and gravel near the Thames River (6MW3D). Intermediate values between 1 and 5 feet/day are for wells screened in the shallow fill and terrace deposits consisting primarily of dense, coarse sand with some gravel and silt. The lowest hydraulic conductivity values, which are less than 1 foot/day, are from wells screened in very dense, silty sand in the shallow overburden (e.g., 15MW3S) and dense, poorly sorted sand in the deeper overburden (e.g., 8MW2D). The results indicate that the overburden materials are generally moderately permeable.

1.2.6.2 General Discussion of Groundwater Flow

The general direction of groundwater flow at NSB-NLON is from Baldwin Hill across the facility to the west (in the direction of the Thames River). However, the water table surface locally mimics the bedrock and topographic surface. High hydraulic potentials develop within the three bedrock highs in the Northern, Central, and Southern Regions of the facility. Precipitation infiltrates into the overburden and bedrock and flows radially from the areas of high bedrock and topographic elevation toward areas of low bedrock and topographic elevation. More specifically, groundwater flows toward the two valleys and ultimately toward the Thames River or directly from the western edges of the three hills toward the Thames River.

Drawings 3 and 4 represent groundwater potentiometric surface maps for overburden and bedrock, respectively. These drawings are based on groundwater elevations recorded on November 20, 1995.

Groundwater elevations were generally lower in August than in March. In most cases, the groundwater elevations at well clusters are similar in the bedrock and overburden. This suggests that the bedrock and overburden are hydraulically connected and that the groundwater flow directions are similar in both, as is evident by comparing the overburden and bedrock flow maps. At a few well clusters, the difference in groundwater elevations between the bedrock and overburden is greater than several feet. In these areas, the bedrock and overburden have a weak hydraulic connection, and local groundwater flow directions may vary.

Limited water-level data obtained in November 1995 from off-site wells show that groundwater in areas east of NSB-NLON are at higher elevations than along the eastern boundary of NSB-NLON, indicating that groundwater at NSB-NLON does not migrate off-site to the east. To the north, off-site wells have relatively low water levels; however, these wells are located in a valley on the opposite side of a large ridge that separates the IR Program sites at NSB-NLON from the wells. The ridge acts as a local groundwater divide, preventing migration of groundwater from the northern sites at NSB-NLON to the off-site wells.

A major basin divide occurs along the ridges of Baldwin Hill. East of Baldwin Hill, water (both surface water and groundwater) is part of the Southeast Coast Major Basin. Water from this basin is not expected to travel toward the facility. West of Baldwin Hill, water is part of the Thames Major Basin. Surface water and groundwater from this basin ultimately discharge into the Thames River.

Hydraulic gradients in the bedrock are greatest where the bedrock surface slope is steepest (along the hillside at Rubble Fill at Bunker A86) and decrease where the bedrock slope is milder (in the valley at Area A Downstream Watercourses). Typically, the hydraulic gradient decreases as the bedrock slope decreases.

The vertical component of groundwater flow is predominantly downward in upland areas of NSB-NLON. However, at the base of the hills, the bedrock surface flattens and the overburden thickens. In these areas, upward gradients may occur, resulting in shallow bedrock groundwater discharge into the overburden. Near the Thames River, upward gradients exist, as is typical for groundwater in major stream valleys. Whether an upward or downward gradient develops depends on factors such as the bedrock configuration, depth of the overburden, topographic features, permeability, distance to the river, and the tides.

1.2.6.3 Tidal and Seasonal Influences on Groundwater Discharge

Based on studies conducted during the Phase I and II RIs and an investigation at Building 31 completed by Halliburton NUS (HNUS, 1993), the groundwater potentiometric surface varies as a result of tidal and seasonal influences. The following conclusions were reached regarding tidal influences on groundwater discharge from NSB-NLON:

- During low tide, the hydraulic gradient of the groundwater table at NSB-NLON is in the direction of the Thames River and results in the highest discharge rate of groundwater to the river.
- During high tide, the hydraulic gradient of the groundwater at NSB-NLON along the Thames River is reversed; flow occurs from the river to the site, temporarily halting the discharge of groundwater from NSB-NLON to the river.
- Tidal changes of 1 to 3 feet are common in the Thames River.
- The reversal in hydraulic gradient resulting from tidal influences occurs only near the Thames River, generally within 300 feet of the river, and does not seem to significantly alter groundwater flow in other areas of NSB-NLON.

Seasonal variations of the groundwater table across the site were recorded during monthly groundwater-level measurements in monitoring wells. The variations of monthly water-level means generally correlate to months with lower and higher precipitation and recharge.

Based on the monthly water-level data, the following conclusions were reached regarding seasonal influences on groundwater discharge from NSB-NLON:

- During periods of limited recharge (i.e., summer and early fall), the hydraulic gradients along the bedrock highs (where there is limited overburden thickness) decrease and the groundwater discharge from these areas decreases. Conversely, during periods of significant recharge (late fall and spring), the hydraulic gradients and groundwater discharge in these areas increase.
- Hydraulic gradients and groundwater discharge in portions of the site with significant overburden (i.e., the valleys and floodplain) remain relatively constant (except for tidal-related variations) throughout the year.

1.2.7 Climat logy

NSB-NLON is in an area that has a variable climate resulting from both continental and maritime air masses and modified by the region's proximity to the Atlantic Ocean. The region lies in the path of prevailing westerly winds and cyclonic disturbances that cross the country from the west or southwest toward the east and northeast. In the summer, prevailing winds are southwesterly, and in the winter they are northwesterly. The average wind speed is about 10 miles per hour. The region is exposed to occasional storms that travel up the Atlantic coast. Storms in the region are laden with moisture from the ocean; in addition, some storms are tropical, and occasional storms are of hurricane intensity.

The average annual temperature for New London, Connecticut, is approximately 50 °F. Average monthly temperatures vary from 58 to 72 °F in July and August and from 23 to 30 °F in January and February.

Precipitation averages approximately 44 inches per year, as measured at New London over an 81-year period. Precipitation ranges from 32 to 65 inches per year. The greatest amount of precipitation occurs in March and August; the least amount occurs in June and September. Evaporation averages approximately 23 inches per year (NAVFAC, 1988).

1.3 SITE DESCRIPTIONS

Thirteen sites were identified in the EDSR that require further investigation during the Basewide Groundwater OU RI. These sites are located within the three regions (Northern, Central, and Southern) defined within the EDSR. Detailed information on these sites is presented below by region.

1.3.1 Northern Region

The Northern Region is bordered by Perimeter Road to the north and Highway 12 to the east. This region also extends to the west to include the golf course west of Shark Boulevard. The southern boundary of the Northern Region is represented by an imaginary line extending from the intersection of Corsair Road and Highway 12 to Pier 32, but stopping at the western edge of the Golf Course prior to the Lower Subase. The following IR Program sites are located within the Northern Region and are recommended for further investigation.

- Site 1 – CBU Drum Storage Area
- Site 2A – Area A Landfill
- Site 2B – Area A Wetland
- Site 3 – Area A Downstream Watercourses and OBDA
- Site 4 – Rubble Fill Area at Bunker A-86

- Site 7 – Torpedo Shops
- Site 14 - OBDANE
- Site 20 – Area A Weapons Center

Site 5 – Hazardous Waste Storage Facility at Bunker A-85 also falls within the Northern Region, but this site is currently being investigated and remediated under RCRA. Therefore, this site will not be investigated as part of this RI.

Because of historical remedial actions (i.e., installation of a cap and a soil removal action), Sites 1, 2A, and 4 are no longer considered to be independent source areas, and therefore a long-term groundwater monitoring program will be implemented to collectively evaluate the quality of groundwater from all three sites. In addition, groundwater from Site 2B will be sampled and evaluated as part of the groundwater monitoring program. Therefore, for the purposes of this RI, the groundwater data collected jointly for the groundwater monitoring program and this RI will be used to evaluate the sites (i.e., Sites 1, 2A, 2B, and 4) mentioned above. The remaining four sites, namely Sites 3, 7, 14, and 20, will be investigated and evaluated independently.

1.3.1.1 CBU Drum Storage Area, Area A Landfill, Area A Wetland, Rubble Fill at Bunker A-86

1.3.1.1.1 CBU Drum Storage Area

The CBU Drum Storage Area was an unpaved area located in the northern section of NSB-NLON, adjacent to the deployed personnel parking lot and within the boundary of the Area A Landfill. The location of the CBU Drum Storage Area in relationship to other NSB-NLON IR Program sites is shown on Drawing 1. Figure 1-2 shows the general arrangement of the site. The site was situated on a flat, open area at the base of a wooded hillside that slopes northeast toward the site at a 25 percent grade. The site was approximately 15 feet in width by 30 feet in length and was placed under the cover system for the Area A Landfill during the interim remedial action at that site.

Twenty-six 55-gallon drums of waste oil, lubricating oil, and paint materials were observed at the site during the 1982 IAS. Some of the drums were reportedly leaking at that time. The IAS report concluded that the site had not been used for several years. Atlantic personnel inspected the site on October 20, 1988, and observed two 55-gallon drums labeled as engine oil. No surface soil staining or stressed vegetation was evident. The drums noted in the IAS report were reportedly removed and properly disposed of by the Navy; the two drums observed in 1988 were subsequently removed.

This site has been capped and paved over with asphalt as a result of the cover system installed at the Area A Landfill. A No Further Action Decision Document has been signed for this site. Therefore, the current conditions at the Area A Landfill site describe the current conditions of the CBU Drum Storage Area. Other physical characteristics known about the site (e.g., geology) are summarized in the final EDSR (TINUS, 1999g).

1.3.1.1.2 Area A Landfill

The Area A Landfill is located in the northeastern and north-central sections of NSB-NLON and encompasses approximately 13 acres. The general configuration of the Area A Landfill and adjacent sites is shown on Figure 1-3. The location of the Area A Landfill in relationship to other NSB-NLON IR Program sites is shown on Drawing 1. Access to the closed landfill is via a paved road off Wahoo Avenue. The thickness of the landfill materials is estimated to be 10 to 20 feet based on test boring data. The Area A Landfill is a relatively flat area bordered by a steep, wooded hillside that rises to the south, a steep wooded ravine to the west, and the Area A Wetland to the north. The landfill extends east along the wetland as far as a recreational area (tennis courts). Most filling occurred within the eastern and western limits of the landfill.

According to the IAS report, the landfill opened sometime before 1957. However, a 1957 aerial photograph shows no apparent landfilling, which may indicate a somewhat later start date. All materials generated by base operations that were not salvageable were incinerated, and the residues were disposed in the Goss Cove and Area A Landfills. The base incinerator, which was located north of the Lower Subbase along the waterfront at the present location of Building 478, ceased operation in 1963. From 1963 to 1973, all refuse and debris were disposed in the Area A Landfill. Because on-site disposal of solid radioactive waste attributed to the Naval Nuclear Propulsion Program (NNPP) has been prohibited since the inception of the program, and based on records, established policy, and interviews, the potential for NNPP radioactive material having been disposed of on site is effectively zero. Small amounts of general radioactive material (G-RAM) incorporated in consumer products (radioluminescent exit signs, smoke detectors, etc.) could have been disposed of with other industrial material in the DRMO, Area A Landfill, or Goss Cove Landfill. However, this possibility is unlikely given what is known about the material used for fill. Furthermore, the potential for G-RAM radioactivity in these former landfills would not vary substantially from that in commercial landfills operated for typical civilian use.

The area fill method was reportedly used in landfill operations. New refuse was dumped from the face of previously deposited refuse and covered with earth. The cover material used on the landfill was sand and gravel obtained from the Groton water supply reservoir. Landfilling operations ceased in 1973. After

closure, a concrete pad was constructed in the southwestern portion of the landfill for aboveground storage of industrial wastes. Up to the time of the interim remedial action at the Area A Landfill, the pad was still in existence at the site and at that time was located adjacent to and northeast of Building 373, and south of the dirt road that extended through this area. In the early 1980s, 42 steel drums, 87 transformers (mineral oil and polychlorinated biphenyl [PCB]), and 60 to 80 electrical switches were stored on the pad. Two transformers and several electrical switches were reportedly leaking. Past leakage of oil was also evident. Most drums were stacked on wooden pallets, and those having PCB labels were covered and bound with plastic sheeting. All these materials have since been properly disposed of off site.

The IAS report indicated that refuse, including steel drums, oxygen candles, wood and metal scrap, concrete, and tires, was exposed at the edge of the landfill adjacent to the wetland. The IAS report also stated that petroleum compounds had recently been poured from containers and had flowed into the wetland at two locations (northwestern portions of the landfill) and that, when batteries were overhauled, spent sulfuric acid solution was transferred to barrels and transported to Area A for disposal. The acid was poured into trenches dug with a bulldozer and subsequently covered with soil.

Atlantic personnel inspected the Area A Landfill on September 30, 1988. Iron floc was observed along the toe of the slope of the landfill extending from the dike to the eastern end of the deployed parking lot. The slope of the landfill had been covered with fill, and material in the landfill was not visible.

Sandbags, salt, and contractors' supplies and equipment were previously stored on top of the uncapped, unpaved sections of the landfill. Several transformers, removed underground storage tanks, crane weights, and other equipment were previously stored on the concrete pad in the southwestern portion of the landfill.

A low-permeability cover system was installed on the Area A Landfill as an interim remedial action for soils at the site. The cover system consists of a bedding/gas management layer underlying a double liner, a drainage layer above the double liner, and an operating surface in selected areas at the top. A majority of the area was paved with asphalt after the cap was installed. The remedial action also included the installation of a surface water and groundwater interception trench along the southern border (upgradient) of the site.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TINUS, 1999g).

1.3.1.1.3 Area A Wetland

The Area A Wetland is adjacent to the northeastern edge of the Area A Landfill and is approximately 23.6 acres in size. The Area A Wetland is depicted on Figure 1-4. The location of the Area A Wetland within NSB-NLON is shown on Drawing 1. This portion of NSB-NLON was undeveloped, wooded land, and possibly wetland until the late 1950s. In the late 1950s, dredge spoils from the Thames River were pumped to this area and contained within an earthen dike that extends from the Area A Landfill to the southern side of the Area A Weapons Center. Based on the boring logs, the total volume of dredged material in the wetlands is approximately 1.2 million cubic yards.

A small pond is located at the southern portion of the wetland, and between 1 and 3 feet of standing water is present during all seasons. Surface water from the Area A Wetland exits the site via a weir/pipe outlet structure located on the western side of the site. The outlet structure discharges through the dike directly into Stream 4 of the Area A Downstream Watercourses site. *Phragmites* is the predominant type of vegetation in the wetland.

Atlantic reported that pesticide "bricks" were placed on the wetland ice during winter and allowed to dissolve as a mosquito control measure. These "bricks" consisted of formulated (water-soluble) DDT and were used in the 1960s, prior to the 1972 ban on 4,4'-DDT.

The physical characteristics of site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.1.1.4 Rubble Fill Area at Bunker A-86

Bunker A86 is located at the end of a dirt road off Wahoo Avenue in the north-central section of NSB-NLON. The Rubble Fill Area was located south of the Area A Landfill, near the landfill's west end. Historical site features are shown on Figure 1-5. The location of the site in relationship to other NSB-NLON IR Program sites is shown on Drawing 1.

The Rubble Fill Area, which constituted Site 4, was located north of the dirt road and west of the bunker. The size of the site was approximately 25 feet in width by 60 feet in length. The site was on a wooded hillside that slopes north-northeast at a grade of approximately 40 percent. The IAS report indicated that discarded construction materials including concrete, asphalt, an electric motor, tar buckets, wood, and gravel were present at the site. As concluded in the IAS report, material had not been disposed of at the site for more than 10 years prior to the date of the IAS (NEESA, 1983).

Atlantic personnel inspected the site on October 20, 1988, and noted that most of the material present at that time was construction debris (wood and concrete). Chemical containers found at the base of the rubble fill area during this inspection included an empty 5-gallon container of monothanolamine (labeled as a corrosive), an empty 5-gallon container of thorite (labeled as non-shrinking compound for patching concrete), and a 55-gallon drum of lubricating oil that was approximately 10 percent full.

In early 1997, construction debris and contaminated soil and sediment were removed from the site as part of a time-critical removal action and incorporated into the Area A Landfill subgrade. Wood debris was sampled and disposed of off site. Subsequently, the Verification Sampling Report determined that the cancer risk associated with the site still exceeded USEPA's target range. Therefore, the remaining contaminated soil was removed from Site 4 in July 1997, leaving only exposed bedrock. This completed the remedial action for the Rubble Fill Area at Bunker A-86.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TINUS, 1999g).

1.3.1.2 Area A Downstream Watercourses and OBDA

The Area A Downstream Watercourses receive surface water and groundwater recharge from the Area A Landfill, Area A Wetland, Torpedo Shops, OBDANE, and surrounding areas and convey them to the Thames River. The Area A Downstream Watercourses include North Lake, which is not interconnected with the other water bodies, 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 is shown on Figure 1-6. The site location is shown on Drawing 1.

The primary discharge point of the Area A Wetland is from four 24-inch diameter metal culverts through the dike. The discharges from these culverts form a small stream (Stream 4) that flows westward for approximately 200 feet into Upper Pond. Under normal flow conditions, Upper Pond discharges to Stream 3, which flows northward and then westward toward Triton Avenue (past the OBDANE site) 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 DRMO outfall. Upper Pond also has a discharge structure on the south side. During periods of high flow and high water in the pond, water also flows out through this structure to Stream 1, which flows westward from the OBDA site. 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 and discharges into Stream 6.

Groundwater discharges from the Area A Landfill to a small pond (the OBDA Pond) at the base of the dike and the former OBDA. Stream 1 flows from this pond westward toward North Lake, a recreational swimming area for Navy personnel. 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 from the discharge weir, flows westward under Shark Boulevard and through the golf course to the Thames River. North Lake does not receive surface water from Streams 1 or 2. The 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.

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, while existing buildings operate under a waiver of these regulations, no further construction is planned. The soil and sediment at Site 3 is currently under remedial design. A Proposed Plan and Record of Decision (ROD) have been completed; the ROD was signed in late 1997. Under this design plan, contaminated soil and sediment at Site 3 will be dredged and hauled off site for disposal, and wetlands and waterways in the area will be restored.

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. This area was used as a disposal site after the earthen dike was constructed in 1957. The 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 (iron floc) were observed in the water discharging from the base of the dike embankment. All the debris from the OBDA area was removed and disposed of off site as part of a time-critical removal action in 1997.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.1.3 Torpedo Shops

The Torpedo Shops site is located in the northern portion of NSB-NLON on the north side of Triton Avenue. Figure 1-7 shows the general site arrangement. The site location is shown on Drawing 1. The site is bordered on the east and north by 60-foot-high bedrock cliffs. The remainder of the site slopes to

the southwest. An earthen berm extends along the base of the eastern portion of the exposed rock face. Three buildings (325, 450, and 477) exist at the site.

Building 325 is a torpedo overhaul facility. It was built in 1955 and had an on-site septic system until 1983, when all plumbing facilities were connected to sanitary sewers. The original septic leach field for Building 325 is located southwest of the building, adjacent to Triton Road. This leach field became clogged in 1975 and was abandoned. A new leach field (south leach field) was constructed next to the original leach field and was used until sanitary sewers were installed in 1983.

Atlantic personnel performed a visual inspection of Building 325 on March 20, 1989 during a site visit. According to interviews with on-site personnel, a variety of fuels, solvents, and petroleum products have been used in the building. Products observed in the maintenance areas included Otto Fuel II [which is comprised of propylene glycol dinitrate (76 percent), 2-nitrodiphenylamine (1.5 percent), and di-n-butyl sebacate (22.5 percent) and produces hydrogen cyanide when burned], high-octane alcohol (190 proof grain alcohol), and TH-Dimer (jet rocket fuel). Solvents including mineral spirits, alcohol, and 1,1,1-trichloroethane, as well as petroleum products such as motor oil and grease, were used in this building. A sink in one area was previously used for film development, and another sink was used for the overhaul of alkaline batteries. This plumbing drained into the on-site septic system until 1983. A maintenance area has a shallow sump that is covered with a flush-mounted steel grate. The area surrounding this sump was previously a washdown and blowdown area for weapons. It is not known where this sump drains, although it probably drains into the south leach field. Two underground No. 2 fuel oil tanks are located on the southern side of this building. A third tank, which was located above ground adjacent to the building, was used for temporary storage of No. 2 fuel oil but, based on field reconnaissance, had been removed as of March 15, 1995.

A smaller building attached to the east side of Building 325 was also inspected by Atlantic personnel. It was previously used as an assembly shop for torpedoes and was a paint shop at the time of the inspection. A storage closet in this building included containers of 1,1,1-trichloroethane and methyl ethyl ketone (2-butanone). Drums and cylinders were stored outside on the eastern side of this building. The vessels were labeled as containing propane, isobutane, 2-butanone, xylol, methylene chloride, propellant, and zinc chromate. An addition to the northern side of Building 325 was under construction at the time of the Atlantic inspection and has since been completed. This building is used as a torpedo shop.

Building 450 is the primary MK-48 torpedo overhaul and assembly facility. It was built in 1974 and was served by its own septic system until 1983, when it was connected to sanitary sewers. Only domestic wastewater from toilets, lavatories, and showers in Building 450 had been directed to the septic field (north leach field). Torpedo overhaul and assembly operations of Building 450 generate fuels, solvents,

and petroleum products as wastes. An Otto fuel and seawater mixture is drained from the torpedoes, which are then replenished with fresh fuel. The IAS report indicated that Building 450 generates approximately 3,000 gallons of Otto fuel wastewater per month. This building was constructed with a waste collection system that collected waste products from floor drains and discharged to an underground waste tank/sump with a capacity of approximately 1,500 gallons. The waste tank was pumped periodically and the contents were disposed of off site. Otto fuel product was previously stored in a 4,000-gallon underground tank south of Building 450 which was subsequently decommissioned.

Building 477, approximately 65 feet east of Building 450, was formerly used to store Otto fuel in drums. On-site personnel report that solvents including 1,1,1-trichloroethane, trichloroethene (TCE), toluene, mineral spirits, alcohol, and bulk freon have been used at this facility. Petroleum products including TL-250 motor oil and hydraulic fluid have also been used in this building for torpedo maintenance. In the past, only domestic wastewater from toilets, lavatories, and showers in Building 450 was directed to the septic field (north system).

Atlantic personnel inspected Building 450 on March 20, 1989. The former septic leach field was located southwest of this building in a flat, elevated area. The hazardous waste sump was no longer in use and, reportedly, was decommissioned in 1987. It was replaced with three 1,000-gallon aboveground tanks located south of the building. The floor drains were sealed and replaced with a new system for pumping waste products to the new tanks. A 4,000-gallon aboveground Otto fuel storage tank replaced the previous tank and is located south of the building. No construction is planned for the immediate future at Building 450.

An interim removal action was completed within the Torpedo Shops along the southern side of Building 325 in December of 1995. This action was completed under the CTDEP UST Program. The focus of the effort was to remove soil contaminated with Total Petroleum Hydrocarbons in excess of the direct exposure remediation standard of residential use. Approximately 12 cubic yards of soil were removed from the site and disposed at an approved landfill.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.1.4 OBDANE

The OBDANE site is located in a heavily wooded area on the edge of a ravine northwest of the Area A Landfill, west of the Area A Weapons Center, and south of the Torpedo Shops. At one time, miscellaneous wastes were apparently dumped over the bedrock edge. The site is circular and approximately 80 feet in diameter. A dirt road provides limited access to the wooded site. Figure 1-8

shows the general site arrangement. The site location is shown on Drawing 1. A nearly vertical 20-foot-high bedrock face is located at the eastern edge of the site. The rest of the site slopes to the southwest.

The IAS report stated that the vegetation at the site indicated that no dumping had occurred within 10 years prior to the 1982 investigation. Atlantic personnel inspected the site on September 30, 1988, and verified the IAS report of the presence of several empty fiber drums. No visual staining or stressed vegetation were observed at this time. No development of this area is currently planned.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.1.5 Area A Weapons Center

The Area A Weapons Center site 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 at the southeastern end of Triton Avenue and is adjacent to and on the northwestern side of the Area A Wetland (see Drawing 1). The general configuration of the Area A Weapons Center site is shown on Figure 1-9.

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 and 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 and the Area A Wetland in the bunker areas. 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.

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.

The weapons storage bunkers are located southeast of Building 524. Liquid fuels 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.

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

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.2 Central Region

The Central Region extends from the southern boundary of the Northern Region to the northern boundary of the Southern Region, which is represented by an imaginary straight line extending from Pier 6 to the southern corner of Building 446 near Highway 12. The Central Region is bounded by the Lower Subbase to the west and Highway 12 to the east. The only IR Program site associated with the Central Region is Site 16 – Hospital Incinerator. A preliminary Site Investigation was recommended for this site in the EDSR.

1.3.2.1 Hospital Incinerator

Site 16 consists of the hospital incinerator. In the 1980s, the Naval Hospital Groton operated a skid-mounted waste incinerator at two sites adjacent to the hospital. The two sites are approximately located west of Tautog Road, adjacent to Building 449 and Building 452 (see Drawing 1). The sites are shown on Figure 1-10. For the purposes of this RI the sites were labeled A (North) and B (South).

According to the FFA, the incinerator was used to destroy medical records and medical waste contaminated with pathological agents. Ash generated by the waste incinerator was transferred to dumpsters for disposal at a municipal landfill off-base.

The skid-mounted incinerator was operated in two areas, one adjacent to Building 449 and the other adjacent to Building 452. Based on mapping provided in the FFA, it appears that these two areas are within or directly adjacent to parking lots.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.3 Southern Region

The Southern Region extends southward from the southern boundary of the Central Region. The Southern Region is bordered by Highway 12 to the east, Crystal Lake Road and Goss Cove to the south, and the Thames River or Shark Boulevard to the west. Initial or additional investigations were recommended in the EDSR for the following IR and underground storage tank (UST) Program sites located within the Southern Region:

- Site 8 – Goss Cove Landfill
- Site 15 – Spent Acid Storage and Disposal Area
- Site 18 – Solvent Storage Area (Building 33)
- Site 23 – Fuel Farm (Includes Site 9 – OT-5 Oily Wastewater Tank)

Site 12 – NEX Gas Station is an UST site that is located within the Southern Region. This site is currently being remediated via an air sparging/soil vapor extraction (AS/SVE) system. No further investigation of this site is recommended during this RI; however, existing monitoring data from the AS/SVE system will be incorporated into the NSB-NLON Environmental Geographic Information System (EGIS) and evaluated during the RI.

1.3.3.1 Goss Cove Landfill

The Goss Cove Landfill is located in the southwestern portion of NSB-NLON, adjacent to the Thames River. It is west of Shark Boulevard and the intersection of Crystal Lake Road and Military Highway, east of the Thames River, and north of Goss Cove. Figure 1-11 shows the general site arrangement and historical sampling locations. The site location is shown on Drawing 1. The Nautilus Museum and a paved parking lot are constructed directly over the site of the former landfill. The Nautilus Museum is a submarine museum operated by the Navy that is open to the public.

The IAS report indicated that a landfill was operated at this site from 1946 through 1957. Incinerator ash and inert rubble were disposed of at the site, in what was then the northern portion of Goss Cove. It is not known whether any other materials were disposed of in the former landfill. Several large compressed gas cylinders were reportedly uncovered during the excavation of a utility trench in the parking area north of the Nautilus Museum building. One of the cylinders was leaking propane, one was filled with ammonia, and the others were empty.

Atlantic personnel reviewed archive photographs for the Goss Cove area available at the Connecticut State Library. In a 1934 aerial photograph, the limits of Goss Cove appeared to be open water with no

evidence of fill. Railroad tracks are shown at their present position between the cove and the Thames River. In 1951 aerial photographs, the fill extended southward to the approximate location of an access driveway to the museum. The 1965 aerial photographs show the landfill extending to the present limit of encroachment on Goss Cove. Aerial photographs from 1965, 1970, 1975, and 1980 show cars parked on the landfill surface. In 1986 photographs, the Nautilus Museum is present on the southern limits of the landfill and a paved parking area extends over the remaining limit of the landfill to the north. Construction of the Nautilus Museum was completed in 1985.

Atlantic personnel reviewed boring logs generated during the construction of the Nautilus Museum. The boring logs indicated the presence of fill material consisting of cinders, metal, brick, glass, sand, and gravel to a depth of 15 feet. Beneath the fill is a layer of organic silt approximately 10 to 15 feet thick. This material is presumably the sediment bottom of the former cove. The silt is underlain by fine sand to depths ranging from 25 to 100 feet below the surface. The thickness of overburden increases from east to west, toward the river.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

The Navy conducted several investigations of the soil, groundwater, sediment, and surface water associated with the landfill and adjacent cove. The findings of the investigations indicated that there are potential risks to human receptors under several hypothetical exposure scenarios. The investigations also revealed that there are potential risks to ecological receptors from exposure to the cove, but these risks are not related to site-specific contaminants. No further action was recommended for the sediment and surface water. A Feasibility Study of remedial alternatives was completed for the Goss Cove Landfill soil OU. The Navy's proposed remedial alternative for the soil OU, as presented in the Proposed Plan, consists of installation of an Engineered Control Cap, Institutional Controls, and Monitoring. The Navy presented their Proposed Plan at a Public Meeting in June 1999. The groundwater OU will be further investigated during this Basewide Groundwater OU RI.

1.3.3.2 Spent Acid Storage and Disposal Area

The SASDA was located in the southeastern section of NSB-NLON between the southern sides of Buildings 409 and 410. The former site location and historical sampling locations are shown on Figure 1-12. The site's location relative to other IR Program sites is depicted on Drawing 1. 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. 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 of in the Area A Landfill.

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 was completed in January 1995 and 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 Leaching Procedure (TCLP) leachate results for lead in excess of 5.0 mg/L were removed by OHM Remediation Services Corporation. The excavated materials were transported off site and disposed of in a RCRA landfill (Environmental Quality Company) in Belleville, 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 CTDEP signed a No Further Action Source Control ROD for this site in 1997 (Navy, 1997c).

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.3.3 Solvent Storage Area

Site 18 consists of Building 33, the Solvent Storage Area. The location of Building 33 is shown on Figure 1-13 and Drawing 1. According to the FFA (1995), this building has been used for the storage of 55-gallon drums of solvents such as TCE and dichloroethene and gas cylinders.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.3.3.4 Tank Farm (Including Site 9 – OT-5 Oily Wastewater Tank)

In the early 1940s, Crystal Lake was drained and dredged to allow for construction of nine concrete USTs (Figure 1-14). When construction was complete, the former lake bed was reportedly filled with soils

excavated from a small hill west of the tank area and graded to create a level surface for development at NSB-NLON. The location of this site is shown on Drawing 1.

The Tank Farm is located at the southern end of NSB-NLON and covers an area of approximately 36 acres. The Tank Farm features are shown on Figure 1-14 and include the following:

- Nine former 110-foot-diameter, 11-foot-high USTs (OT-1 to OT-9)
- A 30,000-gallon, double-walled UST (OT-10)
- An oil/water separator (at OT-10)
- A 10,000-gallon waste oil tank (at OT-10)
- A fuel oil loading area adjacent to Building 482
- Tanker truck dumping pad and trough (at OT-10)
- Associated UST piping systems
- The MWR Recreation Center (Building 461)
- Buildings 310 and 322
- Six baseball/softball fields
- A restroom facility (Building 445)
- AS/SVE facility for the NEX service station
- Two 150,000-gallon diesel aboveground storage tanks

Each of the nine USTs had a holding capacity of 750,000 gallons. No. 6 fuel oil was stored in tanks OT-1 through OT-3 from the date of construction until they were removed from service in the summer of 1991. Tanks OT-7 through OT-9 were decommissioned in the summer of 1990 and were used exclusively for storage of diesel during all 48 years of service.

A reduced demand for diesel fuel at NSB-NLON in the mid-1970s led to the decommissioning and demolition of tank OT-6. Details regarding demolition procedures were not on file at NSB-NLON. The reduced demand for diesel fuel also led to the modification of tank OT-5 for waste oil storage purposes. Tank OT-4 was used to store tank bottom wastes from OT-1. Tank OT-5 was used as part of an oil/water separator system. Tanks OT-4 and OT-5 were reportedly decommissioned after the installation of a new 30,000-gallon waste oil underground tank (OT-10) in 1990. Tanks OT-1 through OT-9 have been demolished and closed in place. Tank closure was accomplished by demolishing the tank roof supports and allowing the roof to collapse into the tank. The void was then filled with gravel, and the site restored using soil and topsoil.

Evidence of releases of petroleum products from these tanks and their associated piping and, possibly, from other nearby sources was detected during previous investigations. Historical sampling locations are shown on Figure 1-14. Both soil and groundwater contamination have been identified. Petroleum hydrocarbons have been detected at the outfall of the Tank Farm storm sewer system on a number of occasions. A number of petroleum spills have been documented by the Navy in the vicinity of the Tank Farm at NSB-NLON.

Product Transfer Lines

Product (No. 6 fuel oil or diesel fuel) was historically delivered via barge to a pier where it was pumped via pipelines to the Tank Farm USTs through the Building 332 valve house. Product was transferred via pipeline from the USTs to the power plant or the submarines at the Lower Subbase on an as-needed basis.

The No. 6 fuel oil transfer lines were situated within concrete-lined trenches, but were removed because No. 6 fuel oil is no longer used at NSB-NLON. The diesel fuel lines have no trenches. Portions of the diesel fuel lines on the Lower Base were recently replaced. The lines located on the Upper Base are cathodically protected.

Storm Drainage System

The UST farm contains an extensive drainage system consisting of numerous catch basins, corrugated metal pipe, perforated corrugated metal pipe, vitrified clay pipe, and reinforced concrete pipe. According to NSB-NLON personnel, the drainage system serves approximately one-third of the entire facility. Portions of the drainage system were installed with perforated corrugated metal pipe to depress the water table in the Tank Farm. The surface water and groundwater collected by the storm sewer system ultimately discharge to a boomed area of the Thames River adjacent to the Goss Cove Landfill. Based on known elevations of storm sewer catch basins, the elevation of the drainage system is below the process piping.

The central drainage line of this system (constructed of perforated corrugated metal pipe) is known to be corroded. The Navy attempted to videotape the storm sewer system but could not move the camera assembly through sections of the pipe. The Navy is currently designing a replacement storm sewer system. Construction of the new system is scheduled to begin in 1999.

Tank Underdrain System

The nine former USTs (OT-1 to OT-9) at the Tank Farm were each rated for a nominal capacity of 750,000 gallons or approximately 100,000 cubic feet. Each tank was approximately 110 feet in diameter and 11 feet in depth. Depending on the season, the depth to groundwater in some areas of the site may be as little as 2 feet below grade.

Tank stability was obtained using a combination of a site-wide drainage system, an underdrain system, and a series of columns inside the tanks. A site-wide storm water drainage and dewatering system was installed through the Tank Farm. The system was constructed of perforated, corrugated metal pipe. This type of pipe allowed for collection of groundwater and conveyance of surface water. A vitrified clay pipe underdrain system was installed around the base of OT-1, OT-2, OT-3, OT-4, and OT-5. The underdrains collected groundwater and discharged it into the site-wide storm water drainage system. A series of 37 columns transmitted the weight of the tank roof and overlying fill to the floor of the tank.

The physical characteristics of the site (topography, surface features, soil characteristics, geology, and hydrogeology) are summarized in the final EDSR (TtNUS, 1999g).

1.4 PROJECT RATIONALE

The sites included in the Basewide Groundwater OU RI were evaluated in the EDSR. The goal of this RI is to carry out the recommendations of the final EDSR. A technically sound, comprehensive sampling program is required to complete the goal of the RI. This section provides general and specific technical information that justifies the approach taken for the sampling program discussed in Section 2.0 (the SAP).

1.4.1 General Project Rationale

The final EDSR indicates that data gaps exist in the following categories for the sites included in the Basewide Groundwater OU RI:

- Nature and extent of soil and groundwater contamination
- Natural attenuation
- Background groundwater quality
- Hydrogeology and contaminant fate and transport

The following subsections provide technical information that justifies the sampling approach to address these data gaps.

1.4.1.1 Nature and Extent of Contamination

Available historical data regarding the nature and extent of contamination in the soil and groundwater are not sufficient to characterize the sites. The following general tasks are required to address the data gaps:

- Complete additional soil borings
- Collect and analyze additional soil samples
- Install additional temporary and permanent monitoring wells (overburden and bedrock)
- Collect and analyze additional groundwater samples from new and existing monitoring wells

The specific tasks and analyses required for each site are detailed below and in Section 2.0.

1.4.1.2 Natural Attenuation

Monitored natural attenuation and/or bioremediation can be viable remedial alternatives for sites contaminated with chlorinated solvents and petroleum hydrocarbons. Several of the sites included in the Basewide Groundwater OU RI have chlorinated solvents (Torpedo Shops and Area A Downstream Watercourses) or petroleum hydrocarbons (Tank Farm) as contaminants of concern. Therefore, it is prudent to collect and analyze samples for specific parameters, indicative of natural attenuation of chlorinated solvents and petroleum hydrocarbons, during this investigation. The data will be used to determine baseline conditions and to examine the viability of monitored natural attenuation and/or bioremediation as remedial alternatives.

Monitored natural attenuation is a passive remediation method that can be used alone or in conjunction with other active remedial technologies to effectively reduce chlorinated solvent and petroleum contamination in soil and groundwater to levels that do not pose a risk to human health and the environment. Source control and performance monitoring are fundamental components of any monitored natural attenuation remedy. The technology works because chlorinated solvents and petroleum contaminants are readily biodegraded by microorganisms that occur naturally in the subsurface environment. However, the effectiveness of natural attenuation varies considerably from site to site and among different types of contaminants.

Natural attenuation results from the combined effects of several natural processes, including biodegradation, dilution, sorption, dispersion, volatilization, chemical and biological stabilization, transformation, and destruction of contaminants (USEPA, 1999a). For petroleum hydrocarbons, biodegradation (i.e., biological oxidation) is the most important process because it transforms contaminants to innocuous by-products such as water and carbon dioxide and reduces the total mass of the contaminants in the subsurface. The other processes act to lower the concentration of the

contaminants in the environment but not to reduce their mass (Kelley et al., 1996). For chlorinated solvents, the biodegradation process is more complicated. Reductive dechlorination is the initial step in biodegrading chlorinated solvents. This process generates daughter products that can be further degraded by direct oxidation. Chlorinated ethenes can also be degraded by cometabolic processes (Navy, 1998).

The Navy and USEPA have developed the following guidance regarding natural attenuation:

- Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Department of the Navy, September 1998.
- Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, USEPA, September 1998, EPA/600-R-98/128.
- Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA, April 1999, Directive 9200.4-17P.

These documents provide guidance for developing technically sound sampling and analysis programs for natural attenuation studies and for evaluating the resulting field and analytical data. Based on the recommendations provided in these documents, the following parameters will be measured in the groundwater at the three appropriate sites (i.e., Area A Downstream Watercourses, Torpedo Shops, and Tank Farm) during the Basewide Groundwater OU RI.

- Dissolved oxygen (DO)
- Nitrate
- Divalent iron
- Sulfide and sulfate
- Methane
- Ammonia
- Total Organic Carbon (TOC)
- Oxidation-reduction (REDOX) potential
- pH
- Chloride
- Salinity
- Temperature
- Specific conductivity

- Alkalinity
- Hardness

Dissolved oxygen data will be collected at background locations and within the contaminant plumes. These data are collected to identify an inverse correlation indicative of aerobic or anaerobic biodegradation. Data on REDOX potential, pH, alkalinity, hardness, divalent iron, dissolved nitrate, sulfate, sulfide, ammonia, and methane will be collected to determine if intrinsic remediation is in progress and to determine the levels of possible nutrients available for microorganisms. Divalent iron, dissolved nitrate, sulfate, and methane are used to identify a correlation between electron acceptors and metabolic by-production indicative of anaerobic biodegradation. TOC data will be collected at locations within the contaminant plume to determine organic carbon levels that could act as nutrients and for modeling future contaminant movement. Data on other general groundwater field parameters such as chloride, conductivity, and temperature will be collected to verify that the site samples are obtained from the same groundwater system. Increased chloride concentrations are also indicative of dechlorination. Salinity measurements will be taken to determine the potential impact of salt-water intrusion on the viability of natural attenuation. High levels of salinity have been shown to impede the natural degradation process.

The documents referenced above also recommend that appropriate samples be taken and analyzed to evaluate the nature and extent of contamination in the groundwater and that appropriate field measurements be taken to characterize the hydrogeology of the aquifer. The site-specific project rationale sections provided below summarize the sampling, analytical, and field testing programs.

After the appropriate data is collected, it will be evaluated on a site-by site basis to determine if natural attenuation of chlorinated solvents and petroleum hydrocarbons is currently occurring in the groundwater and if natural attenuation and bioremediation are viable remedial alternatives. The USEPA bioattenuation screening process (USEPA, 1998) will be used to complete the assessment for sites with chlorinated solvents. The assessment of data from the Tank Farm (petroleum contamination) will be less structured, but will evaluate the trends in the contaminant and electron acceptor data collected from wells located in upgradient, source, and downgradient areas. The evaluation for this site will be similar to the technique used to evaluate natural attenuation in the Lower Subbase RI (TtNUS, 1999b).

1.4.1.3 Background Groundwater Quality

1.4.1.3.1 Developing Background Groundwater Concentrations

Background groundwater quality has not been formally defined for NSB-NLON. Groundwater sampling results from off-site residential wells have been used previously as interim background values. The State of Connecticut defines the background concentration of groundwater at a site as the concentration at the

nearest location upgradient of a release at which groundwater has been unaffected by site operations. The regulations also state that if a release at a site occurred at a groundwater divide, the area considered background will be at the nearest location representative of groundwater quality unaffected by any release. The approach to developing site-specific background groundwater concentrations for organic and inorganic constituents at NSB-NLON will be in accordance with the State of Connecticut regulations. The newly collected data will be further evaluated to determine whether basewide background values can be established for inorganic parameters.

Site-Specific Background Concentrations

For purposes of the RI, the base has been divided into three regions (Northern, Central, and Southern). To determine site-specific background concentrations, existing upgradient bedrock and overburden monitoring wells will be sampled. Basewide potentiometric surface maps of the overburden (Drawing 3) and bedrock (Drawing 4) were reviewed to determine if upgradient wells exist at each site. Where upgradient wells do not exist, new wells will be installed and sampled. Figure 1-15 shows the proposed existing and new monitoring wells that will be sampled to determine background groundwater concentrations. Background groundwater samples will be analyzed for volatile and semivolatile organics, pesticides, PCBs, total and dissolved metals, total suspended solids, total dissolved solids, and chloride.

To generate larger site-specific background data sets, which will result in more reliable statistical results, combined upgradient and downgradient data for inorganic parameters will be evaluated to determine whether they are statistically similar. This evaluation will be performed using probability plots. More information regarding probability plots is provided in the statistical analysis section below. Once the appropriate grouping of the data sets has been identified through the probability plots, site-specific background concentrations can be calculated for each inorganic constituent.

Basewide Background Inorganic Concentrations

The groundwater that is upgradient of the NSB-NLON property flows into three distinct regions of the base. Two bedrock highs exist in the central region of the base, creating groundwater divides between the Northern, Central, and Southern Regions. To determine whether basewide background concentrations for inorganic constituents can be developed, all upgradient groundwater data will be evaluated to determine if the chemical concentrations are from the same population. If the statistical analysis shows that the data are chemically equivalent (i.e., they come from the same population), all the upgradient data will be combined into a single, basewide upgradient data set to determine background concentrations of inorganic constituents.

Statistical Analysis

Generating probability plots to determine whether chemical concentrations are from the same population will be the first step in evaluating both the site-specific and basewide background data sets. The plots are used to determine if the data follow a normal (or lognormal) distribution and are particularly useful for identifying irregularities within a data set (USEPA, 1992d). Probability plots will be generated using non-transformed and log-transformed data.

Data that come from the same population (i.e., share the same mean and standard deviation) would exhibit a tightly organized linear pattern on the probability plot. Those values resulting from contamination would be skewed to the right side of the plot, producing a tailing effect.

To generate the plots, observed concentrations of a constituent are plotted on the x-axis. For the log-transformed plots, these values must be converted to normal units by using the exponential function (e^x). The expected normal probability is plotted on the y-axis. The expected normal probability for the j^{th} constituent concentration value ranked from lowest to highest (Z_j) is defined as:

$$Z_j = \Phi^{-1} \left\{ \frac{(3j - 1)}{(3N + 1)} \right\}$$

Where:

- Φ^{-1} denotes the inverse of the cumulative normal distribution function (literature value)
- j is the rank of the observed concentration from lowest to highest
- N denotes the total number of samples in the data set
- $\{(3j - 1)/(3N + 1)\}$ is the probability (p) that a value falls below that result
- Z_j denotes the probability (p) normalized to a Z score to provide linear results.

The theory is that concentrations from the same population should be normally (or lognormally) distributed except for those locations that are impacted by some residential, industrial, or geochemical process. Chemical concentrations that are normally or lognormally distributed will exhibit a linear pattern on the probability plot. Isolated concentrations that are clearly outside of the "normal" range on the probability plot will be considered outliers and will be removed from either the site-specific or basewide background data set prior to the statistical analysis. If all data are from the same population, the probability plot should exhibit one set of tightly organized, linear data.

Once the appropriate samples have been identified for inclusion in site-specific and basewide background data sets, background concentrations can be determined by calculating an upper tolerance limit (UTL). However, prior to this calculation, analytical results that are reported as not detected must be adjusted for use in the analysis.

In the chemical analysis of environmental samples, some analytes may be present at concentrations that are below the sample quantitation limit (SQL) of the analytical procedure. These analytical results are generally reported as not detected (rather than zero), and the appropriate detection limit is given. The amount of data that are below the detection limit plays an important role in selecting the method for addressing the detection limit. Prior to statistical analysis, any nondetects in a background data set will be replaced with a value equal to one-half the SQL. Clearly, if all the observations are nondetect results, no statistical analysis is warranted. In addition, field duplicate results will be averaged and counted as one sample for use in the statistical analysis.

The first step in calculating an UTL for each constituent in a data set is to determine whether the data were drawn from an underlying normal, lognormal, or undetermined distribution. A number of statistical evaluations may be used to determine which, if either, of the distributions is exhibited by a given data set. As recommended by USEPA, the Shapiro-Wilk "W-test" (for sample sets ≤ 50) will be used to determine whether the data are normally or lognormally distributed (USEPA, 1992d). Data that are neither normally nor lognormally distributed will be assumed to follow a lognormal distribution.

The Shapiro-Wilk W-test is an effective method for determining whether a data set has been drawn from an underlying normal (or lognormal) distribution. In addition, by conducting the Shapiro-Wilk W-test on the log-transformed data, the test may be used to determine whether the data have been drawn from an underlying lognormal distribution. The null hypothesis (H_0) that is tested is:

H_0 The population has a normal (or lognormal when the data is log-transformed) distribution.

The alternate hypothesis (H_A) is:

H_A The population does not have a normal (or lognormal when the data is log-transformed) distribution.

If H_0 is rejected, then H_A is accepted. If H_0 is not rejected, the data set is consistent with the H_0 distribution.

A "W" statistic (W_{calc}) is computed for a data set (or a log transformed data set) and compared to a test statistic (W_{test}). If $W_{calc} \geq W_{test}$, then the null hypothesis is not rejected (i.e., the data are assumed to be normally distributed [or lognormally distributed if log-transformed data are tested]). If $W_{calc} < W_{test}$, then the null hypothesis is rejected and the alternative hypothesis is accepted (i.e., the data are not assumed to be normally distributed [or not lognormally distributed if log transformed data are tested]).

For each constituent, a mean and standard deviation are calculated as part of the Shapiro-Wilk W-test. Based on the nature of the distribution (normal or lognormal), these values are used to calculate the 95 percent UTL for each constituent. This UTL will then be used as the background concentration.

A tolerance interval establishes a concentration range that is constructed to contain a specified proportion (P percent) of the population with a specified confidence coefficient (Y). The proportion of the population included, P, is referred to as the coverage. The probability with which the tolerance interval includes the proportion of the population P is referred to as the tolerance coefficient of the interval.

Coverage of 95 percent is recommended because random observations from the same distribution as the background data would exceed the UTL less than 5 percent of the time. Similarly, a tolerance coefficient of 95 percent is recommended. This means that one has a confidence level of 95 percent that the 95 percent UTL will contain at least 95 percent of the distribution of observations from background well data.

1.4.1.3.2 Mobility of Metals

The mobility of metals such as arsenic and lead has been identified as a concern at NSB-NLON. It has been hypothesized that an existing IR Program site (Area A Landfill) may be causing acidic conditions in the groundwater that would cause natural metals in the soil and bedrock to be solubilized into the groundwater. Additional groundwater quality data is required to address this concern. Development of background groundwater concentrations, as discussed above, will provide information that will be helpful in addressing this concern. In addition, the following water quality parameters will be measured in all monitoring wells during the RI.

- DO
- REDOX potential
- Temperature
- pH
- Salinity
- Turbidity
- Total suspended solids (TSS)

- Total suspended solids (TSS)
- Total dissolved solids (TDS)
- Specific conductivity

These parameters will be evaluated to determine any trends (i.e., significant changes in the water quality parameters between the upgradient and downgradient sides of a site) indicating that specific sites are causing metals to become more mobile. The data will be evaluated using the probability plots described above. In addition, the analysis will include development of basewide isopleths/isoconcentration maps with these data.

1.4.1.4 Hydrogeology and Contaminant Fate and Transport

The final EDSR recommended that additional data be collected to characterize hydrogeology and contaminant fate and transport at the sites included in the Basewide Groundwater OU RI. The approaches to be used to address these data gaps are described below.

1.4.1.4.1 Hydrogeology

To address the uncertainties in the existing basewide and site-specific hydrogeologic information, additional water-level measurements and aquifer testing are required. The water-level measurements are required to determine water table elevations, potentiometric surfaces, and the hydraulic connection between the overburden and bedrock aquifers. The water levels will also be used to determine horizontal and vertical hydraulic gradients necessary to complete groundwater and contaminant transport modeling. Two comprehensive rounds of water-level measurements in all new and existing overburden and bedrock wells will provide adequate information to address the existing data gaps.

Aquifer testing such as slug tests will be completed to determine the bulk characteristics of an aquifer. Three sites within the Basewide Groundwater OU RI (Area A Downstream Watercourses, Torpedo Shops, and Tank Farm) require additional testing. Limited slug tests were completed at the Area A Downstream Watercourses and Torpedo Shops during the Phase I RI (Atlantic, 1992). Slug tests were completed in several shallow overburden wells at the Tank Farm during the Site Investigation (B&RE, 1997e). Rising and falling head slug tests will be completed, as appropriate, in select wells to verify historical data and to characterize other portions of the aquifer, which have not been previously characterized.

contaminant migration. Screening level models should be adequate to complete the necessary contaminant-specific modeling tasks. The two models that would be applicable for the task are ECTran (Excel-Crystal Ball Transport) and BIOSCREEN. Each model is described below. ECTran was used previously at New London to evaluate contaminant transport at the Goss Cove Landfill site. If modeling is necessary during this RI, ECTran will be used to complete all modeling and BIOSCREEN will be used to verify the ECTran model's results for sites contaminated with petroleum products.

ECTran (Chiou et al., 1993) is an efficient and robust analytical groundwater contaminant fate and transport model developed by TtNUS. ECTran is implemented in Microsoft® Excel®. An add-in package for Excel®, Crystal Ball®, can also be used to complete Monte Carlo simulations with the model. The model is based on straightforward mass-balances and advection and dispersion analytical equations, but can be used to simulate a variety of complex conditions. It is a multi-layer, one-dimensional model in the unsaturated zone that can simulate downgradient lateral transport in the saturated zone. ECTran estimates the downgradient concentration at the centerline of the contaminant plume.

BIOSCREEN is an easy-to-use screening model that simulates remediation through natural attenuation of dissolved hydrocarbons at petroleum fuel release sites. The model is one-dimensional and evaluates lateral contaminant transport in the saturated zone. The software, programmed in Microsoft® Excel® and based on the Domenico analytical solute transport model, has the ability to simulate advection, dispersion, adsorption, and aerobic decay as well as anaerobic reactions shown to be the dominant biodegradation processes at many petroleum release sites. Groundwater Services, Inc., of Houston, Texas, developed the model for the Air Force Center for Environmental Excellence Technology Transfer Division at Brooks Air Force Base.

1.4.2 Site-Specific Project Rationale

Table 1-1 presents the number of samples per matrix and site to be collected for this RI. The selection of these locations and matrices analysis are based on the data gaps identified in the EDSR (TtNUS, 1999g). The concerns for each site, as discussed in past reports and based upon historical data, are summarized in Sections 1.4.2.1 through 1.4.2.4.

1.4.2.1 Northern Region

1.4.2.1.1 CBU Drum Storage Area (Site 1), Area A Landfill (Site 2A), Area A Wetland (Site 2B), Rubble Fill Area at Bunker A-86 (Site 4)

A groundwater monitoring program has been developed for the area encompassing these four sites (TtNUS, 1999a). The Navy developed this program with input from USEPA and CTDEP. The monitoring

program will begin during the summer of 1999. The program includes installation of additional overburden wells, quarterly sampling and analysis of existing and new groundwater wells, and evaluation and reporting of the data. The rationale for and details of the program are described in the *draft final Groundwater Monitoring Plan for the Area A Landfill, Naval Submarine Base-New London, Groton, Connecticut* (TINUS, 1999a).

1.4.2.1.2 Site 3 – Area A Downstream Watercourses and OBDA

Several volatile organic compounds (VOCs), including chloroform, vinyl chloride and 1,2-dichloroethene (total), were found in samples collected from overburden wells (and to a lesser extent in bedrock wells) in the north-central and western areas of the site, especially along Triton Road. Several VOCs were detected in groundwater at maximum concentrations exceeding Connecticut remediation standards for GA/GAA groundwater protection and/or other Connecticut and Federal criteria. Connecticut groundwater protection criteria specific to GB designated groundwater are not available; therefore, the Connecticut groundwater protection criteria applicable for GA or GAA designated groundwater are used to protect existing groundwater regardless of classifications. The source of the VOC contamination is unknown, but it is likely from the Torpedo Shops leach field. Additionally, metals and semivolatile organic compounds (SVOCs) were detected in groundwater. Several SVOCs and metals were detected in groundwater at maximum concentrations exceeding Federal and state criteria.

The human health risk assessment (HHRA) from the Phase II RI for Site 3 for the potential receptor group (construction worker) identified a noncarcinogenic risk greater than HI equal to 1.0 due to antimony and manganese. Additionally, carcinogenic risks for the construction worker associated with dermal exposure to groundwater attributable to the presence of vinyl chloride and 1,1,2,2-tetrachloroethane in the groundwater exceed $1E-6$ but were within EPA's target risk range of $1E-4$ to $1E-6$ and less than the CTDEP target cancer risk of $1E-5$. The risk assessment assumed that groundwater was not used as a potable water supply; consequently exposure to groundwater was only evaluated for the construction worker.

Due to the unknown source and extent of VOC contamination in the groundwater, two sampling areas containing temporary monitoring wells will be established in the northcentral and northwest areas of the site. Each of these areas will contain several strategically placed temporary monitoring wells which will be sampled and analyzed for quick-turn VOCs. Depending on the testing results, a second set of temporary monitoring wells will then be placed in an expanded area to further define the limits of contamination. This process will be repeated until the VOC plume has been defined and the extent of its boundaries have been determined. Based on the results of groundwater sampling at the temporary monitoring wells, permanent well clusters will be installed as necessary along the perimeter of the plume

for monitoring purposes. To fully characterize the groundwater contamination at Site 3, the existing wells will also be sampled. The groundwater samples collected from the permanent wells will be analyzed for Target Compound List (TCL) VOCs, TCL SVOCs, TCL pesticides, Target Analyte List (TAL) metals (total and limited dissolved), natural attenuation parameters, and water quality parameters. A limited number of permanent wells at this site will also be slug tested to determine the conductivity of the aquifer.

1.4.2.1.3 Site 7 – Torpedo Shops

Numerous VOCs, SVOCs, and metals were detected in the groundwater at Site 7. These chemicals were found primarily in the overburden wells, especially in the south-central area of the site. Additionally, VOCs, SVOCs, and metals were detected near the abandoned septic system. The abandoned septic system may be a source of contamination; therefore, it will be investigated during the RI. Two VOCs, five SVOCs, and several metals were detected at maximum concentrations exceeding the Connecticut or Federal maximum contaminant levels (MCLs), Connecticut groundwater or surface water protection standards, and/or COPC Screening Levels [i.e., USEPA Region III risk-based concentrations (RBCs)].

During the Phase II RI, human health risks for two potential receptor groups (construction workers and future residents) were evaluated. Noncarcinogenic risks associated with exposure to groundwater exceeded the USEPA acceptable level of 1 for the construction worker under the Reasonable Maximum Exposure (RME) scenario and for the future resident under the RME and Central Tendency Exposure (CTE) scenarios. Manganese was the main contributor to the hazard index for the construction worker, and bis(2-ethylhexyl) phthalate, antimony, arsenic, manganese, and thallium were the main contributors to the hazard index for the future resident. The incremental cancer risk associated with exposure to groundwater for the full time employee and construction worker were within the USEPA target risk range and the CTDEP target cancer risk. The incremental cancer risk for the future resident exceed EPA's target risk range and CTDEP's target cancer risk. Bis(2-ethylhexyl) phthalate and arsenic were the main contributors to the cancer risk for the future resident.

Two soil borings and three temporary monitoring wells will be installed and sampled along the septic line to the south leach field to determine the absence or presence of soil and groundwater contamination along the abandoned septic line. An area containing seven temporary monitoring wells will be established in the south-central area of the site. This area will be aligned with the north-central area to be established for Site 3 and will be expanded with additional Site 3 temporary monitoring wells (north-central area) in stages based on the results of quick turn VOC analyses. The combined Sites 3 and 7 sampling systems will address the uncertainty in the extent of the VOC plume. In addition, the existing monitoring wells at Site 7 will be sampled. Additional permanent monitoring wells will be installed as necessary. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals,

perchlorate, natural attenuation parameters, and water quality parameters. The soil samples will be analyzed for TCL VOCs, TCL SVOCs, and TAL metals. A limited number of permanent wells at this site will also be slug tested to determine the conductivity of the aquifer.

1.4.2.1.4 Site 14 – OBDANE

Carbon disulfide and bis(2-ethylhexyl)phthalate were detected in the two groundwater samples collected from well 14MW1S during historical site investigations. Both chemicals were detected at an estimated concentration of 1 µg/L, which is less than the screening criteria for each chemical. Eleven metals were detected in the unfiltered OBDANE groundwater samples, and 12 metals were detected in the associated filtered groundwater samples. Excluding iron and sodium, which were not quantitatively evaluated against screening levels, arsenic and manganese were the only two metals detected at concentrations exceeding groundwater screening levels. Concentrations of arsenic exceeded the COPC screening level (i.e., USEPA Region III RBCs), and manganese concentrations exceeded the COPC screening level, the Federal MCL, and the Connecticut remediation standard for GA/GAA groundwater protection.

The risk assessment assumed that groundwater was not used as a potable water supply, consequently exposures to groundwater were only evaluated for construction workers. Noncarcinogenic risks associated with dermal exposure to groundwater for the construction worker under both the CTE and RME scenarios were less than the USEPA acceptable level of 1. Estimated lifetime incremental cancer risks for this receptor under both scenarios were also less than USEPA's acceptable target risk range (1E-6 to 1E-4) and the CTDEP target cancer risk (1E-5). Therefore, it was concluded that the site poses little risk to human health.

A removal action is contemplated for this site in conjunction with the remedial action at the Area A Downstream Watercourses and OBDA site. Therefore, it is not anticipated at this time that additional soil sampling will be necessary during the RI. However, the existing overburden well at the site will be sampled during the RI. The sample will be analyzed for TCL VOCs, total TAL metals, and water quality parameters.

1.4.2.1.5 Site 20 – Area A Weapons Center

The major overburden groundwater COCs for this site were bis(2-ethylhexyl)phthalate, polycyclic aromatic hydrocarbons (PAHs) [benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene], and inorganics (antimony, arsenic, boron, chromium, lead, manganese, and thallium). Detected concentrations of each of these COCs exceeded one or more of the groundwater screening criteria (i.e., the COPC screening level, the Federal MCL, the Connecticut MCL, and the Connecticut remediation standards for

GA/GAA groundwater or surface water protection). Most of the maximum metals concentrations were associated with groundwater samples collected from well 2WCMW3S, located south of the site along the drainageway into the Area A Wetland. The primary bedrock groundwater COCs are chlorinated aliphatic hydrocarbons (1,1,2-trichloroethane, 1,2-dichloroethane, and TCE) and inorganics (antimony and manganese). Detected concentrations of each of these COCs exceeded one or more of the previously listed groundwater screening criteria. Monitoring well 2WMW4D is the only bedrock well that was installed and sampled at this site.

The human health risk assessment evaluated construction workers and future residents for potential exposures to groundwater. The estimated noncarcinogenic risk associated with dermal contact with groundwater for the CTE construction worker was less than 1. Noncarcinogenic risks for the RME construction worker and potential future residents (CTE and RME) exceeded the USEPA acceptable level of 1.0. Manganese was the main contributor to the hazard index for the construction worker and manganese, thallium, and arsenic were the main contributors to the hazard index for the future resident. Incremental cancer risks were less than $1E-6$ for the construction worker under both exposure scenarios and for the future resident (for both dermal contact and inhalation exposure routes) under the CTE scenario. The incremental cancer risk associated with the ingestion of groundwater for the CTE future resident was within USEPA's target risk range of $1E-6$ to $1E-4$ but exceeded the CTDEP target cancer risk of $1E-5$. However, for the RME future resident, the cumulative incremental cancer risk associated with exposure to groundwater exceeded the upper limit of USEPA's target risk range ($1E-4$), and the CTDEP target cancer risk. Dibenzo(a,h)anthracene and arsenic were the primary contributors to the cancer risk for the future resident.

The existing overburden and bedrock wells (four total wells) at this site will be sampled during the Basewide Groundwater OU RI. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, perchlorate, and water quality parameters. One sample will also be analyzed for dissolved TAL metals.

1.4.2.2 Central Region

1.4.2.2.1 Site:16 – Hospital Incinerator

There is no existing data for the Hospital Incinerator site. A review of records and personal interviews will be conducted to determine where potential areas of soil and groundwater contamination may exist. An initial Site Investigation will also be conducted to determine the absence or presence of soil and groundwater contamination. Soil borings and temporary wells will be completed during this investigation. The soil and groundwater samples collected will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, TAL metals (total), and dioxins and furans. In addition, the soil samples will undergo

Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by analysis for TCL pesticides and TAL metals, and water quality parameters will be measured in groundwater samples.

1.4.2.3 Southern Region

1.4.2.3.1 Site 8 – Goss Cove Landfill

Numerous VOCs, SVOCs, and metals were detected in groundwater samples collected from Site 8. Maximum concentrations of a majority of the VOCs, SVOCs, and metals detected in groundwater samples from overburden wells (and, to a lesser extent, from bedrock wells) exceeded Connecticut and/or Federal screening criteria. However, groundwater at this site is not used or expected to be used in the future as a drinking water source because of brackish conditions.

The Phase II RI HHRA for Site 8 evaluated the construction worker as a potential receptor group. The noncarcinogenic risk associated with dermal contact with groundwater exceeded 1 for the RME scenario. PCE was the main contributor to the hazard index for the construction worker. The carcinogenic risk associated with dermal contact with groundwater under the RME ($2.8E-5$) exceeded the CTDEP target cancer risk level ($1E-5$). PCE was the major contributor to the cancer risk for the construction worker.

The existing wells at this site will be sampled to determine the extent of groundwater contamination. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total TAL metals, and water quality parameters. One sample will be analyzed for dissolved TAL metals.

1.4.2.3.2 Site 15 – Spent Acid Storage and Disposal Area

The major classes of chemicals detected in the groundwater during previous investigations are SVOCs and metals. Carbon disulfide was the only VOC detected in the groundwater. Its concentration ($3 \mu\text{g/L}$) was less than the COPC screening level ($100 \mu\text{g/L}$) and the Connecticut Remediation Standard for GA/GAA groundwater protection ($700 \mu\text{g/L}$). A single pesticide (heptachlor), three SVOCs, and several metals were detected at maximum concentrations exceeding respective COPC screening levels (i.e., USEPA Region III RBC), Federal or Connecticut MCLs, and/or Connecticut groundwater or surface water protection standards.

The Phase II RI HHRA for Site 15 evaluated the future resident and construction worker as potential receptor groups. The noncarcinogenic risk associated with exposure to groundwater exceeded 1 for the future resident under the RME scenario. Manganese was the main contributor to the hazard index for the future resident. The carcinogenic risk associated with exposure to groundwater for the future resident under the RME scenario exceeded the USEPA target risk range ($1E-6$ to $1E-4$) and the CTDEP target

cancer risk level (1E-5). Bis(2-ethylhexyl)phthalate, 1,4-dichlorobenzene, heptachlor, arsenic, and beryllium were the main contributors to the cancer risk.

The existing monitoring wells will be sampled and the resulting groundwater samples will be analyzed to verify the effectiveness of the removal action and to determine chemical concentrations in the groundwater upgradient of the Tank Farm. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, and water quality parameters.

1.4.2.3.3 Site 18 – Solvent Storage Area (Building 33)

There is no existing data for the Building 33 Solvent Storage Area site. A review of records and personal interviews will be conducted to determine where potential areas of soil and groundwater contamination may exist. An initial Site Investigation will also be conducted to determine the absence or presence of soil and groundwater contamination. Soil borings and temporary wells will be completed during the investigation. The soil and groundwater samples collected will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, and total TAL metals. In addition, the soil samples will undergo SPLP extraction followed by analysis for TCL pesticides and TAL metals and water quality parameters will be measured in groundwater samples.

1.4.2.3.4 Site 23 – Fuel Farm

Numerous VOCs, SVOCs, and metals were detected in the groundwater at Site 23 during previous investigations. Several VOCs, SVOCs, and metals and a single pesticide (heptachlor) were detected at maximum concentrations exceeding respective COPC screening levels (i.e., USEPA Region III RBCs), Federal or Connecticut MCLs, and/or Connecticut groundwater or surface water protection standards.

No quantitative HHRA has been conducted for Site 23. Additionally, data gaps have been identified requiring installation of additional deep overburden monitoring wells. Therefore, two deep overburden monitoring wells will be installed at Site 23. One well (23MW02S) will be installed adjacent to existing bedrock well 23MW02D and one (23MW04S) adjacent to well 23MW04D. Existing shallow overburden wells HNUS-2, HNUS-5, HNUS-7, HNUS-9, HNUS-11, HNUS-13, HNUS-14, HNUS-17, and HNUS-20 will also be sampled. The groundwater samples collected will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total TAL metals, natural attenuation parameters, and water quality parameters. One sample will also be analyzed for dissolved TAL metals. Slug tests will also be completed in two deep overburden and two bedrock wells to estimate bulk hydraulic conductivities.

1.4.2.4 **Backgr und**

Background conditions for groundwater at the NSB-NLON have not been established. To establish background conditions, existing and new monitoring wells upgradient of existing sites will be sampled. Site-specific background values for organic and inorganic compounds will be established for groundwater in the overburden and bedrock at each site. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total and dissolved TAL metals, chloride, and water quality parameters. The analytical data will also be evaluated to determine whether basewide background concentrations can be established. The existing and proposed background monitoring wells to be sampled are shown on Figure 1-15. The following activities will occur at each site to determine background groundwater concentrations:

1.4.2.4.1 Northern Region

Existing overburden monitoring wells 2WMW21S and 2LMW20S and existing bedrock wells 2WMW21D, 4MW1S, and 2WMW22D will be sampled. An overburden monitoring well (2WMW22S) will be installed and sampled adjacent to bedrock well 2WMW22D. These well locations are upgradient of Sites 1, 2A, 2B, 3, 4, 7, 14, and 20.

1.4.2.4.2 Central Region

Existing bedrock monitoring wells 2LMW35B and 2LMW36B will be sampled. An overburden monitoring well (2LMW35S) will be installed and sampled upgradient of Site 16. The overburden monitoring well to be installed upgradient of Site 16 will only be used to determine background for conditions for the site and not potential groundwater contamination.

1.4.2.4.3 Southern Region

Existing bedrock monitoring well 23MW01D will be sampled. An overburden monitoring well (23MW01S) will be installed and sampled adjacent to bedrock well 23MW01D. These well locations are upgradient of Sites 15, 18, and 23.

Existing overburden monitoring wells 8MW8S and HNUS-23 and existing bedrock monitoring wells 8MW8D and 8MW10S will be sampled. These wells are upgradient of Site 8.

1.5 RISK ASSESSMENT

1.5.1 Ecological Risk Assessment

Ecological risks associated with all sites except Sites 16, 18, and 23 were addressed in the Phase II RI or subsequent investigations (i.e., Goss Cove Landfill). No additional ecological risk assessments will be completed for the sites included in the Phase II RI.

Sites 16 and 18 are paved or covered with buildings. The activities conducted at these sites are industrial in nature. Softball fields and a jogging track cover Site 23. The lawn (turf grass) at this site is routinely mowed. The site is used regularly for military training and recreational activities. Therefore, these sites do not provide suitable ecological habitat and these sites are not expected to impact ecological receptors in any nearby ecological habitats. Therefore, ecological risk assessments will not be completed for these sites.

1.5.2 Human Health Risk Assessment

The HHRA evaluates risks for potential receptors under current and future land use in the absence of remedial action. The HHRA for the Basewide Groundwater OU RI will be performed in accordance with guidance set forth in the following documents:

- USEPA (United States Environmental Protection Agency), August 1997. Exposure Factors Handbook. EPA/600/P-95/002Fa. Office of Health and Environmental Assessment, Exposure Assessment Group. Washington, D.C.
- USEPA (United States Environmental Protection Agency), Region I, June 1989. Draft Final Supplemental Risk Assessment Guidance for the Superfund Program. EPA/901/5-89/001. Boston, Massachusetts.
- USEPA (United States Environmental Protection Agency), December 1989. Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual (Part A) - Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response.
- USEPA (United States Environmental Protection Agency), March 25, 1991. Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual - Supplemental Guidance - "Standard Default Exposure Factors" - Interim Final. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response.

- USEPA (United States Environmental Protection Agency), January 1992. Dermal Exposure Assessment: Principles and Applications. EPA/600/8-91/001B. Office of Research and Development.
- USEPA (United States Environmental Protection Agency), May 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication 9285.7-081.
- USEPA (United States Environmental Protection Agency), Region I, August 1994c; August 1995b; November 1996c. Risk Updates, Numbers 2, 3, and 4. Waste Management Division, Boston, Massachusetts.
- USEPA (United States Environmental Protection Agency), January 1998. Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessment) - Interim. EPA 540-R-97-033. Office of Solid Waste and Emergency and Response 9285.7-01D.
- USEPA (United States Environmental Protection Agency), November 1998. Risk Assessment Guidance for Superfund Volume I-Human Health Evaluation Manual-Supplemental Guidance-Dermal Risk Assessment Interim Guidance. Office of Emergency and Remedial Response.
- CTDEP (Connecticut Department of Environmental Protection), January 1996. Remediation Standard Regulations. Bureau of Water Management, Permitting, Enforcement and Remediation Division, Hartford, Connecticut.

Many of the sites to be investigated during the Basewide Groundwater OU RI have undergone extensive study during the Phase I and II RIs. However, groundwater at NSB-NLON sites included in the RI has not been thoroughly characterized. For the Basewide Groundwater OU RI, only environmental media that may contribute to groundwater contamination will undergo further study. Table 1-2 summarizes the risk assessment approach for each site and media to be investigated. This table also lists decision documents that have been issued as a result of previous investigations.

A risk assessment provides the framework for developing risk information necessary to assist in developing potential remedial alternatives for a site. A baseline HHRA consists of five major components, as follows:

- Data evaluation (identification of COCs)
- Exposure assessment

- Toxicity assessment
- Risk characterization
- Uncertainty analysis

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: (1) contaminants with toxic characteristics must be found in environmental media; (2) the contaminants must be released by either natural processes or by human action; (3) potential exposure points must exist; and (4) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of the requirements listed above are absent for a specific site, the exposure route is regarded as incomplete and no potential risks will be considered for human receptors. The risk assessment for the Basewide Groundwater OU RI will estimate the potential for human health risk at each of the individual IR Program sites, although several sites will be calculated together (i.e., one set of risks will be calculated) because of their proximity to each other.

The data evaluation section below addresses the selection of COCs. Both current and historical data will be considered in developing a list of COCs for each medium. In turn, these COCs will be used to evaluate potential human health risks. A generic discussion of the data evaluation process is contained in Section 1.5.2.1.

The toxicity assessment presents the available human health criteria for all the selected COCs. Quantitative toxicity indices are presented when they are available. Enforceable standards such as MCLs, regulatory guidelines such as Ambient Water Quality Criteria (AWQC) and Health Advisories, and dose-response parameters such as Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are presented for each COC.

The exposure assessment section identifies potential human exposure pathways at the source areas under consideration. Exposure routes are identified based on information such as source area chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information to develop conceptual site models for each type of source. One overall set of exposure routes has been developed for the Basewide Groundwater OU RI, but not all routes are applicable to all sites. Section 1.5.2.2 presents the equations and relevant input parameters for estimating chemical intakes. The site-specific risk assessments will present only those routes relevant to each site.

The risk characterization section (Section 1.5.2.3) describes how the estimated intakes will be combined with the toxicity information to estimate risks. General uncertainties associated with the risk assessment process are discussed qualitatively in Section 1.5.2.4.

1.5.2.1 Data Evaluation

Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals at a site are most likely to present a risk to potential receptors. The end result of this qualitative selection process is a list of COCs and representative exposure point concentrations for each medium. The methodology that will be used to identify COCs for the Basewide Groundwater OU RI Report is discussed in Section 1.5.2.1.1. The methodologies that will be used to determine exposure point concentrations for the selected COCs are discussed in Section 1.5.2.1.2.

1.5.2.1.1 Selection of Chemicals of Concern

COCs for the baseline HHRA will be limited to those chemicals that exceed a selection criterion. For the upcoming risk assessment, Federal and state risk-based and health-based criteria will be used to reduce the number of chemicals and exposure routes considered in a risk assessment. The premise of this screening step is that risk is typically dominated by a few chemicals and that, although dozens may actually be detected, many chemicals may contribute minimally to the total risk. The purpose of using Federal and state criteria is to satisfy the potential concerns of each regulatory agency because similar Federal and state criteria may not be developed using the same methodologies and exposure assumptions.

Maximum detected concentrations (in a single sample) at each site and in each medium will be compared to the risk-based and health-based screening criteria. If the maximum concentration exceeds any of the screening criteria, that chemical will be retained as a COC for all exposure routes involving that medium. For example, if barium is a COC for soil, this chemical would be evaluated as a COC for both ingestion and dermal soil exposure routes. If none of the chemicals detected in a medium exceed a criterion, that medium will be dropped from further consideration and the potential risks associated with exposure to that medium will be regarded as relatively insignificant.

In general, all available, validated data from historical investigations and any new data collected during the Basewide Groundwater OU RI sampling effort will be used to identify COCs for a site. Field screening data, unvalidated data, and analytical results qualified as rejected, R, during the data validation process will not be considered because of their potential unreliability. For soil, the COC selection process will not use data obtained from historical sampling locations that have since been excavated, soil collected from depths greater than 10 feet below ground surface (bgs) (the maximum, assumed depth for potential human exposure during excavation and construction), and composite soil samples.

Essentially, two types of COCs may be identified: direct exposure COCs and additional COCs based on potential contaminant migration tendencies. Direct exposure COCs are those chemicals detected at

maximum concentrations in excess of criteria developed for the protection of direct human contact with a medium (e.g., risk-based USEPA Region III COC screening levels for soil and tap water ingestion). When necessary, other health-based criteria (e.g., Connecticut pollutant mobility criteria) will be used to identify additional COCs based on likely contaminant migration pathways.

Although both direct exposure and additional COCs will be identified in the risk assessment, quantitative, numerical risk estimates will be developed for direct exposure COCs only. Additional COCs based only on potential contaminant migration tendencies are not expected to contribute significantly to the direct exposure pathways selected for quantitative evaluation in the risk assessment; therefore, these chemicals will not be included in the numerical risk estimates. The elimination of these chemicals is not expected to adversely impact the results of the risk assessment. Additional COCs will be addressed qualitatively and will be considered when developing recommendations and conclusions for each site (i.e., migration concerns will be used to identify whether additional sampling, groundwater modeling, or remediation is warranted).

The remainder of this section discusses the criteria used for COC selection on a medium-specific basis. Copies of all current screening criteria are contained in Appendix E of this WP.

Soil

COCs will be selected for surface soil (soil from depths of 0 to 2 feet bgs) and "all soil." The "all soil" category refers to soil samples collected from depths of 0 to 10 feet bgs and is used to account for soil to which a construction worker and future resident may be exposed. If a chemical is identified as a COC for surface soil, it is automatically retained as a COC for "all soil." If a compound is found in the subsurface soil at a concentration in excess of a screening criteria, it is retained as a COC for the "all soil" category only.

The following screening criteria will be used to identify COCs for direct exposure:

USEPA Region III COC Screening Levels for Residential Soil Ingestion. Although current and likely future land use at NSB-NLON is strictly industrial, risk-based concentrations for soil ingestion for residential land use will be used as a conservative approach. These values are developed using the current USEPA Region III Risk-Based Concentration (RBC) Table (USEPA, 1999b), which identifies concentrations of potential concern for nearly 600 chemicals in various media (air, drinking water, fish tissue, and soil) using certain RME default assumptions. The residential soil ingestion values are calculated by assuming that a receptor is exposed to soil for 350 days per year for a 30-year exposure period. For carcinogenic chemicals, the values used for COC screening will be based on a 1E-6 target

incremental lifetime cancer risk and incorporate age-adjusted factors for small children and adults. The criteria for noncarcinogenic chemicals will be based on a target HQ of 0.1, which is one-tenth of the suggested cumulative target noncarcinogenic risk for a potential receptor, and exposure defaults for small children. The estimation of cumulative target noncarcinogenic risks is described in greater detail in Section 1.5.2.4.

Connecticut Direct Exposure Criteria (Residential and Industrial). Connecticut direct exposure criteria under residential land use will also be used for COC screening. The Connecticut direct exposure criteria are calculated using methodologies similar to those used to develop the USEPA Region III COC Screening Levels for soil ingestion. However, RME default assumptions used by the state are slightly different than those used by USEPA Region III (i.e., the state assumes that a residential receptor will be exposed to soil at a frequency of 365 days per year, whereas USEPA assumes a 350-day yearly exposure). The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. The State of Connecticut has not developed direct exposure criteria for all chemicals positively detected at NSB-NLON. For those chemicals lacking adopted direct exposure criteria, TtNUS calculated direct exposure criteria during previous phases of investigation at NSB-NLON (B&RE, 1997e and TtNUS, 1998b) using the methodologies outlined in the Connecticut Remedial Standard Regulations guidance (CTDEP, 1996). These previously calculated values were submitted to the state for review and have been revised based on comments received from the state (B&RE, 1998b and TtNUS, 1999f).

In order to identify additional COCs based on potential contaminant migration tendencies, various screening criteria will be used to evaluate shallow soil and "all soil" (soil collected from depths of 0 to 10 feet bgs). The criteria are discussed below.

USEPA Generic Soil Screening Levels (SSLs) for Transfers from Soil to Air (Inhalation) and Migration to Groundwater. USEPA Generic SSLs (USEPA, 1996a) for direct inhalation will be used to evaluate chemicals that may volatilize from soil, as well as contaminated particulates that may be present in air (fugitive dust) as a result of particulate entrainment from soil. Because of the shallow depth to groundwater at NSB-NLON, the SSLs associated with a dilution and attenuation factor of 20 will be used to identify COCs. Both the inhalation and migration to groundwater SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective against potential exposure at most sites. USEPA has calculated generic SSLs for approximately 110 organic and inorganic chemicals. SSLs for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. For noncarcinogenic chemicals, the SSLs are based on a target HQ of 1.

Connecticut Pollutant Mobility Criteria (GB Classified Areas): The state has developed pollutant mobility criteria for GA/GAA (drinking water source) and GB (non-drinking water source) classified areas. Because the NSB-NLON is classified by the state as a GB area, Connecticut pollutant mobility criteria for GB classified areas will be used to identify COCs. For most organic chemicals, pollutant mobility criteria are calculated using methodologies similar to those used to develop the USEPA generic SSLs for migration to groundwater. However, the actual models and RME default assumptions used by the state are different than those used by USEPA Region III. The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. It should be noted that the pollutant mobility criteria for inorganics, pesticides, and PCBs apply to SPLP or TCLP analytical results only. As mentioned previously, for those chemicals lacking adopted pollutant mobility criteria, TtNUS calculated alternative criteria during previous phases of investigation at NSB-NLON (B&RE, 1997e and TtNUS, 1998b) using the methodologies outlined in the Connecticut Remediation Standard Regulation guidance (CTDEP, 1996). These previously calculated values were submitted to the state for review and have been revised based on comments received from the state (B&RE, 1998b and TtNUS, 1999f).

Connecticut Soil Vapor Volatilization Criteria: Connecticut soil vapor volatilization criteria are for sites known to be contaminated with VOCs and where the groundwater depth is within 15 feet of the ground surface or a building. Soil vapor volatilization criteria are calculated using methodology described in American Society for Testing and Materials (ASTM) E1739-95 Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (1995). USEPA does not currently have guidance for the calculation nor has it promulgated corresponding screening criteria.

Background. As per USEPA Region I guidance (USEPA, 1995b), background concentrations developed by Atlantic for chemicals in soil will be presented in the Basewide Groundwater OU RI report but will not be used to eliminate COCs. All COCs for soil that are considered to be attributable to natural, background soil conditions will be addressed in the risk assessment to provide a complete characterization of potential risk. However, a discussion of site data in comparison to the established background levels will be provided in each site-specific section of the risk assessment. It should be noted that background concentrations will be considered when developing recommendations and conclusions for each site (i.e., identifying whether additional sampling, groundwater modeling, or remediation is warranted).

Sediment

Analytical results for sediment samples collected from Site 2B – Area A Wetland and Site 16 – Hospital Incinerator, will be evaluated collectively with analytical results for soil samples collected from each of

these sites. Therefore, the information provided for soil also applies to sediment samples collected from these sites. Analytical results for sediment samples will not be evaluated for any of the other sites because sediment contamination at these sites is not expected to have an impact on the associated site groundwater.

Groundwater

COCs for groundwater will be selected using analytical data for unfiltered and filtered samples. If an inorganic chemical is detected in both the filtered and unfiltered groundwater samples at concentrations in excess of screening criteria, the chemical will be identified as a COC for both sample matrices. However, to be conservative, only data for unfiltered samples will be used in the quantitative risk assessment because the concentration of a chemical in the unfiltered sample matrix includes the chemical concentration associated with the dissolved sample matrix and any suspended particulates. If a chemical is detected in the filtered sample matrix, but not in the unfiltered sample matrix, or if a chemical is present in the filtered sample matrix at a concentration of concern, but not in the unfiltered sample matrix, this chemical will be identified as a COC for the filtered sample matrix only. In this instance, the filtered sample results will be used in the quantitative risk assessment.

COCs for direct exposure to groundwater will be identified using the following screening criteria:

USEPA Region III COC Screening Levels for Tap Water Ingestion. Although groundwater at NSB-NLON is not currently used as a drinking water supply and is not expected to be used as such in the future because of industrial land use and saline groundwater conditions, RBCs for tap water ingestion will be used to conservatively identify COCs. The USEPA Region III criteria are calculated using an age-adjusted exposure equation, which assumes that a receptor uses groundwater for household purposes at a frequency of 350 days per year for 30-year exposure period. The screening values for tap water ingestion, which incorporate exposure via inhalation of volatiles, will be developed using the USEPA Region III RBC Table (USEPA, 1999b). For carcinogenic chemicals, the values used for COC screening will be based on a 1E-6 target incremental lifetime cancer risk. The criteria for noncarcinogenic chemicals are based on a target HQ of 0.1.

Connecticut Groundwater Protection Criteria (GA/GAA). Connecticut groundwater protection criteria are applicable to GA/GAA-classified areas (drinking water source areas) only. Although all of the groundwater included in the Basewide Groundwater OU RI at NSB-NLON is within a GB-classified area (a non-drinking water source area), the groundwater protection criteria for GA/GAA-classified areas will be used for informational purposes and as a conservative approach for COC selection. Groundwater protection criteria for GA/GAA-classified areas are calculated using methodologies similar to those used

to develop the USEPA Region III COC screening levels for tap water ingestion. However, the exposure equation and RME default assumptions employed by the state are slightly different than those advocated by USEPA Region III (a receptor is assumed to be exposed to groundwater at a frequency of 365-days-per-year, instead of USEPA's 350-days-per-year age-adjusted exposure scenario). The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. As mentioned previously, for chemicals lacking adopted groundwater protection criteria, TtNUS will calculate groundwater protection criteria or will use values calculated during previous investigations at NSB-NLON (B&RE, 1997e and TtNUS, 1998b) using the methodologies outlined in the Remediation Standard Regulations (RSR) guidance (CTDEP, 1996). These previously calculated values have been submitted to the state for review and have been revised based on comments received from the state (B&RE, 1998b and TtNUS, 1999f).

Federal and State Maximum Contaminant Levels (MCLs). Federal MCLs are standards promulgated under the Safe Drinking Water Act (USEPA, 1996b) and are designed to protect human health (direct ingestion). State MCLs have been promulgated under guidance for Connecticut agencies (Title 19, Health and Safety, the Public Code of the State of Connecticut, Chapter II, Environmental Health). Both Federal and state MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies. They are designed in a manner similar to the USEPA Region III RBCs (prevent human health effects associated with lifetime exposure of an average adult who consumes 2 liters of water per day). However, MCLs also reflect the technical feasibility of removing the contaminant from water. Although MCLs are typically enforceable standards for groundwater, these standards are not strictly applicable to groundwater at NSB-NLON because groundwater at the site is not currently used as a drinking water supply nor is it expected to be used as such in the future. It should also be noted that primary MCLs and secondary MCLs, based on aesthetic drinking water qualities (color, odor, taste, etc.), will be used to identify COCs.

Connecticut Surface Water Protection Criteria. Because groundwater at the sites that will be addressed during the upcoming RI discharge to nearby surface water bodies and/or ultimately to the Thames River, screening criteria protective of surface water will be used to identify COCs associated with potential contaminant migration pathways. The CTDEP surface water protection criteria are calculated using the lower of the human health criteria or the freshwater aquatic life criteria for a chemical and dilution factors based on the nature of the chemical (CTDEP, January 1996). However, because the Thames River is a marine ecosystem and not a freshwater ecosystem, CTDEP surface water remediation standards based on freshwater aquatic life criteria are not directly applicable for COC screening.

Connecticut Groundwater Volatilization Criteria. Connecticut groundwater volatilization criteria are for sites that are known to be contaminated with VOCs and where the groundwater depth is within 15 feet of the ground surface or a building. Groundwater volatilization criteria are calculated using methodology described in ASTM E1739-95 Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (1995). USEPA has not promulgated corresponding screening criteria for this type of evaluation. As mentioned previously, for chemicals lacking adopted groundwater protection criteria, TtNUS will calculate groundwater volatilization criteria using the methodologies outlined in the RSR, guidance (CTDEP, 1996) or will use values calculated during previous investigations at NSB-NLON (B&RE, 1997e and TtNUS, 1998b). These previously calculated values have been submitted to the state for review and have been revised based on comments received from the state (B&RE, 1998b and TtNUS 1999f).

Background. As per Connecticut guidance, background values will be developed for each site to be investigated during the Basewide Groundwater OU RI. However, as per USEPA Region I guidance (USEPA, 1995b), these newly developed background values will not be used to eliminate COCs. All COCs for groundwater that are considered to be attributable to natural, background groundwater conditions will be addressed in the risk assessment to provide a complete characterization of potential risk. However, each site-specific section of the risk assessment will discuss site data in comparison to the established background levels. It should be noted that background concentrations will be considered when developing recommendations and conclusions for each site (i.e., identifying whether additional sampling, groundwater modeling, or remediation is warranted).

It should be noted that Federal maximum contaminant level goals (MCLGs) and Federal AWQCs are other health-based standards, but these criteria will not be used in the baseline HHRA to identify groundwater COCs. These criteria will not be used because they are very similar to the risk-based and health-based criteria discussed in the previous paragraphs.

Surface Water

Analytical results for surface water samples collected from Site 2B will be qualitatively evaluated. Contamination in surface waters at this site may impact the associated site groundwater. Analytical results for filtered and unfiltered surface water samples will be screened independently to account for suspended sediments. The screening criteria described for groundwater will also be used for COC selection for surface water. This approach results in a conservative list of COCs because surface water is not used as a drinking water supply.

No new surface water data will be collected during the Basewide Groundwater OU RI. A quantitative risk assessment using all historical data and based on direct exposure to surface water was conducted during the Phase II RI.

1.5.2.1.2 Exposure Point Concentrations

According to USEPA Regional guidance, risk assessments are conducted using an exposure point concentration for each COC (except when assessing exposure to groundwater, where the maximum detected concentration and the average plume concentration are used as exposure point concentrations). The exposure point concentration will be defined as the 95 percent UCL and will be calculated using the latest USEPA risk assessment guidance (USEPA, 1992c). A value of one-half the detection limit will be substituted for nondetected values in the calculation. At the direction of USEPA, because of potential problems with sample heterogeneity, the maximum detected concentration reported for field duplicate pair samples will be used in the calculation for soil and sediment matrices. The average for the duplicate pair will be employed for aqueous matrices.

For sample sets consisting of less than 10 samples, the maximum and average concentrations will be used as the exposure point concentrations because the UCL does not provide a good estimation of the upper bound of the mean concentration for these small data sets (USEPA, 1992d). For larger sample sets, the methodology to be used depends on the distribution of the sample set. For this risk assessment, the distribution will be determined using the Shapiro-Wilk W-Test (Gilbert, 1987). If the results of this test are inconclusive and the distribution is regarded as undefined, maximum and average detections will be used as exposure point concentrations for the RME and CTE, respectively.

For normally distributed data, the calculation of the exposure point concentration (UCL) is a two-step process. First, the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\sum(X_i - \bar{X})^2}{(n-1)} \right]^{1/2}$$

where: S = standard deviation
X_i = individual sample value
n = number of samples
x̄ = mean sample value

The one-sided UCL on the mean will be then calculated as follows:

$$UCL = \bar{X} + t \left(\frac{S}{n^{1/2}} \right)$$

where: UCL = 95 percent UCL of the mean
 \bar{X} = arithmetic average
t = one-sided t distribution factor ($t_{0.95}$)
s = standard deviation
n = number of samples

For log-normally distributed data sets, the exposure point concentration will be calculated using the following equation:

$$UCL = \exp \left(\bar{X} + 0.5s^2 + \frac{Hs}{(n-1)^{1/2}} \right)$$

where: UCL = 95 percent UCL of the mean
exp = constant (base of the natural log, e)
 \bar{X} = mean of the transformed data
s = standard deviation of the transformed data
H = H-statistic (from Gilbert, 1987; $H_{0.95}$)
n = number of samples

This equation uses individual sample results that have been transformed by taking their natural logarithm.

As mentioned previously, average and maximum plume concentrations will generally be used as the exposure point concentrations for assessing risks associated with groundwater exposure (EPA Region I, 1994). Because of the multiple rounds of groundwater sampling that have been performed at some of the sites investigated, the first step in developing exposure point concentrations for this medium will be to determine an average chemical concentration for each well (using one-half the detection limit for nondetected results). The maximum plume concentration will then be defined as the highest average in a single well. The average of all the well-specific averages will be considered to represent the average plume concentration. It should be noted that the maximum detected concentration in a single groundwater sample will be used as the exposure point concentration if the calculated average or maximum plume concentration exceeds the maximum detection in a single sample.

1.5.2.2 Toxicity Assessment

The toxicity assessment for the COCs examines information concerning the potential human health effects of exposure to COCs. The goal of the toxicity assessment is to provide, for each COC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values that will be presented in this section of the risk assessment will be integrated with the exposure assessment (Section 1.5.2.3) to characterize the potential for adverse health effects (Section 1.5.2.4).

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the COCs.

The entire toxicological database is used to guide the derivation of CSFs for carcinogenic effects and RfDs for noncarcinogenic effects. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and evaluations of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, most toxicity data used to derive CSFs and RfDs comes from animal studies.

For noncarcinogenic effects, the most appropriate animal model (the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL. When chemical-specific data are not sufficient, an RfD may be derived from data for a chemical with structural and toxicologic similarity.

CSFs for known or probably human carcinogens are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for possible human carcinogens for which the data are sufficient, but are not derived for chemicals with little or no carcinogenicity data or for chemicals shown to be noncarcinogens. No consideration is given to similarity in the animal and human target organs, because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

Toxicological profiles for each of the COCs will be presented in an appendix to the Basewide Groundwater OU RI. Each profile will summarize the available literature on carcinogenic and noncarcinogenic effects associated with human exposure to the chemical.

1.5.2.2.1 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in USEPA's classification system to denote its potential for carcinogenic effects:

- Group A - known human carcinogen
- Group B1 or B2 - probable human carcinogen
- Group C - possible human carcinogen

Chemicals that cannot be classified as a human carcinogen because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are placed in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upperbound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and laboratory animals and are typically calculated for compounds in Groups A, B1, and B2, although some Group C carcinogens also have slope factors and some B2 carcinogens have none (e.g., lead). Slope

factors are specific to a chemical and route of exposure and are expressed in units of $(\text{mg}/\text{kg}/\text{day})^{-1}$ for both oral and inhalation routes. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu\text{g}/\text{m}^3$ [$1/(\mu\text{g}/\text{m}^3)$]. Because cancer risk characterization requires an estimate of reciprocal dose in units of $1/(\text{mg}/\text{kg}/\text{day})$, the inhalation unit risk must be converted to the mathematical equivalent of an inhalation CSF, or risk per unit dose ($\text{mg}/\text{kg}/\text{day}$). This is done by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation unit risk ($1/\mu\text{g}/\text{m}^3$) is divided by 20 m^3 , multiplied by 70 kg, and multiplied by 1,000 $\mu\text{g}/\text{mg}$ to yield the mathematical equivalent of an inhalation slope factor ($1/\text{mg}/\text{kg}/\text{day}$)].

USEPA's Integrated Risk Information System (IRIS) database will be consulted as the primary source for CSF values and RfDs. USEPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) will be consulted, as well as the current USEPA Region III Risk-Based Concentration Table (USEPA, 1999b). If no criteria are available from any of these sources, risks will not be quantified for these chemicals and potential exposures will be addressed in the uncertainty section of the risk assessment.

CSFs exist for several (but not all) Class C compounds. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and limited evidence in animals. For this HHRA, Class C compounds will be evaluated quantitatively as class A/B1/B2 compounds, but the risks associated with exposure to Class C compounds will be discussed separately if these chemicals are major risk drivers, underscoring the uncertainty associated with these estimations.

Dermal CSFs will be derived from the corresponding oral values. In the derivation of a dermal CSF, the oral CSF will be divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose. The oral CSF will be divided by the absorption efficiency because CSFs are to be expressed as reciprocal doses. If no absorption rate is available in the literature, no adjustment will be made.

Risk estimates for PAHs have, in the past, assumed that all carcinogenic PAHs have a potency equal to that for benzo(a)pyrene. While benzo(a)pyrene was well studied, other Class B2 PAHs had insufficient data with which to calculate a CSF. USEPA has published provisional guidance to assess PAHs (USEPA, 1993). Estimated orders of potential potency (rather than a toxicity equivalence factor or TEF) were developed based on skin painting tests and are rounded to one significant figure (based on an order of magnitude). The values are based on a comparable endpoint (complete carcinogenesis after repeated exposure to mouse skin). The quality of the data does not support any greater precision. The orders of

potential potency to be used in this health risk assessment are presented in Table 1-3 and are those proposed for use by USEPA Region I (USEPA, 1994c).

USEPA has determined that the CSF for benzo(a)pyrene is $7.3 \text{ (mg/kg/day)}^{-1}$ and that no acceptable inhalation unit risk factor exists for this compound. Therefore, the guidance is applicable only to oral exposure. There is "no basis for judgment that benzo(a)pyrene or other PAHs will be equipotent by oral and inhalation routes" (USEPA, 1993). The effects of particulates and cocarcinogens on benzo(a)pyrene effects in the lungs have not been addressed, thereby preventing establishment of an inhalation potency for benzo(a)pyrene and relative potencies for other PAHs.

1.5.2.2.2 Noncarcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a RfD. The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways. In particular, Reference Concentrations (RfCs) in units of mg/m^3 are typically presented for the inhalation pathway. Because characterization of noncarcinogenic effects requires a dose estimate in units of mg/kg/day, the inhalation RfC must be converted to an inhalation RfD. The conversion is performed by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation RfC (mg/m^3) is multiplied by $20 \text{ m}^3/\text{day}$ and divided by 70 kg to yield an inhalation RfD (mg/kg/day)].

To derive a RfD, USEPA reviews all relevant human and animal studies for each compound and selects the study (or studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the NOAEL or, if the data are inadequate for such a determination, the LOAEL. The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for extrapolation of data from laboratory animals to

humans (interspecies extrapolation), variation in human sensitivity to the toxic effects of a compound (intraspecies differences), derivation of a chronic RfD based on a subchronic study, or derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

A dermal RfD will be developed by multiplying the oral RfD by the gastrointestinal tract absorption factor. The resulting dermal RfD, based on an absorbed dose, will be used to evaluate the dermal (unabsorbed) dose calculated by the dermal exposure algorithms. Table 1-4 lists the gastrointestinal absorption factors from USEPA guidance (USEPA, 1998c).

USEPA's IRIS database will be consulted as the primary source for RfD values. USEPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual HEAST will be consulted, as well as the current USEPA Region III RBC table (USEPA, 1999b). If no CSF is available from any of these sources, carcinogenic risks will not be quantified, and potential exposures will be addressed in the uncertainty section of the risk assessment.

The primary source for obtaining RfD values is the IRIS database, followed by other USEPA sources described for the carcinogens. When developing noncarcinogenic risk estimates, it is important to note the primary target organs affected by a particular chemical. This information may be used in the Risk Characterization section to segregate risks by target organ effects, unless the HI is below unity.

1.5.2.3 Exposure Assessment

The exposure assessment defines and evaluates the exposures experienced by a receptor population. To have an exposure, several factors must be present. First, there must be a source of contamination. Second, there must be a mechanism through which a receptor can come into contact with the contaminants in that medium. Third, there must actually (or potentially) be a receptor present at the point of contact, and fourth, there must be an exposure route at the point of contact.

The exposure assessment presented consists of several sections that characterize the physical site setting and the receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the points of exposure, and present the equations that will be used to quantify exposure in terms of contaminant intake (dose).

1.5.2.3.1 Exposure Setting

This section contains information on the land use and receptor characteristics in the area surrounding NSB-NLON and the Thames River.

Land Use. NSB-NLON is a base command for naval submarine activities in the Atlantic Ocean. The base includes housing for Navy personnel and their families, submarine training facilities, military offices, medical facilities, and facilities for the maintenance, repair, and overhaul of submarines.

Exposed Populations. NSB-NLON is located within the boundaries of Groton and Ledyard, which had a total population of 45,144 in the 1990 census (Atlantic, 1992). Communities adjacent to the base include Northwest (located east of Route 12; population 5,520 in 1980), Pleasant Valley (located south of the base; population 4,374 in 1980), and the base itself (population 4,099 in 1980). The community of Gales Ferry in Ledyard borders the base on the north (population 7,802 in 1988). A detailed assessment of the types of activities that currently occur and those that are planned is presented in Appendix E of the Phase I RI Report (Atlantic, 1992).

1.5.2.3.2 Conceptual Site Model

This section discusses the general conceptual site model for NSB-NLON. A conceptual site model facilitates consistent and comprehensive evaluation of the risks to human receptors by creating a framework for identifying the paths by which human health may be impacted by contaminants predicted to exist at the source areas. A conceptual site model depicts the relationships between the elements necessary to construct a complete exposure pathway, as follows:

- Sources and potential COCs
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Receptors

Two simple conceptual site models have been developed for all source areas to provide the basis for identifying the potential risks to human health and the environment. One model has been developed for sites at which the source is at the ground surface (Figure 1-16), and the second model considers sites at which the wastes were initially emplaced (either intentionally or unintentionally) in the subsurface (Figure 1-17). These models consider the current operating conditions of the facilities and the actual or potential receptors that could come into contact with the COCs.

The conceptual site models first consider the sources assumed to be available, either currently or in the future. At these sites, the sources are the wastes disposed at the facilities or the contaminated soil resulting from on-site activities. Contaminants may be released from these sources by mechanisms such as wind or water erosion or leaching to the subsurface. Once released from the source, contaminants are transported in media such as air, surface water, or groundwater. Receptors may be exposed either directly or indirectly to contaminants in these media via a variety of mechanisms. The exposure mechanisms considered include routine domestic activities and working outdoors, among others. These exposure mechanisms generally act along one or more exposure routes such as ingestion, inhalation, or direct dermal contact.

The conceptual site models also indicate those exposure routes that are carried through the quantitative risk assessment for each receptor. An objective during the development of the conceptual site model is to focus attention on those pathways that contribute most to the potential impacts on human health and the environment and to provide the rationale for screening out other exposure pathways that are minor components of the overall risk.

Sources of Contamination. Each site has its own source of contamination (e.g., wastes disposed in a landfill or materials stored on the ground surface). The following sites are considered to have potential subsurface sources:

- Area A Landfill (Site 2A)
- Rubble Fill at Bunker A86 (Site 4) (all soil has been removed, but subsurface contamination may have migrated to groundwater prior to soil removal)
- Torpedo Shops (Site 7)
- Goss Cove Landfill (Site 8)
- OBDANE (Site 14)
- Spent Acid Storage and Disposal Area (Site 15) (most soil has been removed, but subsurface contamination may have migrated to groundwater prior to soil removal)
- Tank Farm which includes Site 9 – OT-5 Oily Wastewater Tank (Site 23)

Some of these sites may also have localized surface sources of contamination, as well as subsurface sources.

The following sites are considered to have potential surficial sources of contamination:

- CBU Drum Storage Area (Site 1) (historically this site had potential surficial sources of contamination, but was subsequently covered by the Area A Landfill cap)
- Area A Wetland (Site 2B)
- Area A Downstream Watercourses and OBDA (Site 3) [all soil and sediments with contaminant concentrations above Preliminary Remediation Goals (PRGs) will be remediated]
- Area A Weapons Center (Site 20)
- Hospital Incinerator (Site 16)
- Building 33 Solvent Storage Area (Site 18)

Area A Downstream Watercourses (Site 3), Area A Wetland (Site 2B), and Goss Cove Landfill receive runoff and groundwater recharge from several sites. Although pesticide bricks historically placed at the Downstream Watercourses serve as a potential surficial source of contamination, contamination found at this site may also be attributable to runoff or recharge from other surrounding sites.

Ultimately, these sources have the potential to release chemicals to the surface and subsurface soil. This soil then serves as a secondary source of contamination.

Contaminant Release and Migration Mechanisms. Chemicals may be released from the sites by a variety of mechanisms including stormwater runoff and subsequent erosion of surface soil, infiltration of soluble chemicals and subsequent migration through the subsurface soil to the water table where the chemicals may migrate downgradient, and wind erosion of surface soil from unpaved areas.

Storms generate runoff, which is directed toward stormwater drainageways. Initially, this water may move across a site as sheet flow, which can entrain loose soil material. This soil is moved from the site as a sediment and is deposited where the flow velocity diminishes below that needed to carry a particular grain size. Typically at sites in undeveloped areas, this sediment is deposited in small drainageways and migrates farther downstream with each new storm, which also adds new material.

Soluble chemicals released to the ground surface may also migrate downward through the soil column with infiltrating precipitation. The migration of these chemicals may be somewhat impeded by the chemical's tendency to bind to soil organic material. Eventually, these soluble chemicals may reach the water table. Once in the groundwater, chemicals may continue to migrate via dispersion and advection in the downgradient direction. Eventually, these chemicals may discharge with the groundwater to the Thames River.

Chemicals adsorbed to surface soil may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil via volatilization.

1.5.2.3.3 Potential Routes of Exposure

A receptor can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

Air. This pathway is based on the scenario that, as part of daily living, a receptor is enveloped in air that contains suspended particulates and volatile organic vapors originating from the source areas. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

Initially, a qualitative comparison of maximum detected soil concentrations and USEPA generic SSLs for inhalation and CTDEP volatilization criteria, based on intermedia transfer (from soil to air), will be performed to determine if additional quantitative analysis of this potential exposure pathway is warranted. The inhalation SSLs are based on residential land use and lifetime exposure scenarios and are therefore relatively conservative values for potential receptors under current land use conditions.

Incidental Ingestion of Soil. Incidental ingestion could occur when soils containing COCs are transferred from hand to food or a cigarette.

Direct Contact with Soil. Receptors may come into direct contact with soil affected by the release of chemicals from the source areas. During the receptor's period of contact, the individual may be exposed via inadvertent ingestion of a small amount of soil or via dermal absorption of certain contaminants from the soil.

Direct Contact with Groundwater. It is possible that an excavation (for construction, utility maintenance, etc.) could be deep enough to come into contact with the shallow groundwater. In such an instance, workers could be exposed to the groundwater via dermal contact. In addition, it has been assumed (at the direction of USEPA) that some sites could be developed for future residential land use. Household use of groundwater will be evaluated for these sites unless site-specific conditions (e.g., saline water quality near the Thames River) would prevent its use. Under the potential groundwater use scenario, direct dermal contact with groundwater, ingestion of groundwater, and inhalation of VOCs could occur during routine exposure. Exposure to groundwater is evaluated for the adult future resident. Exposures for child residents are presumed to be a lesser magnitude.

Current USEPA Region I guidance (USEPA, 1995b) will be used to assess the human health risks associated with exposure to volatiles in groundwater used for domestic purposes (showering, bathing, cooking, washing, etc.). This exposure pathway will be evaluated in a qualitative fashion by assuming that the dose from inhalation of VOCs in potable water is equal to that from direct ingestion. Calculated chemical-specific risks for VOCs via ingestion are essentially multiplied by a factor of two to account for ingestion and inhalation exposures.

Incidental Ingestion/Direct Contact with Surface Water. This pathway will not be quantitatively evaluated during the Basewide Groundwater OU RI because no new data will be collected and quantitative risk for this pathway was assessed during the Phase II RI and during the Lower Subbase RI.

Incidental Ingestion/Dermal Contact with Sediment. This pathway will not be quantitatively evaluated during the Basewide Groundwater OU RI because no new data will be collected and quantitative risk for this pathway was assessed during the Phase II RI.

1.5.2.3.4 Potential Receptors

Several potential receptors are identified under both current and future land use conditions. The original list of receptors identified for the sites included in the Phase II RI (B&RE, 1997a) has been modified to conform to current guidance, to provide some consistency between sites, to focus the assessment on potentially meaningful exposures, and, in general, to streamline the risk assessment process. These receptors are as follows:

- Full-time employees - Adult military or civilian personnel assigned to work 40 hours per week at a particular facility.

- Construction workers - Adult civilian personnel who may be involved in a short-term, one-time construction project at a site.
- Older child trespassers (ages 6 to 16) - Older children and teenagers (civilians or family of military personnel) trespassing on or near a site while exploring, playing, or performing other activities.
- Future residents - Persons (adults and children) residing at a site assuming that the facility is closed and developed for residential purposes.

One or more of these receptor groups will be evaluated quantitatively for each of the sites under investigation in this RI. Table 1-5 contains a matrix summary of the particular combinations of receptor groups to be evaluated in the HHRA for each site.

Future residential receptors (adult and child) will be included in the baseline HHRA at the direction of USEPA and CTDEP. These receptors are not potential receptors under current land use and are included only to provide an indication of potential risks if the facility were to close and then be developed for residential use. Although enlisted and officer personnel reside at the base under current conditions, the residential scenario is not applicable for these receptors because (1) they do not reside in the areas of investigation and (2) they are assigned to the base for a relatively short period of time (3 or so years). A future residential land use scenario is also considered unlikely given the critical nature of the facility with respect to support of the submarine fleet and national defense.

Two classes of each receptor will be considered, as per USEPA Region I guidance. The first is identified as a CTE receptor, which is developed using both regional guidance (USEPA, 1994c) and professional judgment regarding site-specific conditions. The second class of receptor is the RME, and is developed as per USEPA guidance (USEPA, 1989d and USEPA, 1994c).

1.5.2.3.5 Exposure Pathways

An exposure pathway consists of four elements: a source and mechanism of release, a route of contaminant transport through an environmental medium, a contact point for a human receptor, and an exposure route at the point of contact. All four components must be present for the exposure pathway to be considered complete. This section summarizes the potentially complete exposure pathways that will be quantitatively evaluated in the upcoming risk assessment and provides the rationale for those pathways that will not be evaluated. Table 1-6 summarizes the potentially complete and incomplete exposure pathways and receptors.

1.5.2.3.6 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of USEPA guidance documents, which are cited in the specific intake estimation sections that follow.

Exposures depend on the predicted concentrations of chemicals in environmental media and local land use practices, and both are subject to change over time. This results in a large number of possible combinations of receptors, media, exposure pathways, and concentrations. As mentioned previously, Table 1-6 summarizes the exposure pathways to be evaluated in the quantitative risk assessment. Some of these scenarios (such as occupational, trespassing, and residential scenarios) may be applicable under both current and future land use conditions.

Exposure model parameters are presented in Tables 1-7 and 1-8 for potential future residents, child trespassers, full-time employees, and construction workers, respectively. The parameters are generally those values used in the Phase II RI (B&RE, 1997a), which were based on parameters identified in the Phase II RI Work Plan (Atlantic, 1993). Values have been updated to reflect current USEPA guidance. All parameters are referenced in footnotes on each table. These parameters are used in the equations presented in this section, along with the exposure point concentrations, to calculate intakes that will be used to determine risks.

Incidental Ingestion of Soil. Intake of contaminants in soil will be estimated using the predicted concentration of a contaminant in the location of interest. This pathway will be evaluated for the construction worker, full-time employee, and child and adult residents. Age-adjusted ingestion factors will be used to estimate intakes for future residents because of the higher ingestion rate experienced by small children. In general, intakes associated with soil ingestion will be calculated using the following equation:

$$\text{Intake}_{si} = \frac{(C_{si})(IR)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where: Intake_{si} = intake of contaminant "i" from soil (mg/kg/day)
C_{si} = concentration of contaminant "i" in soil (mg/kg)
IR = ingestion rate (mg/day)
FI = fraction ingested from contaminated source (decimal fraction)
EF = exposure frequency (days/yr)
ED = exposure duration (yr)

CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg)
AT = averaging time (days);
for noncarcinogens, AT=ED*365 days/yr;
for carcinogens, AT=70 yr*365 days/yr

For adults not involved in construction activities, ingestion rates range from 50 mg/day (adults under CTE conditions) to 200 mg/day (potential future child residents for the RME). Ingestion rates of 480 mg/day (RME) (USEPA, 1991) and 240 mg/day (CTE) will be used for construction personnel. Exposure frequencies range from 80 days per year for the CTE construction worker to 250 days per year for the RME full-time employee. Values of 1.0 for the RME and 0.5 for the CTE will be used for the fraction of soil from the contaminated source ingested by a potential receptor.

Dermal Contact with Soil. Intake of a contaminant in soil via absorption through the skin will be estimated using the predicted concentration in the soil at the location of concern. The dermal absorption pathway will be evaluated for the construction worker, full-time employee, and child and adult residents. As with soil ingestion, age-adjusted contact rates will be used for potential future residents. Dermal absorption from potentially contaminated areas will be calculated using the following equation:

$$\text{Intake}_{si} = \frac{(C_{si})(SA)(AF)(ABS)(Fd)(CF)(EF)(ED)}{(BW)(AT)}$$

where: Intake_{si} = amount of chemical "i" absorbed during contact with soil (mg/kg/day)
C_{si} = concentration of chemical "i" in soil (mg/kg)
SA = skin surface area available for contact (cm²/day)
AF = skin adherence factor (mg/cm²)
ABS = absorption factor (decimal fraction)
Fd = fraction available for contact from contaminated source
(decimal fraction)
CF = conversion factor (10^{-6} kg/mg)
EF = exposure frequency (days/yr)
ED = exposure duration (yr)
BW = body weight (kg)
AT = averaging time (days);
for noncarcinogens, AT=ED*365 days/yr;
for carcinogens, AT=70 yr*365 days/yr

The estimate will assume that dermal contact with soil by potential receptors occurs at the same exposure frequency as soil ingestion. The estimate will also assume that 19 percent of the total body surface area (to account for forearms, head, and hands) for adults and 30 percent of the total body surface area (to account for forearms, head, hands, and feet) for children will be exposed. These values were selected based on default clothing scenarios expressed in the USEPA dermal exposure guidance (USEPA, 1992a). Soil adherence factors will be selected from the published range of 0.07 to 0.2 mg/cm² (USEPA, 1998c). Values of 1.0 (RME) and 0.5 (CTE) will be used for the fraction of soil available for contact from the contaminated source. Dermal absorption factors are provided in Table 1-9 (USEPA, 1998c).

Dermal exposures to COCs in soil will be evaluated in accordance with methodology supplied by USEPA Region I. COCs with chemical-specific absorption factors in Table 1-9 (USEPA, 1998c) will be quantitatively evaluated in the HHRA. For those COCs without chemical-specific dermal absorption factors, dermal exposures will be evaluated using a generic absorption factor of 0.1 for organics and 0.01 for inorganics. The use of those values will be discussed in the uncertainty section.

Dermal Contact with Groundwater. Because the groundwater at NSB-NLON is not used as a potable supply, only limited exposure scenarios are considered under current site conditions. However, as previously mentioned, this scenario will be evaluated for future residents for conservative purposes. Under future land use conditions, deep excavations at the NSB-NLON for activities such as utility maintenance and construction could result in a dermal exposure to the shallow groundwater that is contained in the overburden. Therefore, construction workers will be evaluated for dermal exposure only.

The following equation will be used to assess exposures resulting from dermal contact with water (USEPA, 1992a):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where: DAD_{wi} = dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event} = absorbed dose per event (mg/cm²-event)
EV = event frequency (events/day)
ED = exposure duration (yr)
EF = exposure frequency (days/yr)
A = skin surface area available for contact (cm²)
BW = body weight (kg)
AT = averaging time (days);

for noncarcinogens, $AT=ED*365$ days/yr;

for carcinogens, $AT=70yr*365$ days/yr

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a more traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2 K_p) (C_{wi}) (CF) \left(\frac{\sqrt{6 \tau t_{event}}}{\pi} \right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{wi})(CF) \left(\frac{t_{event}}{1+B} + 2 \tau \left(\frac{1+3B}{1+B} \right) \right)$$

where: t_{event}	=	duration of event (hr/event)
t^*	=	time it takes to reach steady-state conditions (hr)
K_p	=	permeability coefficient from water through skin (cm/hr)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hr)
π	=	constant (unitless; equal to 3.141592654)
CF	=	conversion factor (10^{-3} L/cm ³)
B	=	partitioning constant derived from Bunge Model (dimensionless)

Values for the chemical-specific parameters (t_{event} , t^* , K_p , τ , and B) are obtained from the current dermal guidance. If no published values are available for a particular organic compound, they will be calculated using equations provided in the cited guidance.

The following nonsteady-state equation will be used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p) (C_{wi}) (t_{event})$$

In general, the recommended default value of 0.001 will be used for inorganic constituents.

The exposure frequencies for a construction worker exposed to soil will be 120 days per year for a RME and 80 days per year for a CTE. Construction workers will not be exposed to groundwater the entire time they are at the site, but only when they are excavating below the water table for building footers, foundations, etc. Therefore, the groundwater exposure times for adult construction workers are 4 hours per day for 20 days per year (one work month) for the RME and 2 hours per day for 10 days per year for the CTE. The exposure duration for this receptor will be set at 1 year. Construction workers exposed to

groundwater are assumed to be exposed only on their forearms and hands, for a total available skin surface area of 3,800 cm².

1.5.2.3.7 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters for this chemical. Exposure to lead will be evaluated using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead, version 0.99D (USEPA, 1994a). This model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Exposures to lead by nonresidential adults are evaluated by using a slope-factor approach developed by the USEPA Technical Review Workgroup for Lead (USEPA, 1996c and 1996d). The approach focuses on estimating fetal blood lead concentrations in women exposed to lead-contaminated soils.

Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects to children from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern."

In general, the IEUBK Model and Technical Review Work Group Model for lead will be used to address exposure to lead when groundwater concentrations exceed the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act and when detected soil concentrations exceeded the Office of Solid Waste and Emergency Response (OSWER) soil screening level of 400 mg/kg for residential land use (USEPA, 1994b).

1.5.2.4 **Risk Characterization**

This section characterizes the potential human health risks associated with potential exposure to COCs at the NSB-NLON. Section 1.5.2.4.1 outlines the methods that will be used to estimate the type and magnitude of health risks. Section 1.5.2.5 discusses the uncertainties associated with all aspects of the risk characterization process.

1.5.2.4.1 Risk Characterization Methodology

Potential human health risks resulting from exposure to COCs will be estimated using algorithms established by USEPA (1989d). The methods described by USEPA are protective of human health and

are likely to overestimate risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity. Risks from hazardous chemicals will be calculated for either carcinogenic and noncarcinogenic effects:

Chemical Carcinogens. Risks attributable to exposure to chemical carcinogens will be estimated as the probability of an individual developing cancer over a lifetime. At low doses, the incremental lifetime cancer risk (ILCR) will be determined as follows (USEPA, 1989d):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: ILCR_i = incremental lifetime cancer risk for chemical "i", expressed as a unitless probability

Intake_i = intake of chemical "i" (mg/kg/day)

CSF_i = cancer slope factor of chemical "i" (mg/kg/day)⁻¹

According to the USEPA, risks below 1E-6 (or a risk less than one in one million) are generally considered to be "acceptable", and risks greater than 1E-4 (1 in 10,000) are generally considered to be "unacceptable". According to CTDEP, risks less than 1E-5 (1 in 100,000) are generally considered to be "acceptable", while risks greater than 1E-5 are generally considered to be "unacceptable".

When carcinogenic risks exceed 1E-2 (1 in 100) using the above methodology, USEPA (USEPA, 1989d) specifies that the one-hit model should be used, as follows:

$$ILCR_i = 1 - \exp[-(Intake_i)(CSF_i)]$$

Risks will be estimated for all carcinogenic compounds regardless of the class designation (A, B, or C).

Noncarcinogens. The hazards associated with the effects of noncarcinogenic chemicals will be evaluated by comparing an exposure level or intake to a RfD. The ratio of the intake to the RfD is called the HQ and will be defined as follows (USEPA, 1989d):

$$HQ_i = \frac{Intake_i}{RfD_i}$$

where: HQ_i = hazard quotient for chemical "i" (unitless)
Intake_i = intake of chemical "i" (mg/kg/day)
 RfD_i = reference dose of chemical "i" (mg/kg/day)

If the ratio of the intake to the RfD exceeds unity, noncarcinogenic (toxic) effects may occur. A HI will be generated by summing the individual HQs for all the COCs associated with a specific pathway. If the value of the HI exceeds unity, noncarcinogenic health effects associated with that particular chemical mixture may occur, and therefore it will be necessary to segregate the HQs by target organ effects or mechanism of action. The HQ should not be construed as a probability in the manner of the ILCR, but rather a numerical indicator of the extent to which a predicted intake exceeds or is less than a RfD.

1.5.2.5 Uncertainties Analysis

Uncertainty is associated with all aspects of the baseline HHRA. This section presents a generic summary of these uncertainties and discusses how they might affect the final risk numbers. A more detailed discussion of uncertainty will be provided when the risk assessment is performed.

Uncertainty in the selection of COCs is primarily associated with the current status of the predictive databases and the procedures used to include or exclude constituents as COCs. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route, the methods used and the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing data to support dose-response relationships and the weight of evidence used for determining the carcinogenicity of COCs. Uncertainty in risk characterization includes those uncertainties associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

1.5.2.5.1 Uncertainty in Selection of Chemicals of Concern

A minor amount of uncertainty is associated with the final risk values based on the selection of COCs to be used in the quantitative risk assessment. However, the use of predetermined USEPA Region III screening values based on conservative land use scenarios (i.e., residential land use for soil and ingestion and inhalation for groundwater and surface water) in combination with the reduction of the values for carcinogens to correspond to a 1E-6 cancer risk should ensure that the most significant contributors to risk from a site are evaluated. The elimination of chemicals that are present at concentrations corresponding to a cancer risk less than 1E-6 and an HI less than 0.1 should not affect the final conclusions regarding contaminants that could pose a potential health concern. In addition, other health-based and state risk-based criteria will be used to conservatively select COCs.

1.5.2.5.2. Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises from the methods used to calculate exposure point concentrations, determine land use conditions, select receptors, and select exposure parameters. Each of these is discussed below.

Calculation of Exposure Point Concentrations. For media at some sites, fewer than 10 samples may be available, making the estimation of the 95 percent UCL on the mean highly uncertain. In these cases, the average and maximum detected chemical concentrations will be used to assess risks. As a result, the risk estimated for the RME, where maxima will be used as exposure concentrations, will most likely be overstated because potential receptors are not likely to be exposed to the maximum concentration over the entire exposure period.

For some sites, the risk evaluation will focus on one or more smaller areas of concern. These boundaries are somewhat artificial and originated as investigations of a source area such as a tank or are simply gross geographical boundaries. Exposures may or may not occur in these particular areas; therefore, risks could be under- or overestimated.

Determination of Land Use. The current land use patterns were well established during the Phase I and Phase II RIs. Detailed interviews with base personnel were used to establish the potentially exposed populations and the activities that could bring them into contact with contaminated media. In addition, planned construction projects were identified.

One issue associated with land use that contains a high degree of uncertainty is the potential conversion of the base (particularly the sites under consideration in the RI) to residential uses. This scenario is considered highly unlikely given the dispersed population patterns currently surrounding the base and the heavily industrialized nature of the facility. These factors, in addition to the critical nature of the facility with respect to support for the submarine fleet, make a future industrial land use scenario much more likely, at least for the foreseeable future.

Exposure Routes and Receptor Identification. Exposure routes and receptor groups were fairly well defined. An attempt has been made to simplify the various groups identified and to determine a single set of exposure parameters to apply to each group. These may either under- or overestimate the risks, with the final result dependent on how well the receptors were defined.

Selection of Exposure Parameters. Each exposure factor selected for risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, the selection will use USEPA guidelines for the RME receptor, which generally consist of the 95th percentile for most parameters.

Use of the 95th percentile for each parameter ensures that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate an average or more typical exposure or the risk range expected for individuals in the exposed population. To address these issues, USEPA has suggested the use of the CTE receptor, whose intake variables are set at approximately the 50th percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. Many of the parameters were estimated using professional judgment, although USEPA Region I provides some default parameters (USEPA, 1994c).

An additional source of uncertainty associated with the exposure assessment of the baseline HHRA is the presence of the hospital at the base, which is located near Tautog Avenue. Sick or ailing individuals represent a subpopulation of potential concern because they may experience an increased risk due to increased sensitivity to chemical exposure. Because the Hospital Incinerator is one of the sites under investigation, a significant degree of uncertainty may be associated with this aspect of the exposure analysis.

1.5.2.5.3 Uncertainty in the Toxicological Evaluation

The toxicological data used as the basis for all risk assessments contain uncertainty in the following areas:

- Non-threshold (carcinogenic) effects are extrapolated from high doses administered to laboratory animals to low doses received under more common human exposure scenarios.
- Results of laboratory animal studies are extrapolated to human environmental receptors.
- There are considerable interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical.
- There is considerable variability in sensitivity among individuals of any particular species.

- Short-time toxicological studies are used to predict long-term effects.

Some chemical-specific uncertainties are as follows:

- The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, USEPA has proposed an oral unit risk factor that was used for all oral and dermal exposures to arsenic at this site. Because arsenic is a major risk driver, the risks may be overstated.
- Some uncertainty is associated with the evaluation of chromium, which will be assumed to be present in its hexavalent state. Because hexavalent chromium is considered to be more toxic than the trivalent state, which is more common, risks for this chemical will probably be overestimated.

1.5.2.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple compounds from various exposure routes. High uncertainty exists when cancer risks for several substances are summed across different exposure pathways. This assumes that each substance has a similar effect and mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative risk estimate.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, because it may either underestimate or overestimate potential human health risk.

1.6 PROJECT MANAGEMENT AND ORGANIZATION

TtNUS is responsible for the overall management of the project, including all field sampling activities. 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:

Northern Division
Naval Facilities Engineering Command
Code 1823/ME
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090
(610) 595-0567, ext. 162

Mr. Mark Evans
Remedial Project Manager (RPM)

NSB-NLON
Environmental Department
Building 166
Groton, CT 06349-4899
(860) 694-5176

Ms. Darlene Ward
RPM

Tetra Tech NUS
Foster Plaza VII
661 Andersen Drive
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(412) 921-7090

Mr. John J. Trepanowski, P.E., Program Manager
Mr. Corey A. Rich, P.E., Project Manager
Mr. Paul Frank, Quality Assurance Manager
Mr. Matthew M. Soltis, CIH, CSP, Health & Safety Manager

USEPA
USEPA Region I
1 Congress Street
Suite 1100 (HBT)
Boston, MA 02114-2023
(617) 918-1385

Ms. Kymberlee Keckler
RPM

CTDEP
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

Mr. Mark Lewis
RPM

Figure 1-18 presents the project management organization chart for the Basewide Groundwater OU RI at NSB-NLON, Groton, Connecticut. Under the direction of the Navy RPM, TtNUS is responsible for the overall management, implementation, and inspection of the contract field activities. Navy personnel will be actively involved and will coordinate with TtNUS personnel in a number of areas. The authorities and organizational relationships of key personnel are depicted on Figure 1-18. Responsibilities for program

management, project management, field operations, and laboratory operations are discussed in the following sections.

1.6.1 Field Responsibilities

The TtNUS field investigation team will be organized according to the activities planned. Field team members will be selected based on the type and extent of effort required. All team members will be appropriately skilled and trained for the tasks they are assigned to perform. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL). (The FOL may also fill other roles)
- Site Quality Assurance (QA)/ Quality Control (QC) Advisor
- Site Safety Officer (SSO)
- Field hydrogeologist/geologist(s)

The proposed field activities will be performed by TtNUS personnel and subcontractors, and overseen by the TtNUS FOL. A general discussion of the FOL's responsibilities follows.

The FOL is responsible for coordinating all on-site personnel and for providing technical assistance when required. The FOL or designee will coordinate and be present during all sampling activities and will ensure the availability and maintenance of all sampling materials and equipment. The FOL is responsible for the completion of all sampling, boring, well construction, field, and chain-of-custody documentation and will assume custody of all samples and ensure their proper handling and shipment. The FOL is responsible for providing oversight and technical supervision of the drilling and direct-push subcontractor. Other duties of the FOL include the following:

- Functions as communications link between field crew members, the site QA/QC advisor, SSO, and project manager
- Oversees the mobilization and demobilization of all field equipment and subcontractors
- Resolves logistical, weather, personnel, and equipment problems
- Responsible for maintaining the site logbook
- Initiates field change requests when necessary

The FOL will act as the site QA/QC advisor, who is responsible for ensuring adherence to all QA/QC guidelines as defined in the SAP and QAPP. Strict adherence to these procedures is critical to the collection of acceptable and representative data. The following summarizes the site QA/QC advisor's responsibilities:

- Ensures that field duplicates and field quality control blanks are collected at the proper frequency
- Ensures that additional volumes of sample are supplied to the analytical laboratory at the proper frequency to accommodate laboratory QA/QC analyses
- Ensures that measuring and test equipment are calibrated, used, and maintained in accordance with applicable procedures
- Acts as liaison between site personnel, laboratory personnel, and the QA manager (QAM)
- Manages bottleware shipments and oversees field preservation and filtration activities

The yet-to-be-determined FOL (or assistant) will also serve as the SSO. The duties of the SSO are detailed in the Site Security Plan and HASP (Appendix D). The SSO has stop-work authority, which can be executed upon the determination of an imminent safety hazard.

1.6.2 Laboratory Responsibilities

The subcontracted analytical laboratory will be responsible for analyzing all RI samples in accordance with the specified analytical methods and for reporting data in accordance with the requirements outlined under the Contract Laboratory Program (CLP) and the QAPP (Appendix C). The selected laboratory will be responsible for properly disposing of the unused samples and reporting the receipt of any broken sample bottles or other problems relative to samples (e.g., head-space in VOC vials) to the project manager.

1.7 COMMUNITY RELATIONS

A Community Relations Plan for NSB-NLON, Groton, Connecticut was developed and issued in February 1994 (Atlantic, 1994a). The plan identified issues of community interest and concern regarding NSB-NLON. It also described the program of community relations activities that the Navy will conduct during the IR Program. The Community Relations Plan covers all of the IR Program sites being investigated at NSB-NLON, including those under the Basewide Groundwater OU RI. The applicable community relations programs will be followed during the RI to be conducted at the Basewide Groundwater OU.

A Restoration Advisory Board (RAB) has been established by the Navy for the purpose of allowing individuals the opportunity to give advice to the Navy on the IR Program at NSB-NLON and to act as a focal point for the exchange of information between the Navy and the local community. The NSB-NLON

RAB includes representatives from regulatory agencies such as USEPA Region I and CTDEP, as well as community representatives. The RAB meets quarterly. The scope and findings of the Basewide Groundwater OU RI will be discussed and explained at a future RAB meeting. In addition, feasibility studies and proposed plans related to the Basewide Groundwater OU, which will be developed after the RI, will also be discussed at future RAB meetings.

1.8 DATA DELIVERABLES AND MANAGEMENT

A draft RI report will be issued approximately 6 months after the field sampling effort is completed. The report will discuss methodologies used by field personnel, observations and sampling methodologies, and sampling results. It will also include tables and figures summarizing sampling results generated from this investigation.

The data generated from this investigation shall be validated in accordance with the USEPA's National Functional Guidelines as amended by Region I. Further details on the data validation process and data quality issues are outlined in the QAPP in Appendix C.

Historical analytical data from previous investigations at the NSB-NLON are maintained in an electronic database. This database will be updated with the newly collected data and will be used to identify data trends and anomalous data results, and to compare the results to applicable standards. The database will also be used to identify anomalous results that are statistically significant relative to background values. The approach that will be used to manage the analytical database for the Basewide Groundwater OU RI is discussed below.

1.8.1 Data Management Plan

The purposes of the data management plan are to track investigation data and provide adequate levels of QA. The following subsections summarize the components of the data management plan.

Software

Microsoft Visual FoxPro 3.0 will be the primary software for all data management and data manipulation activities.

Responsibilities

All analytical and field data will be managed by the Information Management Solutions Group of TtNUS, which will be responsible for compiling and maintaining project files that will contain hard copies of the

chains-of-custody, sample log forms, boring logs, sample location maps, and documentation of QA data manipulation. Removal of any files will require the initials of the requestor and date.

All electronic data will be managed on the TtNUS network system under the CTO 312 directory. The security of the database will be maintained by the network backup system, which occurs on a daily basis.

Sample Tracking

A "cradle-to-grave" sample tracking system will be implemented prior to the field effort. All sample numbers, requested laboratory analyses, and field duplicate information will be entered into a database from the approved WP and SAP. The sample tracking database will then be used to generate both sample jar labels and sample log forms to be completed in the field. Chain-of-custody forms will be faxed to the TtNUS Pittsburgh office at the end of each sampling day to be compared against the sample tracking database. This will allow for early detection of errors made in the field so that any necessary adjustments can be made while the field crew is mobilized. An electronic copy of the sample tracking database will be sent to the laboratory to avoid manual entry of sample numbers into the Laboratory Information Management System (LIMS). After successful completion of all requested analyses, the laboratory will submit an electronic deliverable to TtNUS for every sample delivery group (SDG). The format specified for electronic deliverables from the laboratory is shown in Appendix B. Once all electronic deliverables have been received from the laboratory, queries will be run versus the pre-field effort database to ensure that the laboratory performed all of the requested analyses. The project manager will be notified as to any discrepancies. Ideally, discrepancies can be noted early enough so that additional sampling is not necessary.

Sample Information

Before electronic files are received from the laboratory, all sample-specific information will be entered into the data management system. This information will include things such as the depth at which the sample was collected, the associated area of concern, and the aquifer in which the well was screened. The sample information file will allow for the analytical results to be grouped properly for statistical purposes in the RI report.

Survey Data

All survey data will be delivered in Excel spreadsheet format. The files will contain a minimum of northing, easting, ground surface elevation, top of casing elevation, and top of riser elevation. The survey will be based on the Connecticut State Plane Coordinate System (SPCS) North American Datum (NAD) 1983 for horizontal control and the North American Vertical Datum (NAVD) 1988 for vertical control.

Survey data will then be transformed by TtNUS into an appropriate system for NSB-NLON and imported into the data management system.

Data Validation

Once all samples and analyses have been accounted for, the electronic data files are printed for each SDG and analytical fraction and submitted for data validation. Validators will incorporate data qualifiers into the electronic database and resubmit the data to the Information Management Solutions Group.

Project Data Compilation

The new data generated under this RI will be incorporated with all previous data generated at NSB-NLON. All data such as units of measure and chemical nomenclature will be manipulated to maintain consistency with the project database. The project database is a relational database that ensures data structure integrity and data quality for all NSB-NLON data.

Data Summary Output

The project database will be used to generate all statistical tables for the various sections of the RI report such as nature and extent of contamination, HHRA, and data evaluation. Programs have been written to pull data for statistics directly from the database to preserve data integrity and consistency. Report formats have been written in Visual FoxPro to present analytical results in Excel® Spreadsheet-style format, which are typically included as appendices.

For all aqueous data (i.e. groundwater), field duplicates will be averaged for statistical purposes. The maximum concentration will be used to represent field duplicate concentrations in solid media (i.e. soil). The normal, duplicate, average, and maximum concentrations will all be presented in the analytical results appendix.

Geographic Information Systems (GIS)

Upon compilation of all sample, chemical, and positional data, the data will be incorporated into an ArcView GIS project. The basis of the ArcView project will be existing basemaps for NSB-NLON. The GIS system can be used to generate site location maps, sample location maps, contaminant iso-contour maps, potentiometric surface maps, and contaminant tag maps. The data can be delivered to the Navy in Tri-Service Standard format upon request.

1.9 PROJECT SCHEDULE

The field activities for the project are presently scheduled to begin in March 2000 and should be completed in May 2000. The draft RI report is scheduled to be completed within approximately 6 months after the field work is completed and the final RI report is scheduled to be submitted within approximately 6 months after the draft RI report is completed.

TABLE 1-1

SAMPLE SUMMARY TABLE
BASEWIDE GROUNDWATER OU RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Matrix	Parameters	Number of Samples										Back-ground ⁽³⁾	Total
		NORTHERN REGION					CENTRAL REGION		SOUTHERN REGION				
		Sites 1, 2A, 2B, 4	Site 3	Site 7	Site 14	Site 20	Site 16	Site 8	Site 15	Site 18	Site 23		
SHALLOW SOILS ⁽¹⁾	TCL VOC	--	--	--	--	--	9	--	--	5	--	--	14
	TCL SVOC	--	--	--	--	--	9	--	--	5	--	--	14
	TCL PESTICIDES	--	--	--	--	--	9	--	--	5	--	--	14
	TCL PCBs	--	--	--	--	--	9	--	--	5	--	--	14
	DIOXINS/ FURANS	--	--	--	--	--	9	--	--	--	--	--	9
	TAL METALS ⁽⁴⁾	--	--	--	--	--	9	--	--	5	--	--	14
	SPLP PCBs	--	--	--	--	--	9	--	--	5	--	--	14
	SPLP METALS	--	--	--	--	--	9	--	--	5	--	--	14
	Subtotal	0	0	0	0	0	72	0	0	35	0	0	107
DEEP SOILS ⁽²⁾	TCL VOC	--	--	5	--	--	8	--	--	5	--	--	18
	TCL SVOC	--	--	5	--	--	8	--	--	5	--	--	18
	TCL PESTICIDES	--	--	--	--	--	8	--	--	5	--	--	13
	TCL PCBs	--	--	--	--	--	8	--	--	5	--	--	13
	DIOXINS/ FURANS	--	--	--	--	--	8	--	--	--	--	--	8
	TAL METALS ⁽⁴⁾	--	--	5	--	--	8	--	--	5	--	--	18
	SPLP PCBs	--	--	--	--	--	8	--	--	5	--	--	13
	SPLP METALS	--	--	--	--	--	8	--	--	5	--	--	13
	TOC, Bulk Density, pH, porosity	--	1	1	--	--	--	--	--	--	--	2	--
Subtotal	0	1	16	0	0	64	0	0	35	2	0	118	
GROUNDWATER	TCL VOC	11	41 ⁽⁵⁾	28 ⁽⁶⁾	1	4	4	9	4	2	14	15	133
	TCL SVOC	11	22	21	--	4	4	9	4	2	14	15	106
	TCL PESTICIDES	--	22	--	--	--	4	9	--	2	14	15	66
	TCL PCBs	--	--	--	--	--	4	9	--	2	14	15	44
	DIOXINS/ FURANS	--	--	--	--	--	4	--	--	--	--	--	4
	TAL TOTAL METALS ⁽⁴⁾	11	22	21	1	4	4	9	4	2	14	15	107
	TAL DISSOLVED METALS ⁽⁴⁾	--	3	2	--	1	--	1	--	--	2	15	24

TABLE 1-1

SAMPLE SUMMARY TABLE
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT
 PAGE 2 OF 2

Matrix	Parameters	Number of Samples											Back-ground ⁽³⁾	Total
		NORTHERN REGION					CENTRAL REGION	SOUTHERN REGION						
		Sites 1, 2A, 2B, 4	Site 3	Site 7	Site 14	Site 20	Site 16	Site 8	Site 15	Site 18	Site 23			
GROUNDWATER (Continued)	PERCHLORATE	--	--	21	--	4	--	--	--	--	--	--	--	25
	TSS/TDS	11	22	21	1	4 ¹	4	9	4	2	14	15	107	
	NATURAL ATTENUATION ⁽⁷⁾	--	32	21	--	--	--	--	--	--	14	--	67	
	CHLORIDE	11	--	--	--	--	--	--	--	--	--	11	22	
	TOC	11	--	--	--	--	--	--	--	--	--	--	11	
	COD	11	--	--	--	--	--	--	--	--	--	--	11	
	ALKALINITY	11	--	--	--	--	--	--	--	--	--	--	11	
	HARDNESS	11	--	--	--	--	--	--	--	--	--	--	11	
	SULFATE	11	--	--	--	--	--	--	--	--	--	--	11	
	Subtotal	110	164	135	3	21	28	55	16	12	100	116	760	
TOTAL		110	165	151	3	21	164	55	16	82	102	116	985	

- 1 Shallow soils are defined as samples collected from depths of 0 to 1 foot below ground surface.
- 2 Deep soils are defined as samples collected from depths greater than 1 foot below ground surface.
- 3 Two rounds of background samples will be collected. Each round will consist of 15 samples.
- 4 TAL metals analysis does not include cyanide.
- 5 Includes 9 samples to be collected from temporary well points which will have quick-turn VOC analysis. Depending on the results, additional temporary well samples may be collected.
- 6 Includes 7 samples to be collected from temporary well points which will have quick-turn VOC analysis.
- 7 Natural attenuation parameters include total organic carbon (TOC), dissolved oxygen, salinity, oxidation-reduction (REDOX) potential, pH, alkalinity, hardness, divalent iron, chloride, nitrate, sulfide, sulfate, ammonia, methane, temperature, and specific conductivity.

TABLE 1-2

SUMMARY OF RISK ASSESSMENT APPROACH BY SITE AND MEDIA
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT

Site	Previously Investigated	Remedial Investigation	FS PRAP ROD/NFADD	Proposed HHRA Approach for GW OU RI	HHRA				
					SO	GW	SD	SW	
NORTHERN REGION									
Site 1 - CBU Drum Storage Area Site 2A - Area A Landfill Site 2B - Area A Wetland Site 4 - Rubble Fill Bunker A-86 (Sites 1, 2A, 2B, and 4 will be evaluated together under one risk assessment)	Site 1	Yes	Yes	Yes - SO	Qualitative Quantitative	Yes No (RA)	Yes Yes	Yes (Site 2B) NA	Yes (Site 2B) NA
	Site 2A	Yes	Yes	Yes - SO					
	Site 2B	Yes	Yes	No					
	Site 4	Yes	Yes	Yes - SO/SD					
Site 3 - Area A Downstream Watercourses and OBDA	Yes	Yes	Yes - SO/SD/SW	Qualitative	No (RA)	Yes	No (RA)	Yes	
Site 5 - Bunker A-85	NA	NA	NA	Quantitative	No (RA)	Yes	No (RA)	No	
				Qualitative	NA	NA	NA	NA	
Site 7 - Torpedo Shops	Yes	Yes	No	Quantitative	NA	NA	NA	NA	
				Qualitative	Yes	Yes	Yes (Site 3)	Yes (Site 3)	
Site 14 - OBDA NE	Yes	Yes	No	Qualitative	Yes	Yes	Yes (Site 3)	Yes (Site 3)	
				Quantitative	No	Yes	NA	NA	
Site 20 - Area A Weapons Center	Yes	Yes	No	Qualitative	Yes	Yes	Yes (Site 2B)	Yes (Site 2B)	
				Quantitative	No	Yes	No	No	
CENTRAL REGION									
Site 16 - Hospital Incinerator	No	No	No	Qualitative	Yes	Yes	NA	NA	
				Quantitative	Yes	Yes	NA	NA	
SOUTHERN REGION									
Site 8 - Goss Cove Landfill	Yes	Yes	Yes - SO/SD/SW	Qualitative	Yes	Yes	Yes (GC/TR)	Yes (GC/TR)	
Site 12 - NEX Gas Station Site 23 - Tank Farm (Sites 12 and 23 will be evaluated together under one risk assessment)	Site 12	Yes	?	?	Quantitative	No (RA)	Yes	No	No
	Site 23	Yes	Yes - but a quantitative risk assessment was NOT performed	Yes - SO	Qualitative	Yes	Yes	NA	NA
Site 15 - Spent Acid Storage and Disposal Area	Yes	Yes	Yes - SO	Quantitative	No (RA)	Yes	NA	NA	
				Qualitative	Yes	Yes	NA	NA	
Site 18 - Building 33 Solvent Storage Area	No	No	No	Qualitative	Yes	Yes	NA	NA	
				Quantitative	Yes	Yes	NA	NA	

Notes:

NA - Not Applicable
 HHRA - Human Health Risk Assessment
 FS - Feasibility Study
 PRAP - Proposed Plan
 ROD - Record of Decision
 NFADD - No Further Action Decision Document
 GC - Goss Cove

TR - Thames River
 RA - Remedial Action
 SO - Soil
 SD - Sediment
 SW - Surface Water
 GW - Groundwater
 ? - Information Unknown

Qualitative - No new data; screening level assessment of data, discuss previous HHRA, identify mobility issues (no modeling), provide uncertainty discussion
 Quantitative - New data; complete new HHRA; identify mobility issues (potential for modeling), provide uncertainty discussion

TABLE 1-3

POTENTIAL POTENCY FOR CARCINOGENIC PAHs⁽¹⁾
BASEWIDE GROUNDWATER OU RI
NSB-NLON, GROTON, CONNECTICUT

Chemical	Weight-of-Evidence	Order of Potential Potency
Benzo(a)anthracene	B2	0.1
Benzo(b)fluoranthene	B2	0.1
Benzo(k)fluoranthene	B2	0.01
Benzo(a)pyrene	B2	1.0
Chrysene	B2	0.001
Dibenz(a,h)anthracene	B2	1.0
Indeno(1,2,3-cd)pyrene	B2	0.1

1 USEPA, 1993; USEPA, 1994c.

B2 Probable Human Carcinogen

TABLE 1-4

**SUMMARY OF GASTROINTESTINAL ABSORPTION EFFICIENCIES AND RECOMMENDATIONS
FOR ADJUSTMENT OF CSFs AND RFDs FOR SPECIFIC COMPOUNDS ⁽¹⁾
BASEWIDE GROUNDWATER OU RI
NSB-NLON, GROTON, CONNECTICUT**

Compound	GI Absorption	Adjustment Required?
ORGANICS		
Chlordane	80%	No
2,4-Dichlorophenoxyacetic acid	>90%	No
DDT	70-90% (oil)	No
Pentachlorophenol	76% (diet) 100% (water)	No
PCBs	96% (squalene) 80% (emulsion) 81% (corn oil)	No
PAHs	58% (starch solution) 89% (diet)	No
TCDD	50-60% (diet) 70% (diet) 70-83% (corn oil)	No
Other Dioxins/Dibenzofurans	>50%	No
All other organic compounds	generally >50%	No
INORGANICS		
Antimony	15% (aqueous)	Yes
Arsenic	95%	No
Barium	7% (aqueous)	Yes
Beryllium	0.7% (water)	Yes
Cadmium	3-5% (food) 5% (water)	Yes Yes
Chromium (III)	1.3% (feed/aqueous)	Yes
Chromium (IV)	2.5% (aqueous)	Yes
Copper	57%	No
Cyanide	>47%	No
Manganese	6%	Yes
Mercuric chloride (other soluble salts)	7%	Yes
Insoluble or metallic mercury	<7%	Yes
Nickel	4%	Yes
Selenium	30-80%	No
Silver	4%	Yes
Thallium	100%	No
Vanadium	2.6%	Yes
Zinc	highly variable	No

1 USEPA, 1998c.

TABLE 1-5

**SUMMARY OF RECEPTORS BY SITE
BASEWIDE GROUNDWATER OU RI
NSB-NLON, GROTON, CONNECTICUT**

Site	Full-Time Employees	Construction Workers	Older Child Trespassers (6-16 years)	Future Residents (Adult/Child)
NORTHERN REGION				
1 – CBU Drum Storage Area	--	X	--	--
2A – Area A Landfill	--	X	--	--
2B – Area A Wetlands	--	X	--	--
4 – Rubble Fill at Bunker A-86	--	X	--	--
3 – Area A Downstream Watercourses/OBDA	--	X	--	--
7 – Torpedo Shops	X	X	--	X
14 – OBDANE	--	X	--	--
20 – Area A Weapons Center	--	X	--	--
CENTRAL REGION				
16 – Hospital Incinerator	X	X	X	X
SOUTHERN REGION				
8 – Goss Cove Landfill	--	X	--	--
15 – Spent Acid Storage and Disposal Area	--	X	--	X
18 – Solvent Storage Area (Building 33)	X	X	X	X
12 – NEX and 23 – Tank Farm	--	X	--	X

TABLE 1-6

**SUMMARY OF EXPOSURE ROUTES EVALUATED QUANTITATIVELY
BASEWIDE GROUNDWATER OU RI
NSB-NLON, GROTON, CONNECTICUT**

Receptors	Exposure Routes
Potentially Complete Exposure Pathways	
Construction Workers	<ul style="list-style-type: none"> • Soil Ingestion (subsurface and surface) • Soil Dermal Contact (subsurface and surface) • Inhalation of Air/Dust (subsurface and surface) • Dermal Contact with Groundwater
Full-Time Employees	<ul style="list-style-type: none"> • Soil Ingestion (surface) • Soil Dermal Contact (surface) • Inhalation of Air/Dust (surface)
Older Child Trespassers (ages 6-16 years)	<ul style="list-style-type: none"> • Soil Ingestion (surface) • Soil Dermal Contact (surface) • Inhalation of Air/Dust (surface) • Sediment Ingestion • Sediment Dermal Contact
Incomplete Exposure Pathways	
Future Residents (Adult and Child)	<ul style="list-style-type: none"> • Soil Ingestion (surface and subsurface) • Soil Dermal Contact (surface and subsurface) • Inhalation of Air/Dust (surface and subsurface) • Direct Ingestion of Groundwater⁽¹⁾ • Dermal Contact with Groundwater while Showering/Bathing⁽¹⁾

1 Exposure to groundwater not evaluated for site along Thames River (Goss Cove Landfill) because of saline conditions.

TABLE 1-7

EXPOSURE PARAMETERS FOR FUTURE RESIDENTS ⁽¹⁾
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT
 PAGE 1 OF 2

Exposure Scenario	Parameter (units)	Older Child Trespasser (6-16 years)		Future Residents ⁽²⁾			
				Adult		Child	
		RME	CTE	RME	CTE	RME	CTE
Soil/Sediment Ingestion	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL	95% UCL	95% UCL
	Ingestion Rate (mg/day)	100	50	100	50	200	100
	Exposure Frequency (day/yr)	120 ⁽³⁾	52 ⁽³⁾	150	150	150	150
	Exposure Duration (yr)	10 ⁽⁴⁾	3 ⁽⁴⁾	24	7	6	2
	Body Weight (kg)	43 ⁽⁵⁾	43 ⁽⁵⁾	70	70	15	15
Soil/Sediment Dermal Contact	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL	95% UCL	95% UCL
	Body Surface Area (cm ²)	10500 ⁽⁶⁾	10500 ⁽⁶⁾	20000 ⁽⁶⁾	20000 ⁽⁶⁾	6980 ⁽⁶⁾	6980 ⁽⁶⁾
	Fraction Exposed (forearms, head, hands)	0.3 ⁽⁵⁾	0.3 ⁽⁵⁾	0.19 ⁽⁵⁾	0.19 ⁽⁵⁾	0.3 ⁽⁵⁾	0.3 ⁽⁵⁾
	Adherence Factor (mg/cm ²)	0.2 ⁽¹⁰⁾	0.06 ⁽¹⁰⁾	0.07 ⁽¹⁰⁾	0.01 ⁽¹⁰⁾	0.2 ⁽¹⁰⁾	0.06 ⁽¹⁰⁾
	Exposure Frequency (day/yr)	120 ⁽³⁾	52 ⁽³⁾	150	150	150	150
	Exposure Duration (yr)	10 ⁽⁴⁾	3 ⁽⁴⁾	24	7	6	2
Inhalation of Air/Dust	Exposure Concentration (mg/m ³)	1.8E-8 x UCL ⁽³⁾	1.8E-8 x UCL ⁽³⁾	1.8E-8 x UCL ⁽³⁾	1.8E-8 x UCL ⁽³⁾	NA ⁽⁸⁾	NA
	Inhalation Rate (m ³ /hr)	3.2 ⁽⁵⁾	3.2 ⁽⁵⁾	0.833 ⁽⁷⁾	0.833 ⁽⁷⁾	NA	NA
	Exposure Time (hr/day)	4 ⁽⁴⁾	2 ⁽⁴⁾	24	24	NA	NA
	Exposure Frequency (day/yr)	120 ⁽³⁾	52 ⁽³⁾	350	234	NA	NA
	Exposure Duration (yr)	10 ⁽⁴⁾	3 ⁽⁴⁾	30	9	NA	NA
	Body Weight (kg)	43 ⁽⁵⁾	43 ⁽⁵⁾	70	70	NA	NA
Groundwater Ingestion	Exposure Concentration (mg/L)	NA	NA	Maximum	Average	NA	NA
	Ingestion Rate (L/day)	NA	NA	2	1.4	NA	NA
	Exposure Frequency (day/yr)	NA	NA	350	234	NA	NA
	Exposure Duration (yr)	NA	NA	30	9	NA	NA
	Body Weight (kg)	NA	NA	70	70	NA	NA

TABLE 1-7

EXPOSURE PARAMETERS FOR FUTURE RESIDENTS ⁽¹⁾
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT
 PAGE 2 OF 2

Exposure Scenario	Parameter (units)	Older Child Trespasser (6-16 years)		Future Residents ⁽²⁾			
		RME	CTE	Adult		Child	
				RME	CTE	RME	CTE
Groundwater Dermal Contact (Showering/ Bathing)	Exposure Concentration (mg/L)	NA	NA	Maximum	Average	NA	NA
	Body Surface Area (cm ²)	NA	NA	20000 ⁽⁶⁾	20000 ⁽⁶⁾	NA	NA
	Fraction Exposed (whole body)	NA	NA	1.0 ⁽⁴⁾	1.0 ⁽⁴⁾	NA	NA
	Event Frequency (event/day)	NA	NA	1	1	NA	NA
	Duration of Event (hr/event)	NA	NA	0.25 ⁽⁴⁾⁽⁹⁾	0.167 ⁽⁴⁾⁽⁹⁾	NA	NA
	Exposure Frequency (day/yr)	NA	NA	350	234	NA	NA
	Exposure Duration (yr)	NA	NA	30	9	NA	NA
	Body Weight (kg)	NA	NA	70	70	NA	NA

1 USEPA, 1994c, unless otherwise noted.

2 A 30- and 9-year future resident evaluated (RME and CTE). Age-adjusted ingestion and dermal contact rates will be used for soil/sediment exposures.

3 Based on Phase I RI (Atlantic, 1992).

4 Professional judgment.

5 USEPA, 1989b.

6 USEPA, 1992c.

7 20 m³/day.

8 NA - Exposure route not evaluated.

9 For RME, 15 minutes per event, and for CTE, 10 minutes per event.

10 USEPA, 1998c.

TABLE 1-8

EXPOSURE PARAMETERS FOR FULL-TIME EMPLOYEES AND CONSTRUCTION WORKERS ⁽¹⁾
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT

Exposure Scenario	Parameter (units)	Full-Time Employee		Construction Worker	
		RME	CTE	RME	CTE
Soil Ingestion	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL
	Ingestion Rate (mg/day)	100	50	480	240 ⁽²⁾
	Exposure Frequency (day/yr)	150	150	120 ⁽³⁾	80 ⁽³⁾
	Exposure Duration (yr)	25	6 ⁽³⁾	1 ⁽³⁾	1 ⁽³⁾
	Body Weight (kg)	70	70	70	70
Soil Dermal Contact	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL
	Body Surface Area (cm ²)	20000 ⁽⁴⁾	20000 ⁽⁴⁾	20000 ⁽⁴⁾	20000 ⁽⁴⁾
	Fraction Exposed (forearms, head, hands)	0.19 ⁽⁵⁾	0.19 ⁽⁵⁾	0.19 ⁽⁵⁾	0.19 ⁽⁵⁾
	Adherence Factor (mg/cm ²)	0.2 ⁽⁶⁾	0.02 ⁽⁶⁾	0.2 ⁽⁶⁾	0.02 ⁽⁶⁾
	Exposure Frequency (day/yr)	150	150	120 ⁽³⁾	80 ⁽³⁾
	Exposure Duration (yr)	25	6 ⁽³⁾	1 ⁽³⁾	1 ⁽³⁾
	Body Weight (kg)	70	70	70	70
Inhalation of Dust/Air	Exposure Concentration (mg/m ³)	1.8E-8 X UCL ⁽³⁾	1.8E-8 X UCL ⁽³⁾	9E-8 X UCL ⁽³⁾	9E-8 X UCL ⁽³⁾
	Inhalation Rate (m ³ /hr)	2.5 ⁽⁵⁾	2.5 ⁽⁵⁾	3.9 ⁽⁵⁾	3.9 ⁽⁵⁾
	Exposure Time (hr/day)	8 ⁽²⁾	8 ⁽²⁾	8 ⁽²⁾	8 ⁽²⁾
	Exposure Frequency (day/yr)	150	150	120 ⁽³⁾	80 ⁽³⁾
	Exposure Duration (yr)	25	6 ⁽³⁾	1 ⁽³⁾	1 ⁽³⁾
	Body Weight (kg)	70	70	70	70
Groundwater Dermal Contact	Exposure Concentration (mg/L)	NA ⁽⁷⁾	NA	Maximum	Average
	Body Surface Area (cm ²)	NA	NA	20000 ⁽⁴⁾	20000 ⁽⁴⁾
	Fraction Exposed (forearms, head, hands)	NA	NA	0.19 ⁽⁵⁾	0.19 ⁽⁵⁾
	Event Frequency (events/day)	NA	NA	1	1
	Duration of Event (hr/event)	NA	NA	4 ⁽²⁾	2 ⁽²⁾
	Exposure Frequency (days/yr)	NA	NA	20 ⁽²⁾	10 ⁽²⁾
	Exposure Duration (yr)	NA	NA	1 ⁽³⁾	1 ⁽³⁾
	Body Weight (kg)	NA	NA	70	70

1 USEPA, 1994c, unless otherwise noted
 2 Professional judgement
 3 Based on Phase I RI (Atlantic, 1992)
 4 USEPA, 1992b

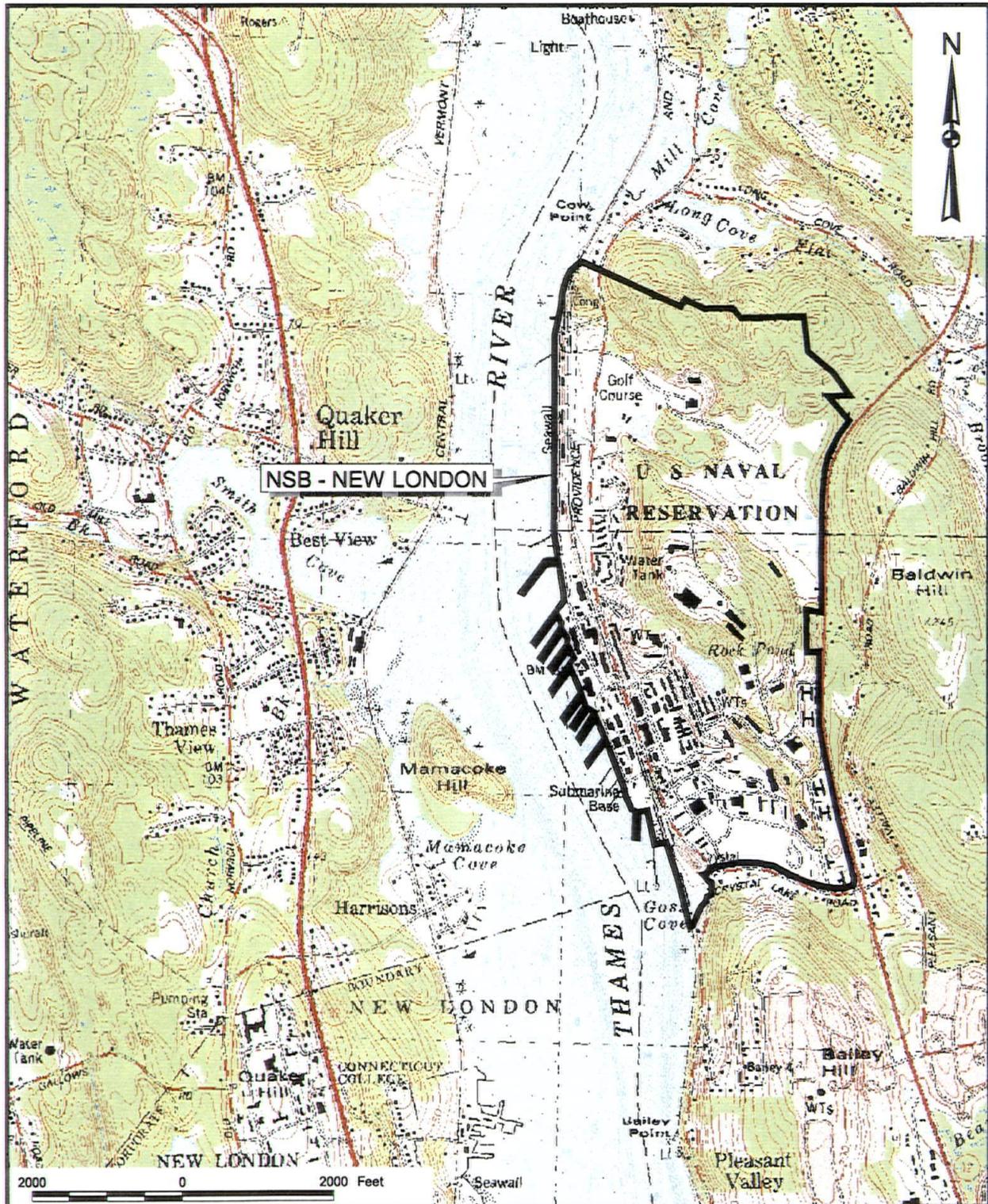
5 USEPA, 1989b
 6 USEPA, 1998c
 7 NA - Exposure route not evaluated

TABLE 1-9

RECOMMENDED DERMAL ABSORPTION FACTOR FROM SOIL⁽¹⁾
 BASEWIDE GROUNDWATER OU RI
 NSB-NLON, GROTON, CONNECTICUT

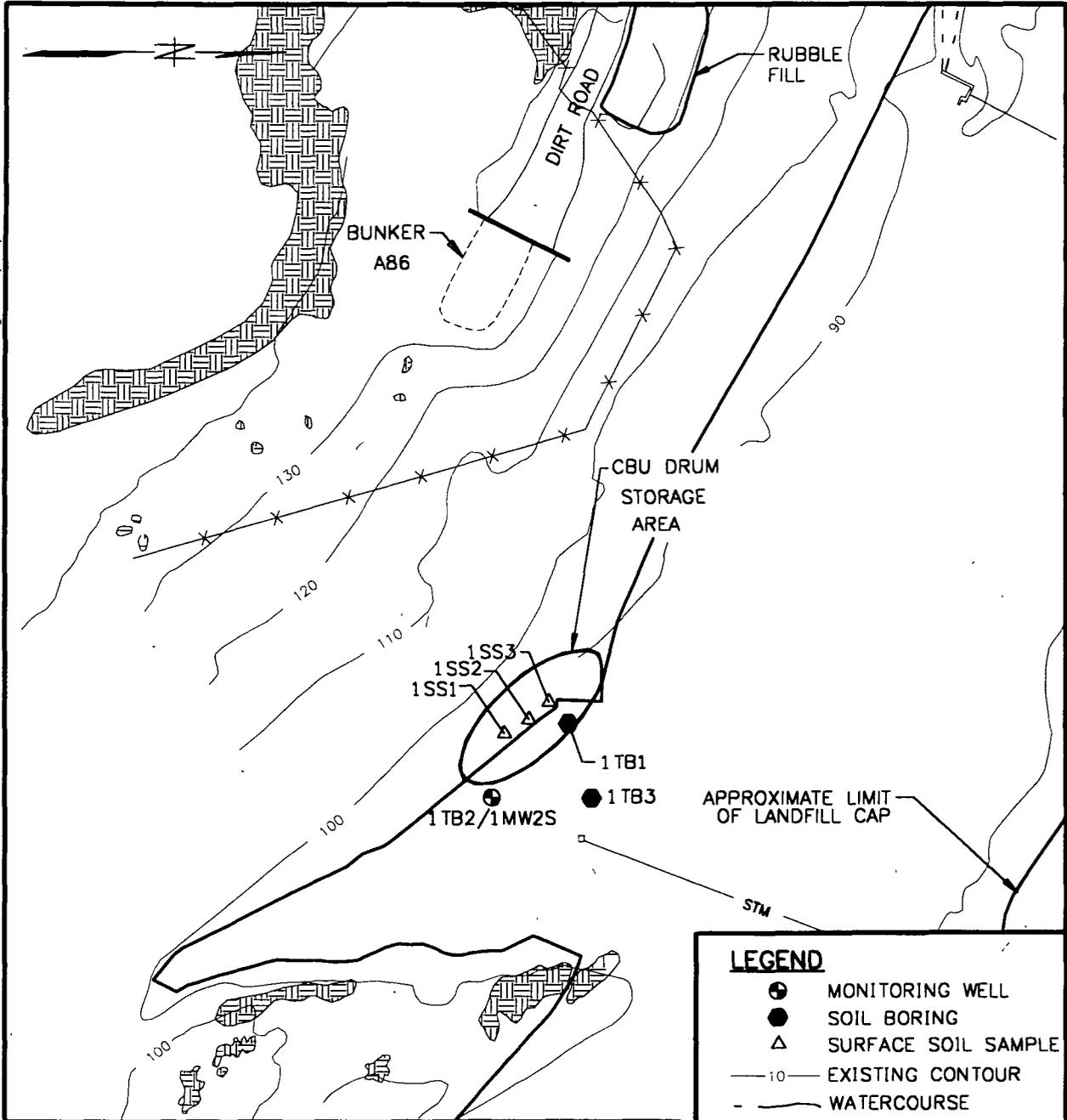
Compound	Dermal Absorption Factor
Arsenic	0.03
Cadmium	0.01
Chlordane	0.04
2,4-Dichlorophenoxyacetic acid	0.05
DDT	0.03
TCDD and other dioxins	
<10% organic soil	0.03
>10% organic soil	0.001
Lindane	0.04
PAHs	
Benzo(a)pyrene	0.13
PCBs	
Aroclor 1254 and 1242	0.14
Pentachlorophenol	0.25
Generic Defaults for Screening	
Semivolatile organic compounds	0.1
Inorganics	0.01

1 USEPA, 1998c



DRAWN BY D. PERRY	DATE 2-DEC-98	Tetra Tech NUS, Inc.	CONTRACT NUMBER 7856	OWNER NO. 312
CHECKED BY <i>HMS</i>	DATE 5/26/99		LOCATION MAP NSB-NEW LONDON GROTON, CONNECTICUT	APPROVED BY <i>Long A. Rail</i>
COST/SCHEDULE-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1	REV 0

ACAD:7856GM01.dwg 06/25/99 HJP



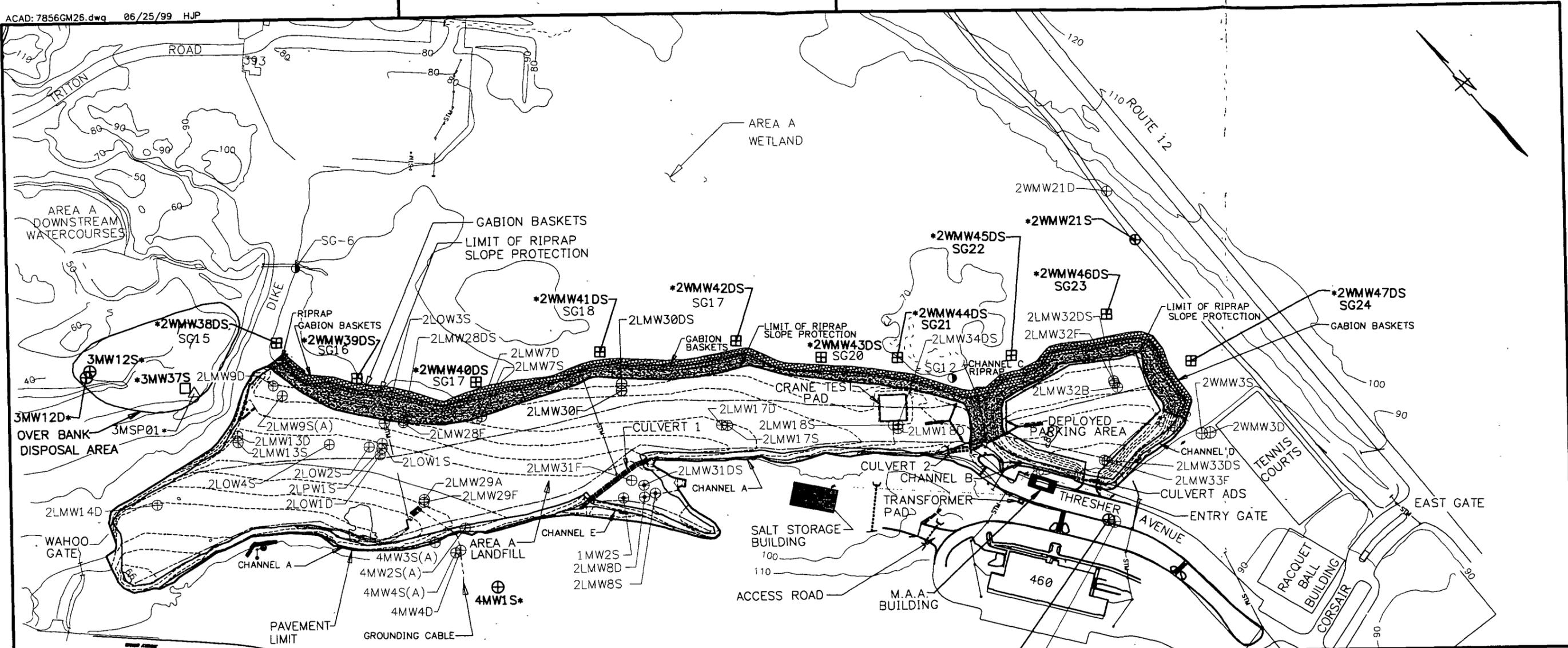
NOTES:
 1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
 2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.
 3. SOIL SAMPLING LOCATIONS WERE COVERED DURING THE INSTALLATION OF THE CAP ON THE AREA A LANDFILL.

LEGEND

- ⊕ MONITORING WELL
- SOIL BORING
- △ SURFACE SOIL SAMPLE
- 10— EXISTING CONTOUR
- - - WATERCOURSE
- STM—□ STORM SEWER AND CATCH BASIN
- ▨ EXPOSED BEDROCK
- *-* FENCE

0 80 160
SCALE IN FEET

DRAWN BY HJP 10/29/98	DATE 10/29/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY 	DATE 	SITE MAP SITE 1-CBU DRUM STORAGE AREA NSB-NLON, GROTON, CONNECTICUT	APPROVED BY <i>Cory A. Kiel</i>	DATE 6/28/99
COST/SCHED-AREA 	 		APPROVED BY 	DATE
SCALE AS NOTED	DRAWING NO. FIGURE 1-2			REV. 0



LEGEND

- ⊕ EXISTING MONITORING WELL
- EXISTING STAFF GAUGE
- ⊞ PROPOSED MONITORING WELL AND STAFF GAUGE
- PROPOSED MONITORING WELL
- △ SEEP LOCATION
- * MONITORING LOCATION
- (A) ABANDONED

NOTE:
1. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN (ATLANTIC, MAY 1993).



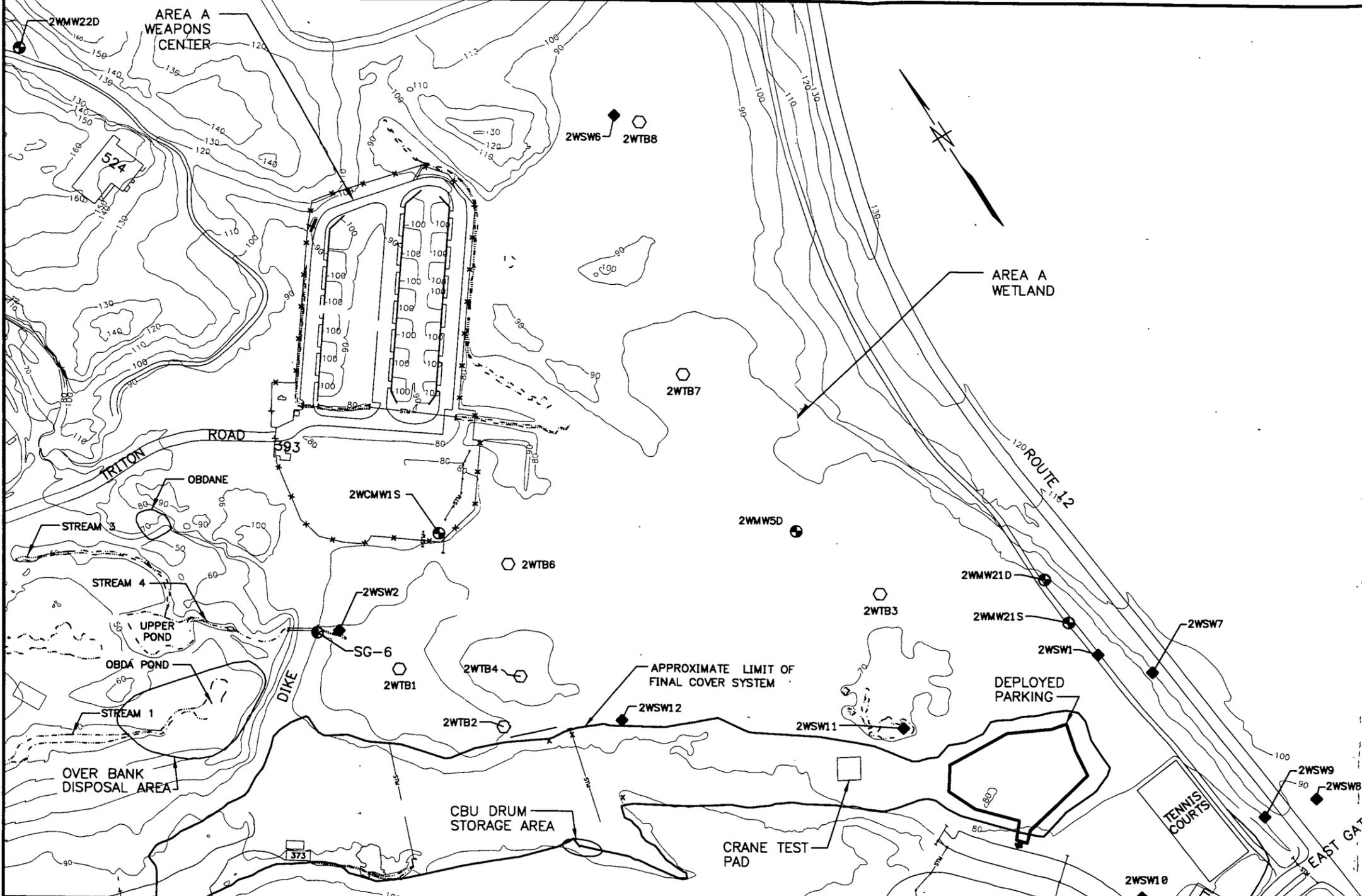
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY	DATE
MF	8/17/98
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

SITE MAP
SITE 2 - AREA A LANDFILL
NSB-NLON
GROTON, CONNECTICUT

CONTRACT NO.	OWNER NO.
7856	312
APPROVED BY	DATE
<i>Drew A. Riel</i>	6/28/99
APPROVED BY	DATE
DRAWING NO.	REV.
FIGURE 1-3	1



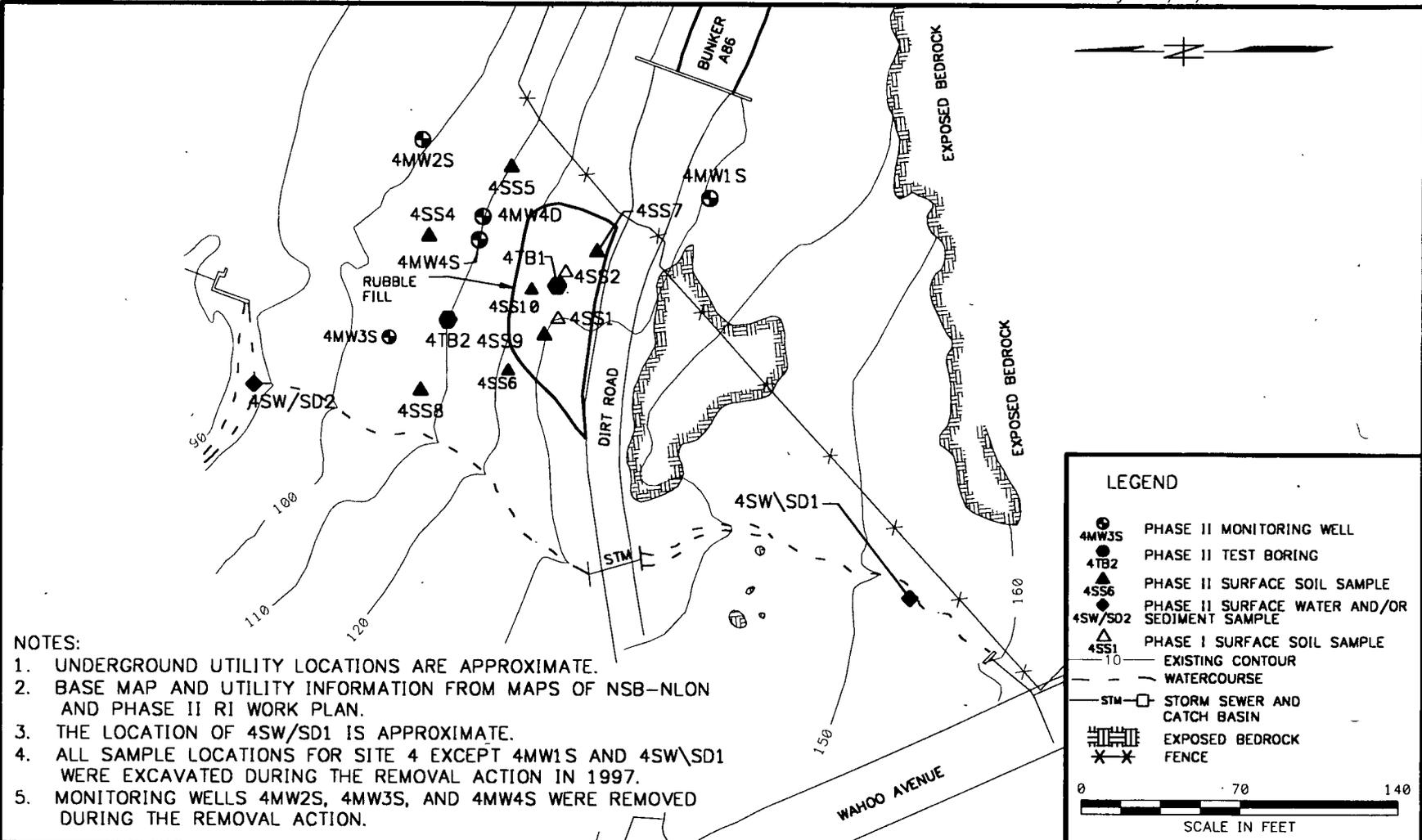
NOTE:
 1. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN (ATLANTIC, MAY 1993).
 2. 2WWW2S WAS NOT COMPLETED DUE TO A LACK OF GROUNDWATER. A SOIL SAMPLE WAS COLLECTED FROM THIS LOCATION.

LEGEND

- ⊕ PHASE I MONITORING WELL
- 2WWW5S PHASE II MONITORING WELL
- 2WTB3 PHASE I TEST BORING
- ⊙ SG-6 PHASE II STAFF GAUGE
- ◆ 2WSW1 PHASE II SURFACE WATER SAMPLE
- 10 — EXISTING CONTOUR
- 123- BUILDING No.
- WATERCOURSE
- STM — □ STORM SEWER AND CATCH BASIN
- ▨ EXPOSED BEDROCK
- * — FENCE

0 250 500
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY HJP	DATE 10/29/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
							CMS	SPJ		SITE MAP SITE 2- AREA A WETLAND NSB-NLON, GROTON, CONNECTICUT	APPROVED BY <i>Craig A. Pail</i>
									APPROVED BY		DATE
									DRAWING NO.	FIGURE 1-4	REV. 0



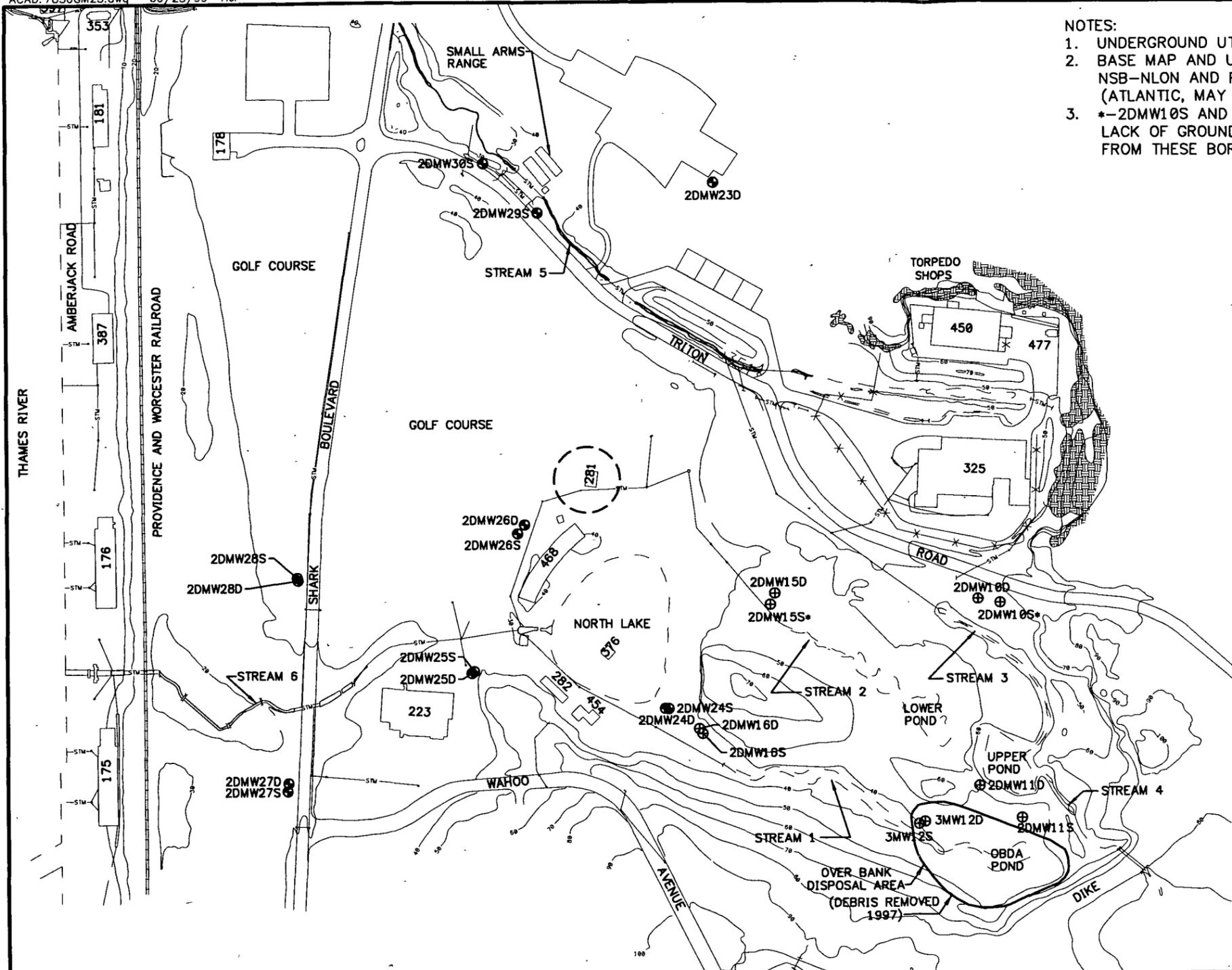
NOTES:

1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.
3. THE LOCATION OF 4SW/SD1 IS APPROXIMATE.
4. ALL SAMPLE LOCATIONS FOR SITE 4 EXCEPT 4MW1S AND 4SW\SD1 WERE EXCAVATED DURING THE REMOVAL ACTION IN 1997.
5. MONITORING WELLS 4MW2S, 4MW3S, AND 4MW4S WERE REMOVED DURING THE REMOVAL ACTION.

DRAWN BY HJP	DATE 10/28/98
CHECKED BY <i>AMS</i>	DATE 5/27/99
COST/SCHED-AREA	
SCALE AS NOTED	

 Tetra Tech NUS, Inc.
SITE MAP
SITE 4-RUBBLE FILL AREA
AT BUNKER A86
NSB-NLON, GROTON, CONNECTICUT

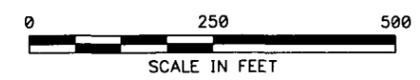
CONTRACT NO. 7856	OWNER NO. 312
APPROVED BY <i>Corey A. Rind</i>	DATE 5/27/99
APPROVED BY	DATE
DRAWING NO. FIGURE 1-5	REV. 0



- 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. *—2DMW10S AND 2DMW15S WERE NOT COMPLETED DUE TO A LACK OF GROUNDWATER. SOIL SAMPLES WERE COLLECTED FROM THESE BORINGS.

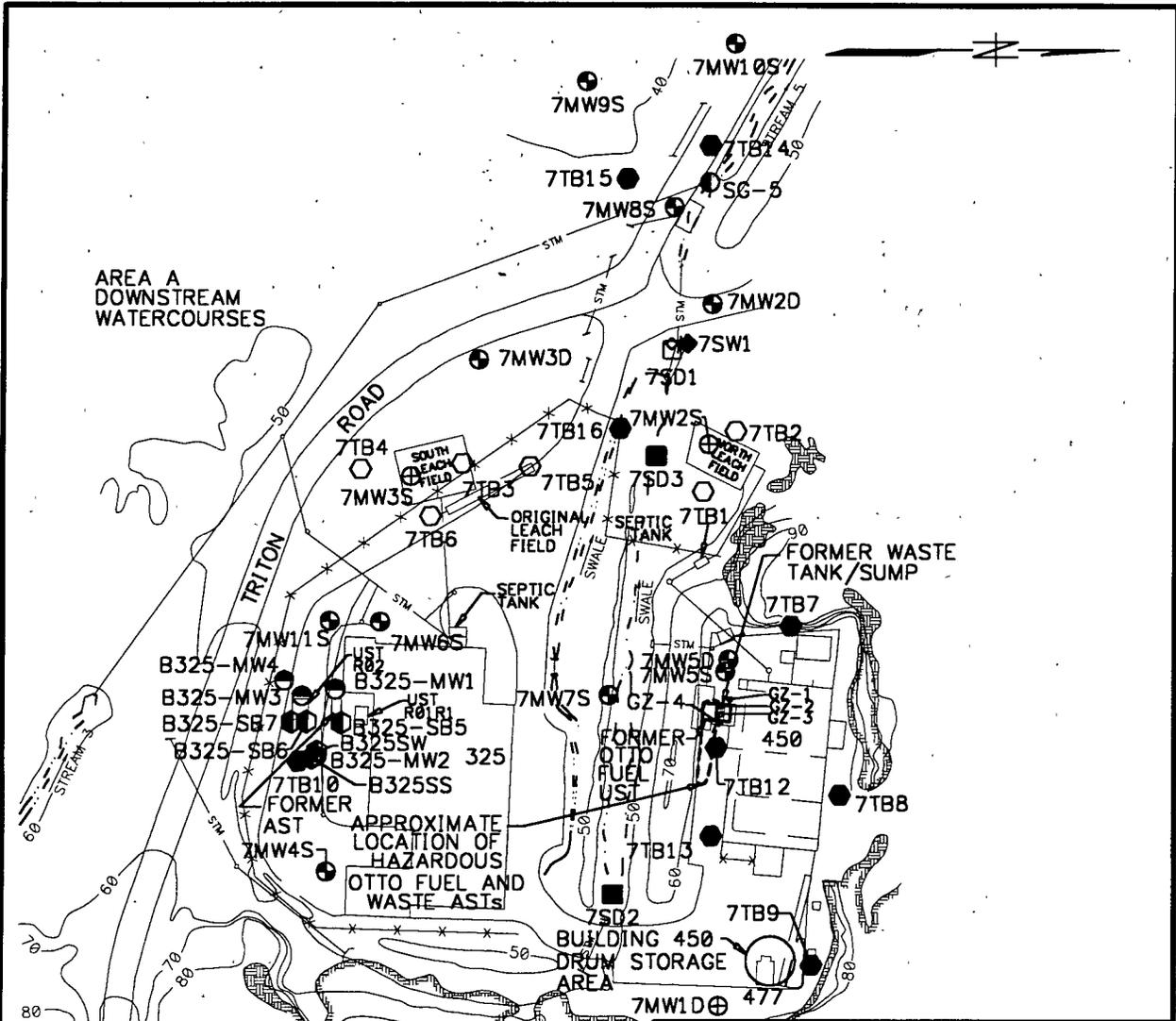


- LEGEND**
- ⊕ 2DMW25D EXISTING MONITORING WELL
 - ⊙ 2DMW26D PHASE II MONITORING WELL
 - 10- EXISTING CONTOUR
 - 123 BUILDING No.
 - WATERCOURSE
 - STM-□ STORM SEWER AND CATCH BASIN
 - ⊘ EXPOSED BEDROCK
 - X-X- FENCE



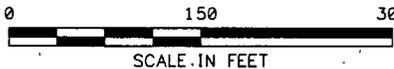
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NO.	OWNER NO.
							HJP	10/29/98			7856
							CHECKED BY	DATE	SITE MAP SITE 3—AREA A DOWNSTREAM WATERCOURSES/OBDA NSB-NLON, GROTON, CONNECTICUT	APPROVED BY	DATE
											<i>Cory A. Rich</i>
							COST/SCHED—AREA			APPROVED BY	DATE
							SCALE AS NOTED			DRAWING NO.	REV.
										FIGURE 1-6	0

ACAD:7856GM22.dwg 06/25/99 HJP



NOTES:

1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.
3. B325SS IS A CONFIRMATION SOIL (S) SAMPLE COLLECTED FROM THE SOUTH (S) END OF THE EXCAVATION.
4. B325SW IS A CONFIRMATION SOIL (S) SAMPLE COLLECTED FROM THE WEST (W) END OF THE EXCAVATION.



LEGEND

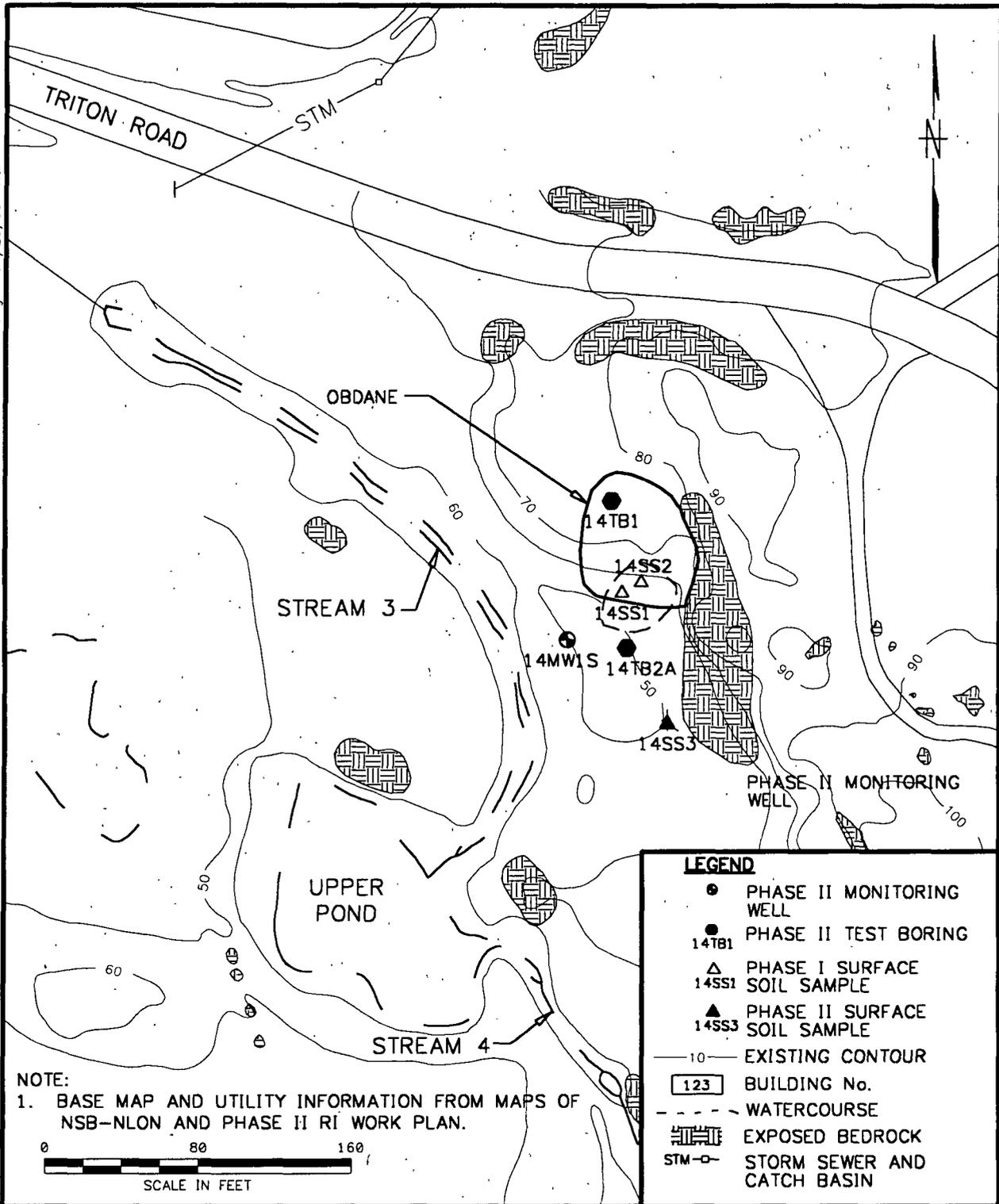
- ⊕ 7MW2S PHASE I MONITORING WELL
- ⊕ 7MW7S PHASE II MONITORING WELL
- ⊕ B325-MW1 SITE CHARACTERIZATION MONITORING WELL
- 7TB1 PHASE I TEST BORING
- 7TB12 PHASE II TEST BORING
- ⊕ B325-SB6 SITE CHARACTERIZATION SOIL BORING
- ◇ 7SW1 PHASE I EXISTING SURFACE WATER SAMPLE
- ◇ 7SW1 PHASE II SURFACE WATER SAMPLE
- 7SD1 PHASE I SEDIMENT SAMPLE
- 7SD3 PHASE II SEDIMENT SAMPLE
- SG-5 PHASE II STAFF GAUGE
- - - EXISTING CONTOUR
- 123 BUILDING No.
- - - WATERCOURSE
- - - - - STW - □ STORM SEWER AND CATCH BASIN
- ⊕ ⊕ EXPOSED BEDROCK
- * * FENCE

DRAWN BY HJP	DATE 10/28/98
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.
SITE MAP
SITE 7-TORPEDO SHOPS
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7856	OWNER NO. 312
APPROVED BY <i>Cory A. Reed</i>	DATE 6/28/99
APPROVED BY	DATE
DRAWING NO. FIGURE 1-7	REV. 0

ACAD: 7856GM25.dwg 05/25/99 HJP

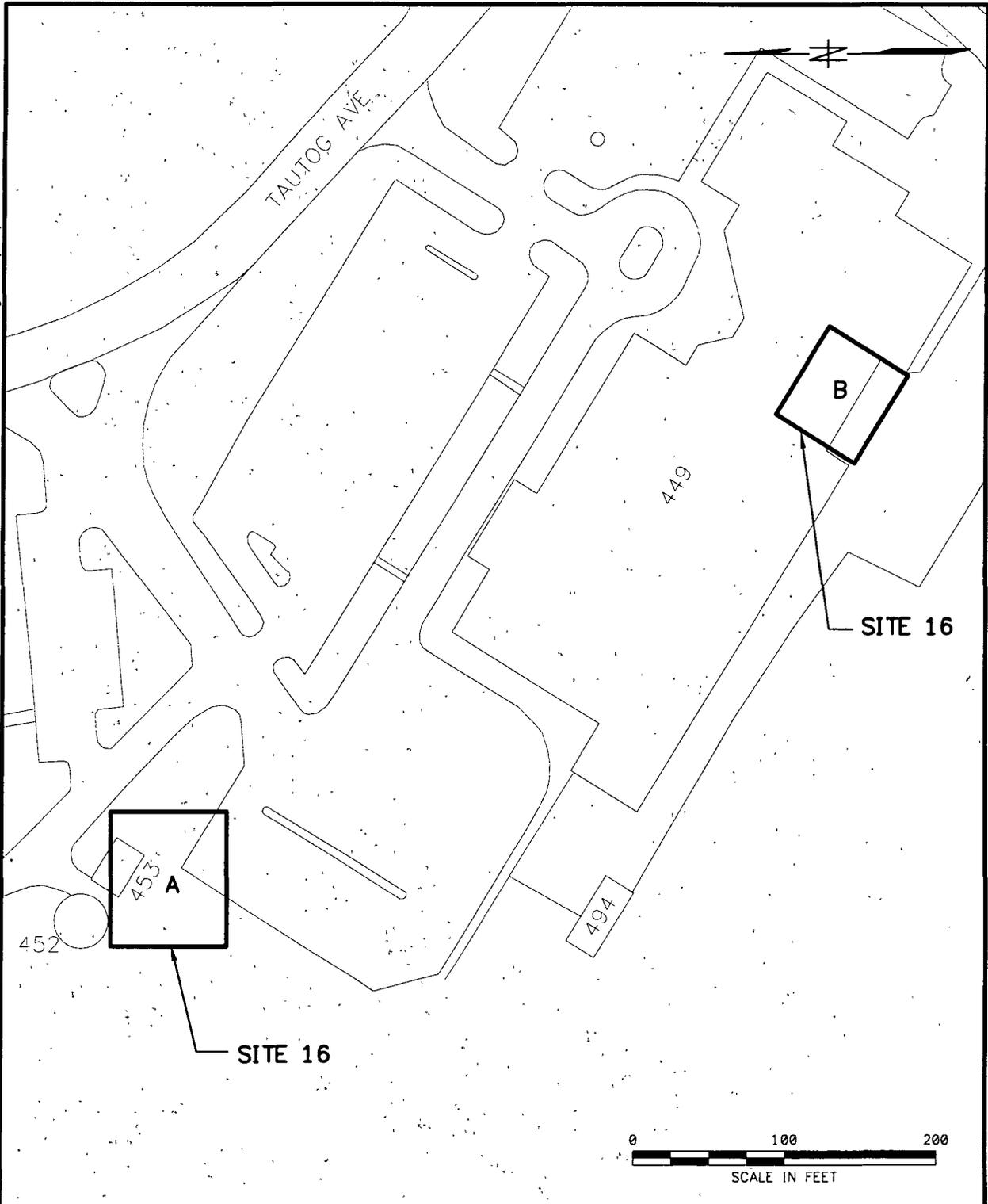


NOTE:
 1. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.

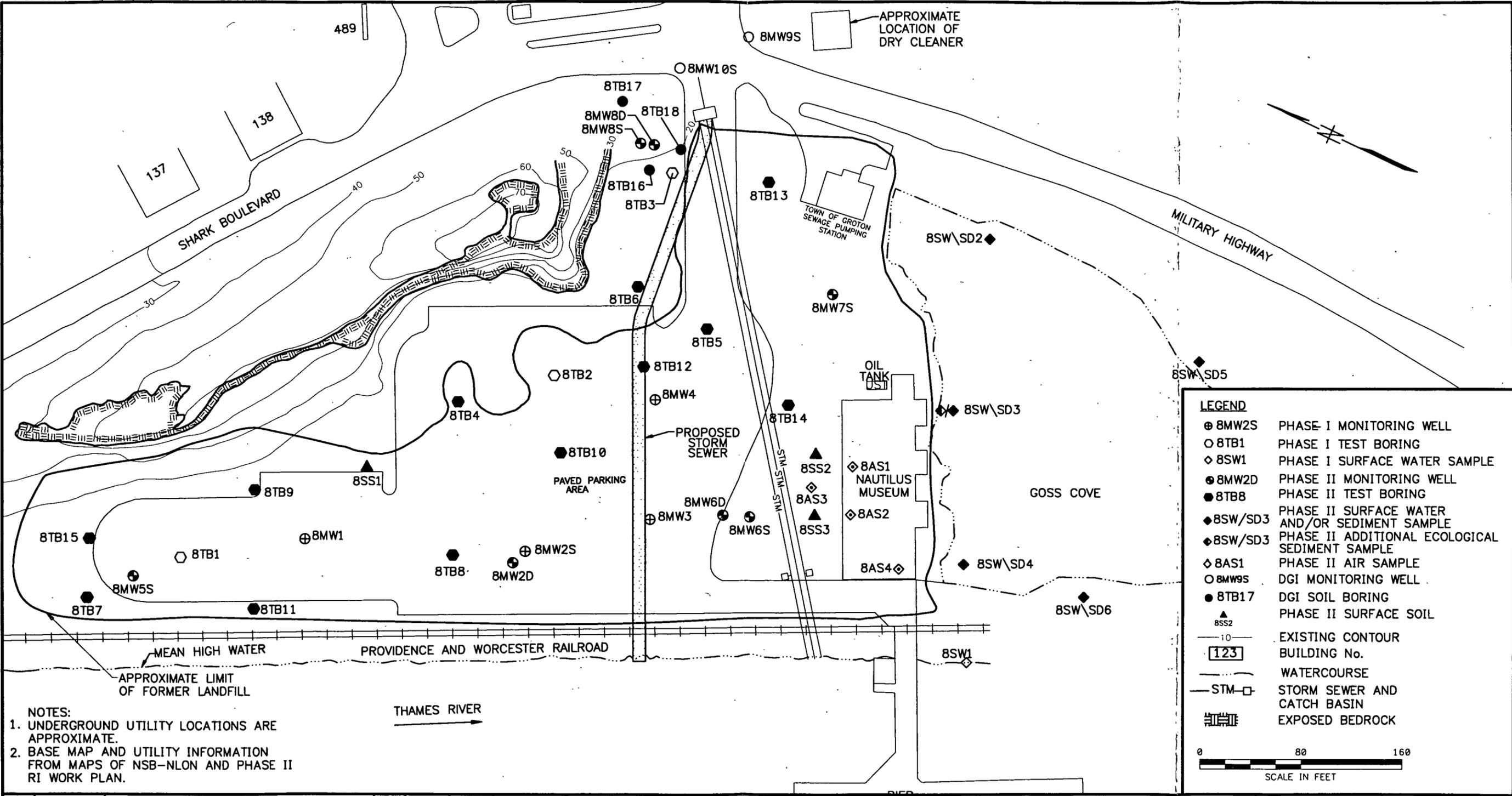
0 80 160
 SCALE IN FEET

DRAWN BY HJP 10/28/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY GMS 5/27/99	SITE MAP SITE 14-OBDA NE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY <i>Corey A. Paul</i>	DATE 5/27/99
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1-8	REV. 0

ACAD. 7856CM21.dwg 06/29/99 DT



DRAWN BY: HJP DATE: 10/28/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY: _____ DATE: _____	SITE MAP SITE 16-HOSPITAL INCINERATOR NSB-NLON, GROTON, CONNECTICUT	APPROVED BY: <i>Cory A. Reed</i>	DATE: 6/30/99
COST/SCHED-AREA _____		APPROVED BY: _____	DATE: _____
SCALE AS NOTED		DRAWING NO. FIGURE 1-10	REV. 0



NOTES:
 1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
 2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.

LEGEND

- ⊕ 8MW2S PHASE I MONITORING WELL
- 8TB1 PHASE I TEST BORING
- ◇ 8SW1 PHASE I SURFACE WATER SAMPLE
- 8MW2D PHASE II MONITORING WELL
- 8TB8 PHASE II TEST BORING
- ◆ 8SW/SD3 PHASE II SURFACE WATER AND/OR SEDIMENT SAMPLE
- ◆ 8SW/SD3 PHASE II ADDITIONAL ECOLOGICAL SEDIMENT SAMPLE
- ◇ 8AS1 PHASE II AIR SAMPLE
- 8MW9S DGI MONITORING WELL
- 8TB17 DGI SOIL BORING
- ▲ 8SS2 PHASE II SURFACE SOIL
- 10 — EXISTING CONTOUR
- [123] BUILDING No.
- WATERCOURSE
- STM — STORM SEWER AND CATCH BASIN
- █ EXPOSED BEDROCK

0 80 160
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	CONTRACT NO.	OWNER NO.
							HJP	10/29/98	7856	312
							CMS	5/26/99	APPROVED BY	DATE
									<i>Corey C. Paul</i>	5/27/99
									APPROVED BY	DATE
									DRAWING NO.	REV.
									FIGURE 1-11	0

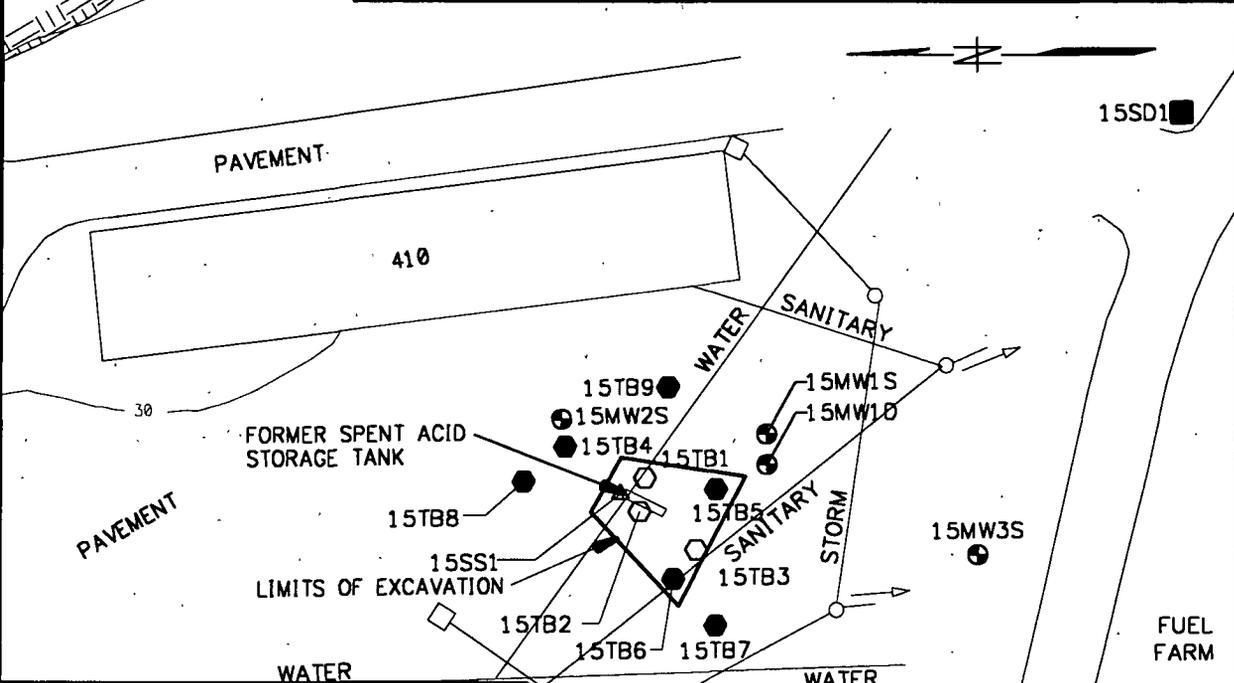
Tetra Tech NUS, Inc.

SITE MAP
 SITE 8-GOSS COVE LANDFILL
 NSB-NLON, GROTON, CONNECTICUT

ACAD: 7856GM05.dwg HJP 06/25/99

NOTES:

1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.
3. 15TB4-15TB9 INSTALLED BY ATLANTIC ENVIRONMENTAL, PHASE II.
4. LOCATIONS OF 15TB4-15TB9 ARE APPROXIMATE. LOCATIONS WERE TAKEN FROM ATLANTIC ENVIRONMENTAL SERVICES, INC. DRAFT FFS, MARCH, 1994.
5. DEPTH OF EXCAVATION IS APPROXIMATELY 4 FEET.
6. SOIL SAMPLING LOCATIONS WITHIN THE EXCAVATION AREA AT DEPTHS LESS THAN 4 FEET HAVE BEEN EXCAVATED.

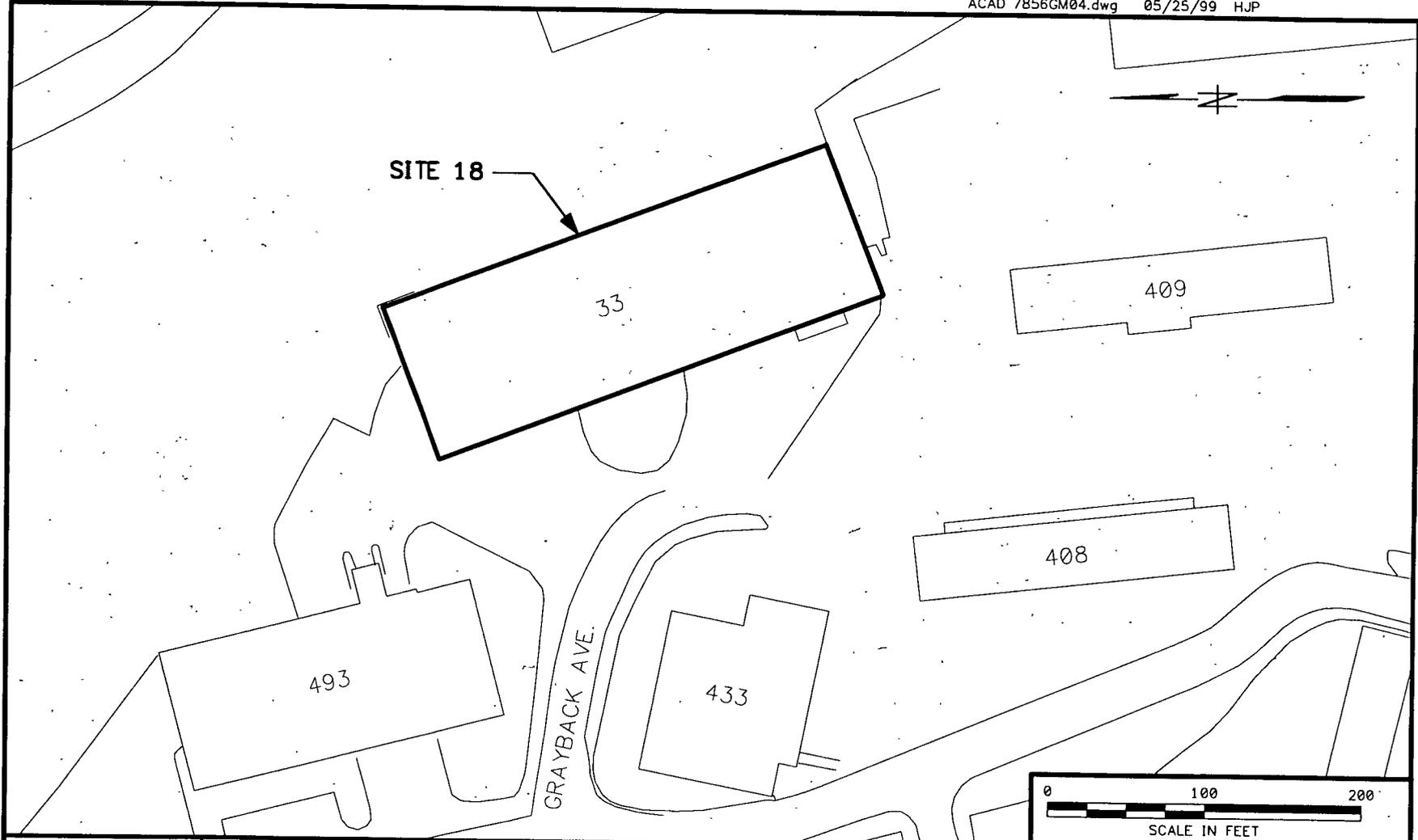


LEGEND

- 15MW2S PHASE II MONITORING WELL
- 15TB3 PHASE I TEST BORING
- 15TB5 FFS TEST BORING
- △ 15SS1 PHASE I SOIL SAMPLE
- 15SD1 PHASE II SEDIMENT SAMPLE
- 10- EXISTING CONTOUR
- [123] BUILDING No.
- - - WATERCOURSE
- STM- □ STORM SEWER AND CATCH BASIN
- ▨ EXPOSED BEDROCK

0 60 120
SCALE IN FEET

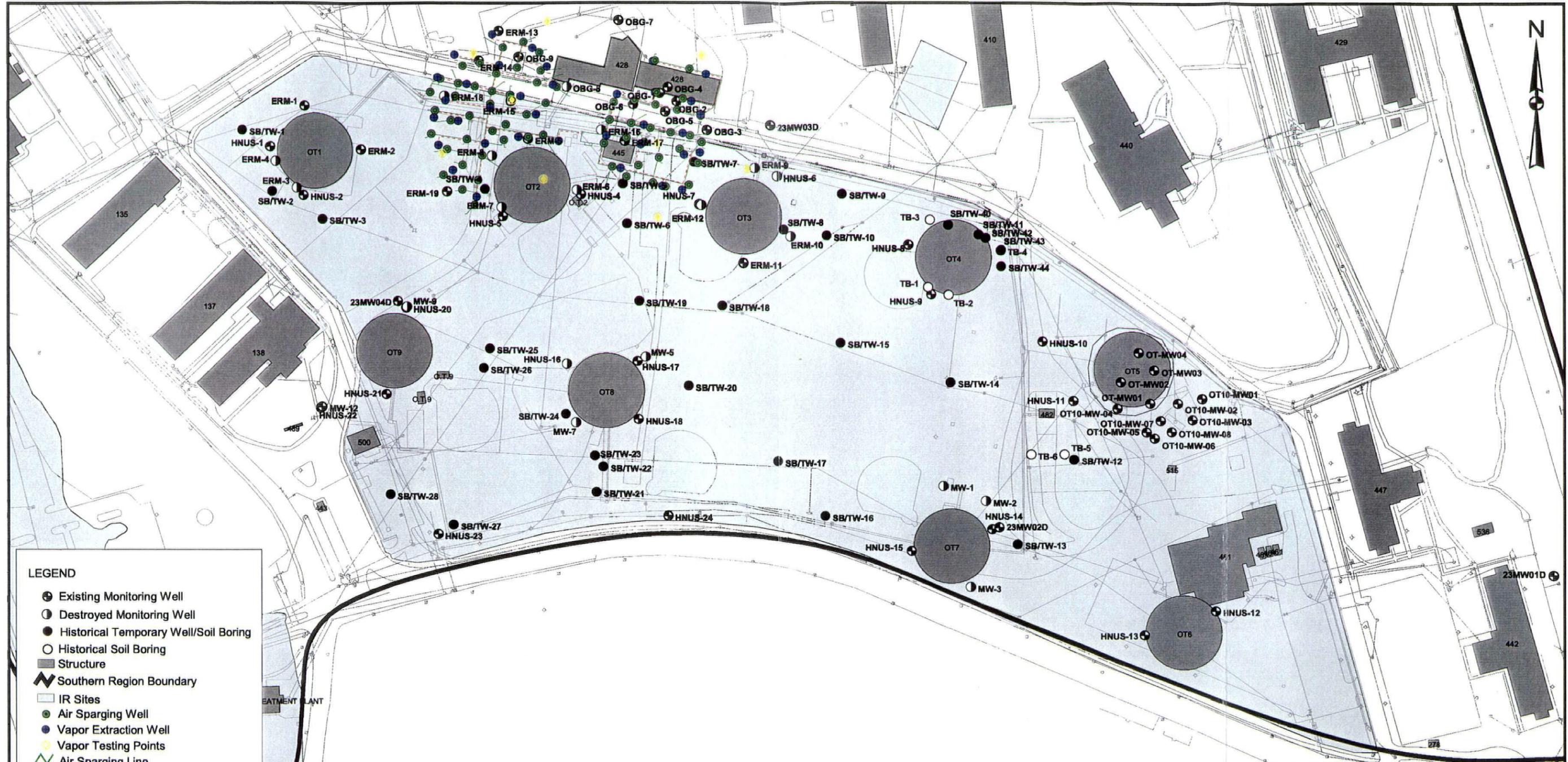
DRAWN BY HJP DATE 10/29/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY DATE	SITE MAP SITE 15-SPENT ACID STORAGE AND DISPOSAL AREA NSB-NLON, GROTON, CONNECTICUT	APPROVED BY <i>Cory A. Rich</i>	DATE 6/28/99
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED	DRAWING NO. FIGURE 1-12	REV. 0	



DRAWN BY HJP	DATE 10/29/98
CHECKED BY <i>AMS</i>	DATE 5/26/99
COST/SCHED-AREA	
SCALE AS NOTED	

 Tetra Tech NUS, Inc.
SITE MAP
SITE 18-SOLVENT STORAGE AREA
(BUILDING 33)
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7856	OWNER NO. 312
APPROVED BY <i>Louy Ci Reed</i>	DATE 5/27/99
APPROVED BY	DATE
DRAWING NO. FIGURE 1-13	REV. 0



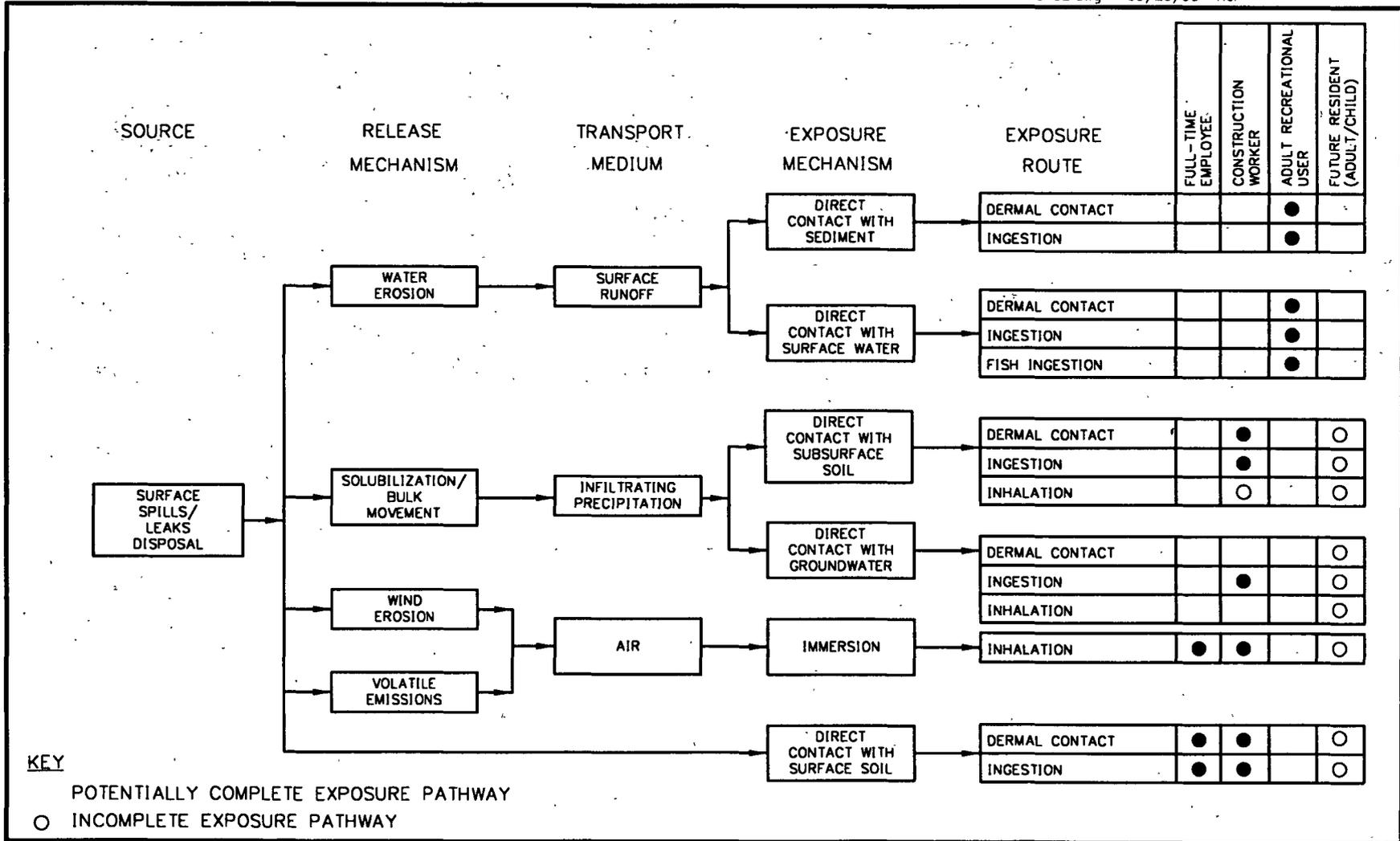
LEGEND

- ⊕ Existing Monitoring Well
- ⊖ Destroyed Monitoring Well
- Historical Temporary Well/Soil Boring
- Historical Soil Boring
- ▭ Structure
- ▬ Southern Region Boundary
- IR Sites
- Air Sparging Well
- Vapor Extraction Well
- Vapor Testing Points
- Air Sparging Line
- Vapor Extraction Line

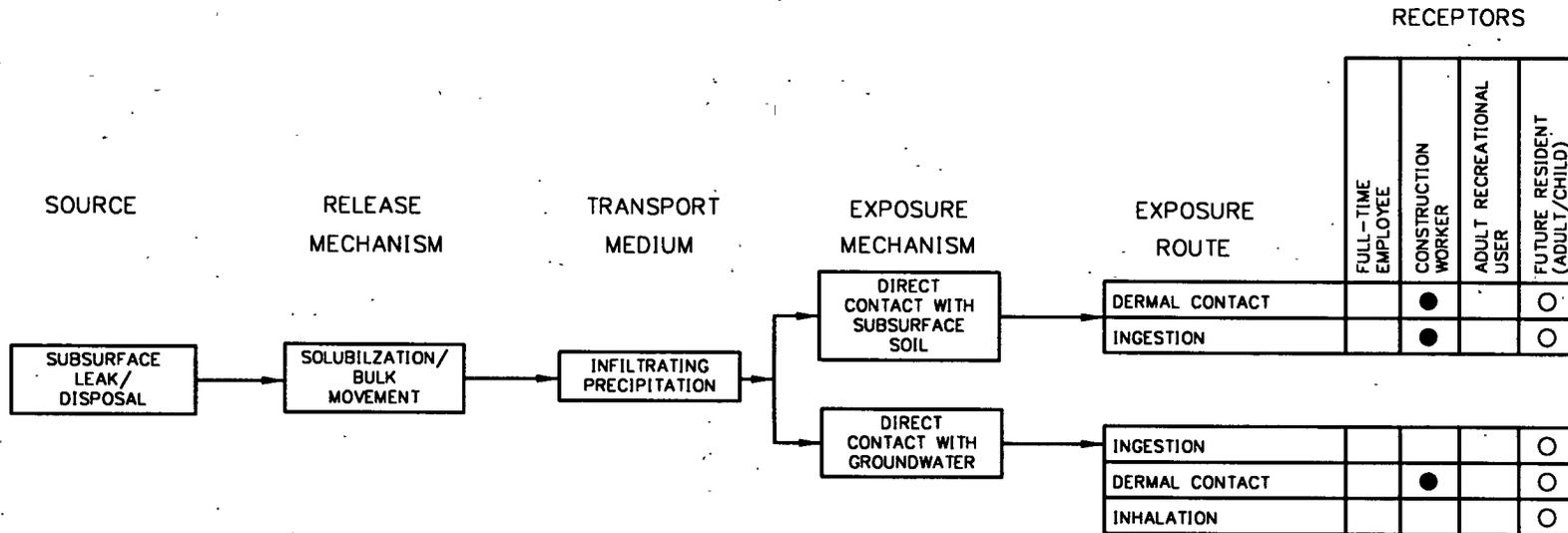


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NUMBER
							D. PERRY	3-NOV-98			7856
							CHECKED BY	DATE		APPROVED BY	DATE
										<i>Long A. Paul</i>	5/27/99
							COST/SCHEDULE-AREA			APPROVED BY	DATE
							SCALE			DRAWING NO.	REV
							AS NOTED			FIGURE 1-14	0

SITE MAP
SITE 23 - TANK FARM
NSB-NLON, GROTON, CT



DRAWN BY HJP DATE 5/25/99	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY <i>[Signature]</i> DATE 5/27/99 COST/SCHED-AREA	CONCEPTUAL SITE MODEL - SURFACE SOURCES NSB-NLON GROTON, CONNECTICUT		APPROVED BY <i>[Signature]</i> DATE 5/27/99
SCALE AS NOTED	DRAWING NO. FIGURE 1-16		REV. 0



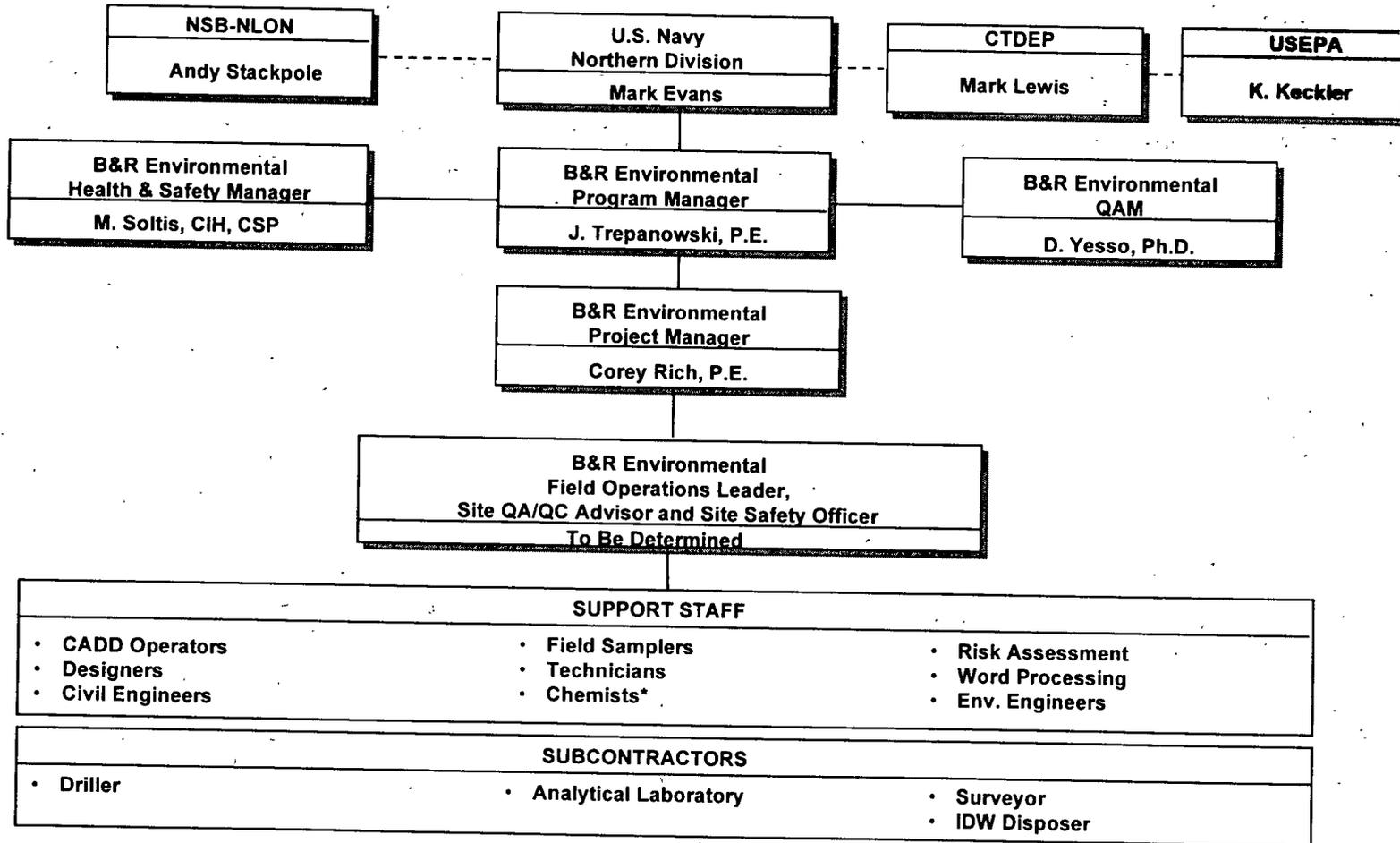
KEY:

● POTENTIALLY COMPLETE EXPOSURE PATHWAY

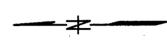
○ INCOMPLETE EXPOSURE PATHWAY

DRAWN BY HJP DATE 5/25/99	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY [Signature] DATE 5/27/99 COST/SCHED-AREA	CONCEPTUAL SITE MODEL - SUBSURFACE SOURCES NSB-NLON GROTON, CONNECTICUT		APPROVED BY [Signature] DATE 5/27/99
SCALE AS NOTED			APPROVED BY DATE DRAWING NO. FIGURE 1-17
			REV. 0

**FIGURE 1-18
ORGANIZATIONAL CHART
NSB-NLON, GROTON, CONNECTICUT**



*J. Samchuck will be responsible for data validation.

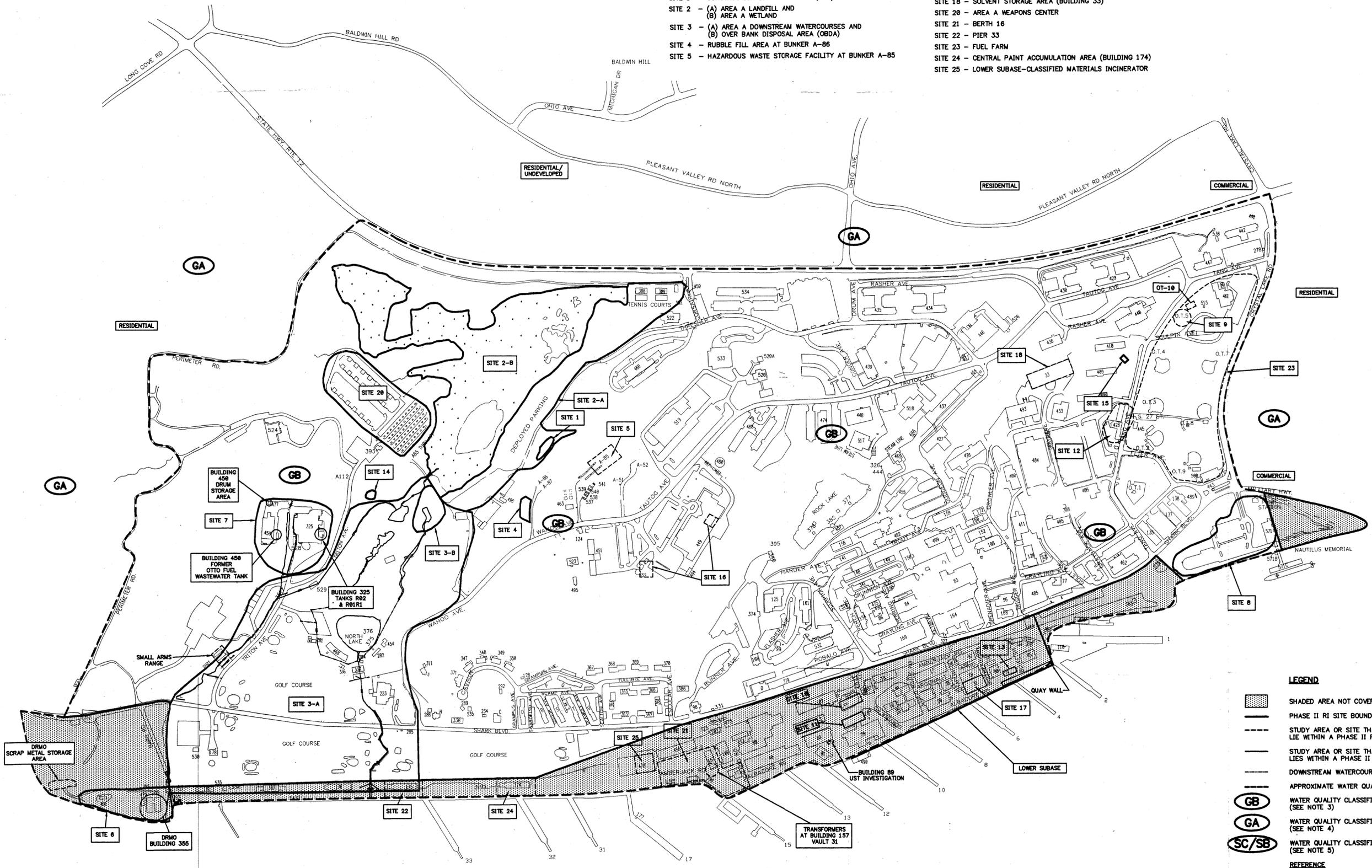


NOTES:

- SITE AND STUDY AREA LOCATIONS WERE TAKEN FROM THE FOLLOWING REPORTS:
 - FEDERAL FACILITY AGREEMENT UNDER CERCLA 128, 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)
- SITE AND STUDY AREA BOUNDARIES 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 WATERCOURSES AND (B) OVER BANK DISPOSAL AREA (OBDA)
 - SITE 4 - RUBBLE FILL AREA AT BUNKER A-86
 - SITE 5 - HAZARDOUS WASTE STORAGE FACILITY AT BUNKER A-85

- 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 SUBBASE-FUEL STORAGE TANKS AND TANK 54-H
- SITE 11 - LOWER SUBBASE-POWER PLANT OIL TANKS
- SITE 12 - BUILDING 428 GAS STATION TANKS
- SITE 13 - LOWER SUBBASE-BUILDING 79 WASTE OIL PIT
- SITE 14 - OVERBANK DISPOSAL AREA NORTHEAST (OBDAE)
- SITE 15 - SPENT ACID STORAGE AND DISPOSAL AREA (SASDA)
- SITE 16 - HOSPITAL INCINERATOR
- SITE 17 - HAZARDOUS MATERIALS/SOLVENT STORAGE AREA (BUILDING 31)
- SITE 18 - SOLVENT STORAGE AREA (BUILDING 33)
- 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 SUBBASE-CLASSIFIED MATERIALS INCINERATOR

- A GROUNDWATER QUALITY CLASSIFICATION GOAL OF GB INDICATES THAT THE GROUNDWATER MAY NOT BE SUITABLE FOR DIRECT HUMAN CONSUMPTION WITHOUT TREATMENT AS A RESULT OF WASTE DISCHARGES, SPILLS, CHEMICAL LEAKS, OR LAND USE IMPACTS. GB WATERS MAY BE USEFUL FOR INDUSTRIAL PROCESS WATERS OR COOLING WATERS. THE STATE'S GOAL IS TO RESTORE THE WATER TO DRINKING WATER QUALITY (GA).
- A GROUNDWATER QUALITY CLASSIFICATION GOAL OF GA SIGNIFIES GROUNDWATERS PRESUMED SUITABLE FOR DIRECT HUMAN CONSUMPTION WITHOUT THE NEED FOR TREATMENT.
- A SURFACE WATER QUALITY CLASSIFICATION GOAL OF SC/SB DESIGNATES THE WATER FOR MARINE FISH, SHELLFISH, AND WILDLIFE HABITAT, CERTAIN AQUACULTURE OPERATIONS, RECREATIONAL USES, INDUSTRIAL AND OTHER LEGITIMATE USE, AND INDICATES THAT THE WATERS PRESENTLY DO NOT MEET WATER QUALITY CRITERIA OR DO NOT SUPPORT ONE OR MORE DESIGNATED USES AS A RESULT OF POLLUTION.



LEGEND

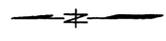
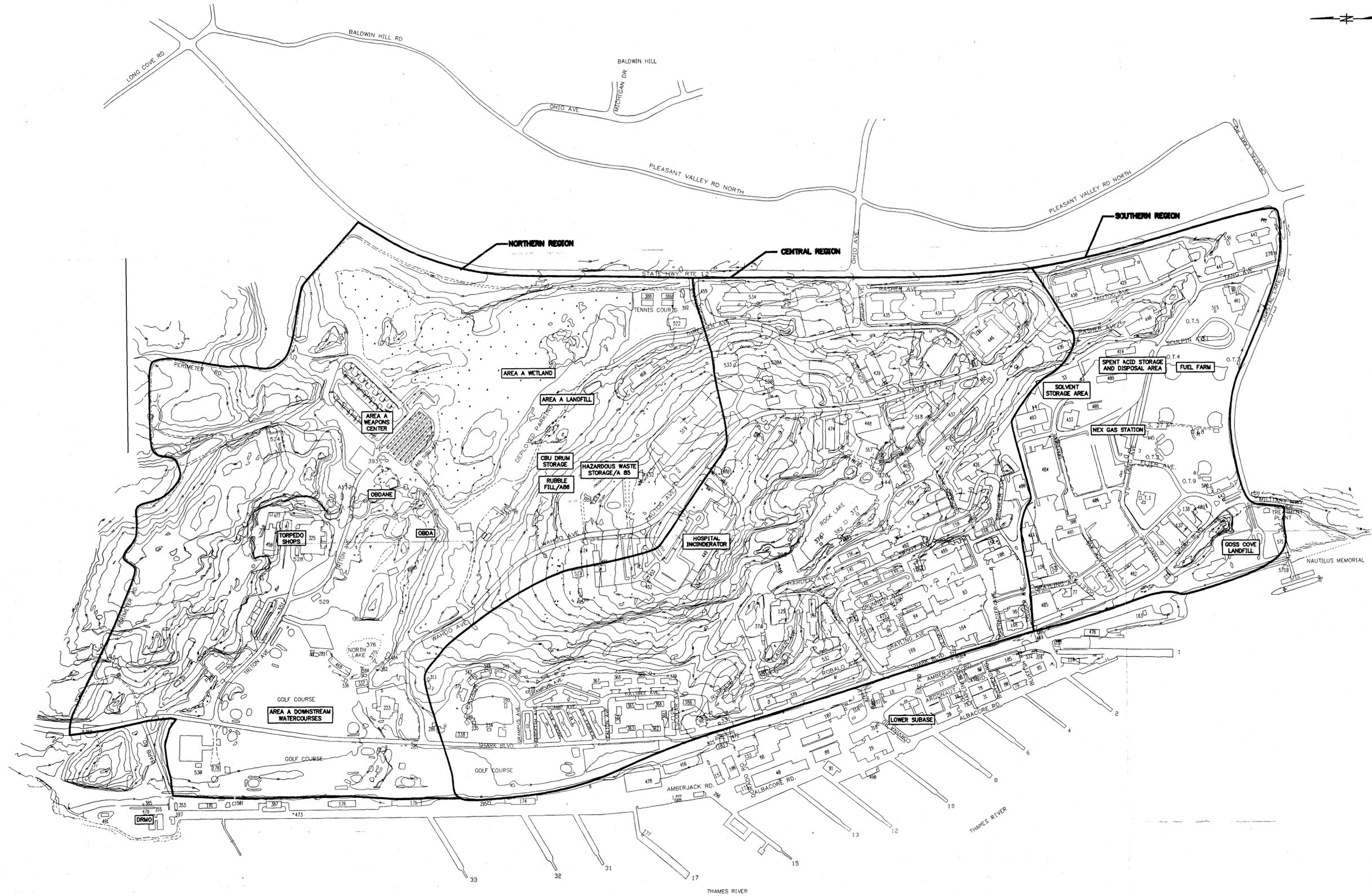
- SHADED AREA NOT COVERED BY BASEWIDE GROUNDWATER OU RI
- PHASE II RI SITE BOUNDARY
- STUDY AREA OR SITE THAT DOES NOT LIE WITHIN A PHASE II RI SITE BOUNDARY
- STUDY AREA OR SITE THAT LIES WITHIN A PHASE II RI SITE BOUNDARY
- DOWNSTREAM WATERCOURSE
- APPROXIMATE WATER QUALITY CLASSIFICATION GOAL BOUNDARY
- GB WATER QUALITY CLASSIFICATION GOAL FOR GROUNDWATER (SEE NOTE 3)
- GA WATER QUALITY CLASSIFICATION GOAL FOR GROUNDWATER (SEE NOTE 4)
- SC/SB WATER QUALITY CLASSIFICATION GOAL FOR SURFACE WATER (SEE NOTE 5)

REFERENCE

APPROXIMATE WATER QUALITY GOAL GROUNDWATER BOUNDARY FROM THE DRAWING "ADOPTED WATER QUALITY CLASSIFICATIONS FOR THE THAMES, SOUTHEAST COAST, PAWCATUCK RIVER BASINS, CTDEP, WATER COMPLIANCE UNIT, DECEMBER 1986, SHEET 1 OF 2".



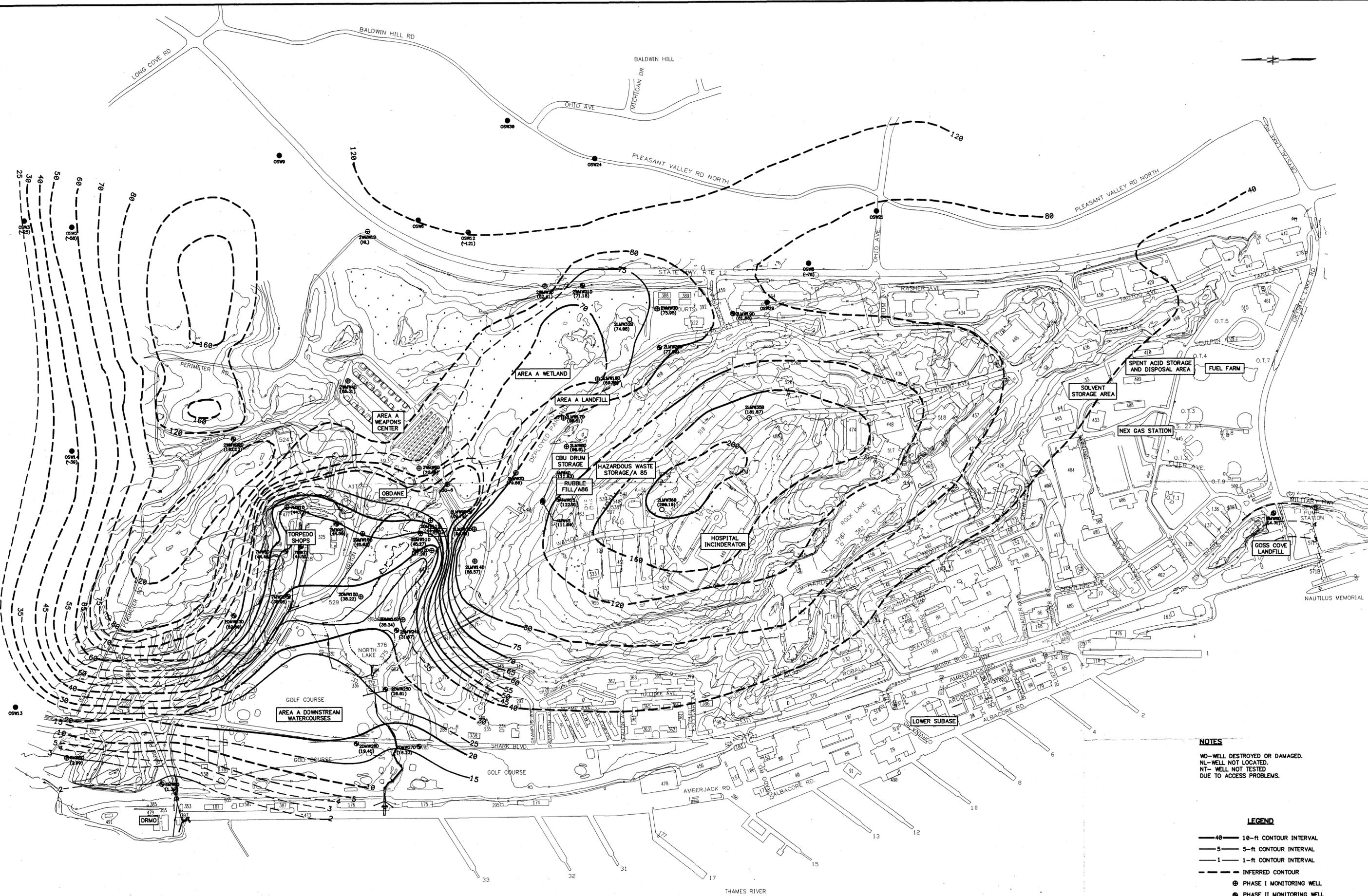
DEPARTMENT OF THE NAVY	NAVAL FACILITIES ENGINEERING COMMAND	REV. DESCRIPTION	PREP BY	DATE	APPROV
NAVAL SUBMARINE BASE, NEW LONDON	CROTON, CONNECTICUT				
NORTHERN DIVISION					
STUDY LOCATIONS, STUDY AREAS, SURROUNDING LAND USE AND CTDEP GROUNDWATER QUALITY CLASSIFICATION GOALS					
SEAL AREA					
SAT TO	DATE				
CODE I.D. NO.	80091				
SCALE:					
SPEC. NO. 04 -					
CONSTR. CONTR. NO.	N62472-				
NAVFAC DRAWING NO.					
SHEET	OF				
SIZE:	DIS. SH. NO.				
D	1				



- NOTES**
1. TOPOGRAPHIC CONTOURS ARE FROM NSB-NLON ENGINEERING DEPARTMENT.
- LEGEND**
- REGION BOUNDARIES

DEPARTMENT OF THE NAVY NAVAL SUBMARINE BASE, NEW LONDON		NAVAL FACILITIES ENGINEERING COMMAND GROTON, CONNECTICUT	
NORTHERN DIVISION TOPOGRAPHIC SURFACE AND REGION BOUNDARIES LOCATION MAP			
APPROVED SEAL AREA		APPROVED NORTH DIVISION COMMANDER, NAVFAC	
SAT TO	DATE	REV. DESCRIPTION	PREP BY DATE APPRV
CODE I.D. NO.	80091		
SCALE :			
SPEC. NO. 04 -			
CONSTR. CONTR. NO.	N62472 - C-		
NAVFAC DRAWING NO.			
SHEET OF	DIS. SH. NO.		
D	2		

TETRA TECH M.S., Inc.
 DR. MF
 SUPPLY CONTRACT NO. 4242
 SUBMITTED BY
 NORTH DIVISION
 DATE
 OFFICER IN CHARGE
 APPROVED



NOTES
 ND- WELL DESTROYED OR DAMAGED.
 NL- WELL NOT LOCATED.
 NT- WELL NOT TESTED
 DUE TO ACCESS PROBLEMS.

- LEGEND**
- 10' 10-ft CONTOUR INTERVAL
 - 5' 5-ft CONTOUR INTERVAL
 - 1' 1-ft CONTOUR INTERVAL
 - - - INFERRED CONTOUR
 - ⊕ PHASE I MONITORING WELL
 - ⊙ PHASE II MONITORING WELL
 - OFFSITE RESIDENTIAL WELL
 - FOCUSED FEASIBILITY STUDY MONITORING WELL

DEPARTMENT OF THE NAVY NAVAL SUBMARINE BASE, NEW LONDON	NORTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND GROTON, CONNECTICUT	REV. DESCRIPTION PREP BY DATE APPROV	Tera Tech LLC, Inc. DR: MF CHECKED: [Signature] SURVEYED BY: [Signature] (FIRM NUMBER) (TITLE) NO. [] HP. [] DIR. [] OFFICER IN CHARGE APPROVED DATE
BEDROCK GROUNDWATER POTENTIOMETRIC SURFACE MAP NOVEMBER 20, 1995		DATE APPROVED NORTH DIVISION FOR COMMANDER NAIFAC	
SEAL AREA		SAT TO DATE CODE I.D. NO. 80091 SCALE: SPEC. NO. 84 - CONSTR. CONTR. NO. N62472 - C- NAIFAC DRAWING NO.	
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2.0 SAMPLING AND ANALYSIS PLAN

This SAP discusses general sampling operations and procedures for the proposed sampling events to be performed at NSB-NLON. Details of the sampling events, including sample locations, sample analytes, and rationale are provided in the following sections.

2.1 FIELD OPERATIONS SUMMARY

The field operations will be divided into two phases. Phase 1 involves site characterization at Sites 16 and 18 to identify the possible presence of contamination in soil and groundwater; collection of shallow and deep soil samples at Site 7; and the installation and sampling of temporary groundwater monitoring wells at Sites 3, 7, 16, and 18. Results for groundwater samples from the temporary wells will be used to determine the location of the shallow and deep permanent well clusters at Sites 3 and 7, as necessary, to be installed during Phase 2.

Phase 2 also includes installing permanent monitoring wells at Site 23 and at background locations; collecting groundwater samples from new and existing wells at Sites 2, 3, 4, 7, 8, 14, 15, 20, 23, and background locations; measuring water levels and free-product thickness in existing and newly installed monitoring wells; and performing slug tests in wells at Sites 3, 7, and 23.

Table 2-1 summarizes the sampling activities and includes, for each sample, the sample identification number, test boring and monitoring well identifier, sample depth, analytical parameters, and sampling rationale. Sample depth is given as feet below ground surface (bgs) for soil samples. For groundwater samples, the aquifer in which the well is installed and the screened interval are given. Although not listed in Table 2-1, water quality parameters will be measured during the collection of groundwater samples from each monitoring well. Figures 2-1 through 2-10 show proposed soil boring, monitoring well, and temporary well locations for each site.

Soil samples for this RI will be collected from shallow depths (0 to 1 foot bgs) and deep depths (1 to 12 feet bgs or to the top of the water table). Soil samples will be collected using direct-push or hollow stem auger drilling techniques. Section 2.4.1 provides more information regarding the soil sampling methodology.

2.2 MOBILIZATION AND DEMOBILIZATION

Following approval of the WP and SAP, 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 FOL will coordinate the mobilization activities for this project. The equipment required for field activities will be mobilized from the TtNUS Pittsburgh, Pennsylvania warehouse to the site by the FOL and the field crew. TtNUS personnel will submit proposed soil boring and groundwater monitoring well location drawings to NSB-NLON engineering personnel for utility clearance purposes. These drawings will be submitted before staff and equipment are mobilized. The FOL will then mobilize to the site to mark the proposed drilling 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 drilling locations. The FOL, NSB-NLON personnel, and project manager will review and agree upon any locations that have to be moved due to access, utility, or logistic problems. Additionally, the FOL will arrange the hookup of a field trailer.

All field team members will review the WP, SAP, HASP, and QAPP 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 Pittsburgh warehouse.

2.3 SAMPLING LOCATIONS

2.3.1 Northern Region

The following sites in the Northern Region will be investigated during the Basewide Groundwater OU RI:

- Sites 1, 2A, 2B, and 4 – CBU Drum Storage Area, Area A Landfill, Area A Wetland, and Rubble Fill Area at Bunker A-86
- Site 3 – Area A Downstream Watercourses and OBDA
- Site 7 – Torpedo Shops
- Site 14 – OBDANE
- Site 20 – Area A Weapons Center

2.3.1.1 Site 1 – CBU Drum Storage Area, Site 2A – Area A Landfill, Site 2B – Area A Wetland, and Site 4 – Rubble Fill Area at Bunker A-86

Groundwater at these four sites in the Northern Region will be monitored under the Groundwater Monitoring Plan (GMP) for the Area A Landfill (TtNUS, 1999a). The purpose of the GMP is to evaluate the effectiveness of the completed interim remedial action (IRA) at the Area A Landfill and to assess whether contamination is migrating from the landfill to downgradient locations. The GMP requires quarterly groundwater sampling and analysis for TCL organics, TAL metals, TOC, TDS, chemical oxygen demand (COD), alkalinity, hardness, chlorides, and sulfates. Water quality parameters, including REDOX potential, pH, specific conductance, DO, and turbidity, will be measured in the field. Water levels in the monitoring wells will also be measured at the time of sampling.

The EDSR (TtNUS, 1999b) recommended that the groundwater data collected for these four sites under the GMP be used to evaluate groundwater conditions in conjunction with the Basewide Groundwater OU RI. As a result, one of the GMP quarterly sampling events and the Groundwater OU RI sampling event will be conducted simultaneously. Sampling locations are shown on Figure 2-1. The GMP contains specific information regarding the sample program rationale (TtNUS, 1999a).

2.3.1.2 Site 3 – Area A Downstream Watercourses and OBDA

The investigation at Site 3 will include installation of temporary and permanent (if necessary) monitoring wells and groundwater sampling for chemical analysis. Subsurface geochemical and hydrogeological data will also be collected to support groundwater modeling, natural attenuation evaluation, and a metals fate and transport study.

During Phase 1, a 300-foot by 300-foot sampling area will be established at Site 3 southwest of monitoring well 2DMW29S. This area will be oriented northwest to southeast, and initially 4 temporary monitoring wells will be installed. A second sampling area, also initially containing 4 temporary monitoring wells, measuring 100 feet by 500 feet will be established at Site 3 northeast of monitoring well cluster 2DMW15S/D. This area will also be oriented northwest to southeast. The sampling areas are shown on Figure 2-2 and were designed to address data gaps identified in the EDSR (TtNUS, 1999b) for Site 3 and the adjacent Site 7. The temporary wells that are bolded on Figure 2-2 will be installed and sampled first. The additional temporary wells shown on Figure 2-2 will be installed as necessary to determine the extent of contamination.

Temporary monitoring wells will be installed using direct-push methods in an effort to determine the source of the VOC contamination and the extent of the VOC plumes. Groundwater samples will be collected from each well using a peristaltic pump and analyzed for quick-turn TCL VOCs. The

investigation area will be expanded as necessary by locating additional monitoring wells based on the groundwater sample results, until the extent of the VOC contamination plume has been identified.

The analytical results from the temporary groundwater wells will be used to determine (if necessary) the location of permanent well clusters at Site 3. During Phase 2, approximately two to three well clusters, consisting of one overburden and one bedrock well each, may be installed within each sampling area to verify the migration of the VOC plume. Samples will be analyzed for TCL VOCs and natural attenuation parameters. The overburden wells will be installed using hollow-stem auger (HSA) methods. The bedrock wells will be installed using air rotary methods. The final permanent well cluster locations at Site 3 will be defined and approved by the Navy and regulators before Phase 2 fieldwork begins.

One bedrock monitoring well will be installed and sampled at the south end of the OBDA Pond. The monitoring well will be designated 3MW13D. The sample will be analyzed for TCL VOCs, TCL SVOCs, total and dissolved TAL metals, TCL pesticides, natural attenuation parameters, TSS, and TDS.

During Phase 2 of the RI, groundwater samples will also be collected from the existing groundwater monitoring wells at Site 3. The samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TCL pesticides, natural attenuation parameters, TSS, and TDS. Two samples will also be analyzed for dissolved TAL metals.

Historic data available for Site 3 indicate that groundwater modeling may be necessary. The necessary groundwater data, including chemical concentrations and TOC, will be obtained from the groundwater sampling effort. Soil samples will be collected from the overburden aquifer during well installation to obtain necessary soil data including TOC content, bulk density, pH, and porosity. One Shelby Tube sample will be collected from the boring for new permanent well 3MW14S.

Additional geochemical data will be collected to evaluate whether site-related contaminants are impacting the mobility of metals (arsenic, lead, and manganese) in the subsurface. Temperature, DO, REDOX potential, pH, salinity, turbidity, and specific conductivity of the groundwater in both the overburden and bedrock aquifers will be measured in the field. Groundwater samples will also undergo laboratory analysis for TSS and TDS.

Based on the available historic data, natural attenuation may be a viable remedial alternative for Site 3. Groundwater samples from every monitoring well will be analyzed for various groundwater parameters for use in this evaluation. Field parameters include DO, REDOX potential, pH, specific conductivity, temperature, divalent iron, and salinity. Laboratory parameters include TOC, chloride, methane, nitrate, sulfate, sulfide, ammonia, alkalinity, and hardness.

Water levels will be measured in each well at the beginning and end of the field effort. Slug tests will be performed in one overburden monitoring well (3MW14S) and one bedrock monitoring well (3MW13D). The slug tests are necessary to determine the hydraulic characteristics of the aquifers to support the groundwater modeling efforts.

2.3.1.3 Site 7 – Torpedo Shops

The investigation at Site 7 will include soil boring installation, temporary monitoring well installation, and soil and groundwater sampling and analysis. Subsurface geochemical and hydrogeological data will also be collected to support groundwater modeling, natural attenuation evaluation, and a metals fate and transport study.

During Phase 1, a sampling area, approximately 100 feet by 500 feet, adjacent to Triton Road, will be oriented northwest to southeast. The sampling area is shown on Figure 2-3 and was designed to address data gaps identified in the EDSR (TINUS, 1999b) for Site 7 and the adjacent Site 3. Temporary monitoring wells will be installed at seven locations using direct-push methods in an effort to determine the source of VOC contamination and the extent of the VOC plumes. Groundwater samples will be collected from each well using a peristaltic pump and analyzed for quick-turn TCL VOCs. Temporary monitoring wells will not be installed at locations near existing permanent monitoring wells.

Two soil borings will be installed using direct-push methods along the septic line extending to the south leach field. These soil borings are designated 7TB17 and 7TB18 and are shown on Figure 2-3. A subsurface soil sample will be collected from each soil boring and analyzed for TCL VOCs, TCL SVOCs, and TAL metals.

Three temporary monitoring wells (7TW8, 7TW9, and 7TW10) will also be installed along the septic line extending from north of Building 325 to the south leach field. A subsurface soil sample will be collected from each boring for each temporary well and analyzed for TCL VOCs, TCL SVOCs, and TAL metals. Groundwater samples will be collected from each well using a peristaltic pump and analyzed for TCL VOCs, TCL SVOCs, total TAL metals, ammonium perchlorate, TSS, TDS, and natural attenuation parameters.

During Phase 2 of the RI, groundwater samples will be collected from the existing groundwater monitoring wells at Site 7. The monitoring well samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, ammonium perchlorate, natural attenuation parameters, TSS, and TDS. Two samples will also be analyzed for dissolved TAL metals.

Based on the results of the groundwater sampling during Phase 2, one or two bedrock monitoring wells may have to be installed at Site 7. The wells will be installed using air rotary methods. The well locations at Site 7 will be defined and approved by the regulators prior to installation. Analytical parameters for groundwater samples collected from these wells will be determined based on the data obtained during Phase 2.

Historic data available for Site 7 indicate that groundwater modeling may be necessary at the site. The necessary groundwater data, including chemical concentrations and TOC will be obtained from the groundwater sampling effort. A soil sample will be collected from the overburden aquifer during well installation to obtain necessary soil data including TOC, bulk density, pH, and porosity. The Shelby Tube sample will be collected from the boring for temporary well 7TW1.

Additional geochemical data will be collected to evaluate whether site-related contaminants are impacting the mobility of metals (arsenic, lead, and manganese) in the subsurface. Temperature, DO, REDOX potential, pH, salinity, turbidity, and specific conductivity of the groundwater in both the overburden and bedrock aquifers will be measured in the field. Groundwater samples will undergo laboratory analysis for TSS and TDS.

Based on the available historic data, natural attenuation may be a viable remedial alternative for Site 7. Groundwater samples from every monitoring well will be analyzed for various groundwater parameters for use in this evaluation. Field parameters include DO, REDOX potential, pH, specific conductivity, temperature, divalent iron, and salinity. Laboratory parameters include TOCs chloride, methane, nitrate, sulfate, sulfide, ammonia, alkalinity, and hardness.

Water levels will be measured in each well at the beginning and end of the field effort. Slug tests will be performed in one overburden monitoring well (7MW1) and one bedrock monitoring well, if installed. The slug tests are necessary to determine the hydraulic characteristics of the aquifers to support the groundwater modeling efforts.

2.3.1.4 Site 14 – OBDANE

The investigation at Site 14 will require groundwater sampling at one existing well (14MW1S) for chemical analysis and measurement of water quality parameters.

During Phase 2, a groundwater sample will be collected at well 14MW1S using a peristaltic pump. The groundwater sample will be analyzed for TCL VOCs, total TAL metals, TSS, and TDS. The monitoring well to be sampled is shown on Figure 2-4.

Water levels will be measured in the well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will also be measured.

2.3.1.5 Site 20 – Area A Weapons Center

The investigation at Site 20 will include groundwater sampling for chemical analysis and geochemical and hydrogeologic data collection.

During Phase 2, groundwater samples will be collected from the existing monitoring wells using a peristaltic pump. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, perchlorate, TSS, and TDS. One sample will also be analyzed for dissolved TAL metals. The monitoring wells to be sampled are shown on Figure 2-5.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will be measured in all wells during the groundwater sampling effort.

2.3.2 Central Region

2.3.2.1 Site 16 – Hospital Incinerator

The Hospital Incinerator site has not been investigated. Therefore, the field investigation will include a data search and limited field sampling to provide a basic understanding of the site conditions.

The data search will include reviewing historic records of NSB-NLON to determine the site history, the operating parameters of the incinerator that was operated at two separate locations (A and B) at the site, and the waste that was incinerated. Base personnel will also be interviewed. TtNUS personnel conducted a site visit in April 1999 to determine the areas most likely to have been impacted by incinerator operation. The sampling locations shown on Figure 2-6 were selected based on the results of the site visit.

Soil borings 16TB1 through 16TB8 will be installed upgradient and downgradient of each of the two former incinerator locations during Phase 1 of this RI. A surface and subsurface soil sample will be collected from each boring. The samples will be analyzed for TCL VOCs, TCL SVOCs, TAL metals, TCL pesticides/PCBs, dioxins/furans, and SPLP extraction followed by PCB and metals analysis. The shallow soil samples will be collected from 0 to 1 foot bgs. An additional surface soil sample will be collected from

a drainage path south of Building 453. This sample will be analyzed for the same parameters as the other soil samples.

Four temporary monitoring wells will be installed upgradient and downgradient of the two locations of the incinerator using direct push methods. The groundwater samples will be collected using a peristaltic pump and analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TCL pesticides/PCBs, dioxins/furans, TSS, and TDS. The temporary wells will be designated 16TW1 through 16TW4.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will be measured in all wells during the groundwater sampling effort.

2.3.3 Southern Region

The following sites in the Southern Region will be investigated during the Basewide Groundwater OU RI:

- Site 8 – Goss Cove Landfill
- Site 15 – Spent Acid Storage and Disposal Area
- Site 18 – Solvent Storage Area (Building 33)
- Site 23 – Fuel Farm

2.3.3.1 Site 8 – Goss Cove Landfill

The investigation at Site 8 will include groundwater sampling for chemical analysis. Geochemical and hydrogeologic data will also be collected during groundwater sampling.

During Phase 2 of the RI, groundwater samples will be collected from the existing groundwater monitoring wells. The groundwater samples will be collected using a peristaltic pump and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total TAL metals, TSS, and TDS. One sample will also be analyzed for dissolved TAL metals. The monitoring wells to be sampled are shown on Figure 2-7.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will be measured in all wells during the groundwater sampling effort.

2.3.3.2 Site 15 – Spent Acid Storage and Disposal Area

The investigation at Site 15 will include groundwater sampling for chemical analysis and geochemical and hydrogeologic data collection.

Groundwater samples will be collected from the four existing groundwater monitoring wells during Phase 2 of the RI. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TSS, and TDS. The monitoring wells to be sampled are shown on Figure 2-8.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will be measured in all wells during the groundwater sampling effort.

2.3.3.3 Site 18 – Solvent Storage Area (Building 33)

The Solvent Storage Area (Building 33) site has not been investigated. Therefore, the field investigation will include a data search and limited field sampling to provide a basic understanding of the site conditions.

The data search will include reviewing historic records of NSB-NLON to determine the site history and the types of solvents or other chemicals that were stored at this site. Base personnel will also be interviewed. TtNUS personnel conducted a site visit in April 1999 to determine the areas most likely to have been impacted by the storage area. The sampling locations shown on Figure 2-9 were selected based on the results of the site visit.

Five soil borings will be installed around Building 33 during Phase 1 of the RI. These soil borings are designated 18TB1 through 18TB5. A surface and subsurface soil sample will be collected from each boring. The samples will be analyzed for TCL VOCs, TCL SVOCs, TAL metals, and TCL pesticides/PCBs. SPLP extraction followed by analysis for PCBs and metals will also be performed on the five soil samples. The shallow soil samples will be collected from 0 to 1 foot bgs.

Temporary monitoring wells will be installed on both the east and west sides of Building 33 for sampling purposes. The groundwater samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, and TCL pesticides/PCBs. The temporary wells will be designated 18TW1 and 18TW2.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH, will be measured in all wells during the groundwater sampling effort.

2.3.3.4 Site 23 – Fuel Farm

The investigation at Site 23 will include permanent monitoring well installation and groundwater sampling for chemical analysis. Geochemical and hydrogeologic data will also be collected to support groundwater modeling and a natural attenuation evaluation.

Site 12, the NEX Gas Station (Building 428), is located just north of Site 23. An AS/SVE system is currently in operation at Site 12 to remediate a groundwater plume. A portion of the AS/SVE system is within the Site 23 boundary because the groundwater at both sites is hydraulically connected, and contamination from Site 12 has impacted the groundwater at Site 23. Groundwater data from the groundwater monitoring program associated with the operation of the AS/SVE system will be incorporated into the Site 23 data and used to evaluate the site.

Two deep overburden wells will be installed just above the top of bedrock and sampled at Site 23 (Figure 2-10). One monitoring well (23MW02S) will be installed adjacent to well 23MW02D. The other proposed monitoring well (23MW04S) will be installed adjacent to well 23MW04D. The samples will be collected from each well using a peristaltic pump and analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TCL pesticides/PCBs, natural attenuation parameters, TSS, and TDS.

Groundwater samples will also be collected from select existing groundwater monitoring wells at Site 23 during Phase 2 of the RI. The existing overburden wells to be sampled include HNUS-2, HNUS-5, HNUS-7, HNUS-9, HNUS-11, HNUS-13, HNUS-14, HNUS-17, and HNUS-20. The existing bedrock wells to be sampled include 23MW02D, 23MW03D, and 23MW04D. The monitoring well samples will be analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TLC pesticides/PCBs, natural attenuation parameters, TSS, and TDS. One sample will also be analyzed for dissolved TAL metals.

Historic data available for Site 23 indicate that groundwater modeling may be necessary. The necessary groundwater data, including chemical concentrations and TOC, will be obtained from the groundwater sampling effort. Soil samples will be collected from the overburden aquifer during well installation to obtain necessary soil data including TOC content, bulk density, pH, and porosity. Samples will be collected from wells 23MW02S and 23MW04S.

Additional geochemical data will be collected to evaluate whether site-related contaminants are impacting the mobility of metals (arsenic, lead, and manganese) in the subsurface. Temperature, DO, REDOX potential, pH, salinity, turbidity, and specific conductivity of the groundwater in both the overburden and bedrock aquifers will be measured in the field. Groundwater samples will undergo laboratory analysis for TSS and TDS.

Based on the available historic data, natural attenuation may be a viable remedial alternative for Site 23. Groundwater samples from every monitoring well will be analyzed for various groundwater parameters for use in this evaluation. Field parameters include DO, REDOX potential, pH, specific conductivity, temperature, divalent iron, and salinity. Laboratory parameters include chloride, methane, nitrate, sulfate, sulfide, ammonia, alkalinity, and hardness.

Water levels will be measured in each well at the beginning and end of the field effort. Slug tests will be performed in the two new overburden monitoring wells (23MW02S and 23MW04S) and two existing bedrock monitoring wells (23MW02D and 23MW04D). The slug tests are necessary to determine the hydraulic characteristics of the aquifers to support groundwater modeling efforts.

2.3.4 Background

During Phase 2 of the RI, three shallow monitoring wells (2WMW22S, 2LMW35S, and 23MW01S) will be installed using HSA methods at areas representative of background conditions as shown on Figure 1-15. Groundwater samples will also be collected from 12 existing groundwater monitoring wells representative of background conditions. The existing monitoring wells to be sampled include 2LMW20S, 2WMW21S, 2WMW21D, 2WMW22D, 4MW1S, 2LMW35B, 2LMW36B, 23MW01D, HNUS-23, 8MW8S, 8MW8D, and 8MW10S.

The samples will be collected using a peristaltic pump and analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, dissolved and total TAL metals, TSS, TDS, and chloride. Background levels of chloride are necessary to determine if dechlorination is occurring at any of the sites due to natural attenuation. Two rounds of sampling and analysis will be performed to provide a sufficiently large data set for determining background concentrations. Background wells will be sampled at the beginning of the Phase 2 field effort, and then again at the end.

Water levels will be measured in each well at both the beginning and end of the field effort. Water quality parameters, including DO, REDOX potential, temperature, specific conductivity, and pH will be measured in all wells during the groundwater sampling effort.

2.4 INVESTIGATION METHODOLOGIES AND TECHNIQUES

2.4.1 Direct-Push Methods

Soil borings and temporary wells will be completed during Phase 1 of the investigation by direct-push methods. A Geoprobe™ or other similar direct-push technology will be used to collect shallow and deep

soil samples during Phase 1 and to install temporary groundwater monitoring wells (Section 2.4.1.1). 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. HSA drilling methods will be used at locations where permanent monitoring wells are to be installed.

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 below the concrete or asphalt surface to the top of the water table using a macro-core sampler and in accordance with procedures outlined in TtNUS SOP SA-1.3 (Appendix B). 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 photoionization detector (PID) or flame ionization detector (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 onto TtNUS boring logs (Appendix A). Soil samples will be collected and logged in accordance with procedures outlined in TtNUS SOP SA 1.3 (Appendix B).

Subsurface soil samples will be collected for laboratory analysis at Sites 7, 16, and 18. Surface soil samples will be collected at Sites 16 and 18. The surface soil sample will be collected from a depth of 0 to 1 foot bgs, and the subsurface soil sample will be collected from a depth greater than 1 foot 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.

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, one soil sample will be collected from across the water table-unsaturated soil interface.

Saturated, subsurface soil samples will also be collected at Sites 3 and 7. These samples will be analyzed for modeling parameters (TOC, pH, bulk density, and porosity). A Shelby Tube will be collected to determine bulk density and porosity.

All borings will be backfilled with bentonite chips and patched with neat cement, cold-patch asphalt, or soil at grade. 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 2.7.

2.4.1.1 Temporary Groundwater Monitoring Wells

During Phase 1 of the RI, 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 Direct Push Technology (DPT). A GeoProbe[®] or similar DPT will be used to advance 2-inch outside diameter macrocore samplers 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 macrocore 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) will be used to advance the boring to the required depth.

The macrocore sampler will be removed from the borehole and a temporary PVC well will be installed. Figure 2-11 shows a typical temporary monitoring well. 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 0.010 inches to minimize the introduction of formation particles into the well. The well screen will be plugged 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) 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.

Each temporary well will be developed by repeatedly pumping the well, creating drawdown, then allowing the well to recover thus causing a surging effect. 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. If a sand pack and bentonite seal is installed, the wells will be developed after waiting approximately 12 hours after installation is complete. 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 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.

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.

2.4.2 Hollow-Stem Augering and Permanent Monitoring Well Drilling and Installation

Permanent overburden monitoring wells will be installed during Phase 2 of the RI. The monitoring wells will be installed using HSA drilling techniques in accordance with TtNUS SOPs GH-1.3 and GH-2.8 (Appendix B) with the following exception. A secondary sand filter pack will be used during monitoring well installation in place of the normal bentonite seal specified in SOP GH-2.8. The use of the filter pack is necessary because the monitoring wells will be installed across the groundwater table, and the bentonite seal will be above the water table and could become dehydrated, shrink, or crack, rendering it ineffective. Furthermore, the effectiveness of bentonite may be reduced in groundwater that contains several classes of contaminants (i.e., xylene, acetone, acetic acid, aniline, ethylene glycol, methanol heptane, some chlorinated solvents, and some petroleum hydrocarbons).

A secondary filter pack is a layer of material placed in the annulus between the primary filter pack and the cement-bentonite grout. The secondary filter pack should be uniformly graded fine sand with 100 percent by weight passing the No. 30 U.S. Standard sieve, and less than 2 percent by weight passing the 200

U.S. Standard sieve. The secondary filter pack will be unaffected by high total dissolved solids, high chloride content, or the class of contaminants.

Continuous split-spoon sampling will be performed at each proposed monitoring well location in accordance with methods outlined in TtNUS SOP SA-1.3 (Appendix B). The purpose of performing continuous split-spoon sampling is to identify potential zones of contamination, collect soil samples for field screening with a PID/FID, and characterize the soil stratigraphy. Vapors from the split-spoon samples will be monitored with a PID/FID meter. Results of the vapor monitoring will be recorded on boring logs.

HSAs will have a minimum 4-1/4-inch inside diameter (ID) to accommodate installation of casing, sand pack, and well seal materials. A 2-foot-long, 2-inch-ID split-spoon sampler will be used for sampling.

Saturated, subsurface soil samples will also be collected at Site 23 from the borings for wells 23MW02S and 23MW04S. These samples will be analyzed for modeling parameters (TOC, pH, bulk density and porosity). A Shelby Tube will be collected from each location to determine bulk density and porosity.

All monitoring wells will be constructed of 2-inch-ID flush jointed PVC riser pipe and 10-foot-long PVC slotted screens. Clean sand (No. 20 to 30 U.S. Standard Sieve size) will be filled in the annulus from 6 inches below the well screen, around the well screen, and up to 3 feet above the top of the screen. A secondary sand filter pack (total thickness of 2 feet) will be installed above the sand as described above. The remaining annular space will be backfilled with a cement-bentonite grout. Each monitoring well will be equipped with a slightly raised flush-mounted surface steel protective casing with a neat Portland cement pad.

All field-related data will be recorded by a TtNUS geologist on boring log forms and in the field logbook dedicated to this project. Examples of field forms are provided in Appendix A. At a minimum, the boring logs will note the sample numbers and types, sample depths, standard penetration data, sample recovery interval, soil density or cohesiveness, soil color and moisture, Unified Soil Classification System (USCS) material description, and organic vapor information. Well completion details will also be recorded on TtNUS forms. This information will include borehole diameter, type and diameter of casing, total installation depth, screen elevation, sand filter pack elevation, seal elevation, and type of protective casing.

All drilling equipment will be steam cleaned before the field investigation begins, steam cleaned between each borehole to prevent cross-borehole contamination, and steam cleaned prior to leaving the site.

2.4.3 Air Rotary Bedrock Monitoring Well Drilling and Installation

Bedrock monitoring wells will be constructed of 6-inch-diameter steel casing with open borehole monitoring intervals (i.e., unscreened). Each 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. If a sufficient seal cannot be made, then a 2-inch PVC monitoring well will be installed inside of the casing. Bentonite will be used inside of the casing to seal off the bedrock aquifer from the overburden aquifer.

An 8-inch or 10-inch-diameter borehole will be advanced through the overburden and approximately 5 feet into competent bedrock using air rotary 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 to 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 advanced using a 5-7/8-inch-diameter air hammer to the first water-bearing fracture with approximately 1 gallon per minute flow rate (as estimated by drilling fluids) or 20 feet below the bedrock surface, whichever is greater. After well installation, clean sand or pea gravel will be backfilled above the annular seal to approximately 6 inches bgs.

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

2.4.4 Permanent Monitoring Well Development

Each newly installed permanent monitoring well will be developed at least 12 hours after the installation is completed. The purpose of well development is to remove sediments from inside the casing and within the sand filter that surrounds the well screen.

The overburden monitoring wells will be developed using a stainless-steel submersible or polypropylene Waterra pump. 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 bedrock monitoring wells will be developed using air jetting or surging. Development will proceed until the discharged water is visibly clear.

Well development information for each monitoring well will be recorded on well development sheets (Appendix A). The sequence for developing the groundwater monitoring wells at this site will proceed from anticipated background and upgradient locations to known or suspected contaminated areas. This sequence will be used to minimize the potential for cross-well contamination.

2.5 GROUNDWATER MONITORING WELL SAMPLING

This section provides guidance for the proper equipment and techniques for groundwater sample collection. All groundwater sampling shall be conducted in accordance with USEPA Region I SOP GW001 and TtNUS SOP SA-1.1 (Appendix B).

2.5.1 Water-Level and Product Thickness Measurements

Water-level and product thickness measurements will be obtained at each existing and newly installed monitoring well location to be sampled. 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 A).

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.

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. Water-level measurements and monitoring well evaluations will be performed in accordance with procedures outlined in TtNUS SOP GH-1.2 (Appendix B).

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 the manufacturer's operations manual. Calibration records will be recorded daily on TtNUS equipment calibrations sheets as per TtNUS SOP SA-6.3 (Appendix B).

2.5.2 Monitoring Well Purging and Groundwater Sampling

Groundwater monitoring wells will be purged immediately before sampling using low-flow purging methods. 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 pump with Teflon® 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. Pharmaceutical-grade silicon tubing will be used in the rotaries of the peristaltic pump. The 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, DO, REDOX potential, salinity, and turbidity will be measured at 3- to 5-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 indicator field parameter values 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, 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 ± 0.1 units
- specific conductivity, 3 percent
- temperature, 3 percent
- DO, 10 percent
- REDOX, ± 10 millivolts
- turbidity, 10 percent for values greater than 10 NTU

If the groundwater quality parameters do not stabilize at nontidally influenced wells within 4 hours and the water level has not been drawn down more than 0.3 feet, then the sample will be collected and the lack of stabilization will be noted in the field notes.

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. SVOC and total metals samples will be transferred directly from the peristaltic pump tubing to the container. Groundwater samples collected for dissolved metals analysis will be dissolved in the field prior to preservation with nitric acid (HNO_3). VOC samples will be collected from the inlet end of the tubing. The discharge end of the tubing will be crimped while filled. The inlet end of the tubing will then be removed from the well and suspended above the sample bottle. Each sample bottle will be filled by gravity flow. 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 2-2.

The groundwater samples will be analyzed for a variety of parameters including TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total and dissolved metals, natural attenuation parameters, TSS, TDS, ammonium perchlorate, and dioxins/furans. Natural attenuation and 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. Divalent iron will be measured in the field using a Hach kit Model IR-18C. Laboratory analysis will be performed for the following natural attenuation parameters: alkalinity, chlorides, dissolved sulfate, nitrates, TOC, hardness, sulfide, ammonia, and dissolved methane.

One ambient blank will be collected per medium sampled per sampling event. One source water blank will be collected per type of source water used for decontaminating sampling equipment. One duplicate sample will be collected per 10 units of a medium sampled. One trip blank will be shipped with each container of VOC samples, and one equipment rinsate blank will be collected per day of sampling. One equipment rinsate blank per dedicated sampling device type will also be collected during the RI. A summary of the QA/QC sample requirements is provided in Table 2-3.

Sampling chain-of-custody requirements are addressed in Section 2.13. 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 A.

2.6 SLUG TESTS

Slug tests will be performed at Sites 3, 7, and 23 to determine the hydraulic characteristics of the overburden and bedrock aquifers. General procedures, data acquisition, and data analysis methods are described in TtNUS SOP GH-2.4, provided in Appendix B.

Before the slug test is performed, the static water level and well construction details must be recorded. Both rising head and falling head tests can be performed either by inserting a solid slug into the well to raise water levels, then measuring the rate of decline in water level, or by removing a slug of water and measuring the rate the water level rises back to equilibrium. The change in water level should be induced as quickly as possible because the analysis assumes an instantaneous change in head. Falling head tests cannot be performed where the water level is within the screened interval. In addition, because slug tests are very sensitive to borehole skin effects, the well must be developed properly in order to obtain accurate data.

Slug test data will be collected using an electronic data logger with pressure transducer or an electronic water level indicator. To facilitate data graphing, the loggers will be programmed to record measurements on a logarithmic time scale. It is ideal to record water level data to at least 90 percent recovery in the well before terminating the test. The resulting plot of time versus head ratio (the head at a given time divided by the initial head) on semilog paper should approximate a straight line. The test should be rerun if data scatter is excessive or if a straight-line approximation is not obtained.

Raw data from the data loggers or field records are used to calculate hydraulic conductivity values in the immediate vicinity of the well screen or open borehole. The data will be analyzed using one or more of the following three methods:

- Hvorslev Method - rapid straight-line method for partially penetrating well screens
- Bouwer and Rice Method - rigorous straight-line method for complex well geometries
- Cooper et al Method - type-curve method for low permeability aquifers

The above methods can be analyzed relatively simply by hand. However, the Bouwer and Rice method and the Cooper et al method may also be analyzed using the AQTESOLV Computer Program (Geraghty & Miller, Inc., 1994).

2.7 FIELD MEASUREMENTS

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, measuring groundwater natural attenuation/water quality parameters, and measuring surface water quality parameters. The following instruments are anticipated to be used during the field activities:

- FID or PID
- YSI 6820 with data logger
- Turbidity meter (LaMonte)
- Electronic water-level meter
- Hach Model IR-18C, Divalent Iron Kit

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 A). 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.

2.8 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. The sampling equipment may include split-spoon and macrocore samplers, a

submersible pump or a 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.

2.9 INVESTIGATION DERIVED WASTE

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 placed in Department of Transportation (DOT)-approved 55-gallon steel drums. The PPE will be disposed of by an IDW disposal subcontractor. The drums will be labeled with the facility name, zone number, and address, the type of contents, the date the container was filled, and the name and phone number of the party responsible for disposal.

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, zone 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 a soil sample from each drum 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, steel drums or a large portable tank and temporarily stored at a Navy-designated location. If 55-gallon drums are used, 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 a liquid sample from each drum or the portable tank at the completion of the field operations. The results of the analysis 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.

2.10 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 SPCS NAD 1983 horizontal control and the 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.

2.11 SAMPLE HANDLING PROCEDURES

Sample handling includes the field-related considerations for the sample identification system, sample packaging, sample custody, quality control samples, and recordkeeping. The sample containers, preservatives, allowable holding times, and analyses are summarized in Table 2-2.

2.12 SAMPLE IDENTIFICATION SYSTEM

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

Soil Sample: S7SB0010201

S7 – Site 7
SB - Soil Boring
001 - Sampling Location
02 – Macrocore Sampler Number
01 - Round 1 for Basewide Groundwater OU RI

Groundwater Sample: S7GW7MW101 (permanent well)

S7 – Site 7
GW - Groundwater
7MW1 - Existing well identification number
01 - Round 1 for Basewide Groundwater OU RI

Groundwater Sample: S3GW3TW101 (temporary well)

S3 – Site 3
GW - Groundwater
3TW1 – Temporary well identification number
01 - Round 1 for Basewide Groundwater OU RI

2.13 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with TtNUS SOP SA-6.1 (Appendix B). 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

Groundwater samples collected during Phase 1 will be analyzed using either a 24-hour quick-turn turnaround time (VOCs at Sites 3 and 7 only) or a standard 21-day turnaround time (all other samples). Media sampled during Phase 2 will be analyzed using a standard 21-day laboratory turnaround time.

2.14 SAMPLE CUSTODY

Custody of samples must be maintained and documented at all times as per TtNUS SOP SA-6.1 (Appendix B). Chain-of-custody begins with the collection of samples in the field. A sample chain-of-custody record is provided in Appendix A.

2.15 FIELD QUALITY CONTROL SAMPLES

Several types of QC samples will be collected or generated during environmental sampling activities. QC samples include ambient blanks, field duplicates, equipment rinseate blanks, source water blanks, and trip blanks. Section 2.5.3 of this document presents the type and frequency of collection required for QC samples. The QC samples required for the project are summarized in Table 2-3. The five types of field QC samples are defined as follows:

Ambient Blanks. Ambient blanks are collected to check for background contamination during a sampling event. A minimum of one ambient blank will be collected per matrix during the RI. If ambient conditions change during the sampling event, then additional ambient blanks will be prepared and analyzed for each change. The need for additional ambient blanks will be determined by the FOL. Field personnel prepare ambient blanks by filling the sample containers with laboratory-grade deionized water while under typical sampling conditions.

Field Duplicates. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Field duplicates will be collected at a frequency of 10 percent per sampling matrix. Duplicates shall be analyzed by the laboratory for the same parameters as their environmental sample counterparts.

Equipment Rinsate Blanks. Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through decontaminated sample collection equipment (bailer, split-spoon, etc.). Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. One equipment rinsate blank will also be collected from each dedicated sampling device for this RI. Equipment rinsate blanks will be analyzed for the same suite of analytical parameters as the associated environmental samples and will be collected in the appropriate sample containers.

Source Water Blank - Source water blanks are collected to assess the presence of contamination in the water used to decontaminate the sampling equipment. Field personnel prepare source water blanks. One source water blank is to be collected for each type of decontamination water (deionized water, tap water, etc.) used during this sampling event.

Trip Blanks. Trip blanks are included when analyzing for VOCs will be prepared and provided by the subcontract laboratory. Trip blanks will remain with the sample containers at all times and are thus subjected to the same field conditions as the field samples. One trip blank will be included in every shipping cooler that contains samples for VOC analyses, regardless of sample matrix.

2.16 RECORDKEEPING

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 B). 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, TtNUS 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.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
GROUNDWATER MONITORING PLAN FOR THE AREA A LANDFILL - SITE 1, SITE 2A, SITE 2B, and SITE 4				
Groundwater Samples				
2LGW3MW37S ⁽¹⁾	3MW37S	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater downgradient of the western portion of the landfill.
2LGW2WMW38DS ⁽¹⁾	2WMW38DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater downgradient of the western portion of the landfill.
2LGW2WMW39DS ⁽¹⁾	2WMW39DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW40DS ⁽¹⁾	2WMW40DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW41DS ⁽¹⁾	2WMW41DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW42DS ⁽¹⁾	2WMW42DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
2LGW2WMW43DS ⁽¹⁾	2WMW43DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW44DS ⁽¹⁾	2WMW44DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW45DS ⁽¹⁾	2WMW45DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW46DS ⁽¹⁾	2WMW46DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.
2LGW2WMW47DS ⁽¹⁾	2WMW47DS	OVERBURDEN	VOCs, SVOCs, metals, TOC, TSS, TDS, COD, alkalinity, hardness, chlorides, sulfates	Monitor groundwater along wetland boundary.

SITE 3 – AREA A DOWNSTREAM WATERCOURSES AND OBDA

Soil Samples

S3SB3MW14S01	3MW14S	TBD	TOC, Bulk Density, pH, Porosity	Determine TOC, Bulk Density, pH, and porosity in overburden aquifer for use in groundwater modeling.
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Groundwater Samples

S3GW3TW101	3TW1	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW201 (Tentative)	3TW2	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW3TW301 (Tentative)	3TW3	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW401	3TW4	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW501 (Tentative)	3TW5	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW601 (Tentative)	3TW6	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW701 (Tentative)	3TW7	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW801 (Tentative)	3TW8	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW901 (Tentative)	3TW9	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1001	3TW10	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1101 (Tentative)	3TW11	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1201 (Tentative)	3TW12	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1301 (Tentative)	3TW13	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1401 (Tentative)	3TW14	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1501	3TW15	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1601 (Tentative)	3TW16	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.

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TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW3TW1701	3TW17	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1801 (Tentative)	3TW18	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW1901	3TW19	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2001 (Tentative)	3TW20	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2101 (Tentative)	3TW21	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2201	3TW22	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2301 (Tentative)	3TW23	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2401 (Tentative)	3TW24	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2501	3TW25	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2601	3TW26	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2701 (Tentative)	3TW27	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.
S3GW3TW2801 (Tentative)	3TW28	OVERBURDEN	VOCs – quick turn	Determine lateral extent and source of VOC contamination.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW3MW13D01	3MW13D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination at OBDA pond.
S3GW3MW14S01	3MW14S	OVERBURDEN	VOCs, natural attenuation parameters	Determine lateral extent of VOC contamination.
S3GW3MW14D01	3MW14D	BEDROCK	VOCs, natural attenuation parameters	Determine lateral and vertical extent of VOC contamination.
S3GW3MW15S01	3MW15S	OVERBURDEN	VOCs, natural attenuation parameters	Determine lateral extent of VOC contamination.
S3GW3MW15D01	3MW15D	BEDROCK	VOCs, natural attenuation parameters	Determine lateral and vertical extent of VOC contamination.
S3GW3MW16S01	3MW16S	OVERBURDEN	VOCs, natural attenuation parameters	Determine lateral extent of VOC contamination.
S3GW3MW16D01	3MW16D	BEDROCK	VOCs, natural attenuation parameters	Determine lateral and vertical extent of VOC contamination.
S3GW3MW17S01	3MW17S	OVERBURDEN	VOCs, natural attenuation parameters	Determine lateral extent of VOC contamination.
S3GW3MW17D01	3MW17D	BEDROCK	VOCs, natural attenuation parameters	Determine lateral and vertical extent of VOC contamination.
S3GW3MW18S01	3MW18S	OVERBURDEN	VOCs, natural attenuation parameters	Determine lateral extent of VOC contamination.
S3GW3MW18D01	3MW18D	BEDROCK	VOCs, natural attenuation parameters	Determine lateral and vertical extent of VOC contamination.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW2DMW10D01	2DMW10D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW11S01	2DMW11S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW11D01	2DMW11D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW3MW12S01	3MW12S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination. Note: analytical data from this sample will also be used to evaluate groundwater at the Area A Landfill.
S3GW3MW12D01	3MW12D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination. Note: analytical data from this sample will also be used to evaluate groundwater at the Area A Landfill.
S3GW2DMW15D01	2DMW15D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW16S01	2DMW16S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW2DMW16D01	2DMW16D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW23D01	2DMW23D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW24S01	2DMW24S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW24D01	2DMW24D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW25S01	2DMW25S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW25D01	2DMW25D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW26S01	2DMW26S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S3GW2DMW26D01	2DMW26D	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW27S01	2DMW27S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW27D01	2DMW27D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination
S3GW2DMW28S01	2DMW28S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW28D01	2DMW28D	BEDROCK	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral and vertical extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW29S01	2DMW29S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.
S3GW2DMW30S01	2DMW30S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, natural attenuation parameters, TSS, TDS	Determine lateral extent of VOC, SVOC, metals, and pesticide contamination.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
SITE 7 – TORPEDO SHOPS				
Soil Samples				
S7SB0170201	7TB17	TBD	VOCs, SVOCs, metals	Determine the absence or presence of subsurface soil contamination.
S7SB0180201	7TB18	TBD	VOCs, SVOCs, metals	Determine the absence or presence of subsurface soil contamination.
S7SBT7W801	7TW8	TBD	VOCs, SVOCs, metals	Determine the absence or presence of subsurface soil contamination.
S7SB7TW901	7TW9	TBD	VOCs, SVOCs, metals	Determine the absence or presence of subsurface soil contamination.
S7SB7TW1001	7TW10	TBD	VOCs, SVOCs, metals	Determine the absence or presence of subsurface soil contamination.
S7SB7TW101	7TW1	TBD	TOC, Bulk Density, pH, porosity	Determine TOC, Bulk Density, pH, and porosity in overburden aquifer for use in groundwater modeling.
Groundwater Samples				
S7GW7TW101	7TW1	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW201	7TW2	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW301	7TW3	OVERBURDEN	VOC-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW401	7TW4	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW501	7TW5	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW601	7TW6	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.

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SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S7GW7TW701	7TW7	OVERBURDEN	VOCs-quick turn	Determine lateral extent and source of VOC contamination.
S7GW7TW801	7TW8	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7TW09	7TW9	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7TW10	7TW10	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW1D01	7MW1D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW2S01	7MW2S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW2D01	7MW2D	BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW3S01	7MW3S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.

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TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S7GW7MW3D01	7MW3D	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW4S01	7MW4S	BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW5S01	7MW5S	OVERBURDEN/ BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW5D01	7MW5D	BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW6S01	7MW6S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW7S01	7MW7S	BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GW7MW8S01	7MW8S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S7GW7MW9S01	7MW9S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW10S01	7MW10S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GW7MW11S01	7MW11S	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GWB325MW101	B325-MW1	OVERBURDEN/ BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GWB325MW201	B325-MW2	BEDROCK	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S7GWB325MW301	B325-MW3	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.
S7GWB325MW401	B325-MW4	OVERBURDEN	VOCs, SVOCs, metals, natural attenuation parameters, perchlorate, TSS, TDS	Determine the lateral extent of groundwater contamination.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
SITE 14 – OBDANE				
Groundwater Samples				
S14GW14MW1S01	14MW1S	OVERBURDEN	VOCs, metals, TSS, TDS	Determine the extent of groundwater contamination.
SITE 20 – AREA A WEAPONS CENTER				
Groundwater Samples				
S20GW2WCMW1S01	2WCMW1S	OVERBURDEN	VOCs, SVOCs, metals, perchlorate, TSS, TDS	Determine the nature of groundwater contamination.
S20GW2WCMW2S01	2WCMW2S	OVERBURDEN	VOCs, SVOCs, metals, perchlorate, TSS, TDS	Determine the nature of groundwater contamination.
S20GW2WCMW3S01	2WCMW3S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), perchlorate, TSS, TDS	Determine the nature of groundwater contamination.
S20GW2WMMW4D01	2WMMW4D	BEDROCK	VOCs, SVOCs, metals, perchlorate, TSS, TDS	Determine the nature of groundwater contamination.
SITE 16 – HOSPITAL INCINERATORS				
Soil Samples				
S16SB0010101	16TB1	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0010201	16TB1	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0020101	16TB2	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S16SB0020201	16TB2	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0030101	16TB3	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0030201	16TB3	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0040101	16TB4	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0040201	16TB4	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0050101	16TB5	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0050201	16TB5	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0060101	16TB6	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP	Determine the absence or presence of subsurface soil contamination.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
			PCBs and metals	
S16SB0060201	16TB6	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0070101	16TB7	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0070201	16TB7	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0080101	16TB8	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SB0080201	16TB8	TBD	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S16SS0010101	16SS1	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, SPLP PCBs and metals	Determine the absence or presence of contamination in a storm water drainage path.
Groundwater Samples				
S16GW16TW101	16TW1	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, TSS, TDS	Determine the absence or presence of groundwater contamination.

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TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
 NSB-NLON, GROTON, CONNECTICUT
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Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S16GW16TW201	16TW2	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, TSS, TDS	Determine the absence or presence of groundwater contamination.
S16GW16TW301	16TW3	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, TSS, TDS	Determine the absence or presence of groundwater contamination.
S16GWT16W401	16TW4	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, dioxins/furans, TSS, TDS	Determine the absence or presence of groundwater contamination.

SITE 8 – GOSS COVE LANDFILL

Groundwater Samples

S8GW8MW101	8MW1	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW2S01	8MW2S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW2D01	8MW2D	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW301	8MW3	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW401	8MW4	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW5S01	8MW5S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.

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TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 17 OF 23

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S8GW8MW6S01	8MW6S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW6D01	8MW6D	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW7S01	8MW7S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.
S8GW8MW9S01	8MW9S	BEDROCK	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the lateral extent of groundwater contamination.

SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA

Groundwater Samples

S15GW15MW1S01	15MW1S	OVERBURDEN	VOCs, SVOCs, metals, TSS, TDS	Determine the lateral extent of groundwater contamination.
S15GW15MW1D01	15MW1D	OVERBURDEN	VOCs, SVOCs, metals, TSS, TDS	Determine the lateral and vertical extent of groundwater contamination.
S15GW15MW2S01	15MW2S	OVERBURDEN	VOCs, SVOCs, metals, TSS, TDS	Determine the lateral extent of groundwater contamination.
S15GW15MW3S01	15MW3S	OVERBURDEN	VOCs, SVOCs, metals, TSS, TDS	Determine the lateral extent of groundwater contamination.

SITE 18 – SOLVENT STORAGE AREA (BUILDING 33)

Soil Samples

S18SB0010101	18TB1	0 to 1 100	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
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TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 18 OF 23**

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S18SB0010201	18TB1	TBD	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0020101	18TB2	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0020201	18TB2	TBD	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0030101	18TB3	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0030201	18TB3	TBD	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0040101	18TB4	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0040201	18TB4	TBD	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0050101	18TB5	0 to 1	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.
S18SB0050201	18TB5	TBD	VOCs, SVOCs, metals, pesticides, PCBs, SPLP PCBs and metals	Determine the absence or presence of subsurface soil contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 19 OF 23**

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
Groundwater Samples				
S18GW18TW101	18TW1	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the absence or presence of groundwater contamination.
S18GW18TW201	18TW2	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS	Determine the absence or presence of groundwater contamination.
SITE 23 – FUEL FARM				
Soil Samples				
S23SB23MW02S01	23MW2S	TBD	TOC, Bulk Density, pH, porosity	Determine TOC, Bulk Density, pH, porosity in overburden aquifer for use in groundwater modeling.
S23SB23MW04S01	23MW04S	TBD	TOC, Bulk Density, pH, porosity	Determine TOC, Bulk Density, pH, porosity in overburden aquifer for use in groundwater modeling.
Groundwater Samples				
S23GW23MW02S01	23MW02S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GW23MW02D01	23MW02D	BEDROCK	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GW23MW03D01	23MW03D	BEDROCK	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine lateral extent of groundwater contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 20 OF 23**

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S23GW23MW04S01	23MW04S	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GW23MW04D01	23MW04D	BEDROCK	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS201	HNUS-2	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS501	HNUS-5	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS701	HNUS-7	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS901	HNUS-9	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS1101	HNUS-11	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 21 OF 23**

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S23GWHNUS1301	HNUS-13	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS1401	HNUS-14	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS1701	HNUS-17	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.
S23GWHNUS2001	HNUS-20	OVERBURDEN	VOCs, SVOCs, metals, pesticides, PCBs, TSS, TDS, natural attenuation parameters	Determine the lateral extent of groundwater contamination.

BACKGROUND SAMPLES

Groundwater

NORTHERN REGION				
S2GW2LMW20S01	2LMW20S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S2GW2WMW21S01	2WMW21S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.

TABLE 2-1

**SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 22 OF 23**

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
S2GW2WMW21D01	2WMW21D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S2GW2WMW22S01	2WMW22S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S2GW2WMW22D01	2WMW22D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S4GW4MW1S01	4MW1S	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS	Determine the background groundwater conditions.
CENTRAL REGION				
S2GW2LMW35S01	2LMW35S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS	Determine the background groundwater conditions.
S2GW2LMW35B01	2LMW35B	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS	Determine the background groundwater conditions.
S2GW2LMW36B01	2LMW36B	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS	Determine the background groundwater conditions.

TABLE 2-1

SUMMARY OF SAMPLING ACTIVITIES
NSB-NLON, GROTON, CONNECTICUT
PAGE 23 OF 23

Sample I.D.	Sample Location	Sample Depth (ft)	Analytical Parameters	Sample Rationale
SOUTHERN REGION				
S23GW23MW01S01	23MW01S	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S23GW23MW01D01	23MW01D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S23GWHNUS2301	HNUS-23	OVERBURDEN	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S8GW8MW8S01	8MW8S	OVERBURDEN/ BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S8GW8MW8D01	8MW8D	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.
S8GW8MW10S01	8MW10S	BEDROCK	VOCs, SVOCs, metals (total and dissolved), pesticides, PCBs, TSS, TDS, chlorides	Determine the background groundwater conditions.

1 A two-digit numeric round indicator (01, 02, etc.) will be added to these sample identification numbers in the field, based on which round of the GMP is performed concurrently with the sampling for the Basewide Groundwater OU RI.

TBD – To be determined

TABLE 2-2

**ANALYTICAL METHODS, BOTTLE REQUIREMENTS, PRESERVATIVE REQUIREMENTS, AND HOLDING TIMES
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3**

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 ⁽⁴⁾
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 ⁽⁴⁾
Polyaromatic Hydrocarbons (PAHs)	Amber glass, Teflon-lined cap	1000 mL	Cool to 4 °C	7 days to extraction; 40 days to analysis	SW846 8310 ⁽⁹⁾
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 ⁽⁴⁾
TAL Metals (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	ILM04.0 ⁽⁵⁾
TOC	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4 °C, HCL or H ₂ SO ₄ to pH < 2	28 days to analysis	EPA Method 415.1 ⁽⁶⁾
Alkalinity (as CaCO ₃)	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4 °C	14 days to analysis	EPA Method 310.1 ⁽⁶⁾
Hardness (as CaCO ₃)	Polyethylene bottle, plastic cap, plastic liner	250 mL	HNO ₃ to pH < 2	180 days to analysis	EPA Method 130.1 ⁽⁶⁾
Sulfate Nitrate Chloride	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4 °C	48 hours to analysis	EPA Method 375.4 ⁽⁶⁾ EPA Method 353.2 ⁽⁶⁾ EPA Method 325.3 ⁽⁶⁾
Methane	Septated serum vial	(2) 30 mL	HCL to pH < 2	14 days to analysis	EPA RSK SOP-175 ⁽⁷⁾
Sulfide	Polyethylene bottle, plastic cap, plastic liner	1000 mL	Cool to 4 °C, NaOH to pH > 12	7 days to analysis	EPA Method 376.2 ⁽⁶⁾
Ammonia	Polyethylene bottle, plastic cap, plastic liner	1000 mL	Cool to 4 °C, H ₂ SO ₄ to pH < 2	28 days to analysis	EPA Method 350.1 ⁽⁶⁾
Perchlorate	Lab will specify	Lab will specify	Cool to 4 °C	28 days to analysis	California Method ⁽⁸⁾
Dioxins/Furans	Amber glass, Teflon-lined lid	(4) 1000 mL	Cool to 4 °C	30 days to extraction; 45 days to analysis	SW846 8290 ⁽⁹⁾
TSS	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4 °C	7 days to analysis	EPA Method 160.2 ⁽⁶⁾
TDS	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4 °C	7 days to analysis	EPA Method 160.2 ⁽⁶⁾
COD	Amber glass, Teflon-lined lid	1000 mL	Cool to 4 °C, HCL to pH < 2	28 days to analysis	EPA Method 410.1 ⁽⁶⁾

TABLE 2-2

**ANALYTICAL METHODS, BOTTLE REQUIREMENTS, PRESERVATIVE REQUIREMENTS, AND HOLDING TIMES
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3**

Parameter	Sample Container ⁽¹⁾	Container Volume	Preservation ⁽²⁾	Maximum Holding Time ⁽³⁾	Analytical Methodology
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 5035/8260B ⁽⁹⁾
TCL SVOCs (minus PAHs)	Glass, Teflon-lined cap	8 oz ⁽¹⁰⁾	Cool to 4 °C, dark	14 days to extraction; 40 days to analysis	SW846 8270C ⁽⁹⁾
PAHs	Glass, Teflon-lined cap	8 oz.	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8310 ⁽⁹⁾
TCL Pesticides	Glass, Teflon-lined cap	8 oz ⁽¹⁰⁾	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8081A ⁽⁹⁾
TCL PCBs	Glass, Teflon-lined cap	8 oz ⁽¹⁰⁾	Cool to 4 °C	14 days to extraction; 40 days to analysis	SW846 8082 ⁽⁹⁾
TAL Metals	Glass, Teflon-lined cap	8 oz ⁽¹⁰⁾	Cool to 4 °C	180 days to analysis; except mercury 28 days to analysis	ILM04.0 ⁽⁵⁾
Synthetic Precipitation Leaching Procedure (SPLP) PCBs	Glass, Teflon-lined cap	8 oz.	Cool to 4 °C	14 days to extraction, 14 days to method 8082 extraction; 40 days to analysis	SW846 1312/8082
SPLP Metals	Glass, Teflon-lined cap	8 oz.	Cool to 4 °C	180 days to extraction; 180 days to analysis	SW846 1312/6010B
Dioxins/Furans	Glass, Teflon-lined cap	4 oz.	Cool to 4 °C	30 days to extraction; 45 days to analysis	SW846 8290 ⁽⁸⁾
Bulk Density	Shelby Tube	3 in diameter by 36 in length ⁽¹¹⁾	None required	None required	ASTM D2937-94 ⁽¹²⁾
pH	Wide-mouthed jar, Teflon-lined cap	8 oz ⁽¹⁰⁾	Cool to 4 °C, dark	Analyze as soon as possible	SW846 9045C ⁽⁹⁾
Porosity	Shelby Tube	3 in diameter by 36 in length ⁽¹¹⁾	None required	None required	Porosity calculated using specific gravity of soils [ASTM D854-98 ⁽¹²⁾] and moisture content [ASTM D2216-98 ⁽¹²⁾]
TOC	Glass, Teflon-lined cap	4 oz.	Cool to 4 °C	28 days to analysis	SW846 9060 ⁽⁹⁾

TABLE 2-2

ANALYTICAL METHODS, BOTTLE REQUIREMENTS, PRESERVATIVE REQUIREMENTS, AND HOLDING TIMES
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

- 1 Container volume may vary based on laboratory.
- 2 HCL = Hydrochloric acid, NaOH = Sodium hydroxide, HNO₃ = Nitric acid, H₂SO₄ = Sulfuric acid.
- 3 All holding times are from date of collection.
- 4 USEPA (U.S. Environmental Protection Agency) CLP, 1994. Statement of Work for Organic Analysis, Low-Concentration, OLC02.1.
- 5 USEPA CLP, Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration, ILM04.0.
- 6 USEPA, 1983. Methods for Chemical Analysis of Water and Wastes.
- 7 USEPA, R.S. Kerr Environmental Laboratory, B.S. Newell, Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, Revision No. 0, August 1994.
- 8 State of California, California Department of Health Services, June 3, 1997. Determination of Perchlorate by Ion Chromatography, Rev. 0.
- 9 USEPA, June 14, 1997. Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW846) Third Edition, up to and including Update III.
- 10 For soil samples, a single 8-ounce jar will provide sufficient sample volume for semivolatile organics, pesticides, PCBs, metals, and pH analyses.
- 11 A single Shelby tube will provide sufficient sample volume for both bulk density and porosity analyses.
- 12 American Society for Testing and Materials, Volume 4.08, Soil and Rock.

TABLE 2-3

**SUMMARY OF QA/QC SAMPLES AND ANALYSIS
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2**

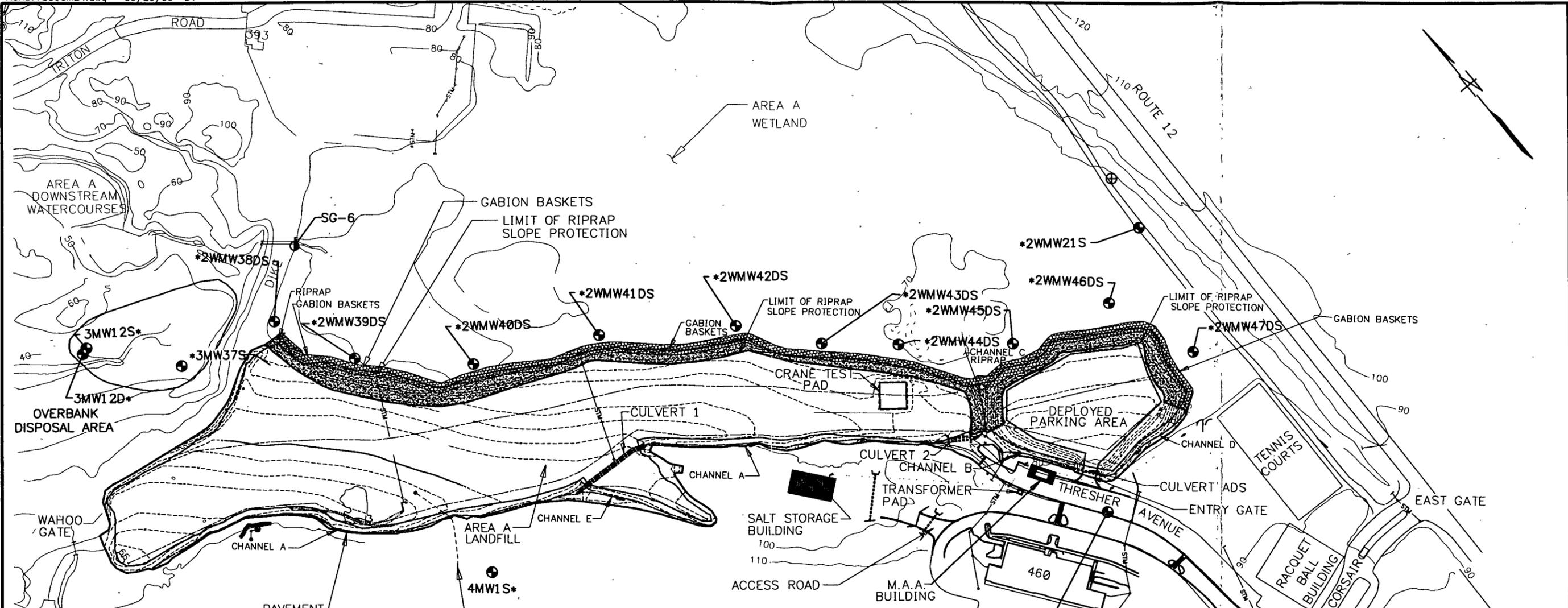
Analysis	Method	Environmental Samples	Field Duplicates	Trip Blanks ⁽¹⁾	Rinsate Blanks	MS/MSD Samples	Source Blanks ⁽²⁾	Ambient Blank ⁽³⁾	Totals
GROUNDWATER									
TCL VOC-Low Conc. (quick turn)	CLP OLC02.1	35 ⁽⁴⁾	0	TBD ⁽⁵⁾	NA ⁽⁶⁾	NA	TBD	TBD	35+
TCL VOC-Low Conc.	CLP OLC02.1	138	14	TBD	TBD	8	TBD	TBD	160+
TCL SVOC (minus PAHs)	CLP OLC02.1	125	13	NA	TBD	7	TBD	TBD	145+
PAHs	SW846 8310	125	13	NA	TBD	7	TBD	TBD	145+
TCL Pesticides	CLP OLC02.1	85	9	NA	TBD	5	TBD	TBD	99+
TCL PCBs	CLP OLC02.1	63	7	NA	TBD	4	TBD	TBD	74+
Dioxins/Furans	SW846 8290	4	1	NA	TBD	1	TBD	TBD	6+
TAL Metals (total)	CLP ILM04.0	126	13	NA	TBD	7	TBD	TBD	146+
TAL Metals (dissolved)	CLP ILM04.0	38	4	NA	TBD	3	TBD	TBD	45+
Perchlorate	California Method	25	3	NA	TBD	2	TBD	TBD	30+
TSS	EPA 160.2	126	13	NA	TBD	NA	TBD	TBD	139+
TDS	EPA 160.1	126	13	NA	TBD	NA	TBD	TBD	139+
Natural Attenuation	See footnote ⁽⁷⁾	70	7	NA	TBD	NA	TBD	TBD	77+
Chloride	EPA 325.3	11	2	NA	TBD	NA	TBD	TBD	13+
TOC	EPA 415.1	14	2	NA	TBD	NA	TBD	TBD	16+
COD	EPA 410.1	14	2	NA	TBD	NA	TBD	TBD	16+
Alkalinity	EPA 310.1	14	2	NA	TBD	NA	TBD	TBD	14+
Hardness	EPA 130.1	14	2	NA	TBD	NA	TBD	TBD	16+
Sulfate	EPA 375.4	14	2	NA	TBD	NA	TBD	TBD	16+
Field Parameters ⁽⁸⁾	TiNUS SOP SA. 1-1	134	NA	NA	NA	NA	NA	NA	134
SOIL									
TCL VOC	SW846 8260B	29	3	TBD	TBD	2	TBD	TBD	34+
TCL SVOC (minus PAHs)	SW846 9270C	29	3	NA	TBD	2	TBD	TBD	34+
PAHs	SW846 8310	29	3	NA	TBD	2	TBD	TBD	34+
TCL Pesticides	SW846 8081A	27	3	NA	NA	2	TBD	TBD	32+
TCL PCBs	SW846 8082	27	3	NA	NA	2	TBD	TBD	32+

TABLE 2-3

**SUMMARY OF QA/QC SAMPLES AND ANALYSIS
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2**

Analysis	Method	Environmental Samples	Field Duplicates	Trip Blanks ⁽¹⁾	Rinsate Blanks	MS/MSD Samples	Source Blanks ⁽²⁾	Ambient Blank ⁽³⁾	Totals
Dioxins/Furans	SW846 8290	17	2	NA	TBD	2	TBD	TBD	21+
TAL Metals	CLP ILM04.0	29	3	NA	TBD	2	TBD	TBD	32+
SPLP PCBs	SW846 1312/8082	27	3	NA	NA	NA	TBD	TBD	30+
SPLP Metals	SW846 1312/6010B	27	3	NA	NA	NA	TBD	TBD	30+
TOC	SW846 9060	6	1	NA	NA	NA	TBD	TBD	7+

- 1 Trip blanks will be generated at a frequency of one per cooler containing samples for VOC analysis. All trip blanks will be analyzed for low-concentration VOCs (OLC02.1).
- 2 Source water blanks will be generated at a rate of one per decontamination water source (e.g., deionized and potable water).
- 3 Number of ambient blanks will be determined on site depending on conditions during sampling (e.g., organic vapors, exhaust, the presence of windy and dusty conditions), with a minimum of one ambient blank being collected during the investigation.
- 4 No QA/QC samples will be collected for the quick-turn analyses.
- 5 TBD-To Be Determined; rinsate blanks will be generated at a minimum rate of one per day of sampling per matrix. If pre-cleaned, dedicated, or disposable equipment is used, one rinsate blank per type of equipment used will be collected as a "batch blank."
- 6 NA-Not Applicable.
- 7 Samples that require analysis for natural attenuation parameters will be analyzed for the following: TOC (EPA 415.1), alkalinity (EPA 310.1), hardness (EPA 130.1), chloride (EPA 325.3), nitrate (EPA 353.2), sulfate (EPA 375.4), sulfide (EPA 376.2), ammonia (EPA 350.1), and methane (EPA RSKSOP-175). Additional field parameters for natural attenuation include oxidation-reduction (REDOX) potential and divalent iron.
- 8 Field parameters include temperature, pH, specific conductivity, turbidity, salinity, and dissolved oxygen.



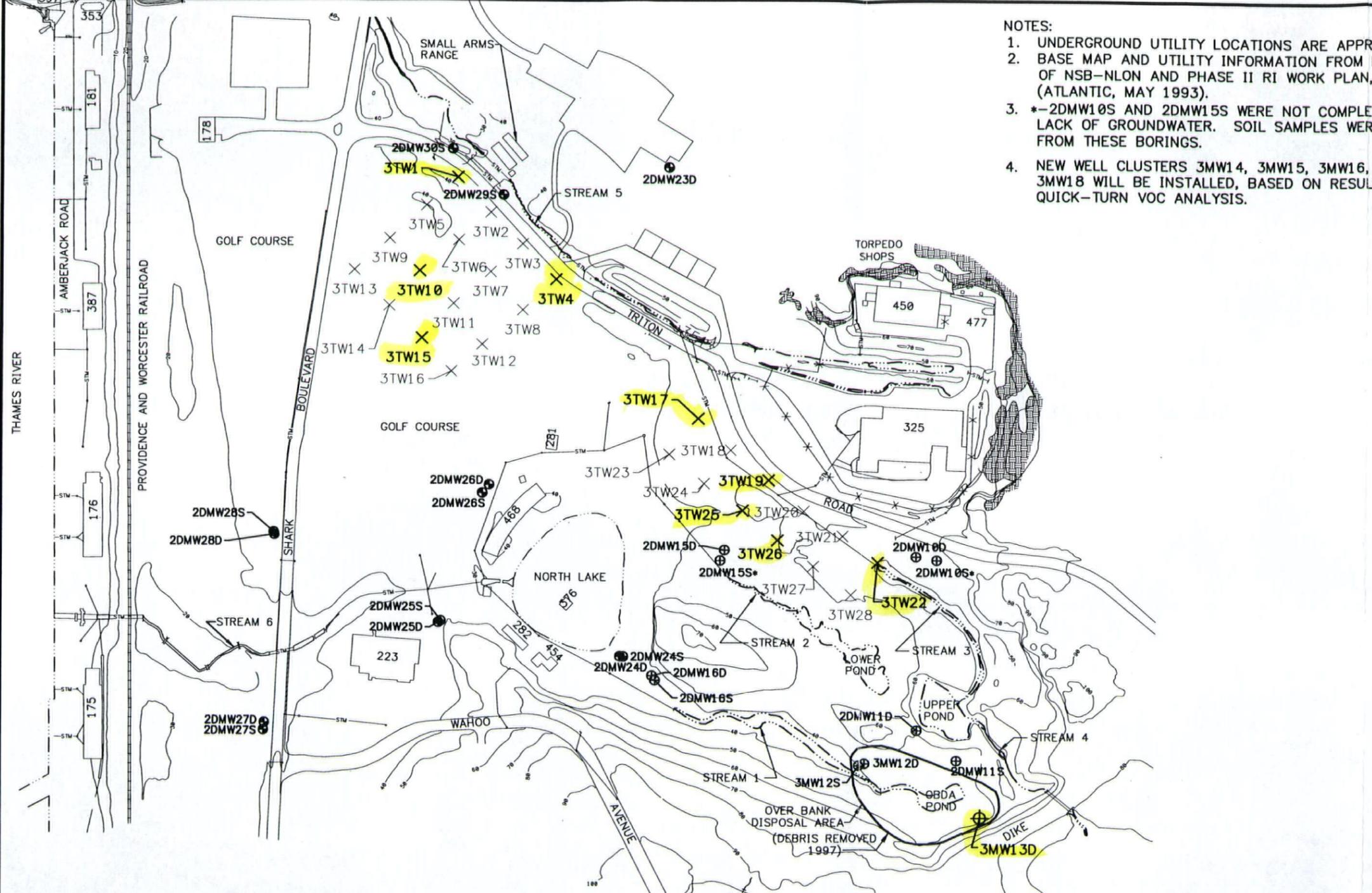
LEGEND

- MONITORING WELL
- STAFF GAUGE

NOTE:
1. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN (ATLANTIC, MAY 1993).

0 200 400
SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	Tetra Tech NUS, Inc. MONITORING LOCATIONS SITE 2 - AREA A LANDFILL NSB-NLON GROTON, CONNECTICUT	CONTRACT NO.	OWNER NO.	
							MF	8/17/98		7856	312	
							CHECKED BY	DATE		APPROVED BY	DATE	
							COST/SCHED-AREA			<i>Cory A. Paul</i>	6/30/99	
							SCALE	AS NOTED	APPROVED BY	DATE	DRAWING NO.	REV.
											FIGURE 2-1	1

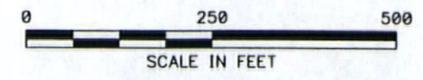


- NOTES:
1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
 2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN, (ATLANTIC, MAY 1993).
 3. *-2DMW10S AND 2DMW15S WERE NOT COMPLETED DUE TO A LACK OF GROUNDWATER. SOIL SAMPLES WERE COLLECTED FROM THESE BORINGS.
 4. NEW WELL CLUSTERS 3MW14, 3MW15, 3MW16, 3MW17, AND 3MW18 WILL BE INSTALLED, BASED ON RESULTS OF THE QUICK-TURN VOC ANALYSIS.



LEGEND

- × PROPOSED TEMPORARY WELL POINT
- 3TW1
- ⊕ PROPOSED DEEP MONITORING WELL
- ⊕ 2DMW25D EXISTING MONITORING WELL
- ⊕ 2DMW26D PHASE II MONITORING WELL
- 10- EXISTING CONTOUR
- 123 BUILDING No.
- WATERCOURSE
- STM-□ STORM SEWER AND CATCH BASIN
- ⊕ EXPOSED BEDROCK
- ×× FENCE



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

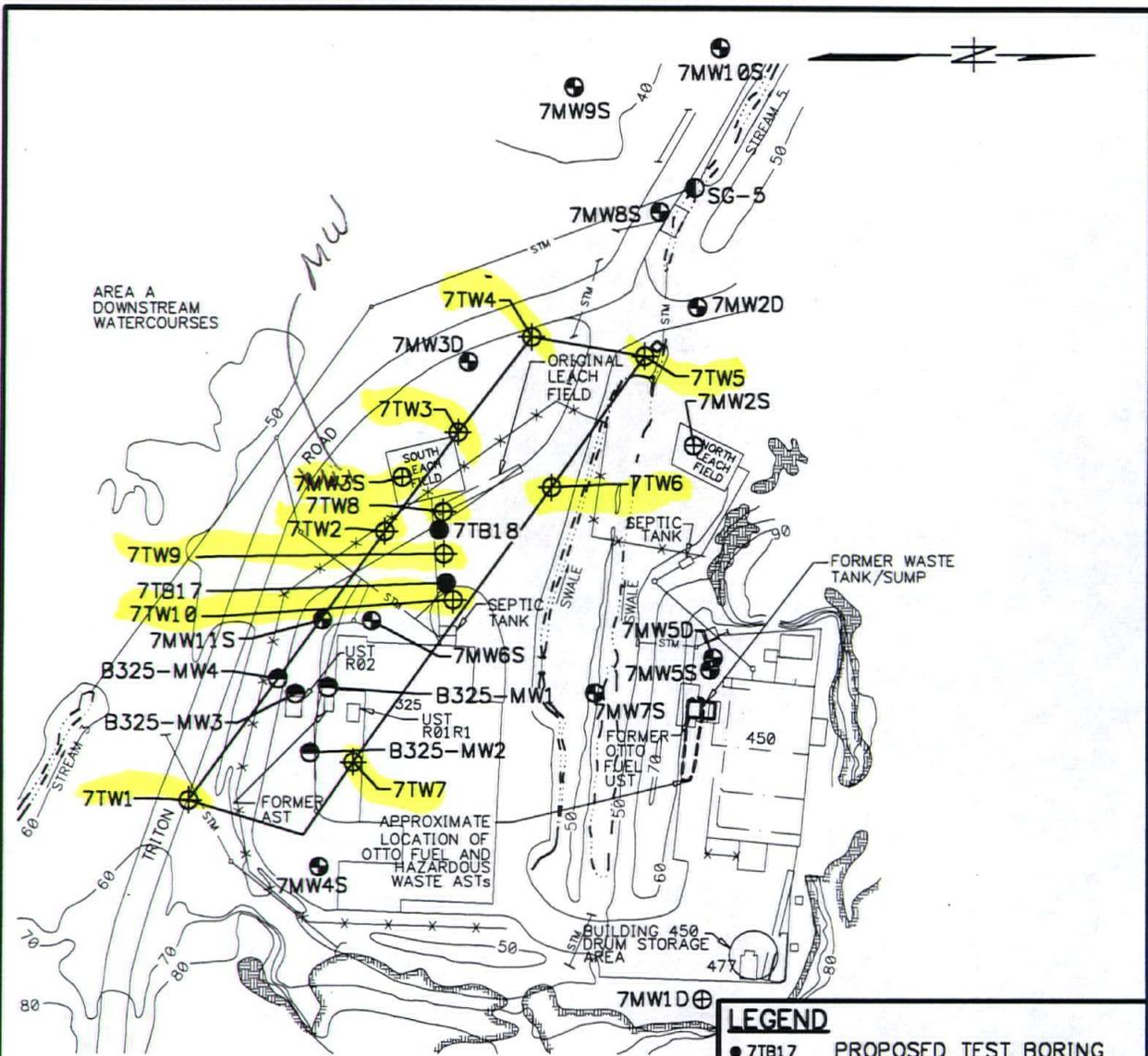
DRAWN BY	HJP	DATE	10/29/98
CHECKED BY		DATE	
COST/SCHED-AREA			
SCALE	AS NOTED		

Tetra Tech NUS, Inc.

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

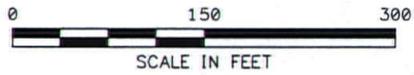
CONTRACT NO.	7856	OWNER NO.	312
APPROVED BY	<i>[Signature]</i>	DATE	6/30/99
APPROVED BY		DATE	
DRAWING NO.	FIGURE 2-2	REV.	0

ACAD: 7856GM17.dwg 06/25/99 HJP



NOTES:

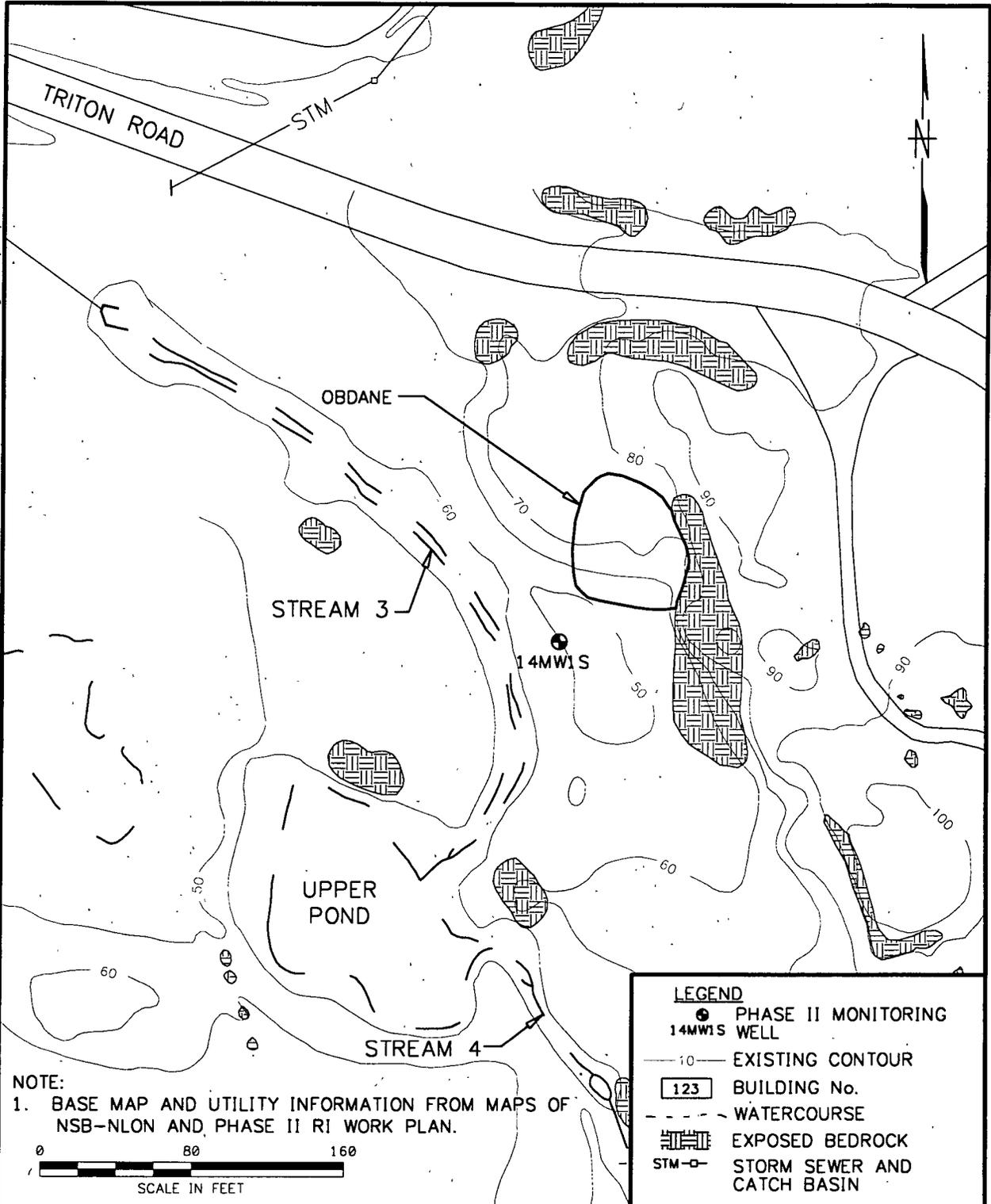
1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.



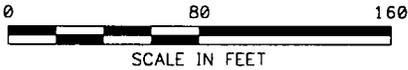
LEGEND	
● 7TB17	PROPOSED TEST BORING
⊕ 7TW1	PROPOSED TEMPORARY WELL POINT
⊕ 7MW2S	PHASE I MONITORING WELL
⊕ 7MW7S	PHASE II MONITORING WELL
⊕ B325-MW1	SITE CHARACTERIZATION MONITORING WELL
⊕ SG-5	PHASE II STAFF GAUGE
— 10 —	EXISTING CONTOUR
123	BUILDING No.
— — — —	WATERCOURSE
— STM — □	STORM SEWER AND CATCH BASIN
	EXPOSED BEDROCK
* *	FENCE

DRAWN BY HJP DATE 10/28/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY DATE	SAMPLE LOCATION MAP SITE 7-TORPEDO SHOPS NSB-NLON, GROTON, CONNECTICUT	APPROVED BY <i>Greg A. Riel</i>	DATE 6/28/99
COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 2-3	REV. 0

ACAD:7856GM09.dwg 06/30/99 DT



NOTE:
 1. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.



LEGEND	
	PHASE II MONITORING WELL 14MW1S
	EXISTING CONTOUR
	BUILDING No. 123
	WATERCOURSE
	EXPOSED BEDROCK
	STM - STORM SEWER AND CATCH BASIN

DRAWN BY DATE
 HJP 10/28/98

Tetra Tech NUS, Inc.

CONTRACT NO.
 7856

OWNER NO.
 312

CHECKED BY DATE

APPROVED BY *Greg A. Paul* DATE 6/30/99

COST/SCHED-AREA

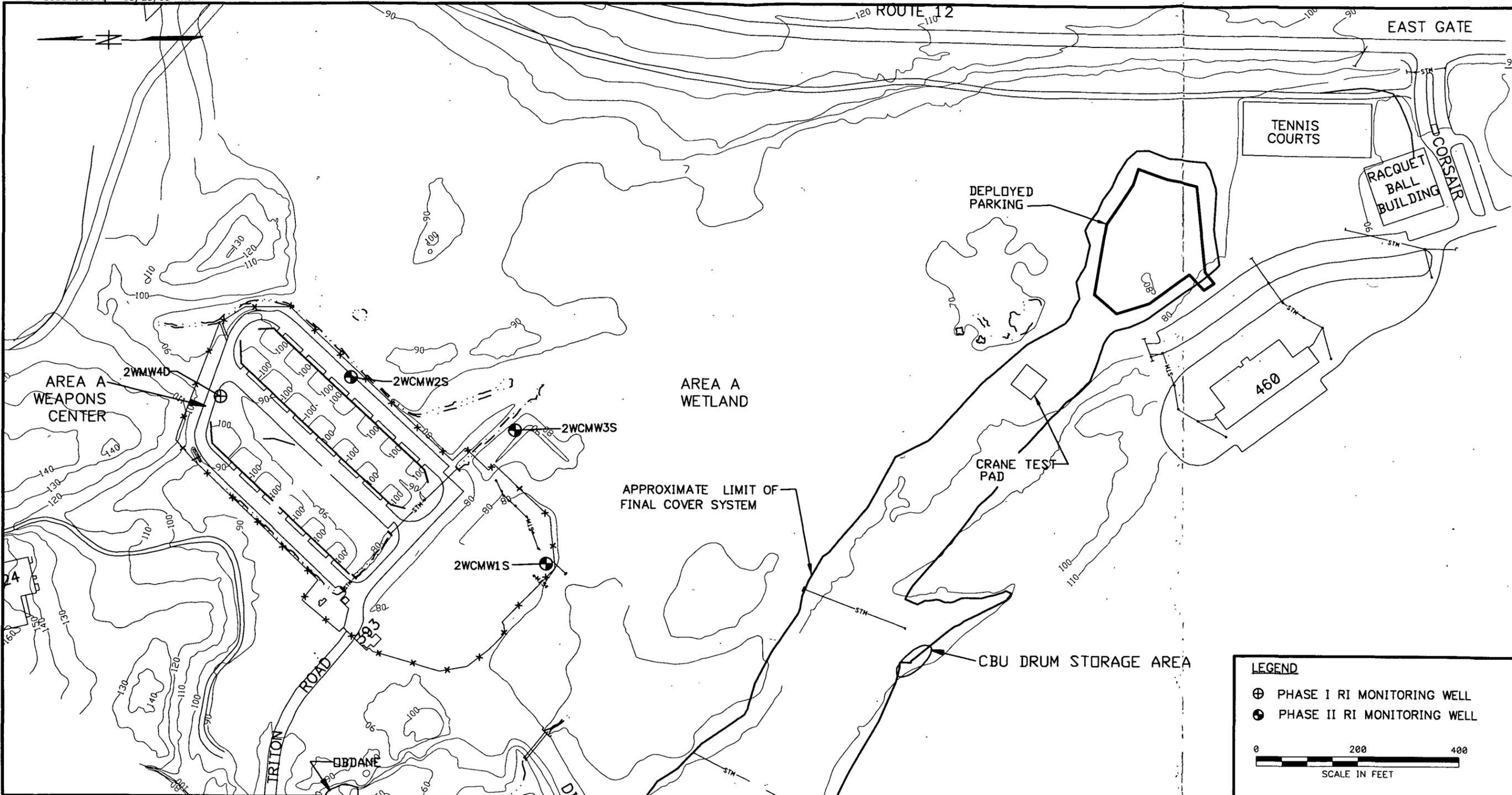
APPROVED BY DATE

SCALE AS NOTED

SAMPLE LOCATION MAP
 SITE 14-OBDA NE
 NSB-NLON, GROTON, CONNECTICUT

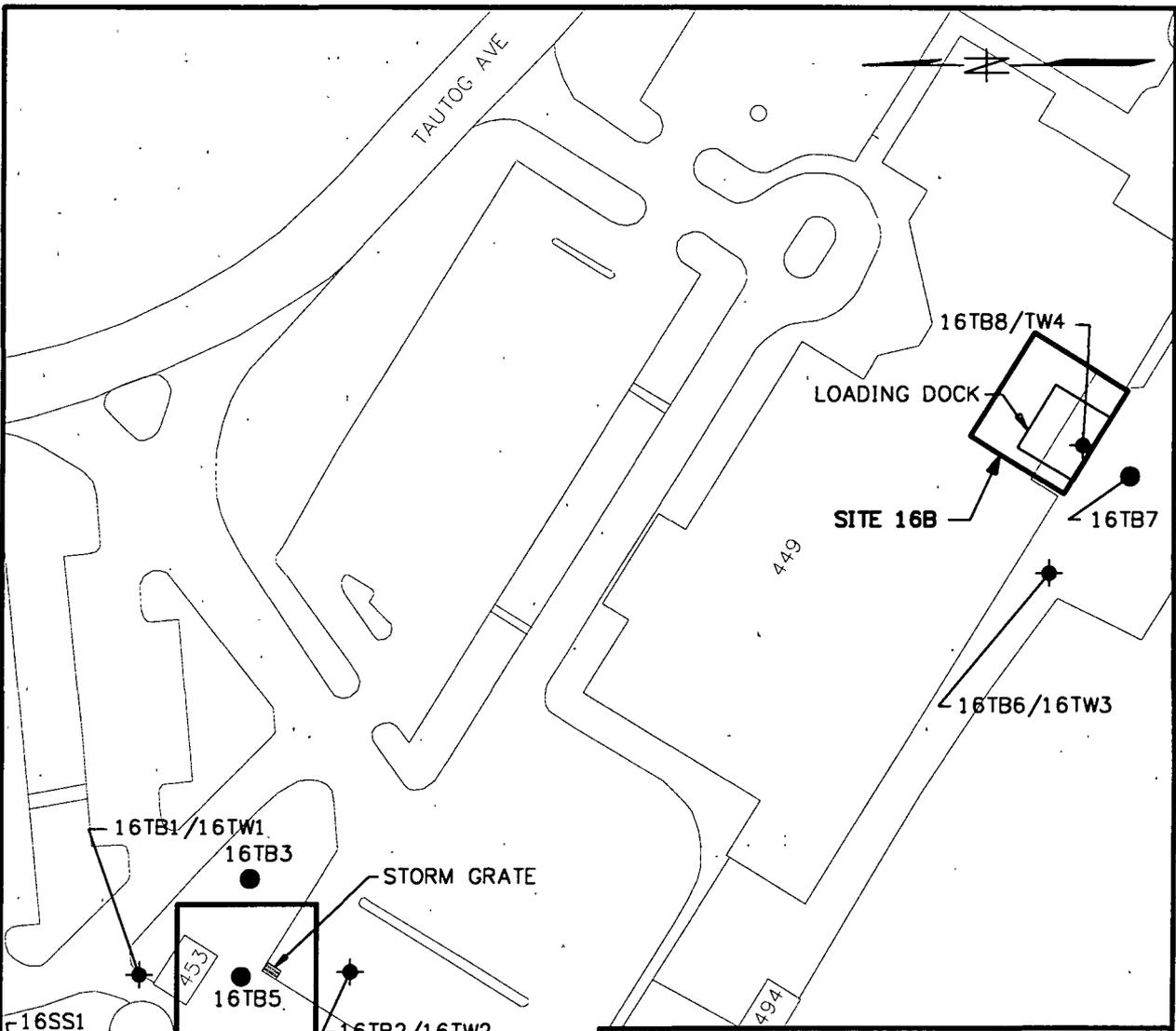
DRAWING NO. FIGURE 2-4

REV: 0



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NO.	OWNER NO.
							HJP	10/28/98		7856	312
							CHEKED BY	DATE	APPROVED BY	DATE	
							AMS	5/26/99	<i>Craig A. Paul</i>	5/27/99	
							COST/SCHED-AREA		APPROVED BY	DATE	
							SCALE		DRAWING NO.	REV.	
							AS NOTED		FIGURE 2-5	0	

ACAD. 7856GM18.dwg 06/29/99 DT

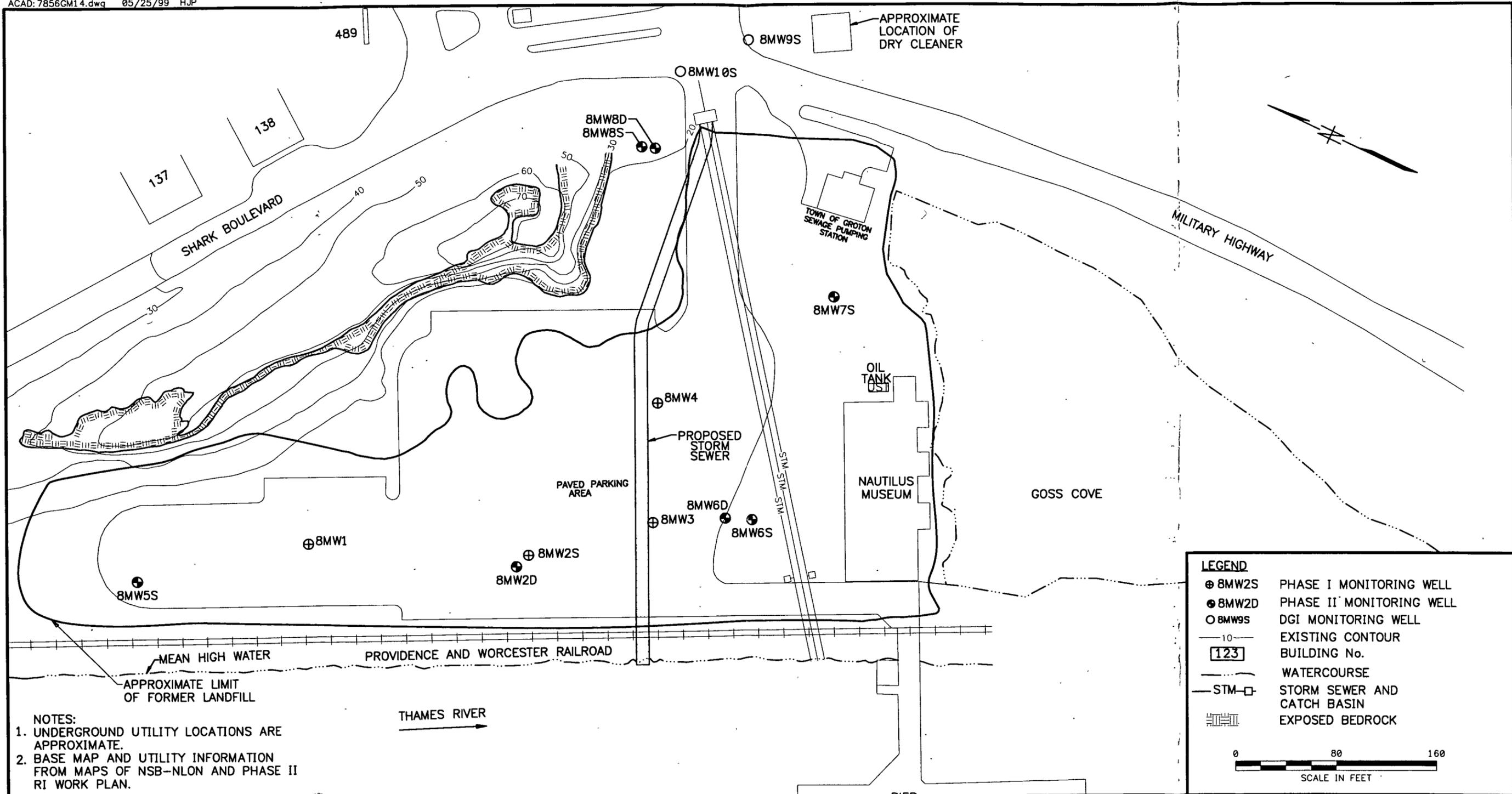


LEGEND

- PROPOSED TEST BORING AND TEMPORARY WELL POINT
 16TB1/16TW1
- PROPOSED TEST BORING
 16TB3
- PROPOSED SURFACE SOIL SAMPLE
 16SS1

0 100 200
SCALE IN FEET

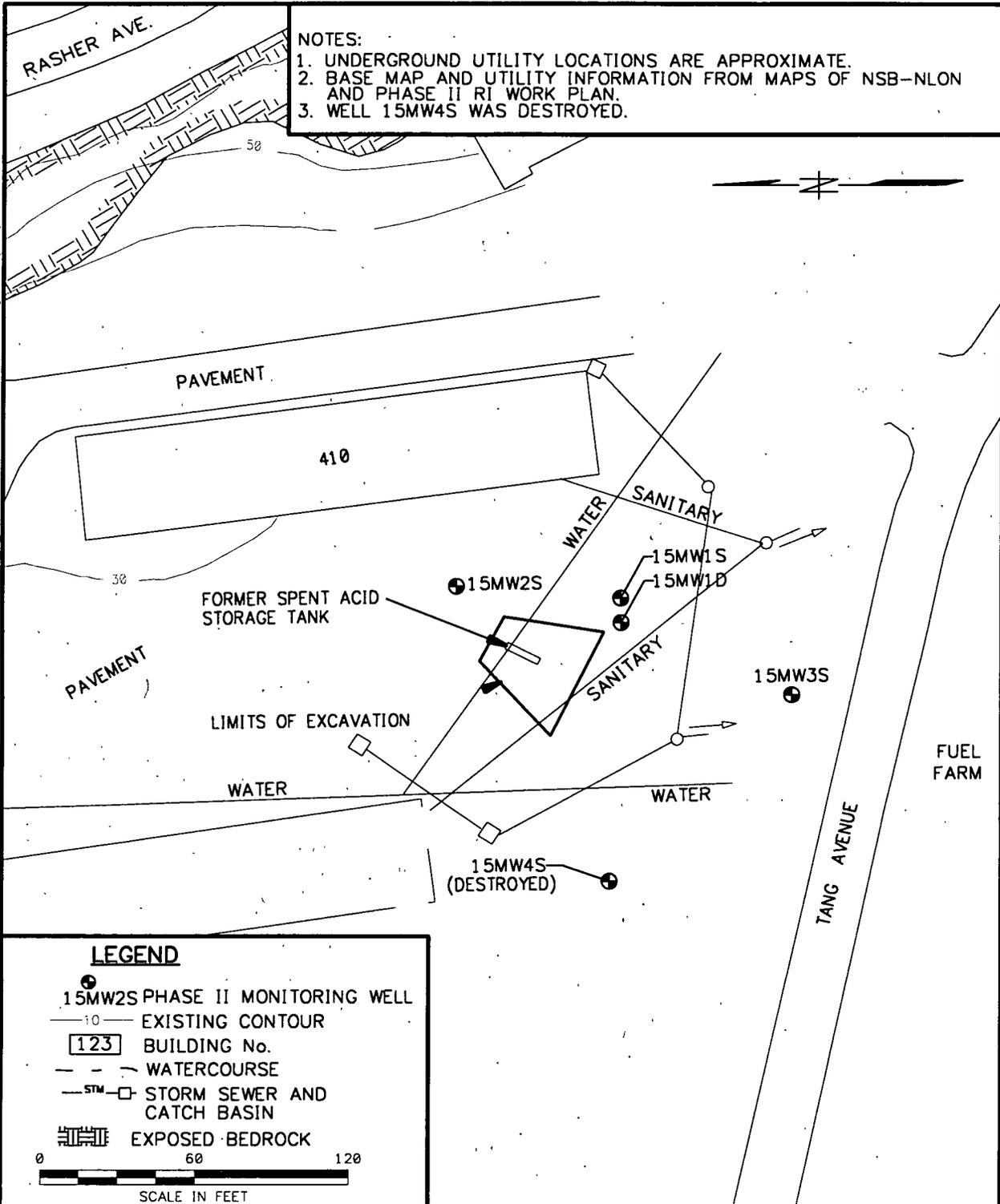
DRAWN BY HJP DATE 10/28/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY DATE		APPROVED BY <i>Cory A. Paul</i> DATE 6/30/99	
COST/SCHED-AREA SCALE AS NOTED	SAMPLE LOCATION MAP SITE 16-HOSPITAL INCINERATOR NSB-NLON, GROTON, CONNECTICUT	APPROVED BY DATE	
		DRAWING NO. FIGURE 2-6	REV. 0



NOTES:
 1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
 2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY HJP	DATE 10/29/98	Tetra Tech NUS, Inc. SAMPLE LOCATION MAP SITE 8-GOSS COVE LANDFILL NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 7856	OWNER NO. 312
							CHECKED BY MS	DATE 5/26/99		APPROVED BY <i>Cory A. Paul</i>	DATE 5/27/99
									APPROVED BY	DATE	
									DRAWING NO.	FIGURE 2-7	REV. 0

ACAD: 7856GM19.dwg 05/25/99 HJP



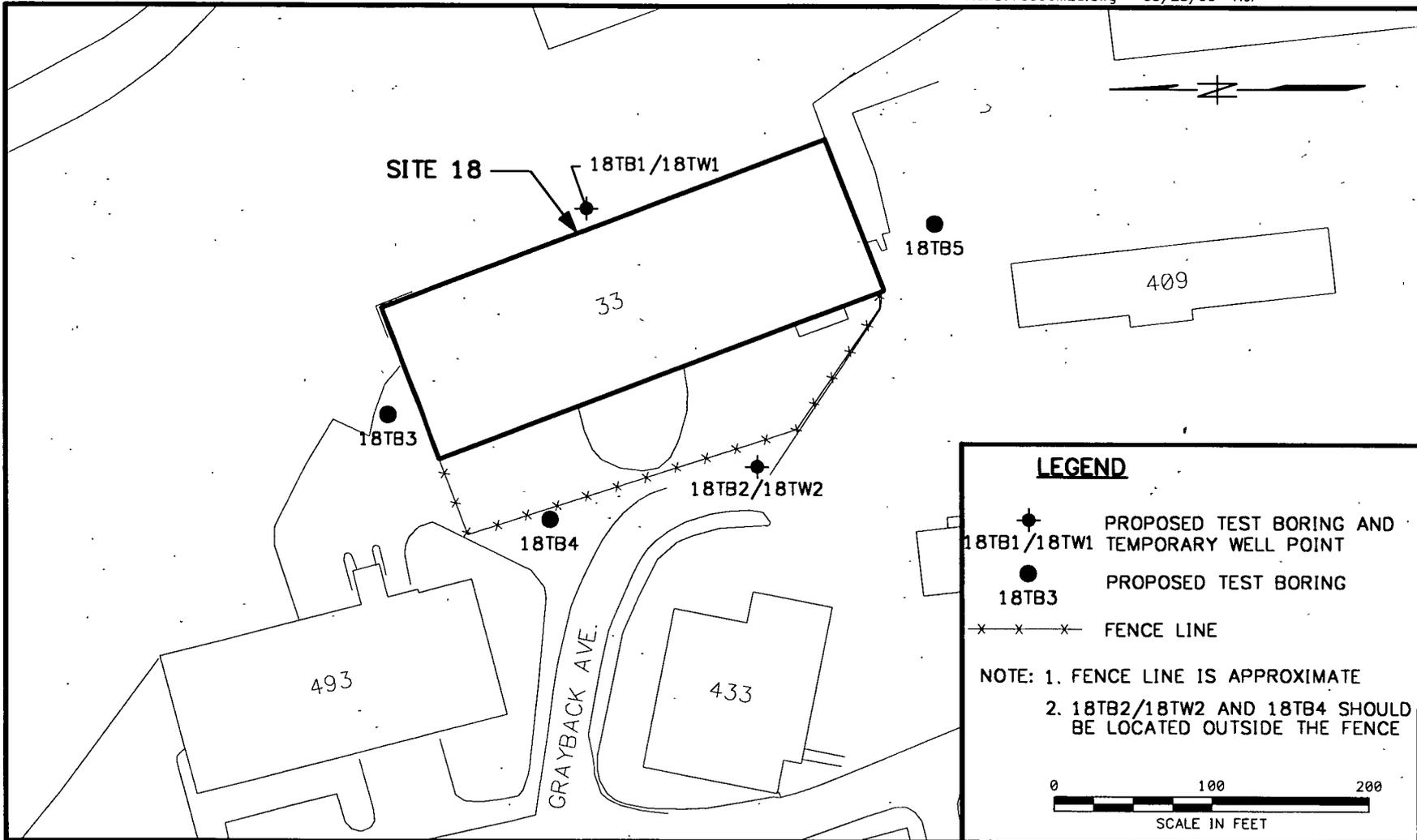
NOTES:
 1. UNDERGROUND UTILITY LOCATIONS ARE APPROXIMATE.
 2. BASE MAP AND UTILITY INFORMATION FROM MAPS OF NSB-NLON AND PHASE II RI WORK PLAN.
 3. WELL 15MW4S WAS DESTROYED.

LEGEND

- 15MW2S PHASE II MONITORING WELL
- - - 10 - - - EXISTING CONTOUR
- 123 BUILDING No.
- - - WATERCOURSE
- - - STM - - - STORM SEWER AND CATCH BASIN
- █ EXPOSED BEDROCK

0 60 120
 SCALE IN FEET

DRAWN BY HJP	DATE 10/29/98	Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY <i>[Signature]</i>	DATE 5/27/99		APPROVED BY <i>[Signature]</i>	DATE 5/27/99
COST/SCHED-AREA		SAMPLE LOCATION MAP SITE 15-SPENT ACID STORAGE AND DISPOSAL AREA NSB-NLON, GROTON, CONNECTICUT	APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2-8	REV. 0



DRAWN BY DATE
 HJP 10/29/98

Tetra Tech NUS, Inc.

CONTRACT NO.
 7856

OWNER NO.
 312

CHECKED BY DATE
 JMS 5/26/99
 COST/SCHED-AREA

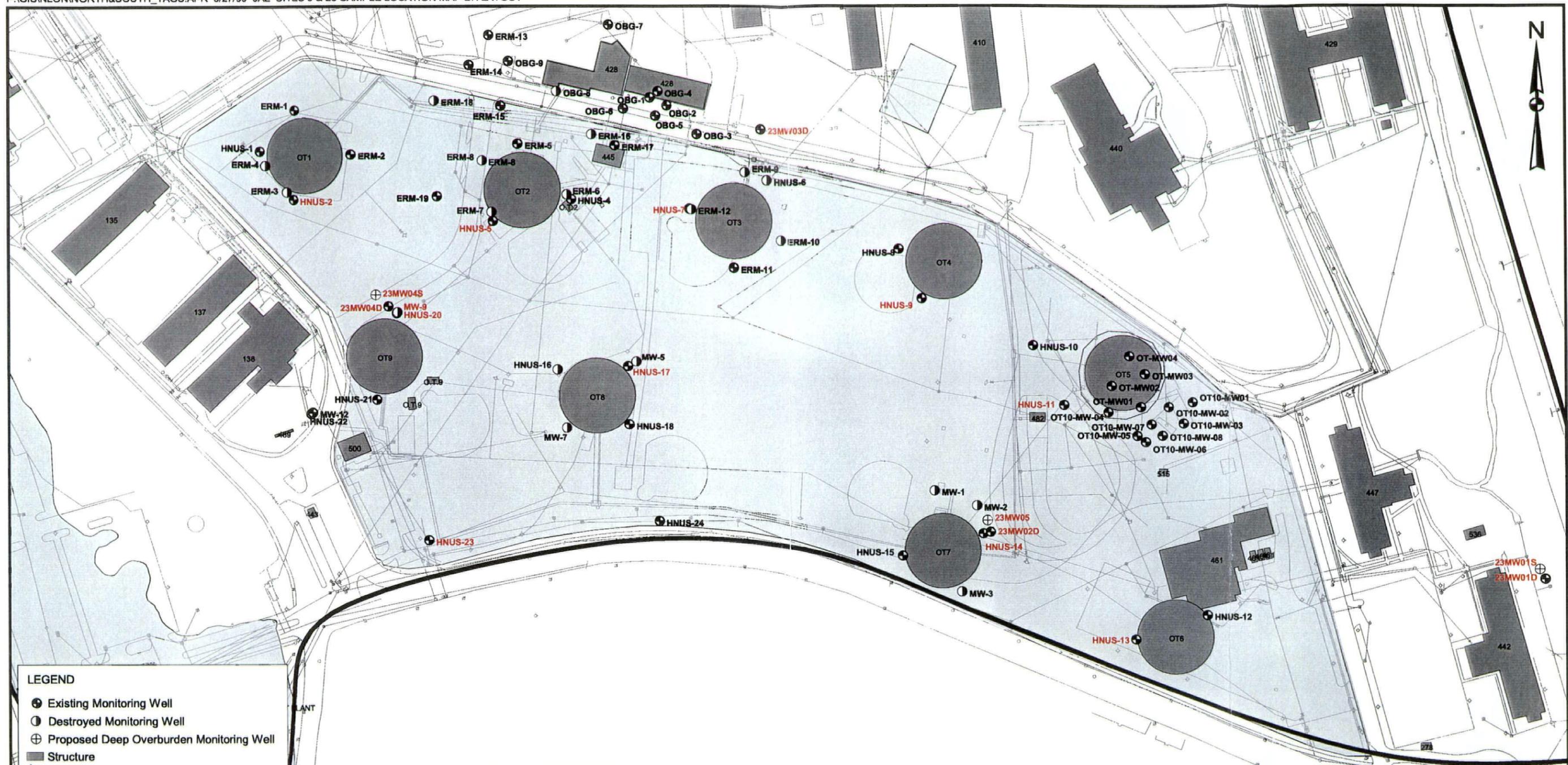
**SAMPLE LOCATION MAP
 SITE 18-SOLVENT STORAGE AREA
 (BUILDING 33)
 NSB-NLON, GROTON, CONNECTICUT**

APPROVED BY DATE
 Cory A. Paul 5/27/99
 APPROVED BY DATE

SCALE
 AS NOTED

DRAWING NO. **FIGURE 2-9**

REV.
 0



LEGEND

- Existing Monitoring Well
- Destroyed Monitoring Well
- ⊕ Proposed Deep Overburden Monitoring Well
- Structure
- ▬ Southern Region Boundary
- IR Sites

NOTE: Monitoring wells to be sampled are labelled in red.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

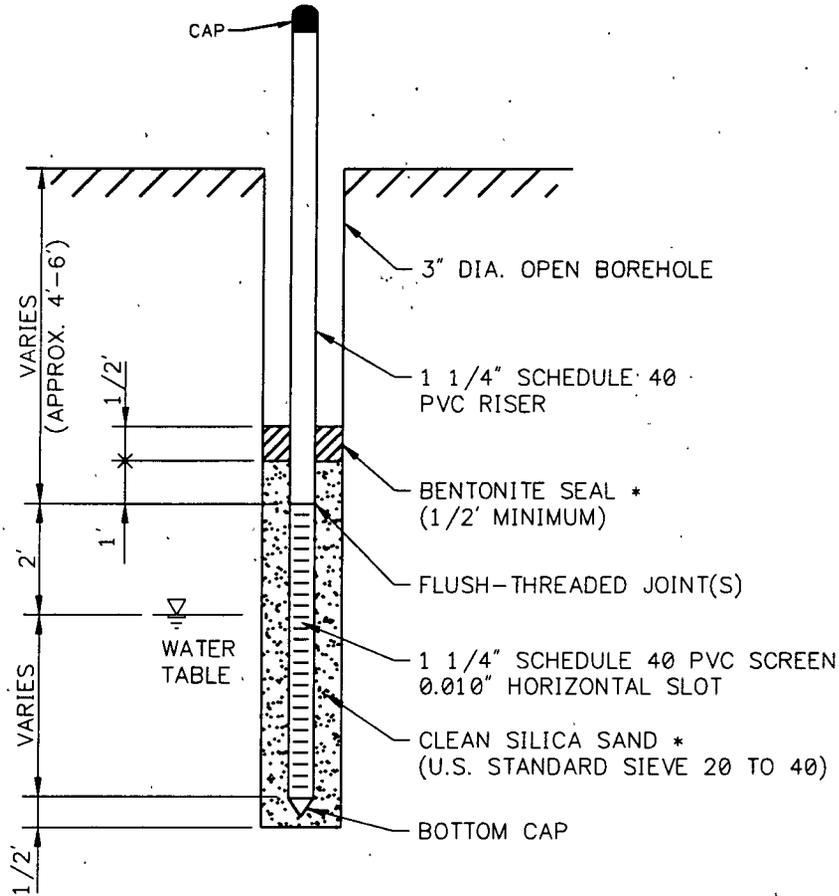
DRAWN BY D. PERRY	DATE 3-NOV-98
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SAMPLE LOCATION MAP
SITE 23 - TANK FARM
NSB-NLON, GROTON, CT

CONTRACT NUMBER 7856	OWNER NUMBER 312
APPROVED BY <i>Chris A. P. [Signature]</i>	DATE 5/27/99
APPROVED BY	DATE
DRAWING NO. FIGURE 2-10	REV 0

ACAD:7856C001.dwg 06/25/99 HJP



* INSTALLED UNLESS FORMATION COLLAPSES AROUND WELL PIPE.

DRAWN BY DLT	DATE 3/1/99	 Tetra Tech NUS, Inc.	CONTRACT NO. 7856	OWNER NO. 312
CHECKED BY	DATE		APPROVED BY <i>Louise A. Reid</i>	DATE 6/28/99
COST/SCHED-AREA	TYPICAL TEMPORARY GROUNDWATER MONITORING WELL NSB-NLON, GROTON, CONNECTICUT		APPROVED BY	DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 2-11	REV. 0

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APPENDIX A

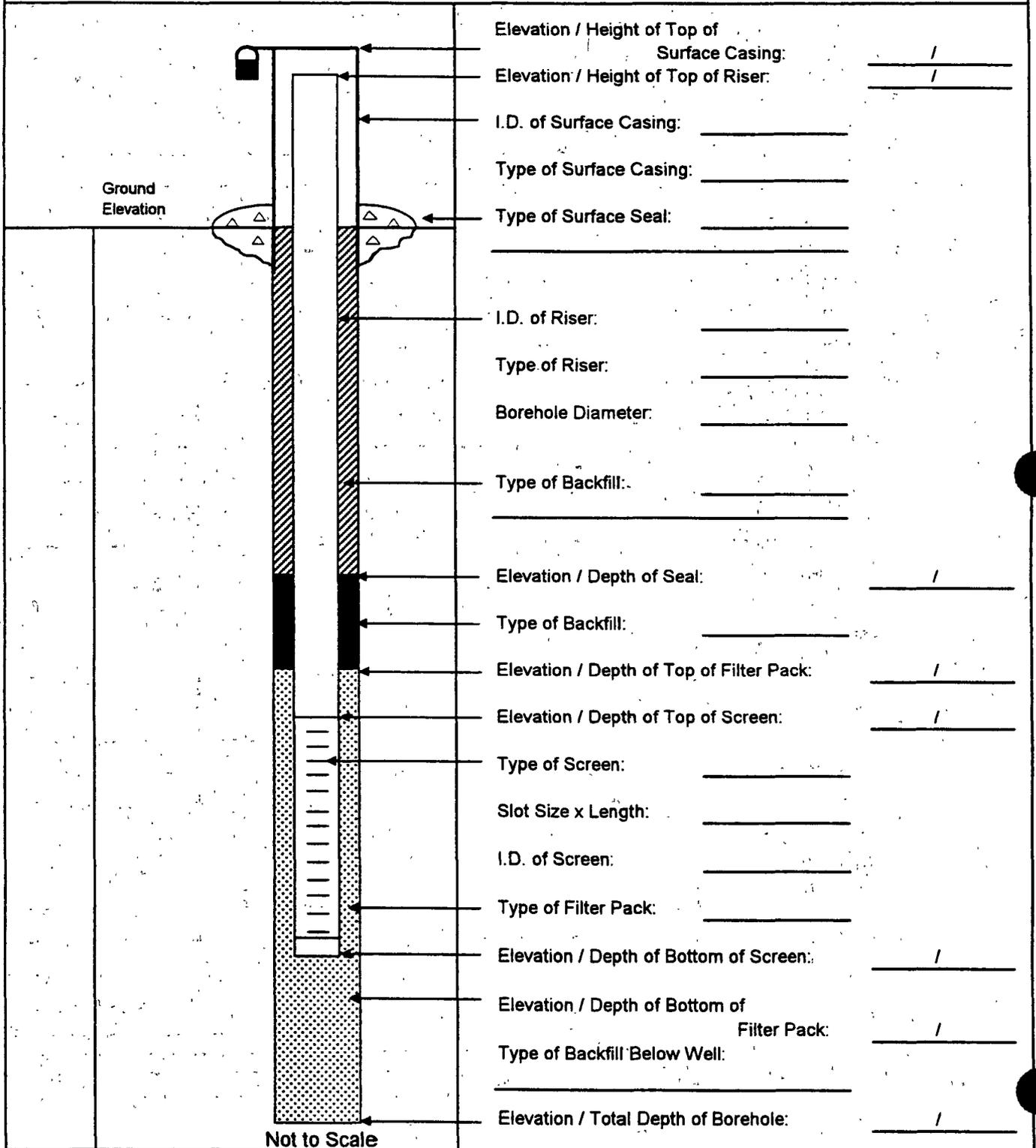
FIELD FORMS

- 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



MONITORING WELL SHEET

PROJECT: _____	DRILLING Co.: _____	BORING No.: _____
PROJECT No.: _____	DRILLER: _____	DATE COMPLETED: _____
SITE: _____	DRILLING METHOD: _____	GROUND ELEVATION: _____
GEOLOGIST: _____	DEV. METHOD: _____	ELEVATION DATUM: _____



BEDROCK MONITORING WELL SHEET OPEN HOLE WELL

PROJECT _____ PROJECT NO. _____ ELEVATION _____ FIELD GEOLOGIST _____	LOCATION _____ BORING _____ DATE _____	DRILLER _____ DRILLING METHOD _____ DEVELOPMENT METHOD _____
--	--	--

	<p>ELEVATION OF TOP OF CASING: _____</p> <p>STICK UP OF CASING ABOVE GROUND SURFACE: _____</p> <p>TYPE OF SURFACE SEAL: _____</p> <p>I.D. OF CASING: _____</p> <p>TYPE OF CASING: _____</p> <p>TEMP. / PERM.: _____</p> <p>DIAMETER OF HOLE: _____</p> <p>TYPE OF CASING SEAL: _____</p> <p>DEPTH TO TOP OF ROCK: _____</p> <p>DEPTH TO BOTTOM CASING: _____</p> <p>DIAMETER OF HOLE IN BEDROCK: _____</p> <p>DESCRIBE IF CORE / REAMED WITH BIT:</p> <p>_____</p> <p>_____</p> <p>DESCRIBE JOINTS IN BEDROCK AND DEPTH:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>ELEVATION / DEPTH OF HOLE: _____</p>
--	---



Project / Site: _____ Sample ID No.: _____
 Project No.: _____ Sample Location: _____
 Monitoring Well Sampler: _____
 Domestic Well
 Other: _____

SAMPLING DATA								
Date:	Color	pH	S.C. mS/cm	Temp. °C	Turbidity NTU	DO mg/L	Salinity ppt	Eh mV
Time:								
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:		Signature(s): _____
<input type="checkbox"/> MS / MSD	<input type="checkbox"/> DUPLICATE / ID No.:	

APPENDIX B

STANDARD OPERATING PROCEDURES

CT-04	Sample Nomenclature
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement
GH-1.3	Rock and Soil Drilling
GH-2.4	In-situ Hydraulic Conductivity Testing
GH-2.8	Groundwater Monitoring Point Installation
GW0001	USEPA Region I – Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-1.3	Soil Sampling Procedures
SA-6.1	Non-Radiological Sampling Handling
SA-6.3	Field Documentation
SA-7.1	Decontamination of Field Equipment and Waste Handling
ME-12	Photovac 2020 Photionization air Monitor
ME-15	Photovac Micro-FID Handheld Flame Ionization Detector

Format for Electronic Data Deliverables



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STANDARD OPERATING PROCEDURES

Number
CT-04

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1 of 6

Effective Date
03/01/96

Revision
0

Applicability
B&R Environmental, NE

Prepared
Risk Assessment Department

Approved
D. Senovich

Subject
SAMPLE NOMENCLATURE

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1.0 PURPOSE

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

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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.

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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"):

E E E A A E E E N 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:

E E E - A A - E E E - N 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:

E E E - A A - E E E - N N - N 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).

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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.

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

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

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

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

Location - Examples of the location field are as follows:

- A01 - Grid node A1
- 001 - Monitoring Well 1

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

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

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

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

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

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

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5.4 Example Sample Numbers

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

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



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GH-1.2

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Applicability
B&R Environmental, NE

Prepared
Earth Sciences Department

Subject
EVALUATION OF EXISTING MONITORING WELLS
AND WATER LEVEL MEASUREMENT

Approved
D. Senovich

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating existing monitoring wells, and determining water level measurements.

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 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 of data points needed and which wells shall be used for 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.

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 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.

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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 conditions, 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 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.

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

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infiltrated into the well. This may invalidate previous sampling results since the time when leakage started is unknown.

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 evacuation 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.

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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 weather changes, and at least during the same day.

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 best, and thus are the most often utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. 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 the float recorder or pressure transducer methods. 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.
2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A):

Well number.

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- 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.
- Time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points.

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. If the band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.3.6.

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.

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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).

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.

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B rehole 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 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.

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.



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Subject
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1.0 PURPOSE

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

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

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

3.0 GLOSSARY

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

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

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

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Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager).

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

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5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.
- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.
- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.
- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.
- Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which is the objective of the borehole construction. With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotasonic
- Drive and wash
- Jetting

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However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to

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~~remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.~~

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air-rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

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Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

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5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

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Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.

The method is slower than other methods (average drilling progress is 30 to 50 feet per day).

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- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.
- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobbles or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).
- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.
- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

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- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).

Large quantities of water are often needed.

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5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

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Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:
 - Hand augers and lightweight motorized augers.
 - Retractable plug samplers—driven by hand (hammer).

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- Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismantled tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.
- Small truck-mounted drilling equipment using a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.
- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.
- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.
- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:
 - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.
 - Barge-mounted drill rigs.
 - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.
 - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

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For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (\pm 2-pound) hammer dropping 30 inches (\pm 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

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5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and

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sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.
- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.
- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

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For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

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

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

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

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

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

~~5.7 Rock Sampling (Coring) (ASTM D2113-83)~~

~~Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average~~

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output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.
- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.
- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.
- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

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FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line <u> </u> / <u> </u> / <u> </u>	1 7/8	1	1.875	1.000
BX Wire line <u> </u> / <u> </u> / <u> </u>	2 3/8	1 7/16	2.345	1.437
NX Wire line <u> </u> / <u> </u> / <u> </u>	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

 / / Wire line dimensions and designations may vary according to manufacturer.

**FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
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Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	---	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	---	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	---	5.500			5.650	---	---	---	---
SW	---	6.625			6.790	---	---	---	---
UW	---	7.625			7.800	---	---	---	---
ZW	---	8.625			8.810	---	---	---	---
---	AX <u> </u> <u> </u> \	---	---	---	---	1.875	1.750	1.000	---
---	BX <u> </u> <u> </u> \	---	---	---	---	2.345	2.250	1.437	---
---	NX <u> </u> <u> </u> \	---	---	---	---	2.965	2.813	1.937	---

* All dimensions are in inches; to convert to millimeters, multiply by 254.
 / Wire line dimensions and designations may vary according to manufacturer.

**NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES.
(DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889**

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- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box. The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

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~~Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).~~

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DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	---
	7 1/4	6 1/4	3 1/4	---
	13 1/4	12	6	---
Thin Wall Tube Samplers (Ref. 7)	---	2	1 7/8	---
	---	2 1/2	2 3/8	---
	---	3	2 7/8	---
	---	3 1/2	3 3/8	---
	---	4 1/2	4 3/8	---
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thicken ss (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
12	12.750	11.750	0.500	

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

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DRILLING EQUIPMENT SIZES
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Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.



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Subject
IN-SITU HYDRAULIC CONDUCTIVITY TESTING

Approved
D. Senovich

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1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests with regard to the quality of data obtained and time/cost considerations. A disadvantage of constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross-sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot² (gpd/ft²).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity times the saturated thickness.

Slug Test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist, in conjunction with the Project Manager, shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project hydrogeologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and shall oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

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Field Geologist - The field geologist is responsible for performing the planned field tests as specified in the project planning documents, (or approved modifications thereto). The field geologist also generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies used and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume (slug) to change the water level is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system, which might raise doubts regarding the representativeness of future groundwater samples. A bailer or pump can be used to withdraw water from the well. If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both of these methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0; . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells.

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A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water level measurements need to be obtained during the performance of a slug test.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

A variation of the slug test, called a constant-head test, is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements are recorded in place of time/recovery data for approximately 10 to 20 minutes. The hydraulic conductivity is then calculated from this information. The constant-head test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level is measured and recorded. The water level is then raised (falling head test) or lowered (rising head test) and the change in water level is measured at time intervals determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water level measurements will vary according to the formation's

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hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals must be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test is to be conducted until the water level again stabilizes, or for a minimum of 20-minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method for conducting a slug test during drilling consists of placing a temporary well with a short screen into the cleaned-out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. This method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant-head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity is calculated from this. This method is the most accurate method depicted in this section, and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the constant-head test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means, before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973) have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, which factors in partial/full penetration and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist and in concurrence with the Project Manager and client.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the

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length of the gravel pack (if longer than the screened interval) may be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project central file.

6.0 REFERENCES

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United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A (or equivalent).¹ Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the bound site logbook or field notebook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the logbook/notebook.

¹ If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annotated to include the relevant data form, or attached to the form shown as Attachment A.



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Approved
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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 permanent 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 properly screened (if screening is necessary, e.g., open borehole), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface 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.

Rig Geologist - The rig 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.

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5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well:

- Health and safety equipment as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted 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 installations tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow and potential well locations can be determined 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 levels 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

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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 (1 to 2 feet) 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. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples). The volume of water in the monitoring well available for sampling is dependent on the well diameter as follows:

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Casing Inside Diameter (Inch)	Standing Water Depth to Obtain 1 Gallon Water (Feet)	Total Depth of Standing Water for 4 Gallons (Feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials 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 for wells in which screens are installed. Properties of these two materials are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but Schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps 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 by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not

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recommended where samples may be collected for metal 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 at slightly more costs. 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 screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or 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 fine-to medium-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), and 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 well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging, and to provide a better seal. However, in 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 two assemblages of material, (e.g., cement-bentonite). A cement-bentonite grout normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus

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3 to 5 pounds of granular or flake-type bentonite, and 6 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1- 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 often placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole-type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

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 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

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than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above and one below the screen, to assure enough annular space for sand pack placement.

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 the unconfined and confined aquifer. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells (with the exception of not using a temporary casing during installation). Sufficient time (determined by the rig 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 feet into the 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 through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

~~5.3.5 Innovative Monitoring Well Installation Techniques~~

~~Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface.~~

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Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch-diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet of the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each manufacturer offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. This system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The second system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method shall be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

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 used 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

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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 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 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611; Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

7.0 RECORDS

A critical part of monitoring well installation is recording of 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 thus 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

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will need to be recorded depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

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® | 5 | Lo-Carbon Steel |
| 2 | Stainless Steel 316 | 6 | Galvanized Steel |
| 3. | Stainless Steel 304 | 7 | Carbon Steel |
| 4 | PVC 1 | | |

* 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® | 5 | PE Conventional |
| 2 | Polypropylene (PP) | 6 | Plexiglas/Lucite (PMM) |
| 3. | PVC Flexible/PE Linear | 7 | Silicone/Neoprene |
| 4 | Viton® | | |

* Trademark of DuPont

Source: Barcelona et al., 1983

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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 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.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE
FOR THE COLLECTION OF GROUND WATER SAMPLES
FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permeability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use

must include check measurements with a water level "tape" at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two

feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

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 indicator field parameter values 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, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is

recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch

may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII. FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered, should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Subject
GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER
QUALITY TESTING

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. For groundwater measurements, a volume of water contained in a 1 cm x 1 cm sample container (the water acts as the conductor). Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only the current flows in the opposite direction due to the external source of applied voltage. Electrolytic cells are used in dissolved oxygen measurement.

Galvanic Cell - A electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit. Galvanic cells are used in dissolved oxygen measurement.

Ohm - Standard unit of electrical resistance (R). Used in specific conductance measurement. A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance. Used in measurement of specific conductance.

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4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
 - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

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- The intake line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling ground water wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Thermometer, pH paper/meter, camera and film (if appropriate), appropriate keys (for locked wells), engineer's rule, water level indicator, specific conductivity meter, and turbidity meter (as applicable).
- Pumps
 - Shallow-well pumps: Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or air-lift apparatus where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary). Bailers or submersible centrifugal pumps shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvents (e.g., methanol, acetone, hexane), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

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5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

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5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

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Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

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Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or basicity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone 150 portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.

Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.

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- Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the solution. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted:

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

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It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration. Attachment B provides guidance in this regard.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.

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- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen Concentration

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

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The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked in the warehouse before going to the field.

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- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

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5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with deionized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.
- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.5.6 **Measurement of Turbidity**

5.5.6.1 General

Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

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It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurements Techniques for Specific Conductance

The steps involved in taking turbidity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

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- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode with deionized water.

5.6 Sampling

5.6.1 **Sampling Plan**

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 **Sampling Methods**

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see SOP SA-6.3); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.

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4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling.
10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).
13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain

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"representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon). Peristaltic pumps may be used only for inorganic sample collection.
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon lined polyethylene, polyethylene, PVC, tygon steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.

Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - eH and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.

- Decontamination supplies.

Logbook(s), and other forms (e.g., well purging forms).

Sample Bottles.

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- Sample preservation supplies (as required by the analytical methods).
- Sample tags or labels.
- Well construction data, location map, field data from last sampling event.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbid free water samples may be difficult if there is three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every three to five minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every three to five minutes (or as appropriate). Purging is complete and sampling may begin when

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all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at three to five minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every three to five minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

VOC samples are preferably collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A
PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet		X	X	X	X			
	Water Level >25 feet				X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

**ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 2**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geitek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas. (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
 AC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

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ATTACHMENT B

**SPECIFIC CONDUCTANCE OF 1 MOLAR KCl
AT VARIOUS TEMPERATURES¹**

Temperature (°C)	Specific Conductance (umhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

¹ Data derived from the International Critical Tables 1-3-8.

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ATTACHMENT C

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
AS A FUNCTION OF TEMPERATURE AND SALINITY**

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

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**ATTACHMENT C
 VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
 AS A FUNCTION OF TEMPERATURE AND SALINITY
 PAGE TWO**

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore, used to correct measured D.O. concentration) using Attachment B.



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability B&R Environmental, NE
Prepared Earth Sciences Department

Subject
SOIL SAMPLING

Approved
D. Senovich *DS*

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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. Brown & Root Environmental considers all confined space as permit-required confined spaces.

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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 effect 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.

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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 include 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 is 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.

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If the lower detection limits are necessary, an option 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.

5.2.1.2 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 effervescent 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

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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

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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.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel 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.
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.

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- 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 trowels.

The following equipment is necessary to collect near surface soil samples:

- Clean shovel.
- Plus the equipment listed under Section 5.3 of this procedure.

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 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.
- Plus 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.).

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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.

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- Stainless steel mixing bowls.
- Plus 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., OVA, HNu, 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 were 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 Excavation and Sampling of Test Pits and Trenches

5.7.1 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.

5.7.2 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

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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.

5.7.3 Sampling in Test Pits and Trenches

5.7.3.1 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.

5.7.3.2 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.

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- 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).

5.7.3.3 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 photionization 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

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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.

5.7.3.4 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.

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5.7.3.5 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.

5.7.4 **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.

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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.

5.8 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 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.

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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.

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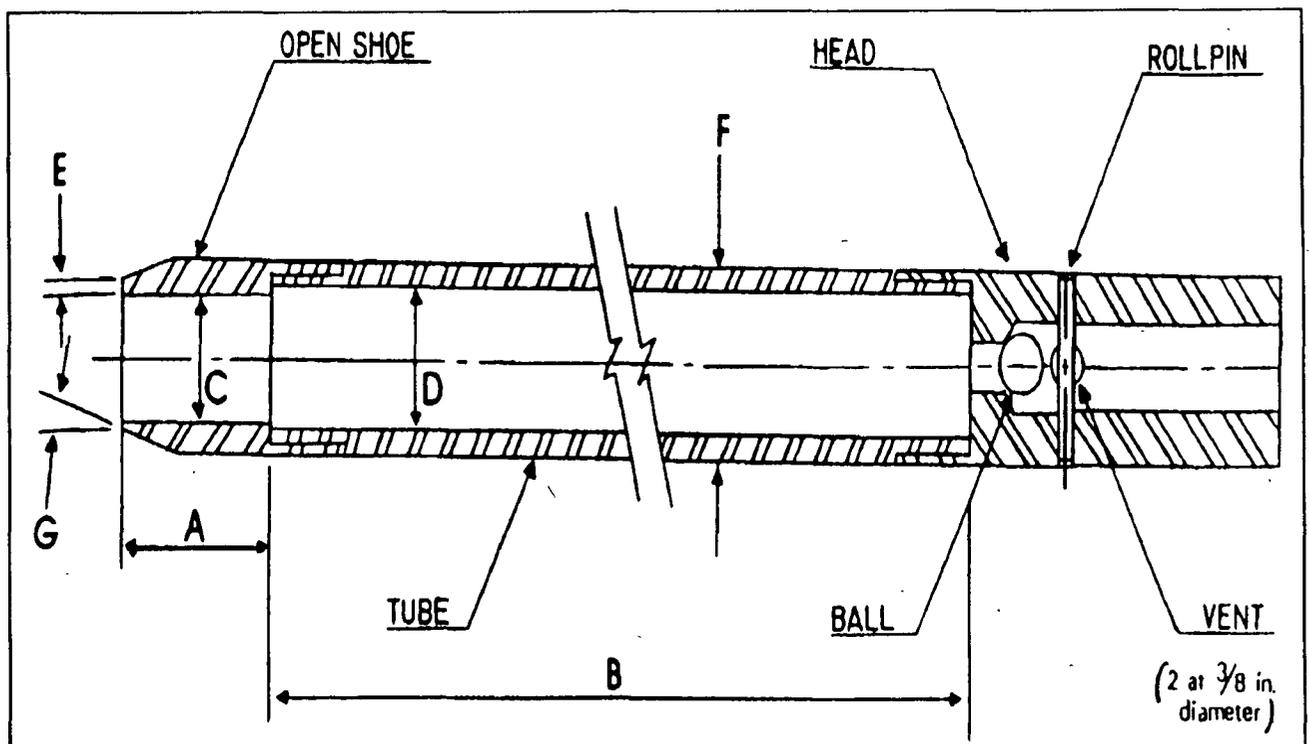
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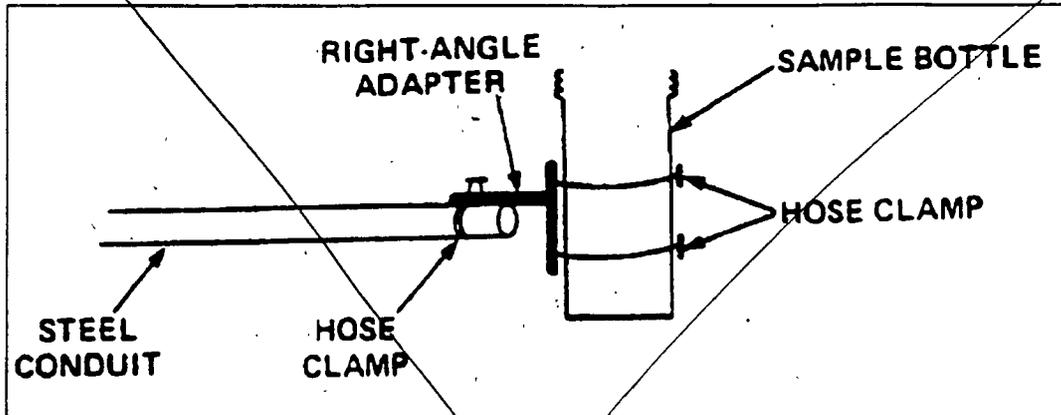
ATTACHMENT A
SPLIT-SPOON SAMPLER



- 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**





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Subject

NON-RADIOLOGICAL SAMPLE HANDLING

Approved
D. Senovich *DS*

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SAMPLE HANDLING				

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) regulations.

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.

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 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 (y261.20 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.

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Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - Na₂S₂O₃

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. Thus, a one-molar solution of HCl, containing 1 gram-atom of H, is "one normal," whereas a one-molar solution of H₂SO₄, containing 2 gram-atoms of H, is "two normal."

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 common carrier.

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 bottle orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

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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 and high-hazard organics samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, 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 preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.2 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 ₂ SO ₄)	1 part concentrated H ₂ SO 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

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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 (assuming 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, generally, 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.

- To test if sodium thiosulfate must be added to remove residual chlorine from a sample, test the sample for residual chlorine using a field test kit especially 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, generally, 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.

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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 silicon tubing, and a peristaltic pump with pressure or vacuum pumping squ eze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).
- To perform filtration, thread the silicon 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.
- 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 sample container, properly identified and 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).
- 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.

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- If cooling is required (see Attachments A and B), double-bag ice in Ziploc baggies and place around 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 **Determination of Shipping Classification for Hazardous Material Samples**

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.4.2.1 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. (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 a chemist for all possible technical names a material can have. If your material is not listed by its technical name, then . . .
2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed, then . . .
3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed, then . . .
4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then . . .

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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.

5.4.2.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT hazardous materials classification of a material having more than one hazard. This procedure is outlined in DOT Regulation 49 CFR 173.2a. (This can be found in Attachment C of this SOP.)

The correct shipping classification for an unknown sample is selected through a process of elimination, as outlined in DOT Regulation 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 Department of Transportation (DOT) and can be found in Attachment D of this SOP.

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 imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

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.

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- Proper shipping name from the hazardous materials table (DOT Regulation CFR 49 172.101). Example: "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325." This will include packing group (see Section 5.3.4.2, No. 2.)

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. If identified, the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Determine packing group. The packing group is part of the proper shipping name and must be included on the shipping papers in the description section.

- I. Most Hazardous
- II. Medium Hazard
- III. Least Hazardous

The packing group will be listed in the hazardous materials table, column 5.

3. Place all information on outside shipping container as on can (or bottle), specifically:

- Proper shipping name
- UN or NA number
- Proper label(s)
- Addressee and sender

Place the following labels on the outside shipping container: "Cargo Aircraft Only" and DOT label such as: "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the Flammable Solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement. Provide the following information in the order listed (one form may be used for more than one exterior container):

- Proper shipping name. (Example: "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325 Packing Group I, II, III").
- "Limited Quantity" (or "Ltd. Qty."). (See No. 3, below.)
- "Cargo Aircraft Only."
- Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.

"Laboratory Samples" (if applicable).

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2. Include Chain-of-Custody Record, properly executed in outside container: use custody seals.

3. "Limited Quantity" means the maximum amount of a hazardous material for which there is a specific labeling or packaging exception (DOT CFR 49 171.8). This may mean that packages are exempted from labeling requirements. To determine if your sample meets the Limited Quantity Exception, refer to DOT Regulation CFR 49 Subpart C 173.50 through 173.156. First, determine the proper classification and shipping name for the material; then refer to the exception requirements for that particular class of material beginning with 173.50.

Example: "Flammable Liquid n.o.s. UN1993 Packing Group 1." The outer package can weigh no more than 66 pounds gross weight. The inner package or container can weigh no more than 0.1 gallon net capacity for each container.

To determine whether the material can be shipped as a "Limited Quantity," you must check the specific requirement for that class of material.

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 the FOL or Project Manager.

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 powered by lithium batteries. The Department of Transportation has determined that lithium batteries are a hazardous material and are to be shipped using the following information:

¹ Note: If you are unsure as how to ship the sample (hazardous or environmental sample), contact the FOL or Project Manager so that a decision can be made as to the proper shipping practices. The DOT penalties for improper shipment of a hazardous material are stringent and may include a prison term for intentional violations.

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- Product Designation
 - Hermit SE 1000
 - Hermit SE 2000
- DOT Proper Shipping Name
 - Lithium batteries, contained in equipment, UN3091
- 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 with the following wording:

- Lithium Batteries Contained in Equipment
 - UN-3091
 - Shipped Under CA-9206009

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

U.S. Department of Transportation, 1993. 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.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁸⁾
	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
		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
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(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.

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ATTACHMENT B

**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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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 ₂ SO 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 ₂ SO 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 ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool. 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool. 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool. 4°C	48 hours
Oil & Grease	G	Cool. 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool. 4°C; HCl or H ₂ SO 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 ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool. 4°C; H ₂ SO 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

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE TWO**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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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 ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool. 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool. 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool. 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11), (12)}	G, Teflon-lined cap	Cool. 4°C; 0.008% Na ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE THREE**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
-----------------------	--------------------------	--------------------------------	-------------------------------------

RADIOLOGICAL TESTS:

1-5 Alpha, beta and radium	P, G	HNO ₃ to pH 2	6 months
----------------------------	------	--------------------------	----------

- (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-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ 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% Na₂S₂O₃.

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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)

PRECEDENCE OF HAZARD TABLE

(Hazard Class and Packing Group)

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.

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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.

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**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 your 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.

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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 SEPARATION 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	X
Explosives 1.3		*	*	*	*	*	X		X	X	X		X	X	X	X	X			X
Explosives 1.4		*	*	*	*	*	O		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	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	O						X			O
Oxidizers 5.1	A	X	X		X				X	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 before shipment.

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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: <i>(delete non applicable)</i>	Airport of Departure
<input checked="" type="checkbox"/> PASSENGER AIRCRAFT ONLY	<input type="checkbox"/> CARGO AIRCRAFT ONLY
Airport of Destination: 19CYS	

Shipment type: *(delete non-applicable)*

NON-RADIOACTIVE RADIOACTIVE

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)

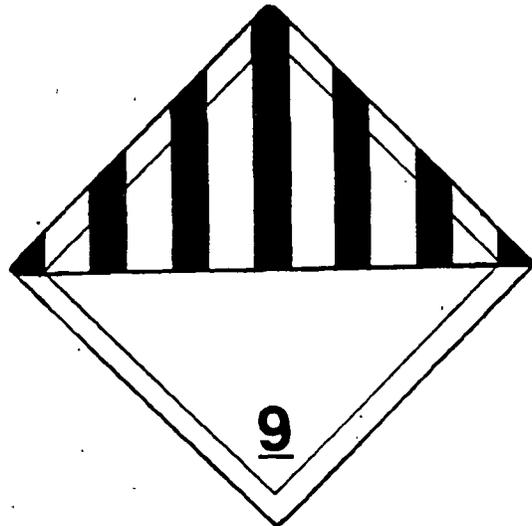
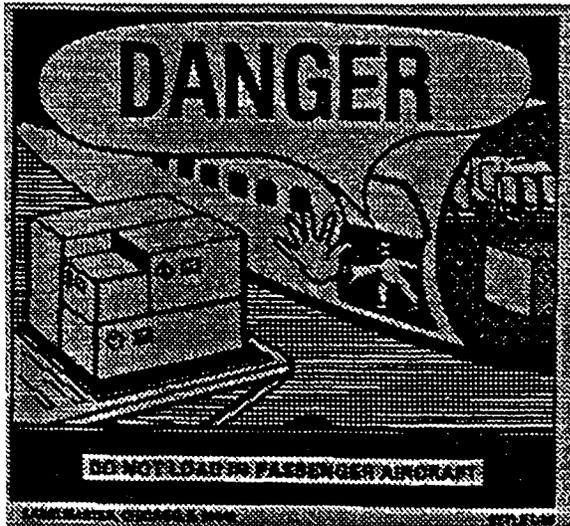
I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.	Name/Title of Signatory
	Place and Date
	Signature <i>(see warning above)</i>
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
LITHIUM BATTERY SHIPPING PAPERS

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**ATTACHMENT G (CONTINUED)
LITHIUM BATTERY SHIPPING PAPERS**



**LITHIUM BATTERIES CONTAINED
IN EQUIPMENT.
UN-3091.
SHIPPED UNDER CA-9206009**



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich <i>NS</i>	

Subject 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 Brown & Root Environmental field activities.

2.0 SCOPE

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

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

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

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

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

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

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

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

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

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

5.1.2 Photographs

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

5.2 Site Notebooks

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

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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 and Request for Analysis

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. A 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 or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

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

5.3.1.4 Chain-of-Custody Seal

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

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5.3.2 Geohydrological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

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

~~5.3.2.2 Data Sheet for Pumping Test~~

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

~~5.3.2.3 Packer Test Report Form~~

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

5.3.2.4 Summary Log of Boring

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

5.3.2.5 Monitoring Well Construction Details Form

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

~~5.3.2.6 Test Pit Log~~

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

5.3.3 Equipment Calibration and Maintenance Form

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

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

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

5.4 Field Reports

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

5.4.1 Weekly Status Reports

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

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

5.4.2 Daily Activities Report

5.4.2.1 Description

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

5.4.2.2 Responsibilities

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

5.4.2.3 Submittal and Approval

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

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6.0 ATTACHMENTS

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

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**ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY**

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL: _____

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

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

ACTIVITIES:

1. Steam jenny 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 manager 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-3
EXAMPLE SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET**

		SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET		Page ___ of ___
Project Site Name: _____		Sample ID No.: _____		
Project No.: _____		Sample Location: _____		
<input type="checkbox"/> Surface Soil <input type="checkbox"/> Subsurface Soil <input type="checkbox"/> Sediment <input type="checkbox"/> Other _____ <input type="checkbox"/> QA Sample Type: _____		Sampled By: _____		
		C.O.C. No.: _____		
Sample Method:	Composite Sample Data			
	Sample	Time	Color/Description	
Depth Sampled:				
Sample Date and Time:				
Type of Sample <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab-Composite <input type="checkbox"/> High Concentration <input type="checkbox"/> Low Concentration				
	QA Sample Data			
	Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)		
Analyte	Container Requirements	Collected P/L	Map:	
Observations/Notes:				
Circle if Applicable:			Signature(s):	
MS/MSD	Duplicate ID No:			

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**ATTACHMENT B-4
CONTAINER SAMPLE LOG SHEET FORM**



Brown & Root Environmental

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Container Data

Case #: _____

By: _____

Project Site Name: _____ Project Site No. _____

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

Container Source		Container Description			
<input type="checkbox"/> Drum <input type="checkbox"/> Bung Top <input type="checkbox"/> Lever Lock <input type="checkbox"/> Bolted Ring <input type="checkbox"/> Other _____ <input type="checkbox"/> Bag/Sack <input type="checkbox"/> Tank <input type="checkbox"/> Other _____		Color: _____ Condition: _____ Markings: _____ Vol. of Contents: _____ Other: _____			
Disposition of Sample		Sample Description			
<input type="checkbox"/> Container Sampled <input type="checkbox"/> Container opened but not sampled. Reason: _____ <input type="checkbox"/> Container not opened. Reason: _____		Phase	Layer 1 <input type="checkbox"/> Sol. <input type="checkbox"/> Liq.	Layer 2 <input type="checkbox"/> Sol. <input type="checkbox"/> Liq.	Layer 3 <input type="checkbox"/> Sol. <input type="checkbox"/> Liq.
		Color			
		Viscosity	<input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H	<input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H	<input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H
		% of Total Volume	_____	_____	_____
		Other	_____	_____	_____
Monitor Reading:		Type of Sample			
Sample Method:		<input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration			
		<input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab-composite			
Sample Date & Time:		Sample Identification	Organic	Inorganic	
Sampled by:					
Signature(s):					
			Date Shipped		
Analysis:		Time Shipped			
		Lab			
		Volume			

ATTACHMENT B-5

SAMPLE LABEL

	Brown & Root Environmental	PROJECT: _____
STATION LOCATION: _____		
DATE: ____/____/____		TIME: ____ hrs.
MEDIA: WATER <input type="checkbox"/>	SOIL <input type="checkbox"/>	SEDIMENT <input type="checkbox"/>
CONCENTRATION: LOW <input type="checkbox"/>	MEDIUM <input type="checkbox"/>	HIGH <input type="checkbox"/>
TYPE: GRAB <input type="checkbox"/>	COMPOSITE <input type="checkbox"/>	
ANALYSIS		PRESERVATION
VOA <input type="checkbox"/>	BNAs <input type="checkbox"/>	Cool to 4°C <input type="checkbox"/>
PCBs <input type="checkbox"/>	PESTICIDES <input type="checkbox"/>	HNO ₃ to pH < 2 <input type="checkbox"/>
METALS: TOTAL <input type="checkbox"/>	DISSOLVED <input type="checkbox"/>	NaOH to pH > 12 <input type="checkbox"/>
CYANIDE <input type="checkbox"/>		_____ <input type="checkbox"/>
Sampled by: _____		
Remarks: _____		

ATTACHMENT B-6

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

PROJECT NO.		PROJECT NAME				NO. OF CONTAINERS	REMARKS				
SAMPLERS: (Signature)											
STA NO.	DATE	TIME	STATION LOCATION								
Relinquished by: (Signature)		Date/Time	Received by: (Signature)			Relinquished by: (Signature)		Date/Time	Received by: (Signature)		
Relinquished by: (Signature)		Date/Time	Received by: (Signature)			Relinquished by: (Signature)		Date/Time	Received by: (Signature)		
Relinquished by: (Signature)		Date/Time	Received for Laboratory by: (Signature)			Date/Time	Remarks:				

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ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

Signature <hr/>		CUSTODY SEAL <hr/>
Date <hr/>		Date <hr/>
CUSTODY SEAL		Signature <hr/>

LEGEND

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 No. 200 Sieve Size					
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)			GROUP SYMBOL	TYPICAL NAMES	
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size					
					DAY 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 sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	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.
		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	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	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	OL	Organic silts and organic silt-clays of low plasticity.
SANDS 50% (+) < 1/4" Ø	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.	SILTS AND CLAYS Liquid Limit > 50	Slight to Medium	Slow to None	Slight to Medium	ML	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see CL)	SM	Silty sands, poorly graded sand-silt mixtures.		Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.		HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture.		Pt

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 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"-3"
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:

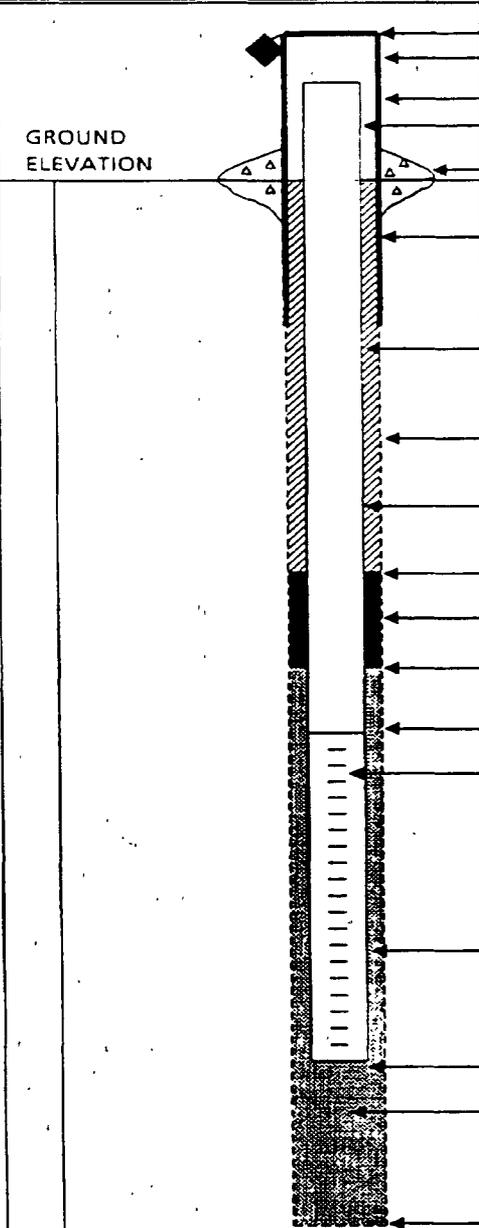
SOIL SAMPLES - TYPES
 S-2" Split-Barrel Sample
 ST-3" O.D. Undisturbed Sample
 O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES
 X-MX (Conventional) Core (-2-1/8" O.D.)
 Q-MQ (Wireline) Core (-1-7/8" O.D.)
 Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
 12/18
 Initial Level w/Date & Depth
 Stabilized Level w/Date & Depth

**ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET**

		BORING NO.: _____
<h3 style="margin: 0;">OVERBURDEN MONITORING WELL SHEET</h3>		
PROJECT _____ PROJECT NO. _____ ELEVATION _____ FIELD GEOLOGIST _____	LOCATION _____ BORING _____ DATE _____	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: _____ / _____	

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

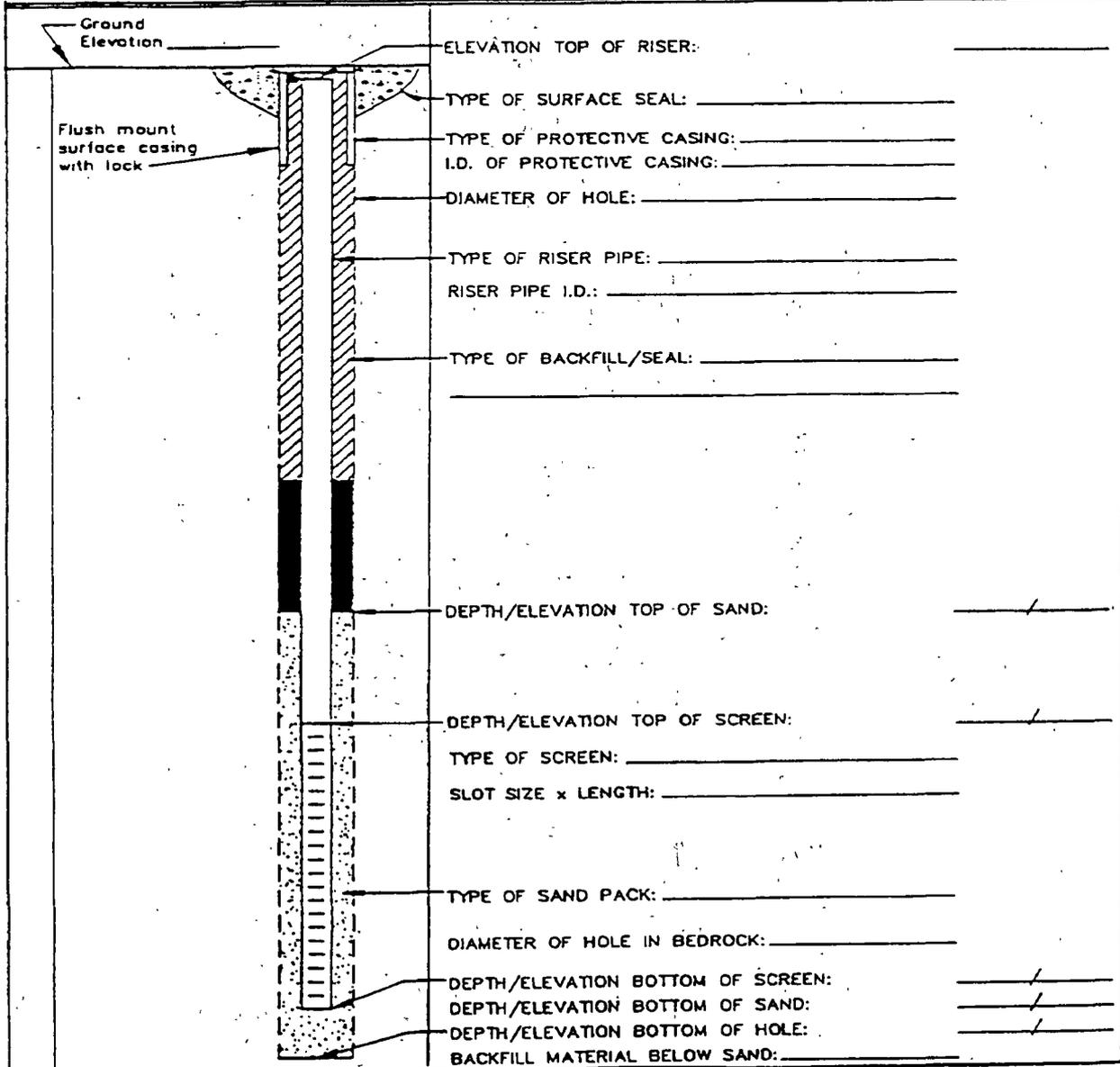
BORING NO.:



MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



SCALE: 1/8" = 1' OVERBURDEN

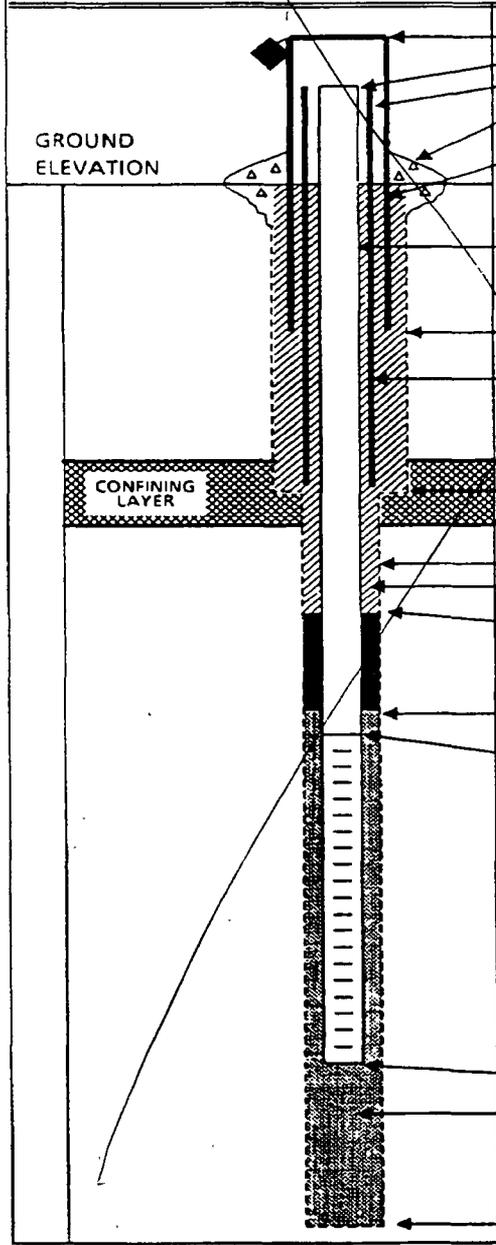
**ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET**

BORING NO.: _____



CONFINING LAYER MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		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**



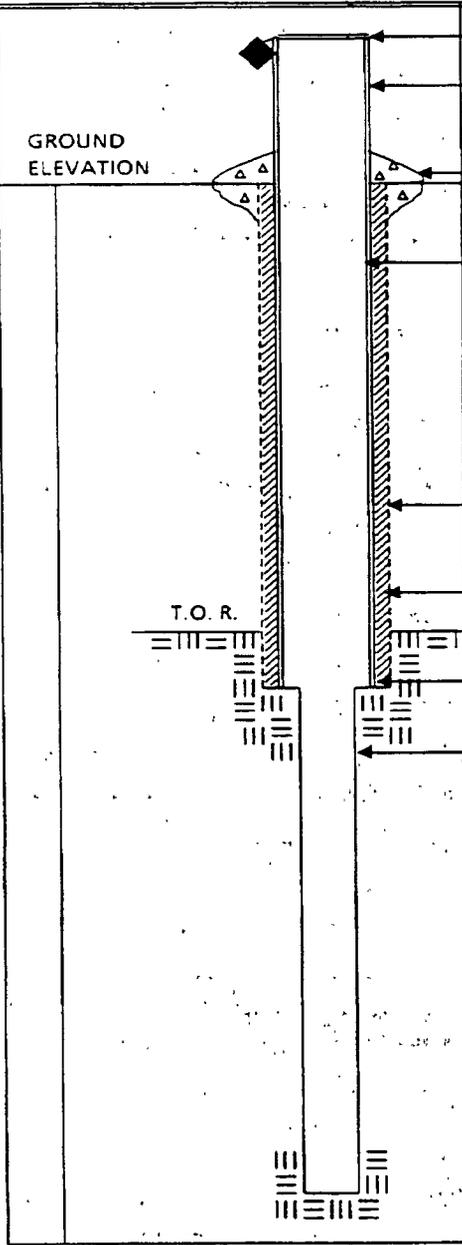
**BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL**

BORING NO : _____

PROJECT _____
 PROJECT NO. _____
 ELEVATION _____
 FIELD GEOLOGIST _____

LOCATION _____
 BORING _____
 DATE _____

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: _____

Subject

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



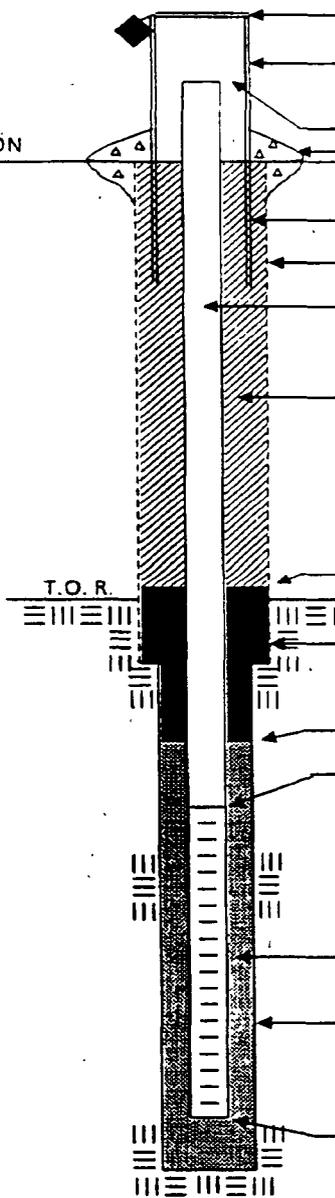
BORING NO.: _____
**BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK**

PROJECT _____
PROJECT NO. _____
ELEVATION _____
FIELD GEOLOGIST _____

LOCATION _____
BORING _____
DATE _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____

GROUND ELEVATION



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

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

TYPE OF BACKFILL: _____

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

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____

ELEVATION / DEPTH BOTTOM OF HOLE: _____

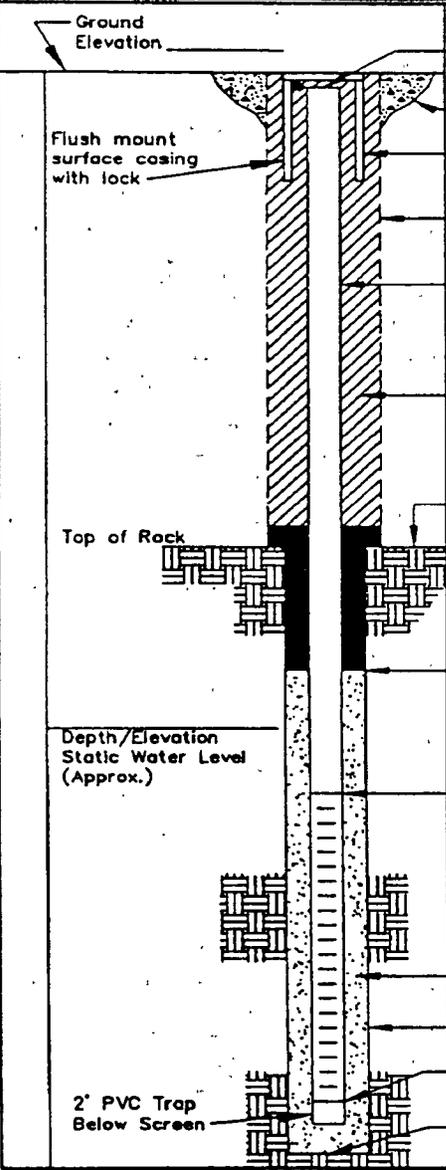
**ATTACHMENT C-8A
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)**

BORING NO.: _____



**BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK**

PROJECT: _____	LOCATION: _____	DRILLER: _____
PROJECT NO.: _____	BORING: _____	DRILLING METHOD: _____
ELEVATION: _____	DATE: _____	DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____		



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

DEPTH/ELEVATION TOP OF BEDROCK: _____

DEPTH/ELEVATION TOP OF SAND: _____

DEPTH/ELEVATION TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____

DEPTH/ELEVATION BOTTOM OF SAND: _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____

BACKFILL MATERIAL BELOW SAND: _____

ACFILE: L070\GEO\BEDRM.DWG

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**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: _____

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**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: _____



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Effective Date 03/16/98	Revision 2
Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich	

Subject **DECONTAMINATION OF FIELD EQUIPMENT
AND WASTE HANDLING**

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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.

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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.

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~~

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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 fractions 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.

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.

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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). 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.

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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

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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.



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Applicability B&R Environmental, NE	
Prepared Health Sciences Department	
Approved D. Senovich <i>DS</i>	

Subject **PHOTOVAC 2020 PHOTOIONIZATION
AIR MONITOR**

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1.0 PURPOSE

To establish procedures for the use, maintenance, and calibration of the Photovac 2020 Photoionization Air Monitor.

2.0 SCOPE

Applies to each usage of the Photovac 2020 Photoionization Air Monitor by Brown & Root Environmental personnel.

3.0 GLOSSARY

Electron volt (eV) - A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum. It is equal to $1.602192 \pm 0.000007 \times 10^{-18}$ volts.

Intrinsically Safe (I.S.) - Based on wiring, configuration, design, operation, gasketing, construction, this instrument may be employed within locations in which flammable gases and/or vapors may exist.

Ionization Potential (I.P.) - The energy required to remove an electron from a molecule yielding a positively charged ion and a negatively charged free electron. The instrument measures this energy level.

Photoionization Detector (PID) - Photoionization detector employed as general reference to air monitors of this type. PIDs detection method employs ultraviolet (UV) radiation as an energy source. As air and contaminant are drawn through the ionization chamber the UV light source causes the contaminant with ionization potentials equal to or less than the UV source to break into positive and negatively charged ions. The created ions are subjected to an electrostatic field. The voltage difference is measured in proportion to the calibration reference and the concentration of the contaminant.

Ultraviolet Radiation (UV) - Ultraviolet radiation is the energy source employed by the instrument to ionize collected sample gas streams. The UV lamp source is required to be equal to or greater than the ionization potential of the substance drawn through the instrument in order to create separate ionized species.

4.0 RESPONSIBILITIES

Health and Safety Manager (HSM) - The HSM shall ensure that the user has been appropriately trained and certified in the usage of the Photovac 2020 instrument.

Equipment Manager - The Equipment Manager shall ensure all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuing any instrument for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.

Field Operations Leader (FOL)/Field Team Leader (FTL) - The FOL/FTL shall ensure all field team members employing the monitoring instruments as part of their assigned duties are adequately trained in the operation and limitations of this instrument. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities.

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Health and Safety Officer (HSO) - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASP).

Site Safety Officer (SSO) - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO, and that any action levels specified are observed for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO, during specific air monitoring applications including STEL and TWA mode measurements, will be responsible for the operation and application of this specialty air monitoring device.

5.0 PROCEDURES

5.1 Principle of Operation

The Photovac portable photoionizer detects the concentration of many organic (and a few inorganic). The basis for detection of this instrument is the ionization of components of captured gaseous streams. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. Molecules are transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively-charged ion and the free electron. The instrument measures this energy level.

This instrument measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations. It does not distinguish between individual substances. Readings displayed represent the total concentration of all photoionizable chemicals present in the sample. This instrument is factory set to display concentration in units of ppm or mg/m³.

The 2020 instrument is easy to operate. The meter display updates itself once per second. Concentrations are directly displayed on the readout.

2020 also performs short-term exposure limit (STEL), time-weighted average (TWA), and PEAK calculations. You can view any of these results, but only one mode may be viewed at a time.

2020 has 6 keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate 2020. They allow you to manipulate the concentration data in various ways.

All information entered with the keys and stored in 2020's memory is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be set each time 2020 is turned on.

5.1.1 Displays

The 2020 has a meter display for reporting detected concentration, and a display used to display status information and guide you through configuration options. All functions of the 2020 will be controlled or reported using one of these displays.

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5.1.1.1 Meter Display

The meter display is a 4-digit display. It will always be used for reporting detected concentration. When the detector and pump are off, the meter display will be blank.

In order to accommodate the range of concentrations 2020 can detect, the meter reading will be reported using one of 2 resolutions. A resolution of 0.1 will be used for concentrations below 100 ppm, and a resolution of 1 will be used for concentrations above 100 ppm.

5.1.1.2 Status Display

The status display is a 2 line by 16 character display. The top line is used to display status information and prompts you for information. The bottom line is used for soft key names. Up to 3 names can be displayed for the 3 soft keys. If a name does not appear for a soft key, then the soft key has no associated function.

5.1.2 **Keys**

5.1.2.1 Fixed Keys

The three round keys below the soft keys each have a fixed function. The first key is the ON/OFF key, the middle key is the EXIT key, and the last key is the ENTER key.

The ON/OFF key is used to both turn power on to the 2020 as well as turn the power off. To turn on 2020, press the ON/OFF key. To turn the power off, press the ON/OFF key and hold it down for 2 seconds, and then release it. This is done to prevent accidental power off.

The EXIT key provides a way of returning to the default display. In the functional map, the soft keys allow you to advance and the EXIT key provides a way to go back. If you are at the initial entry of the menu, EXIT will return you to the default display

The ENTER key has a context sensitive function. When you are operating or navigating through the function map, the ENTER key is used to exit the functions and return you to the default display. When entering data such as a name, number, date or time ENTER is used to confirm the entry

5.1.2.2 Soft Keys

The three soft keys on 2020 are located directly below the status display. Each key has varying functions for configuring 2020, editing the data logger and controlling the display. Since only three soft keys are available, each function is broken down into a path

5.1.2.3 Entering Text With the Soft Keys

For all information that you must enter, the left, center, and right soft keys correspond to the up, down, and right arrow.

The up and down arrows are used to change the character highlighted by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right most character, it wraps around to the first character again. To accept the changes, press the ENTER key. To ignore the change, press EXIT.

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Formatting characters, such as the colon (:) in the time, the decimal (.) in a concentration, and the slash (/) in the date are skipped when advancing the cursor.

All inputs are an 8 character input, which is displayed on the right side of the top line of the status display. The prompt, describing the input, occupies the left half of the top line. The soft keys are defined on the bottom line of the status display.

5.2 Default Display

The meter display shows the detected concentration. The resolution of the display changes with the magnitude of the reading. A reading of 0 to 99.9 will be displayed with a resolution of 0.1 ppm or mg/m³. A reading greater than 99.9 will be shown with a resolution of 1 ppm or mg/m³. The meter will display concentrations up to 2000 ppm or 2(XX) mg/m³.

The status display is used to display the instrument status, date, time, units, and active soft keys.

The default display provides the following information: instrument status, current detected concentration, time, date, and measurement units. The status display toggles between showing time and units and then the date.

When the display mode is MAX, the date and time correspond to the date and time the MAX concentration was recorded. In TWA mode, the time represents the number of hours and minutes during which the TWA has been accumulating. For PEAK and STEL monitoring, the date and time correspond to the current date and time.

5.3 Monitoring

5.3.1 Instrument Status

The instrument status is shown on the left of the first line of the status display and on the Table and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.3.2 Alarms

While operating the instrument, any one of three alarm conditions can occur. To accurately identify the source of the alarm, each type of alarm has been given a unique status.

In addition to the status, 2020 also has an audible alarm and a visual alarm LED. To conserve power, the 2020 alternates between these two alarm indicators, rather than operating both concurrently. Different alarms are identified by the frequency at which the 2020 alternates as follows: PEAK alarm-5 times per second; STEL alarm-2.5 times per second, and TWA alarm-1.25 times per second.

The left soft key is used for acknowledging alarms, and is named "Ack." If no alarm exists, then the "Ack" key is not shown. To clear the alarm, press the "Ack" key. Once acknowledged, the alarm indicators are cleared. The alarm status will remain until the alarm condition clears.

2020 updates the peak concentration once every second. Following every update, the peak concentration is compared to the peak alarm level, and if exceeded, an alarm is triggered.

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If 15 minute average exceeds the selected STEL, a STEL alarm is generated.

The TWA alarm is generated when the current average of concentration, since the TWA was last cleared, has exceeded the TWA exposure limit.

During calibration, all alarms are disabled. Once the calibration is complete the alarms are re-enabled.

5.4 STEL, TWA, MAX, and PEAK Operation

The 2020's meter display can be configured to show one of four values: STEL, TWA, PEAK, and MAX.

5.4.1 **Short-term Exposure Limit (STEL) Mode**

The Short-term Exposure Limit (STEL) mode displays the concentration as a 15 minute moving average. 2020 maintains 15 samples, each representing a one-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new one minute average. This moving average provides a 15-minute average of the last 15 minutes with a one-minute update rate. Since the average is calculated using 15 one-minute averages, the meter display will only update once every minute.

STEL is set to zero each time the instrument is turned on. Since STEL is a 15-minute moving average, there is no need to clear or reset the STEL.

STEL calculations are always being performed by 2020. You can display the results of the calculations by selecting STEL as the Display mode.

5.4.2 **Time-weighted Average (TWA) Mode**

The TWA accumulator sums concentrations every second until 8 hours of data have been combined. If this value exceeds the TWA alarm setting, a TWA alarm is generated. The TWA is not calculated using a moving average. Once 8 hours of data have been summed, the accumulation stops. In order to reset the TWA accumulator, press the "Clr" key.

This sum will only be complete after 8 hours, so the meter displays the current sum divided by 8 hours. While you are in TWA mode, the time on the status display will show the number of minutes and hours of data that TWA has accumulated. When this reaches 8 hours, 2020 stops accumulating data and the TWA is complete.

TWA calculations are always being performed by 2020. You can display the results of the calculations by selecting TWA as the Display mode.

5.4.3 **MAX Mode**

The MAX mode displays the maximum signal, with the date and time that it was recorded. 2020 continues to log data according to the selected averaging interval, but only the maximum detected concentration is displayed on the meter display.

The right soft key is used to clear the meter when displaying MAX. The "Clr" key only affects the reading that the meter is displaying. For example, if you display the MAX reading, and you press "Clr," only the MAX value is cleared. The TWA is still accumulating in the background.

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5.4.4 **PEAK Mode**

The PEAK mode displays the current detected concentration. The reading is updated once a second. In the background, the 2020 data logger is sampling the concentration and measuring minimum, maximum, and average concentrations for the selected averaging interval. At the end of every interval, one entry is placed in the data logger until the data logger is full. Typical application concerning the use of this instrument is operated in this mode. Operation within the other specialized modes are the responsibility of the SSO.

5.5 **Set Functions**

Set functions are used to setup 2020. There are three functions which can be set on the 2020: Calibration, Pump and Clock.

5.5.1 **Pump**

The Pump function is used to control the pump. After selecting Set Pump, 2020 responds by displaying the new pump status.

The detector is also turned off when you turn the pump off. This prevents the detector from being damaged when there is no sample flowing through the detector.

When the pump and the detector are off, the meter display will be blank. Turn the pump and detector off when concentration measurements are not necessary, and 2020 will only be used for reviewing data or generating reports. By operating the instrument with the pump and detector off when you do not need them, you will conserve the lives of the battery and ultraviolet (UV) lamp.

- 1 Press the ENTER key. The top line of the status display changes to "Select?". The bottom line displays 3 soft key names "Set," "Log" and "Disp"
- 2 Press the soft key below "Set."
- 3 The names of the soft keys change to reflect the Set options. The display now shows 3 devices which can be set: "Clock," "Pump" and "Cal." Press the "Pump" key.
- 4 The 2020 turns the pump off. If the pump was off, pressing "Pump" will turn the pump on.
- 5 A message will be displayed to show you the status of the pump. 2020 reverts back to the previous menu after a few seconds
- 6 To return to the default display, press the ENTER key.

5.5.2 **Clock**

The Clock function is used to set both the current date and time.

- 1 Press the ENTER key.
- 2 Press the "Set" key.
- 3 When the names of the soft keys change, press the "Clock" key.

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The up and down arrows are used to change the character underlined by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right-most character, it wraps around to the first character again.

Formatting characters, such as the colon (:) in the time and the slash (/) in the date are skipped when advancing the cursor.

4. Use the "arrow keys" to enter the correct time. The time is formatted as Hour:Minute:Second.
5. Press the ENTER key to confirm the time and move to the date option.
6. When setting the date, the 2020 prompts you for the current date formatted as Year/Month/Day. Use the "arrow keys" to enter the correct date.
7. Press the ENTER key to confirm the date and return to the Set options. You can wait for the display to timeout or press ENTER to return to the default display.

5.5.3 Calibration (Cal)

Cal allows you to setup and calibrate 2020. You have three options under the Cal function: "Zero," "Span," and "Mem."

A calibration memory consists of a name, a response factor, and PEAK, TWA, and STEL alarm levels.

The "Zero" and "Span" keys are covered in detail in the manufacturer's operations manual for the instrument.

To edit the calibration memory, select "Mem" and then "Chng." The 2020 prompts you with two new soft keys "User" and "Lib."

5.5.4 Library (Lib)

Library selections simplify Cal Memory programming and provide standard response factors for approximately 70 applications. "Lib" allows you to select an entry from a pre-programmed library. The name, response factor, and three alarm levels are all set from the library. To select a library entry to program the selected Cal Memory:

1. Select "Set," "Cal," "Mem," "Chng," and "Lib."
2. Use the "Next" and "Prev" keys to scroll through the list. See the manufacturer's manual Appendix 8.7 for a list of the library entries.

5.6 Preparing for Field Operation of the Photovac 2020

Turning 2020 On

1. Turn 2020 on by pressing the ON/OFF key.
2. 2020 will display the software version number. Wait for the 2020 to proceed to the default display.
3. Allow 10 minutes for the instrument to warm up and stabilize.

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4. Press the Enter Key. The default display will provide 3 soft key selection "Set," "Log," and "Display."
5. Press "Set." From this option 3 other soft key selections will be offered: "Pump," "Clock," and "Cal."
6. Press "Cal." This will begin the calibration sequence. The first selection is to Zero the instrument.
7. Press Enter, zeroing will begin. (Note: When employing zero gas attach and activate zero gas supply at this time.)
8. The next selection offered will be Span. Press Enter at which time the concentration will be requested. The isobutylene calibration gas employed under general service will be marked on the side of the container. Use the soft keys to toggle into position and to log the concentration. Once the concentration is logged press "Enter." The direction or status display will indicate spanning. At this time hook up the span gas with a regulator to the Photovac 2020, and open it to supply enough flow to elevate the flow rate indicator to the green indicator line (1/8" from the r st position).
9. Once spanning is complete, the alarms which have been disabled during calibration will activate indicating that calibration is complete
10. Document this calibration procedure using a Document of Calibration form as illustrated in Figure 5-1.

This instrument is ready for general purpose application

Calibration is to be performed daily or prior to each use in accordance with Section 5.6 of this SOP.

5.7 Maintenance and Calibration Schedule

Function	Frequency
Routine Calibration	Prior to each use
Factory Inspection and Calibration	Once a year, or when malfunctioning
Wipe Down the Outer Casing of the Unit	After each use
Clean UV Light Source	Every 24 hours of operation
Sample Inlet Filter	Change on a weekly basis or as required by level of use
Battery charging	After each use
Clean ionization chamber	Monthly

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5.7.1 **Cleaning the UV Light Source Window**

1. Turn the FUNCTION switch to the OFF position. Use 2020 multi-tool and remove lamp housing cover.
2. Tilt the lamp housing with one hand over the opening, slide the lamp out of the housing.
3. The lamp window may now be cleaned with any of the following compounds using lens paper:
 - a. 11.7 eV Lamp - Dry Aluminum Oxide Powder (3.0 micron powder)
 - b. HPLC Grade Methanol - All other lamps
4. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace o-ring as necessary, reinstall lamp housing cover, tighten using 2020 multi-tool. (Do not over tighten).
5. Recalibrate as per Section 5.6.

5.7.2 **Cleaning the Ionization Chamber**

1. Turn the FUNCTION switch to the OFF position and remove the lamp housing cover and lamp as per Section 5.7.1.
2. Using a gentle jet of compressed air, gently blow out any dust or dirt.
3. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace o-ring as necessary, reinstall lamp housing cover, tighten using 2020 multi-tool. (Do not over tighten).
4. Recalibrate as per Section 5.6

5.8. **Instrument Advantages**

The Photovac 2020 is easy to use in comparison to many other types of monitoring instrumentation. Its detection limit range is in the low parts-per-million range. Response time rapidly reaches 90 percent scale of the indicated concentration (less than 3 seconds for benzene). This instrument's automated performance covers multiple monitoring functions simultaneously, incorporating data logging capabilities.

5.9 **Limitations of the Photovac 2020 Photoionization Monitor**

- Since the 2020 is a nonspecific total gas/vapor detector, it cannot be used to identify unknown chemicals; it can only quantitate them in relationship to a calibration standard (relative response ratio).
- For appropriate application of the 2020, ionization potentials of suspected contaminants must be known.

Because the types of compounds that the 2020 can potentially detect are only a fraction of the chemicals possibly present at a hazardous waste site or incident, a background or zero reading on this instrument does not necessarily signify the absence of air contaminants.

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- The 2020 instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected.
- PID's are generally not specific. Their response to different compounds is relative to the calibration gas used. This is referred to as relative response ratio. Instrument readings may be higher or lower than the true concentration. This can be an especially serious problem when monitoring for total contaminant concentrations if several different compounds are being detected at once.
- The 2020 is a small, portable instrument which cannot be expected to yield results as accurately as laboratory instruments.

5.9.1 Variables Affecting Monitoring Data

Monitoring hazardous waste site environment can pose a significant challenge in assessing airborne concentrations and the potential threats to site personnel. Several variables may influence both dispersion and the instrument's ability to detect actual concentrations. Some of the variables which may impact these conditions are as follows:

- Temperature - changes in temperature or pressure will influence volatilization, and effect airborne concentrations. Additionally, an increase or decrease in temperature ranges may have an adverse effect on the instrument's ability to detect airborne concentrations.
- Humidity - excessive levels of humidity may interfere with the accuracy of monitoring results.
- Rainfall - through increased barometric pressure and water may influence dispersion pathways effecting airborne emissions
- Electromagnetic interference - high voltage sources, generators, other electrical equipment may interfere with the operation and accuracy of direct-reading monitoring instruments.

6.0 TROUBLESHOOTING

6.1 Fault Messages

When the "Fault" status is displayed, 2020's operation is comprised

Fault 1: Signal from zero gas is too high.

Cause: If another fault occurred while 2020 was setting its zero point, then this fault is displayed.

Action: Ensure no faults are occurring and calibrate 2020 again.

Cause: Contamination of sample line, sample line, sample probe or fittings before the detector.

Action: Clean or replace the sample line, sample probe or the inlet filter.

Cause: Span gas and zero air are mixed up.

Action: Ensure clean air is used to zero 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

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Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of ambient air, use a supply of commercial zero grade air to zero 2020.

Fault 2: Signal from span gas is too small.

Cause: Operator may have confused the span gas and zero air.

Action: Ensure clean air is used to zero 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Action: Ensure the span gas is of a reliable concentration.

Cause: UV lamp window is dirty.

Note: Do not remove the detector lamp in a hazardous location.

Action: Clean the UV lamp window.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp

Cause: Incompatible application

Action: The concentration and sample gas are incompatible for use with 2020.

Fault 3: UV lamp fault. UV lamp has not started.

Cause UV lamp has not started immediately

Action: This fault may be seen momentarily when 2020 is first turned on. Allow 30 to 60 seconds for the UV lamp to start and the fault to clear.

Cause UV lamp serial number label is blocking the photocell.

Note: Do not remove or replace the detector lamp in a hazardous location

Action: If you have a UV lamp with a white serial number label, it is possible that the label is blocking the photocell. Rotate the lamp approximately 90 degree and then try to start 2020 again. If the fault persists, replace the lamp.

Cause UV lamp not installed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a UV lamp.

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Cause: UV lamp has failed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Electronic problem.

Action: If a new UV lamp still generates this fault, then contact the Photovac Service Department.

Fault 4: Pump current too low or too high.

Cause: If the pump sounds labored, then the pump is operating beyond normal operating parameters.

Action: Check for an obstruction in the sample line. Make sure sample line, sample probe or inlet filter are not plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Action: Ensure the sample outlet, located on the underside of 2020, is not obstructed.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.

Cause: 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the Equipment Manager.

Cause: The pump has failed

Action: Contact the Equipment Manager.

6.2 Specific Problems

Problem: Very low or no instrument response detected, yet compounds are known to be present.

Cause: 2020 has not been calibrated properly

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 3.2 or 3.3 of the User's Manual.

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After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Equipment Manager.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Disconnect the battery charger before calibrating 2020.

Cause: Calibration Memories have not been programmed correctly.

Action: Program all the calibration memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory.

Cause: Response factor has been set to zero.

Action: Enter the correct response factor. Refer to Appendix 8.6 for a list of response factors. If the compound is not listed in Appendix 8.6 or you are measuring gas mixtures, then enter a value of 1.0. See User's Manual.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application.

Note: It does not matter which Cal Memory is selected or which response factor is entered. 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector is leaking. A decrease in sensitivity may be due to a leak in the detector.

Note: Do not remove or replace the detection lamp in a hazardous location.

Action: Ensure the UV lamp has been installed correctly.

Action: Ensure the lamp cover has been tightened down. Do not overtighten the cover.

Action: Ensure the o-ring seal on the lamp cover is positioned correctly.

Cause: UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the Equipment Manager.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

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Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.

Cause: Sampling environment is extremely humid.

Action: Water vapor is not ionized by the PID, but it does scatter and absorb the light and results in a lower reading.

The 2020 detector has been designed to operate under high humidity conditions. Under extreme conditions you may notice decreased response due to humidity.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Cause: High concentration of non-ionizable compounds.

Action: Chemical compounds, such as methane, with IPs greater than the 10.6 V scatter and absorb the UV light. Sensitivity may be decreased significantly.

Application with high backgrounds of such materials, may be incompatible with 2020. Contact the Photovac Applications Group for more information.

Problem: Erroneously high readings.

Cause: Sampling environment is extremely humid

Action: Water vapor may contain mineral salts which carry a charge. The water vapor becomes an electrolytic solution which becomes ionized when it enters the detector

Atmospheric water in areas around the sea or stagnant water may produce a response in the absence of contaminants. The same effect may be seen when conducting ground water investigations in areas where the water is hard because it contains a significant concentration of minerals.

Cause: 2020 has not been calibrated properly

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 5.6.

After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not contact the Equipment Manager

Cause: Cal Memories have not been programmed correctly.

Action: Program all the Cal Memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory. See Section 3.4. of the User's Manual.

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Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application. See Section 3.2.2 or 3.3.2, of the User's Manual.

Note: It does not matter which Cal Memory is selected or which response factor is entered. 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the Equipment Manager.

Problem: Date and time settings are not retained.

Cause: The battery pack has been removed before 2020 was turned off.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack and reset the time and date. Ensure 2020 has been turned off before removing the battery pack.

Cause: 2020 has not been used for 3 months or more and the internal battery (not the external battery pack) has discharged.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Connect 2020 to the AC adapter and turn 2020 on. Turn the pump off. While 2020 is running the internal battery is charging. Leave the instrument running for approximately 24 hours.

Problem: Instrument status shows "Over."

Cause: High concentrations of gases and vapors will cause a rapid change in signal level. The detector and associated electronics may become temporarily saturated.

Action: Wait a few seconds for the status to return to normal. PIDs are designed to detect relatively low concentrations of gases and vapors. Exposure to very high concentrations may result in a very high or maximum response.

Cause: The detector has become saturated.

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Action: Move 2020 to a location where it can sample clean air. Sample clean air until the reading stabilizes around 0.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust or dirt in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the Equipment Manager.

Problem: Display is blank.

Cause: Battery pack is critically low.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack or connect 2020 to the AC adapter.

Cause: The battery pack is not connected to the instrument correctly.

Action: Ensure the battery pack connector is securely attached to the connector on 2020

Cause: There is an undetermined problem

Action: Reset 2020. You must leave the instrument on while you disconnect the battery pack. This will reset the instrument. Reconnect the battery pack and close the battery hatch. Turn on 2020, set the time and date and program all the calibration memories that you are using.

Action: Contact the Equipment Manager

Problem: Sample flow rate is less than 300 ml/min.

Cause: Inlet filter is plugged

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace inlet filter

Cause: Inlet filter has not been installed properly.

Action: Ensure that the inlet filter has been installed correctly.

Cause: UV lamp is too long, causing flow to be restricted.

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Note: Do not remove or replace the detector lamp in a hazardous location.

- Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the Equipment Manager.
- Cause: UV lamp is too wide, causing flow to be restricted.
- Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.
- Cause: 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.
- Action: Contact the Equipment Manager.
- Cause: Sample outlet is obstructed
- Action: Ensure the sample outlet is? not obstructed in any way.
- Cause: Pump has been damaged.
- Action: Contact the Equipment Manager.
- Problem: Liquid has been aspirated.**
- Cause 2020 has been exposed to a solvent that can pass through the inlet filter.
- Action: Contact the Equipment Manager
- Problem: Corrosive gases and vapors have been sampled.**
- Cause: 2020 has been exposed to corrosive gases and vapors.
- Action: Corrosive gases and vapors can affect the electrodes within the detector as well as the lamp window. Prolonged exposure to corrosive materials may result in permanent fogging or etching of the window. If 2020 is exposed to corrosive material contact the Equipment Manager.

7.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no calibration gas cylinder accompanying the kit. When shipping or transporting the calibration gas, a Hazardous Airbill including the information as stipulated in Figure 7-1 will be entered.

8.0 REFERENCES

Photovac 2020 Photoionization Monitor User's Manual, 1995.

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FIGURE 7-1

EXAMPLE OF A HAZARDOUS AIRBILL FOR ISOBUTYLENE

SHIPPER'S DECLARATION FOR DANGEROUS GOODS (Provide at least two copies to the airline)

Shipper: BROWN & ROOT ENVIRONMENTAL SPRING RUN ROAD EXTENSION CORADPOLIS, PA 15108		Air Ways No. Page of Pages Shipper's Business Number	
Consignee		FedEx Federal Express	
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: <small>(SEE REGULATIONS)</small> <table border="1" style="display: inline-table;"> <tr> <td>PASSENGER AND CARGO AIRCRAFT</td> <td>EXHIBIT AIRCRAFT</td> </tr> </table>			PASSENGER AND CARGO AIRCRAFT
PASSENGER AND CARGO AIRCRAFT	EXHIBIT AIRCRAFT		
Airport of Departure Airport of Destination:		Shipment type: (delete non-applicable) <input checked="" type="checkbox"/> NON-RADIOACTIVE <input checked="" type="checkbox"/> EXHIBIT	

NATURE AND QUANTITY OF DANGEROUS GOODS							
Dangerous Goods Identification					Quantity and type of packaging	Packing Inst.	Authorization
Proper Shipping Name	Class or Division	UN ID No.	Pack- ing Code	Subsidi- ary Risk			
COMPRESSED GAS R.O.S. (AIR, ISOBUTYLENE)	2.2	UN 1956			1 FIBER BOARD box X KG	200	

Additional Handling Information

Emergency Telephone Number (412) 262-4583

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations.	Name/Title of Signatory TOM PATTON - EQUIPMENT MANAGER
	Place and Date PITTSBURGH, PA Signature (see warning above)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

Form 61-1421 10/88 L00024 801170046



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Effective Date 05/01/96	Revision 0
Applicability B&R Environmental, NE	
Prepared Health Sciences Department	
Approved D. Senovich	

Subject **PHOTOVAC MICROFID HANDHELD
FLAME IONIZATION DETECTOR**

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1.0 PURPOSE

To establish procedures for the use, calibration, maintenance, troubleshooting, and shipment of the Photovac MicroFID handheld flame ionization detector.

2.0 SCOPE

Applies to all Brown & Root Environmental personnel who operate the MicroFID instrument during the performance of their work.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Health and Safety Manager (HSM) - The HSM shall ensure that the user has been appropriately trained and certified in the usage of the Photovac 2020 instrument.

Equipment Manager - The Equipment Manager shall ensure that all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuance for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.

Field Operations Leader (FOL)/Field Team Leader (FTL) - The FOL/FTL shall ensure all field team members using monitoring instruments as part of their assigned duties are adequately trained in their proper operation and limitations. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities.

Health and Safety Officer (HSO) - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASP).

Site Safety Officer (SSO) - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO and action levels employed as contingencies marks for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls are employed as directed. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO during specific air monitoring applications including STEL and TWA mode measurements will be responsible for operation and application of this specialty air monitoring employment duty.

5.0 PROCEDURES

5.1 Principles of Operation

The MicroFID is a flame ionization detector used for the measurement of combustible organic compounds in air at parts per million levels. Permanent air gases (argon, carbon dioxide, nitrogen, oxygen, water vapor, etc.) are not ionized by the flame.

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When the MicroFID is turned on, the display prompts you to turn on the hydrogen. The internal pump draws air in through MicroFID's inlet. This sample air provides the oxygen necessary for combustion in the hydrogen-fueled flame. When the proper ratio of hydrogen to air is present in the combustion chamber, the flame is automatically started with a glow plug. A thermocouple is used to monitor the status of the flame. When the sample passes through the flame the combustible organic compounds in the sample will be ionized. After the compounds have been ionized, they are subjected to a continuous electric field between the repeller electrode at the jet and the collector electrode. The ions in the electric field generate a current which is proportional to the concentration of the ionized molecules in the ionization chamber. An electrometer circuit converts the current to a voltage that is then fed to the microprocessor which interprets the current in units of ppm. After the sample passes through the flame and has become ionized, it is vented from the detector through a flame arrestor. The flame arrestor prevents the flame from igniting any flammable gases present in the working atmosphere.

MicroFID is strictly an organic compound detector. It does not respond to inorganic compounds. MicroFID's sensitivity is highly dependent on chemical structure and bonding characteristics. The combustion efficiency of a compound determines its sensitivity. Simple saturated hydrocarbons (methane, ethane, etc.) possess high combustion efficiencies and are among the compounds that produce the highest MicroFID response. Organic fuels (acetylene, refined petroleum products), burn easily and are also extremely well detected.

The presence of substituted functional groups (amino, hydroxyl, halogens) on a simple hydrocarbon reduces its combustion efficiency and the MicroFID's sensitivity to the compound. For example, methanol and chloromethane are detectable with MicroFID, but not at the same sensitivity as methane. The number of carbon atoms can also affect the instrument's sensitivity due to substitution. For example, MicroFID is more sensitive to n-butanol than it is to methanol. For additional information regarding response factors of the MicroFID, consult Appendix 8.5 of the User's Manual.

Beginning Operation

You can operate MicroFID without the flame to print or review logged data. In this way you can conserve the hydrogen fuel.

If you choose to start the flame, MicroFID will attempt to ignite the flame once you have turned on the flow of hydrogen gas. If the MicroFID has not been used for a while, it is possible that the gas supply lines are filled with air. If the flame cannot be started, MicroFID will begin a 30 second purge cycle. During the purge cycle it will flush the gas supply lines with hydrogen. After the purge cycle, it will attempt to light the flame again. If it fails again, another purge cycle will be performed and MicroFID will try a third time to ignite the flame. The following steps summarize proper start-up procedures.

1. Turn the instrument on by pressing the front of the On/Off switch. When the instrument is powered up, the version number and creation date of the instrument software are displayed. Press ENTER.
2. You will be prompted to start the flame. If you do not want to start the flame, use the ARROW keys to select "No Flame Needed" and press ENTER. To start the flame, use the ARROW keys to select Start Flame and press ENTER.
3. If you selected "Start Flame," MicroFID will prompt you to turn on the hydrogen. Turn the shut-off valve counterclockwise to start the flow of hydrogen and press ENTER.

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4. The pump will start and MicroFID will then ignite the flame. You will hear a small pop when the flame has been ignited. Once the flame has been started the message "Detector flame has been started OK" will be displayed followed by the default display.

The default display provides the following information: instrument status, current detected concentration, event name (if the datalogger is on), time, and date. If an event name is longer than three characters, the bottom line of the display will scroll through the information.

The instrument status appears at the left of the upper line of the display and on the Print and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.2 Calibration

The calibration (CAL) key is used to calibrate MicroFID. Before beginning calibration, ensure that you have a reliable source of both zero air and calibration gas. To document calibration efforts, field personnel will record information on Figure 1-1. A brief description of the functions under the CAL key are as follows:

1. When you press the CAL key you will first be prompted to select a Cal Memory. Each Cal Memory stores a unique zero point, sensitivity setting, response factor and alarm level.
2. You will then be prompted to enter a response factor. Refer to Appendix 8.5 of the User's Manual for a list of response factors. If the compound is not in that reference, or if you are measuring mixtures, enter a value of 1.00. The concentration detected by MicroFID will be multiplied by the response factor before it is displayed and logged.
3. Next select Low Range or High Range operation. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling concentrations between 10 and 50,000 ppm (methane equivalents).
4. You will now be prompted to connect a supply of zero air. You can use ambient air or, for best results, use a clean sampling bag filled with zero grade air. In most cases, ambient air will be used provided calibration is performed in an area in which airborne concentrations of contaminants are not present. If using ambient air, press <ENTER> to begin zeroing.
5. If you are using a charcoal filter to clean ambient air, connect the filter by loading the Teflon ferrules into the nut (the ferrules and the nut are supplied with the filter). Connect the nut to MicroFID's inlet. Do not tighten the nut. Remove the charcoal filter from its plastic bag and insert it into the nut. Finger tighten the nut onto the inlet. If the filter is not secure, ensure you have inserted the tube far enough into the nut. Do not over-tighten the fitting. Press <ENTER> and the MicroFID will set its zero point. NOTE: The charcoal filter does not filter methane or ethane. If these compounds are present, use a gas bag with a supply of commercial zero air.
6. If you are using a gas bag with zero air, connect the gas bag to the inlet. Open the bag and press <ENTER>. MicroFID will set its zero point.
7. After MicroFID has set its zero point, you can then enter the concentration of the calibration gas (span gas), and then connect the gas bag adapter to the inlet. Open the bag and press <ENTER>. MicroFID sets its sensitivity. Note: You must have a supply of calibration gas ready before calibrating MicroFID. When calibrating MicroFID, ensure the instrument is level. If MicroFID is tilted from side to side, gravity will affect the flame height and cause erroneous readings.

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8. When MicroFID's display reverts to normal, it is calibrated and ready to use. Remove the span gas bag from the inlet.
9. Press the ALARM key and enter the alarm level for the selected CAL memory.

5.3 Routine Maintenance

5.3.1 Battery Charging

A fully charged battery will power the MicroFID for approximately 15 hours. If the instrument is to be used for more than 15 hours, carry a spare battery pack. Battery life is reduced if the instrument is turned off and then on again repeatedly.

When the instrument status displays "LoBat," the battery pack requires changing. When the "LoBat" status is displayed, you have a few minutes of operation left. MicroFID will turn itself off before the battery pack becomes critically low.

To remove the battery pack:

1. Stop the flow of hydrogen gas by turning the hydrogen shut-off valve fully clockwise. Turn the instrument off by pressing the On/Off switch twice.
2. Use the MicroFID multi-tool to loosen the two captive screws in the bottom of the battery pack.
3. A retainer at the rear of the instrument helps secure the battery pack to the instrument. Free the battery pack from the instrument.
4. Connect the charged battery pack to the retainer at the rear of the instrument.
5. Retighten the two captive screws and the bottom of the battery pack.

To charge the battery pack:

1. Ensure the correct plug is installed on the line cord of the battery charger.
2. Plug the charger into the jack located on the front of the battery pack.
3. Plug the charger into an AC outlet. The LED on the battery pack indicates the charge state. Red indicates the battery is being charged. Green indicates the battery is fully charged and ready for use. It is normal for a fully charged battery to indicate it is charging (red light) when first plugged in. The LED will turn green as the battery charges.
4. When the battery pack is charged remove the charger, first from the wall outlet then from the battery pack.

Charging a fully discharged battery pack will take approximately 8 hours. Leaving the charger connected to a charged battery pack will not harm the battery or the charger in any way. If a battery pack is to be left indefinitely, leave it connected to the charger so that it will be fully charged and ready for operation.

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5.3.2 Emptying the Hydrogen Cylinder

When you transport the MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination.

To empty the cylinder:

1. Turn the MicroFID off and open the hydrogen shut-off valve.
2. Remove the battery pack as described above
3. Locate the purge outlet. It is located on the underside of the instrument.
4. Use the MicroFID multi-tool to turn the screws counterclockwise. Loosen the screw but do not remove it.
5. Leave the instrument so that the purge outlet is facing up. If the purge outlet is facing down, hydrogen will vent into MicroFID's case
6. If the cylinder is full, it will take approximately 15 minutes to empty.
7. Watch the Contents gauge. When the cylinder is empty, close the purge outlet. Use the MicroFID multi-tool to turn the screw clockwise
8. Replace the battery pack as discussed above

5.3.3 Replacing the Sample Inlet Filter

MicroFID is equipped with a combined dust and water filter to reduce detector contamination. As the filter collects dust, MicroFID's inlet flow rate and sensitivity decrease. The filter will not allow water to pass through, but the filter will not stop all solvents

Replace the filter on a weekly basis, or more frequently if MicroFID is used in a dusty or wet environment. You must replace the filter if MicroFID has been exposed to liquid water. The pump will sound labored when the filter requires replacement.

1. Turn off the instrument and unscrew the filter housing from the detector housing. Be careful not to lose the o-ring seal.
2. Remove the Teflon/Polypropylene filter and install the new filter. Place the filter in the filter housing with the Teflon side facing down into the filter housing and the mesh side facing the MicroFID. Handle the filter disk only by the edges. The mesh may be damaged or contaminated by excessive handling. Use forceps if possible
3. Replace the filter housing.
4. Calibrate the CAL Memories that you are using before continuing operation.

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5.4 Troubleshooting

This section provides guidance for troubleshooting the MicroFID. If problems are not corrected through these troubleshooting methods, contact the Photovac Service Department.

5.4.1 MicroFID Fault Messages

When the "Check" status is displayed, MicroFID's operation is compromised. Press the <TUTOR> key for a two-line description of the fault. One exception is the flame out fault. When a flame out fault occurs, the instrument status changes to "NoFlm."

Fault: Detector flame has gone out.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the cylinder purge outlet has been closed.

Cause: Oxygen supply is deficient.

Action: Ensure there is an adequate supply of oxygen. If you are sampling very high concentrations it is possible you are sampling above the flame out concentration. The flame concentration for methane is approximately 52,000 ppm (5.2 percent methane in air).

A minimum of 17 percent oxygen is required to start the hydrogen flame. The oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Flame out also may occur when sampling enclosed or confined spaces where vapors and gases cannot escape. Watch for indications of increased flame height such as erratic readings or sudden high concentrations followed by a flame out fault.

If you will be using the MicroFID in a highly contaminated area where it is possible that the oxygen content is below 10 percent, watch for indication of reduced flame height such as lowered detection limits or a flame out fault.

Cause: High concentrations of flammable gases (gases within their flammable range) are present. High concentrations of flammable gases can act as an additional fuel source. When this happens, the flame height may increase beyond the confines of the combustion chamber. The hydrogen supply will then be cut-off and the flame will go out.

Action: Move to a location where there is an adequate supply of air and restart the flame. See the information above. Watch for indications of increased flame height such as erratic readings or sudden height concentrations followed by a flame out fault.

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Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor, a by-product of the hydrogen flame, may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Cause: Sample line is blocked.

Action: Ensure the sample line is not obstructed in any way. If you are using the long sample probe, ensure flow is maintained through the entire length of tubing.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Fault: Signal form zero gas is too high.

Cause: Contamination of sample line or fittings before the detector.

Action: Clean or replace the sample line of the inlet filter.

Cause: Span gas is used instead of zero gas

Action: Ensure clean gas is used to zero the MicroFID. Mark the calibration and zero gas bags clearly.

Cause: Ambient air is contaminated

Action: If you are unsure about the quality of the ambient air, use a charcoal filter or a supply of commercial zero grade air.

Cause: Hydrogen supply is contaminated

Action: Hydrogen may react with the carbon element of the steel tank to produce methane. This will only occur if the cylinder is in poor condition and if the hydrogen has a high moisture content. Replace the hydrogen tank. Empty and refill the MicroFID internal cylinder with fresh hydrogen.

Fault: Signal form the span gas is too small

Cause: Span gas and zero air are switched

Action: Ensure calibration is used to calibrate MicroFID. Mark the calibration and zero gas bags clearly. Ensure the span gas is of a reliable concentration.

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Fault: Detector field voltage is low.

Cause: Internal fault in electronics.

Action: Contact the Photovac Service Department.

Problem: No instrument response detected, yet compounds are known to be present.

Cause: MicroFID has not been calibrated properly.

Action: Ensure calibration gas is of a reliable concentration and then calibrate the instrument. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Photovac Service Department.

Action: When calibrating the MicroFID, ensure the instrument is level. If the MicroFID is tilted side to side, gravity will affect the flame height and cause erroneous readings. If the sampling location is difficult to reach without tilting the instrument, use the long sample probe.

Cause: Background contamination from the hydrogen.

Action: It is possible that the hydrogen has become contaminated and is contributing a high background signal. If the hydrogen supply tank is more than 6 months old it should be replaced with a new cylinder. When ordering hydrogen, specify ultra-high purity (99.999 percent pure). Empty the MicroFID hydrogen cylinder and then refill with hydrogen from the new cylinder.

Problem: Date and time settings are not retained.

Cause: MicroFID has not been used for 3 months or more and the internal battery (not the external battery pack) has been discharged.

Action: Turn MicroFID on and allow it to run until a "LoBat" status appears. This will take approximately 15 hours. Remove the battery pack and recharge it overnight. Repeat this procedure for 3 or 4 days. While MicroFID is running the internal battery is charging.

Problem: Cannot fill the internal hydrogen cylinder to 1800 psig.

Cause: Supply tank has less than 1800 psig of pressure. You can only fill the internal cylinder to a pressure of less than or equal to the tank pressure.

Action: Fill the internal cylinder to the pressure of the tank or replace the tank with a full one.

Cause: The hydrogen purge outlet is open.

Action: Close the outlet and fill the cylinder.

Cause: There is a problem with the refill adapter.

Action: Contact the Photovac Service Department.

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Problem: Instrument status shows "Over."

Cause: Rapid change in signal level. The detector electronics have been momentarily saturated.

Action: Wait a few seconds for the status to return to "Ready."

Cause: The detector has become saturated.

Action: Move the MicroFID to a location where it can sample clean air. Sample zero air until the reading stabilizes around "0." If you were using Low Range, switch to High Range. Calibrate the CAL Memory you were using when the "Over" status appeared.

Problem: Display contrast bars are on or display is blank.

Cause: Battery pack is critically low.

Action: Recharge the battery pack or connect the MicroFID to the battery charger.

Cause: The battery pack is not connected to the instrument properly.

Action: Ensure the battery pack has been aligned correctly. Ensure the battery pack is secured by the retainer at the rear of the instrument.

Problem: Sample flow rate varies from 600 ml/min. +/-10 percent.

Cause: Inlet filter has not been installed

Action: Install an inlet filter

Cause: Inlet filter has not been tightened onto the detector cap

Action: Finger-tighten the filter cap

Cause: Inlet filter is plugged.

Action: Replace the inlet filter

Cause: Pump has been damaged

Action: Contact the Photovac Service Department

Cause: Exhaust port is blocked.

Action: At low temperatures water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

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Problem: Flame will not ignite.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the hydrogen purge outlet is closed.

Cause: Oxygen supply is deficient.

Action: Ensure there is an adequate supply of oxygen. Do not attempt to ignite the flame in a location where there is greater than 10,000 ppm methane or the equivalent concentration of a flammable gas. Move to a location where there are lower concentrations, start the flame and then begin sampling higher concentrations. If the flame goes out while you are sampling very high concentrations, it is possible you are sampling above the flame out concentration. The flame out concentration of methane is approximately 52,000 ppm (5.2 percent methane in air). A minimum of 17 percent oxygen is required to start the hydrogen flame. Oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Cause: Hydrogen supply lines are full of air

Action: If MicroFID has not been operated for some time, it is possible that the hydrogen supply lines contain air. Fill the hydrogen cylinder and then open the hydrogen shut-off valve. Allow the hydrogen to purge the system for about 5 minutes and then turn MicroFID on and start the flame.

Cause: Hydrogen lines are blocked

Action: Contact the Photovac Service Department.

Problem: Liquid has been aspirated.

Cause: MicroFID has been exposed to a solvent that can pass through the Teflon/Polypropylene filter.

Action: Contact the Photovac Service Department.

5.5 Transporting MicroFID

When you transport MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination. If you are traveling by passenger aircraft, you must empty the hydrogen cylinder. You cannot transport MicroFID by passenger aircraft with hydrogen in the cylinder.

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The MicroFID can be shipped to sites. However, if shipment is to be performed while the cylinder still contains hydrogen, a hazardous materials airbill must be filled out. Examples of various completed forms are provided as Figures 6-1 and 6-2.

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no hydrogen fuel source or calibration gas cylinder accompanying the kit. If shipping or transporting the hydrogen fuel source, a Hazardous Airbill (such as the example in Figure 6-1) must be completed. When shipping or transporting the calibration gas, a separate Hazardous Airbill such as the one illustrated in Figure 6-2 must be prepared.

7.0 REFERENCES

MicroFID Handheld Flame Ionization Detector User's Manual, 1995.

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FIGURE 6-1

EXAMPLE OF A HAZARDOUS AIRBILL FOR HYDROGEN

SHIPPER'S DECLARATION FOR DANGEROUS GOODS

(Provide at least two copies to the airline)

Shipper: BROWN & ROOT ENVIRONMENTAL SPRING RUN ROAD EXTENSION CORAOPOLIS, PA 15108		Air Waybill No. Page of Pages Shipper's Reference Number		
Consignee		FedEx Federal Express		
<i>Two completed and signed copies of this Declaration must be handed to the operator.</i>		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: <table border="1" style="width: 100%;"> <tr> <td style="text-align: center;"> <input checked="" type="checkbox"/> PASSENGER AIRCRAFT ONLY <input type="checkbox"/> CARGO AIRCRAFT ONLY </td> <td style="text-align: center;"> <input type="checkbox"/> PASSENGER AIRCRAFT ONLY <input checked="" type="checkbox"/> CARGO AIRCRAFT ONLY </td> </tr> </table>	<input checked="" type="checkbox"/> PASSENGER AIRCRAFT ONLY <input type="checkbox"/> CARGO AIRCRAFT ONLY	<input type="checkbox"/> PASSENGER AIRCRAFT ONLY <input checked="" type="checkbox"/> CARGO AIRCRAFT ONLY	Airport of Departure	Shipment type: (delete non-applicable) <input type="checkbox"/> NON-RADIOACTIVE <input checked="" type="checkbox"/> HAZARDOUS
<input checked="" type="checkbox"/> PASSENGER AIRCRAFT ONLY <input type="checkbox"/> CARGO AIRCRAFT ONLY	<input type="checkbox"/> PASSENGER AIRCRAFT ONLY <input checked="" type="checkbox"/> CARGO AIRCRAFT ONLY			
Airport of Destination:				

NATURE AND QUANTITY OF DANGEROUS GOODS							
Dangerous Goods Identification					Quantity and type of packaging	Packing Inst.	Authorization
Proper Shipping Name	Class or Division	UN or ID No.	Pack- ing Group	Quantity			
HYDROGEN, COMPRESSED	2.1	UN 1049			1 PLASTIC BOX	KG	200

Additional Handling Information
(412) 262-4583

Emergency Telephone Number

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations.

Name/Title of Signatory
TOM PATTON, EQUIPMENT MGR.
Place and Date
PITTSBURGH, PA
Signature
(see warning above)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

FedEx 99-1421 1096 LOGO 06 04170648

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FIGURE 6-2.

EXAMPLE OF A HAZARDOUS AIRBILL FOR METHANE IN AIR

SHIPPER'S DECLARATION FOR DANGEROUS GOODS (Provide at least two copies to the airline)

Shipper <i>Brown & Root ENVIRONMENTAL</i> <i>SPRING RUN RD. EXT.</i> <i>CORAUGHS, PA 15108</i>		No. of copies: <i>1 of 1</i> Pages Shipper's business number:
Consignee		
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:		
Airport of Departure		Shipment type: (delete non-applicable) <input checked="" type="checkbox"/> NON-RADIOACTIVE <input type="checkbox"/> RADIOACTIVE
Airport of Destination:		
<input type="checkbox"/> PASSENGER AND CARGO AIRCRAFT <input checked="" type="checkbox"/> CARGO AIRCRAFT ONLY		

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification					Quantity and type of packaging	Packing Inst.	Authorization
Proper Shipping Name	Class or Division	UN or ID No.	Pack. ing Group	Haz. Group			
<i>COMPRESSED GAS</i> <i>N.O.S.</i> <i>(METHANE IN AIR)</i>	<i>2.2</i>	<i>UN 1956</i>			<i>1 FIBERBOARD</i> <i>Box x _____ KG</i>	<i>200</i>	

Additional Handling Information

Emergency Telephone Number *(412) 262-4583*

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations.

Name/Title of Signatory
Tom Patton, Equip Mgr.
 Place and Date
Pittsburgh, PA
 Signature
(see warning above)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

The analytical data shall be delivered electronically in a Dbase III file format (filename.dbf). The exact structure of the database is described in the table below. It shall be the responsibility of the laboratory to ensure that all electronic entries are in strict accordance with the information provided on the Form I.

An example database shall be sent for review prior to the first electronic deliverable in Dbase III format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable shall be directed to Patrick Hooper at Tetra Tech NUS (412)921-8250.

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
SAMPLE_NO	C	25	Field sample ID as listed on the chain-of-custody. The sample number indicated in this field should never be truncated. The only exception for this field not matching the chain-of-custody is for reanalyses and matrix spike results in which a RE or MS suffix will be added to the sample number respectively.
TRUNCATE	C	15	If the field sample ID listed on the Chain of Custody is truncated by the laboratory for use with the laboratory software, the truncated sample ID should appear in this field.
LAB_ID	C	15	Laboratory number for the given sample.
LABORATORY	C	25	Laboratory name.
BATCH_NO	C	10	Laboratory code for batch of samples included in a given run.
ASSOC_BLNK	C	15	Laboratory name of the method blank associated with that particular batch of samples.
QC_TYPE	C	15	Normal Environmental Sample = "NORMAL", Laboratory Duplicate = "DUPLICATE", Matrix Spike = "MS", Matrix Spike Duplicate = "MSD", Laboratory Control Sample = "LCS", Laboratory Control Sample Duplicate = "LCSD", Method Blank = "M_BLANK", Preparation Blank = "P_BLANK"
SAMP_DATE	D	8	Date of sample collection as indicated on the Chain of Custody. Example: 11/07/93
REC_DATE	D	8	Date sample was received by the laboratory.
EXTR_DATE	D	8	Date sample was extracted or prepared by the laboratory.
ANAL_DATE	D	8	Date sample was analyzed by the laboratory.
RUN_NUMBER	N	2 (0)	The number of the analytical run for a given sample in sequence. For example, if a sample is diluted and reanalyzed, the original run number would be 1 and the reanalysis would be 2.
SDG	C	15	Sample delivery group identifier assigned by the laboratory. This number should <u>exactly</u> match the SDG designated on the hardcopy data package.

DATA FIELD	DATA TYPE	FIELD WIDTH	DATA FIELD DESCRIPTION
PROJECT_NO	C	10	Identification of Project Number or CLEAN Task Order (CTO) number
PROJ_MNGR	C	25	The Brown & Root Project Manager's last name, followed by a comma, followed by the first initial of the Project Manager (e.g. Hutson, D)
PARAMETER	C	45	Chemical or analyte name <u>exactly</u> as reported on Form I
CAS_NO	C	10	Chemical Abstract Service number for the parameter listed. The CAS number should be reported exactly as it is listed in publications such as the Merck Index. This field should be left blank for those parameters not having CAS numbers (e.g. Total Organic Carbon)
FRACTION	C	5	Metals = 'M', Volatiles = 'OV', Semivolatiles/BNAs = 'OS', Pesticides = 'PEST', Herbicides = 'HERB', Polychlorinated Biphenyls = 'PCB', Explosives = 'EXP', Any petroleum hydrocarbon or fuel = 'TPH', Wet Chemistry = 'WET', Radionuclide = 'RAD', Miscellaneous = 'MISC'
METHOD	C	20	Analytical method used to quantitate parameter concentrations as listed in the laboratory technical specification (e.g. '8270A' for SW-846 Method 8270A).
LAB_RESULT	N	20 (6)	Reported value in units specified in the UNITS field containing the proper number of significant digits. The % Recovery shall be placed in this field for matrix spike and laboratory control sample results.
UNITS	C	5	The units of measure as reported on the Form I
LAB_QUAL	C	2	The laboratory qualifier as reported on the Form I. For example, a 'U' qualifier should be used for all nondetected results.
IDL	N	15 (6)	Instrument detection limit in units specified in the UNITS field
MDL	N	15 (6)	Method detection limit in units specified in the UNITS field and method specified in the METHOD field
CRDL_CRQL	N	15 (6)	Contract Required Detection/Quantitation Limit in the units specified in the UNITS field. RDL for non-CLP parameters
DIL_FACTOR	N	6 (1)	Dilution factor
PCT_MOIST	N	5 (1)	Percent moisture for soil samples, blank for water samples
COMMENTS	C	20	Analytical result qualifier or comment other than that listed in the LAB_QUAL field. Example: 'Reanalysis'

C = Character string (everything shall be reported in capital letters)

N = Numeric string (decimal places are in parentheses in field width column)

D = Date (Ex: 05/25/97)

APPENDIX C

QUALITY ASSURANCE PROJECT PLAN

Quality Assurance Project Plan
for
**Basewide Groundwater
Operable Unit
Remedial Investigation**

**Naval Submarine Base
New London
Groton, Connecticut**



**Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0312**

June 1999

**QUALITY ASSURANCE PROJECT PLAN
FOR
BASEWIDE GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION**

**NAVAL SUBMARINE BASE
NEW LONDON
GROTON, CONNECTICUT**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:
Northern Division
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 N62472-90-D-1298
CONTRACT TASK ORDER 0312**

JUNE 1999

PREPARED BY:



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ACRONYMS

AS	Air Sparging
ASTM	American Standard Test Methods
AWQC	Ambient Water Quality Criteria
B&RE	Brown & Root Environmental
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
COD	Chemical Oxygen Demand
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
DO	Dissolved Oxygen
DRMO	Defense Reutilization and Marketing Office
ECTran	Excel-Crystal Ball Transport
EDSR	Existing Data Summary Report
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
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	Incremental Lifetime Cancer Risk
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
IR	Installation Restoration
LIMS	Laboratory Information Management System
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
msl	mean sea level
NAD	North American Datum
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NNPP	Naval Nuclear Propulsion Program
NOAEL	No Observed Adverse Effect Level
NORTHDIV	Northern Division
NPL	National Priorities List
NSB-NLON	Naval Submarine Base New London
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
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
SECWA	Southeastern Connecticut Water Authority
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCS	State Plane Coordinate System
SPLP	Synthetic Precipitation Leaching Procedure
SQL	Sample Quantitation Limit
SSL	Soil Screening Level
SSO	Site Safety Officer
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TiNUS	Tetra Tech NUS, Inc.
TOC	Total Organic Carbon
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UTL	Upper-Tolerance Limit

VOC	Volatile Organic Compound
WP	Work Plan
WPCA	Water Pollution Control Authority

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 Northern Division 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 N62472-90-D-1298, Contract Task Order (CTO) 312. The QAPP and other associated documents, including the Work Plan and Sampling and Analysis Plan (WP/SAP) and the Health and Safety Plan (HASP), constitute the project planning documents for the Basewide Groundwater Operable Unit (OU) Remedial Investigation (RI) 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/SAP for the site investigation. 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, and zones of investigation, is provided in Sections 1.2 and 1.3 of the WP/SAP.

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. Project objectives are discussed in more detail in Section 1.1 of the WP/SAP.

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.

In addition, as part of a natural attenuation investigation, groundwater samples from Area A Downstream, Torpedo Shops, and the Tank Farm, will be analyzed for divalent iron. Divalent iron will be measured using a field test kit. Divalent iron, along with dissolved oxygen, REDOX, temperature, salinity, pH, specific conductance, and several laboratory parameters, will be used to assess the potential for natural attenuation of chlorinated and petroleum hydrocarbons in the groundwater system at NSB-NLON.

Further details regarding field sampling and analysis methods are provided in Sections 2.4, 2.5, and 2.7 of the WP/SAP.

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 Basewide Groundwater OU RI 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; dioxins/furans; perchlorate; and total organic carbon (TOC). 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 in groundwater samples, whereas 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. The Synthetic Precipitation Leaching Procedure (SPLP) followed by analysis for TCL PCBs or TAL metals will be performed for soil samples to determine the potential mobility of these constituents in soil at the site. Analyses of groundwater samples for total dissolved solids (TDS) and total suspended solids (TSS) will also be performed to verify the effectiveness of the low-flow sampling methodology. At the request of USEPA Region I, analysis for chemical oxygen demand (COD) will also be performed for groundwater samples collected from the Area A Landfill. Additional laboratory parameters, which will be used in conjunction with the field parameters previously discussed to evaluate natural attenuation of chlorinated and petroleum hydrocarbons in the groundwater system, include alkalinity, hardness, chloride, nitrate, sulfate, sulfide, ammonia, and methane. Finally, saturated soils from Sites 3, 7, and 23 will be analyzed for pH, bulk density, TOC, and porosity. The resulting data will be used for groundwater modeling for these three sites. Tables 1-1 through 1-7 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 1.4 of the WP/SAP. Figures displaying all proposed sampling locations are provided in Section 2.0 of the WP/SAP.

1.5 PROJECT SCHEDULE

The project schedule is discussed in Section 1.9 of the project WP/SAP.

TABLE 1-1
ANALYTICAL DETECTION LIMITS - TCL LOW-CONCENTRATION ORGANICS
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
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	(2)
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	(2)
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
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Parameter	CRQL ⁽¹⁾ Groundwater Samples (µg/L)
Semivolatile Organic Compounds	
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
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 1-5.

TABLE 1-2
ANALYTICAL DETECTION LIMITS - TCL ORGANICS
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Parameter	PQL ⁽¹⁾ Soil Samples (µg/kg)
Volatile Organic Compounds	
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
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4**

Parameter	PQL ⁽¹⁾ Soil Samples (µg/kg)
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	167
Bis(2-chloroethyl)ether	167
Bis(2-ethylhexyl)phthalate	167
4-Bromophenyl-phenylether	167
Butylbenzylphthalate	167
Carbazole	(2)
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	(2)
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
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Parameter	PQL ⁽¹⁾ Soil Samples (µg/kg)
Semivolatile Organic Compounds	
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
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 4

Parameter	PQL ⁽¹⁾
Pesticides/PCBs	Soil Samples (µg/kg)
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 1-5.

TABLE 1-3
ANALYTICAL DETECTION LIMITS - TAL METALS
NSB-NLON, GROTON, CONNECTICUT

Parameter	CRDL ⁽¹⁾	
	Groundwater Samples	Soil Samples
	(µg/L)	(mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	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 ILM04.0.

TABLE 1-4
ANALYTICAL DETECTION LIMITS – DIOXINS/FURANS
NSB-NLON, GROTON, CONNECTICUT

Parameter	PQL ⁽¹⁾	
	Groundwater Samples (pg/L)	Soil Samples (ng/kg)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)	10	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (1,2,3,7,8-PeCDD)	50	5
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,6,7,8-HxCDD)	50	5
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (1,2,3,4,7,8-HxCDD)	50	5
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (1,2,3,7,8,9-HxCDD)	50	5
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)	50	5
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (1,2,3,4,6,7,8,9-OCDD)	100	10
2,3,7,8-Tetrachlorodibenzofuran (2,3,7,8-TCDF)	10	1
1,2,3,7,8-Pentachlorodibenzofuran (1,2,3,7,8-PeCDF)	50	5
2,3,4,7,8-Pentachlorodibenzofuran (2,3,4,7,8-PeCDF)	50	5
1,2,3,6,7,8-Hexachlorodibenzofuran (1,2,3,6,7,8-HxCDF)	50	5
1,2,3,7,8,9-Hexachlorodibenzofuran (1,2,3,7,8,9-HxCDF)	50	5
1,2,3,4,7,8-Hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF)	50	5
2,3,4,6,7,8-Hexachlorodibenzofuran (2,3,4,6,7,8-HxCDF)	50	5
1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)	50	5
1,2,3,4,7,8,9-Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)	50	5
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (1,2,3,4,6,7,8,9-OCDF)	100	10
Total Tetrachlorodibenzo-p-dioxin (Total TCDD)	10	1
Total Pentachlorodibenzo-p-dioxin (Total PeCDD)	50	5
Total Hexachlorodibenzo-p-dioxin (Total HxCDD)	50	5
Total Heptachlorodibenzo-p-dioxin (Total HpCDD)	50	5
Total Tetrachlorodibenzofuran (Total TCDF)	10	1
Total Pentachlorodibenzofuran (Total PeCDF)	50	5
Total Hexachlorodibenzofuran (Total HxCDF)	50	5
Total Heptachlorodibenzofuran (Total HpCDF)	50	5

1 PQL Typical Practical Quantitation Limit; actual PQL may vary based on the laboratory.

TABLE 1-5

**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
Carbazole	1.0	33
Chrysene	0.10	5
Dibenz(a,h)anthracene	0.1	5
Dibenzofuran	1.0	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 1-6

**ANALYTICAL DETECTION LIMITS - NATURAL ATTENUATION PARAMETERS
NSB-NLON, GROTON, CONNECTICUT**

Parameter	PQL ⁽¹⁾ Groundwater Samples (mg/L)
Alkalinity (as CaCO ₃)	20
Hardness (as CaCO ₃)	5.0
Chloride	1.0
Nitrate	0.050
Sulfate	1.0
Sulfide	1.0
Ammonia	0.10
Methane	0.001

- 1 PQL Typical Practical Quantitation Limit; actual PQL may vary based on the laboratory.

TABLE 1-7

**ANALYTICAL DETECTION LIMITS – MISCELLANEOUS AND GEOTECHNICAL PARAMETERS
NSB-NLON, GROTON, CONNECTICUT**

Parameter	PQL ⁽¹⁾	
	Groundwater Samples (mg/L)	Soil Samples (mg/kg)
Bulk Density	NR ⁽²⁾	NA ⁽³⁾
Chemical Oxygen Demand (COD)	50	NR ⁽²⁾
Perchlorate	0.004	NR ⁽²⁾
pH	NR ⁽²⁾	1
Porosity	NR ⁽²⁾	NA ⁽³⁾
Total Dissolved Solids (TDS)	10	NR ⁽²⁾
Total Suspended Solids (TSS)	5	NR ⁽²⁾
Total Organic Carbon (TOC)	1	100

- 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 NSB-NLON Basewide Groundwater OU RI is discussed in Section 1.6 of the WP/SAP.

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 PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are discussed in the remainder of this section. 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 dissolved methane, perchlorate, and low-concentration organic analyses (TCL volatiles, semivolatiles, and pesticides/PCBs), precision for organic analyses (TCL volatiles, TCL semivolatiles, TCL pesticides, TCL PCBs, dioxins/furans, 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 dissolved methane and perchlorate analyses will be monitored with field duplicate samples only since laboratory duplicates are not applicable for these parameters. Precision for TAL metals analysis will be measured via RPDs for laboratory duplicates and the precision control limits are presented in Table 3-1. Precision for the remaining parameters (i.e., natural attenuation and miscellaneous parameters) will typically be measured via the RPD results for laboratory duplicate samples. 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. Precision analyses will not be performed for the geotechnical parameters (i.e., bulk density and porosity).

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

TABLE 3-1

**PRECISION CONTROL LIMITS (RPDs)⁽¹⁾
LABORATORY DUPLICATE SAMPLES
METALS ANALYSIS VIA ILM04.0⁽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, ILM04.0.
- 3 For aqueous sample results less than 5X CRDL, a control limit of \pm CRDL is used.
- 4 For solid sample results less than 5X CRDL, a control limit of \pm 2X CRDL is used.

associated samples of like matrix. Surrogate spike analysis is performed for all chromatographic organic analyses with the exception of dissolved methane and dioxin/furan analysis. 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. Surrogate spike, MS/MSD, and LCS analyses are not applicable for dissolved methane analysis. 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 ILM04.0). Accuracy for the remaining parameters (volatiles, semivolatiles, pesticides, PCBs, PAHs and dioxins/furans via SW-846 methods; natural attenuation parameters; and miscellaneous parameters) 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. Neither surrogate spike, matrix spike, nor LCS analyses are applicable to geotechnical parameters (i.e., bulk density and porosity).

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 (February 1994) and Inorganic Data Review (February 1994). Data rejected as a result of the validation process will be treated as unusable data.

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 ILM04.0⁽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, ILM04.0.

3 No spike required.

TABLE 3-4

**ACCURACY CONTROL LIMITS (%R)⁽¹⁾
LABORATORY CONTROL SAMPLES
METALS ANALYSIS VIA ILM04.0⁽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, ILM04.0.
- 3 TBD - To Be Determined at time of analysis based on USEPA LCS lot number.
- 4 Advisory limits only.
- 5 NA - Not Applicable.

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 SAP is followed and that proper sampling techniques are used. The sampling network for the NSB-NLON Basewide Groundwater OU RI was designed to provide data representative of facility conditions. During development of this network, consideration was given to past waste disposal practices, existing analytical data, and physical setting and processes. The rationale of the sampling network is discussed in detail in Section 1.4 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), PAHs, and dioxins/furans 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.

4.0 SAMPLING PROCEDURES

Field sampling procedures and related field investigation tasks for the NSB-NLON Basewide Groundwater OU RI are discussed in detail in the following sections of the WP/SAP.

- Mobilization and demobilization - Section 2.2
- Investigation methodologies and techniques – Section 2.4
- Groundwater monitoring well sampling - Section 2.5
- Slug Tests – Section 2.6
- Field measurements - Section 2.7
- Decontamination - Section 2.8
- Investigation derived waste - Section 2.9
- Surveying - Section 2.10
- Sample handling procedures – Section 2.11
- Sample identification system - Section 2.12
- Sample packaging and shipping - Section 2.13
- Sample Custody – Section 2.14
- Field quality control samples - Section 2.15
- Recordkeeping - Section 2.16

Standard Operating Procedures (SOPs) regarding sampling, recordkeeping, and field investigation tasks are included in Appendix B of the WP/SAP.

5.0 CUSTODY PROCEDURES

Custody is one of several factors that is necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. A sample or evidence file is under custody if:

- the item is in the actual physical possession of an authorized person, or;
- the item is in view of the person after being in his or her possession, or;
- the item was placed in a secure area to prevent tampering; or
- the item is in a designated and identified secure area with access restricted to authorized personnel only.

The chain-of-custody (COC) report is a multi-part, standardized form used to summarize and document pertinent sample information, such as sample identification and type, matrix, date and time of collection, preservation, and requested analyses. Furthermore, through the sequential signatures of various sample custodians (e.g., sampler, airbill number, laboratory sample custodian), the COC report documents sample custody and tracking. A "Cradle-to-Grave" sample tracking system, as further described in Section 1.8.1 of the WP/SAP, will be employed. Custody procedures apply to all environmental and associated field quality control samples obtained as part of the data collection system.

5.1 FIELD CUSTODY PROCEDURES

The FOL (or designee) is responsible for the care and custody of the samples collected until they are relinquished to the analyzing laboratory or entrusted to a commercial overnight courier. COC reports are completed for each sample shipment. The reports are filled out in a legible manner, using waterproof ink, and are signed (and dated) by the sampler. Pertinent notes, such as whether the sample was field filtered, or whether the sample is suspected to be high in contaminant concentration, are also indicated on the COC report. Information similar to that contained in the COC report is also provided on the sample label, which is securely attached to the sample bottle. COC report forms and sample labels will be supplied by the laboratory subcontractor. In accordance with NFESC guidelines, samples for chemical constituent analysis must be sent (for next-day receipt) to the laboratory within 24-hours of collection.

Full details regarding sample COCs (including use of custody seals and sample shipment protocols) are contained in TtNUS SOP SA-6.1, which is provided in Appendix B of the attendant WP/SAP. TtNUS SOP SA-6.3, also provided in Appendix B of the WP/SAP, discusses maintenance of site logbooks, site notebooks, and other field records. Additionally, each of the various sampling SOPs incorporated into the WP/SAP contains a section that addresses relevant sample documentation (i.e., completion of sample logsheets, etc.). All sample records are eventually docketed into the TtNUS project central file.

5.2 LABORATORY CUSTODY PROCEDURES

When samples are received by the laboratory subcontractor, the laboratory's sample custodian examines each cooler's custody seals to verify that they are intact and that the integrity of the environmental samples has been maintained. The sample custodian then signs the COC report. The custodian then opens the cooler and measures its internal temperature. The temperature reading is noted on the accompanying COC report. The sample custodian then examines the contents of the cooler. Sample container breakages or discrepancies between the COC report and sample label documentation are recorded. With the exception of samples for volatile analysis, the pH of chemically preserved samples is checked using Hydrion paper and recorded. All problems or discrepancies noted during this process are to be promptly reported to the TtNUS Project Manager. Inter-laboratory COC procedures and specific procedures for sample handling, storage, dispersment for analysis, and remnant disposal will be followed as specified by the subcontract laboratory's SOPs and/or QA Plan.

5.3 FINAL EVIDENCE FILES

The TtNUS central file will be the repository for all documents that constitute evidence relevant to sampling and analysis activities as described in this QAPP. TtNUS is the custodian of the evidence file and maintains the contents of these files, including all relevant records, reports, logs, field notebooks, photographs, subcontractor reports and data reviews in a secure, limited access location and under custody of the TtNUS facility manager. The control file will include at a minimum:

- field logbooks
- field data and data deliverables
- photographs
- drawings
- soil boring logs
- laboratory data deliverables
- data validation reports
- data assessment reports

- progress reports, QA reports, interim project reports, etc.
- all custody documentation (COCs, airbills, etc.)

Upon completion of the contract, all pertinent files will be relinquished to the custody of the United States Navy.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

All instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments as it does to fixed laboratory instruments. Field instrument calibration is discussed in Section 6.1. Laboratory instrument calibration is discussed in Section 6.2.

6.1 FIELD INSTRUMENT CALIBRATION

Field instrument calibration is discussed in Section 2.7 of the attendant WP/SAP.

6.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for a specific laboratory instrument will consist of initial calibration (generally 3 to 5 points), initial calibration verification (inorganic methods only), and continuing calibration verification. In all cases, the initial calibration will be verified using an independently prepared calibration verification solution. The frequency of calibration will be performed according to the requirements of the specific methods.

All standards used to calibrate analytical instruments must be obtained from the National Institute of Standards and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards must be traceable to NIST reference standards, where possible, and appropriate documentation will be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to an USEPA-supplied known or previous NIST-traceable standard.

The calibration procedures and frequencies used by the subcontract laboratory will comply with the applicable CLP SOW or analytical method. Brief descriptions of calibration procedures for major instrument types follow.

6.2.1 GC/MS Volatile Organic Compound Analyses

For VOCs, the gas chromatograph/mass spectrometer (GC/MS) system will be tuned and calibrated in accordance with SW-846 8260B (soil samples) or the CLP SOW low-concentration water - OLC02.1 (aqueous samples). A bromofluorobenzene (BFB) instrument performance check (tuning check) must be run prior to the initial and each continuing calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations as specified in the method. A BFB tuning check and

a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour shift during which analyses are performed.

6.2.2 GC/MS Semivolatile Organic Compound Analyses

For semivolatile organic compounds, the GC/MS system will be tuned and calibrated in accordance with SW-846 8270C (soil samples) or the CLP SOW low-concentration water - OLC02.1 (aqueous samples). A decafluorotriphenyl phosphine (DFTPP) instrument performance check (tuning check) must be run prior to the initial and each continuing calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank plus five different concentration levels as specified in the method. A DFTPP tuning check and a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour shift during which analyses are performed.

6.2.3 Organochlorine Pesticide/PCB Analyses

For organochlorine pesticide and PCB analyses, the GC system will be calibrated in accordance with SW-846 8081A/8082 (soil samples) or the CLP SOW low-concentration water - OLC02.1 (aqueous). For both methods, the initial calibration is required before any samples are analyzed and a multi-point initial calibration sequence is analyzed using dual column injection.

CLP SOW OLC02.1

The calibration sequence consists of a resolution check to prove analyte separation, a performance evaluation mixture (PEM) to show endrin and 4,4'-DDT degradation, and a three-point calibration of the individual pesticides to prove linearity. An instrument blank, to show system cleanliness, and a second PEM sample are then analyzed.

If all initial calibration criteria are met, samples may be analyzed for a period of 12 hours after the injection of the instrument blank. At the end of the 12-hour period, a second instrument blank followed by continuing calibration standard mixtures must be analyzed. If continuing calibration criteria are met, sample analysis may continue for an additional 12 hours. At this point, an instrument blank followed by a PEM is analyzed. The 12-hour clock continues, alternating between the continuing calibration standard mixtures and the PEM, until failure to meet method-specified criteria requires a new initial calibration.

SW-846

A minimum of a five point initial calibration with standards bracketing the range of detection (for PCBs five point for Aroclor 1016/1260 mixture and the other aroclors are analyzed and a one point calibration factor

is determined). If all initial calibration criteria are met, samples may be analyzed for a period of 12 hours. The calibration must be verified (continuing calibration every 12 hours). Calibration standards must be injected after every 20 samples. If continuing calibration criteria are met continue analyzing samples. If continuing calibration criteria are not met it is necessary to recalibrate.

6.2.4 Metals Analyses

6.2.4.1 Inductively Coupled Argon Plasma (ICP) Analyses

Inductively coupled plasma (ICP) spectrometry systems will be calibrated for the analysis of TAL metals in accordance with the USEPA CLP protocols outlined in ILM04.0. Initial calibration is required each day before any samples are analyzed and consists of a calibration blank and at least one standard. The standard must be within the demonstrated linear range of the instrument. The linear range is verified quarterly. Following initial calibration, an initial calibration verification sample (obtained from a different source than the solutions used for calibration), an initial calibration blank, and an interference check sample are analyzed. A continuing calibration verification sample and a continuing calibration blank are run every 2 hours or every 10 samples, whichever occurs first. A continuing calibration verification sample, a continuing calibration blank, and an interference check sample are also run after analysis of the last sample. The initial calibration verification standard, continuing calibration verification standard, and interference check sample each contain analytes of interest at different concentrations. In addition, a standard prepared at a concentration of two times the quantitation limit is analyzed at the beginning and end of each sample analysis run or a minimum of twice per 8-hour period. Linearity spanning the range of analysis is verified using this combination of standards. All calibration standards contain acids at the same concentrations as the sample digestates.

6.2.4.2 Atomic Absorption Analyses

Graphite furnace and cold vapor atomic absorption (GFAA and CVAA) analyses will be calibrated in accordance with the USEPA CLP protocols outlined in ILM04.0. Initial calibration is required each day before any samples are analyzed and consists of a calibration blank and at least three calibration standards (at least four standards for mercury) covering the range of concentrations of interest. The correlation coefficient of the regression of concentration versus response should be 0.995 or greater. Immediately following initial calibration, an initial calibration verification sample (obtained from a different source than the solutions used for calibration) and an initial calibration blank are analyzed. A continuing calibration verification sample and a continuing calibration blank are run every two hours or every 10 samples, whichever occurs first. A continuing calibration verification sample and a continuing calibration blank are also run after analysis of the last sample.

6.2.5 Dioxin/Furan Analyses

For dioxin/furan analysis, the High Resolution (HR) GC/MS system will be tuned and calibrated in accordance with SW-846 8290. A perfluorokerosene (PFK) instrument performance check (tuning check) must be run prior to the initial calibration and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a GC column performance check solution plus six concentration levels as specified in the method. Continuing calibrations must be performed at the beginning of a 12-hour period after successful mass resolution and quality control resolution performance checks. A continuing calibration is also required at the end of a 12-hour shift.

6.2.6 Miscellaneous Parameters

Calibration and standardization requirements for the analysis of the remaining parameters will be performed as specified in the applicable analytical methods. Analytical methods are further discussed in Section 7.0 of this QAPP.

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/SAP.

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). In addition, divalent iron will be measured for groundwater samples using a field test kit. Measurement of field parameters and calibration of field instruments are discussed in Section 2.7 of the WP/SAP.

All groundwater and soil samples collected for fixed-laboratory analysis during the NSB-NLON Basewide Groundwater OU RI 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 (ILM04.0). 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 Basewide Groundwater OU RI.

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.

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	ILM04.0 ⁽²⁾
TCL PAHs	SW-846 8310 ⁽³⁾
Total Organic Carbon (TOC)	SW-846 9060 ⁽³⁾
Dioxins/Furans	SW-846 8290 ⁽³⁾
Alkalinity (as CaCO ₃)	USEPA 310.1 ⁽⁴⁾
Hardness (as CaCO ₃)	USEPA 130.2 ⁽⁴⁾
Perchlorate	California Method ⁽⁵⁾
Chemical Oxygen Demand	USEPA 410.1 ⁽⁴⁾
Chloride	USEPA 300.0 ⁽⁴⁾
Nitrate	USEPA 300.0 ⁽⁴⁾
Sulfate	USEPA 300.0 ⁽⁴⁾
Sulfide	USEPA 376.2 ⁽⁴⁾
Total Dissolved Solids (TDS)	USEPA 160.1 ⁽⁴⁾
Total Suspended Solids (TSS)	USEPA 160.2 ⁽⁴⁾
Ammonia	USEPA 350.1 ⁽⁴⁾
Methane	USEPA RSKSOP-175 ⁽⁶⁾

- 1 USEPA CLP, 1996. 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.
- 5 State of California, California Department of Health Services, June 3, 1997. Determination of Perchlorate by Ion Chromatography; Rev. No. 0. Sanitation & Radiation Laboratories Branch.
- 6 USEPA, R.S. Kerr Environmental Laboratory, B.S. Newell, Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, Revision No. 0, August 1994.

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⁾ 8260B
TCL Semivolatile Organics (minus PAHs)	SW-846 8270C
TCL Pesticides	SW-846 8081A
TCL PCBs	SW-846 8082
TCL PAHs	SW-846 8310
Dioxins/Furans	SW-846 8290
TAL Metals	ILM04.0 ⁽²⁾
Bulk Density (In-place density of soil)	ASTM ⁽³⁾ D2937-94
pH	SW-846 9045C
Porosity (calculated using specific gravity and moisture content of soils)	ASTM D854-98 and ASTM D2216-98
Total Organic Carbon (TOC)	SW-846 9060
Synthetic Precipitation Leaching Procedure (SPLP)	SW-846 1312

- 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.
- 3 American Society for Testing and Materials. Volume 4.08, Soil and Rock

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.

8.0 INTERNAL QUALITY CONTROL CHECKS

Field-related QC checks were discussed in Section 3.0 of this QAPP and in Section 2.15 of the attendant WP/SAP. This section provides additional information regarding internal quality control checks for the field and the laboratory.

8.1 FIELD QUALITY CONTROL CHECKS

QC procedures for field measurements will include calibrating the instruments as discussed in Section 2.7 of the WP/SAP. Assessment of field sampling precision and bias will be made by collection of field duplicates and rinsate blanks for laboratory analysis as discussed in Section 3.6 of this QAPP.

8.2 LABORATORY QUALITY CONTROL CHECKS

The subcontract laboratory will have a QC program that ensures the reliability and validity of the analyses performed at the laboratory. Internal quality control procedures for CLP analyses (aqueous volatile, semivolatile, pesticide/PCB organics and metals) will comply with the SOWs for low-concentration water organics (OLC02.1) and inorganics (ILM04.0). Internal quality control procedures for non-CLP analyses will comply with the applicable analytical method requirements.

Several internal laboratory QC checks are briefly discussed in the remainder of this section.

Laboratory method blanks are prepared and analyzed in accordance with the analytical method employed to determine whether contaminants originating from laboratory sources have been introduced and have affected environmental sample analyses. A method blank generally consists of an aliquot of analyte-free water (or purified sodium sulfate for soil/sediment samples) that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. With the exception of recognized volatile and semivolatile common laboratory contaminants (i.e., methylene chloride, acetone, 2-butanone, and phthalate esters) detected through use of the organic SOW, method blanks must not contain levels of target analytes above the reported detection limits (above 2.5X the CRQL for methylene chloride and above 5X the CRQL for acetone, 2-butanone, and phthalate esters). If method blank contamination is found to exist above allowable limits, corrective actions indicated in the CLP SOWs or laboratory SOPs must be followed. Under no circumstances are laboratory method blank contaminant values subtracted from environmental sample analysis results.

Matrix spike analysis for organic fraction analyses is performed in duplicate as a measure of laboratory precision. For inorganic analyses, one matrix spike analysis and one **laboratory duplicate** analysis are

performed for every 20 environmental sample analyses of like matrix. With the exception of VOC MSD analyses, laboratory duplicates are prepared by thoroughly mixing and splitting a sample aliquot into two portions and analyzing each portion following the same analytical procedures that are used for the environmental sample analyses. For VOC MSD analyses, a second sample aliquot is used for analysis in order to avoid VOC constituent loss through the homogenization process. The field crew provides extra volumes of sample matrices designated for laboratory quality control analyses, as required. As discussed in Section 3.0 of this QAPP, control limits for MS and laboratory duplicate analyses are specified in the SOWs for CLP analyses and are established by the laboratory for non-CLP analyses.

Surrogates are organic compounds (typically brominated, fluorinated, or isotopically labeled) that are similar in nature to the compounds of concern, and that are not likely to be present in environmental media. Surrogates are spiked into each sample, standard, and method blank prior to analysis, and are used only in organic chromatographic analysis procedures as a check of method effectiveness. As discussed in Section 3.0, surrogate recoveries are evaluated against control limits specified in the CLP SOW, where applicable, or laboratory-derived control limits.

Laboratory control samples serve to monitor the overall performance of each step during the analysis, including the sample preparation. Laboratory control sample analysis will be performed for low-concentration TCL volatiles, TAL metals, and as required by the applicable analytical methods for non-CLP methods. Aqueous LCS results must fall within the control limits specified in the CLP SOW, where applicable, or established by the laboratory. Solid LCS results must fall within the control limits established by the supplier of the LCS standard. Aqueous and solid LCSs shall be analyzed utilizing the same sample preparations, analytical methods, and QA/QC procedures as employed for the samples.

Internal standard performance criteria ensure that volatile and semivolatile GC/MS analysis sensitivity and response are stable during every analytical run. Internal standard area counts for samples and blanks must not vary by more than a factor of two (- 50% to + 100%) from the associated 12-hour calibration standard ($\pm 40\%$ for low-concentration volatile analysis). The retention time of the internal standards in samples and blanks must not vary by more than ± 30 seconds from the retention time of the associated 12-hour calibration standard (± 20 seconds for low-concentration volatile analysis).

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, validation, and reporting for the NSB-NLON Groundwater OU RI. All data generated during the course of the investigation will be maintained in hardcopy format by TtNUS in the Naval Facilities Engineering Command Northern Division designated central files located in the TtNUS Pittsburgh, Pennsylvania office.

In addition to the central files, photocopies of all hardcopy data (as well as electronic data) will be maintained in the Chemistry/Toxicology/Risk Assessment Department database records files located in the TtNUS Pittsburgh, Pennsylvania office. Upon completion of the contract, all files will be relinquished to the Navy.

9.1 DATA REDUCTION

Data reduction will be completed for both field measurements and laboratory-generated analytical data. Field data reduction will be relatively limited versus the degree of laboratory data reduction required for the project. Reduction of both field data and laboratory data are discussed in the remainder of this section.

9.1.1 Field Data Reduction

Field data will be generated as a result of real time measurement of organic vapor concentrations via a PID or FID (for health and safety monitoring and to support selection of soil samples for shipment to the analytical laboratory), through on-site water quality testing for general indicator parameters including pH, specific conductance, turbidity, and temperature, and through the use of field instruments or field test kits for measurement of additional parameters including REDOX potential, dissolved oxygen, salinity, and divalent iron.

Field measurements of organic vapor concentrations (parts per million on a volume/volume basis relative to methane or benzene) will be recorded in the site logbook and incorporated into the RI Report. The remaining field parameters will be recorded in the site logbook and on sample logsheets immediately after the measurements are taken and later encoded in the NSB-NLON database for presentation in the RI Report. If an error is made in the logbook, the error will be legibly crossed out (single-line strikeout), initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. No calculations will be necessary to reduce these data for inclusion in RI Report. Field data will be entered in the electronic database manually, and the entries will be verified by an independent reviewer to

make sure that no "transcription" errors occurred. Field measurements will be recorded and reported in the following units:

- Hydronium ion concentration - standard pH units
- Temperature - degrees Celsius
- Specific Conductance - millimhos
- Turbidity - Nephelometric turbidity units
- Dissolved oxygen – milligrams per liter (mg/L)
- Divalent iron - mg/L
- REDOX Potential – millivolts (mV)
- Salinity - %

Standard pH units as specified above is the negative logarithm (base 10) of the hydronium ion concentration in moles/liter.

9.1.2 Laboratory Data Reduction

Data reduction for laboratory analytical data generated via the USEPA CLP analytical protocol, quality assurance requirements, and reporting procedures (TCL volatile, semivolatile, pesticide/PCB organics and TAL metals) will be completed in accordance with the most current SOWs for Low Concentration Organic and Low/Medium Concentration Inorganic Analysis as identified in previous sections of this QAPP. Laboratory data reduction of analytical results generated via non-CLP methods will be completed in accordance with the applicable analytical methods.

Laboratory analytical data will be reported using standard concentration units to ensure comparability with regulatory standards/guidelines and previous analytical results. Reporting units for solid and aqueous matrices for the classes of chemicals under consideration are as follows:

Groundwater samples:

- TCL volatile, semivolatile, PAHs, and pesticide/PCB organics – micrograms per liter ($\mu\text{g/L}$)
- Dioxin/Furans – picograms/liter (pg/L)
- Perchlorate - $\mu\text{g/L}$
- TAL metals - $\mu\text{g/L}$
- TOC, alkalinity, hardness, chloride, nitrate, sulfate, sulfide, ammonia, and methane - mg/L

Soil samples:

- TCL volatile, semivolatile, pesticide, and PCB organics – micrograms per kilogram ($\mu\text{g}/\text{kg}$)
- Dioxin/Furans – nanograms per kilogram (ng/kg)
- TAL metals – milligrams (mg/kg)
- Bulk density – grams per cubic centimeter (g/cm^3)
- pH – standard pH units
- Porosity - nondimensional
- TOC – mg/kg

SPLP Leachates:

- TAL metals and TCL PCBs - $\mu\text{g}/\text{L}$

Field QC sample results will be included in the database for the NSB-NLON Basewide Groundwater OU RI. Specifically, the analytical results for field duplicates, source water blanks, trip blanks, rinsate blanks, and ambient condition blanks will be provided. The results for field QC samples will be considered during the course of data validation (in concert with laboratory method blanks) to eliminate false positive results according to the 5- and 10-times rules specified in the National Functional Guidelines for Organic and Inorganic Data Review. The results for laboratory QC samples such as method blanks will not be presented in the RI Report database. In addition, only the original (unspiked) sample results for MS/MSD samples will be provided in the database.

9.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are discussed in this section. Validation of field data will be limited to real time "reality" checks whereas laboratory analytical data will be validated in accordance with current USEPA guidance. Validation of field measurements is discussed in Section 9.2.1. Validation of laboratory analytical data is discussed in Section 9.2.2.

9.2.1 Field Measurement Data Validation

Field measurements will not be subjected to a formal data validation process. However, field technicians will ensure that the equipment used for field measurement is performing accurately via calibration as discussed in Section 2.7 of the WP/SAP. As described in Section 9.1.1, all field data entered into the electronic database will be independently reviewed for transcription errors.

9.2.2 Lab ratory Data Validation

One hundred percent of the laboratory data will be validated. Validation of analytical data will be completed by the TtNUS Chemistry Department located in TtNUS's Pittsburgh, Pennsylvania office. Final review and approval of validation deliverables will be completed by the Department's Data Validation Coordinator.

All CLP laboratory analytical data will be subjected to validation in accordance with the National Functional Guidelines for Organic and Inorganic Data Review. Data validation will be completed to ensure that the data are of evidentiary quality. Particular emphasis will be placed on holding time compliance, equipment calibration, spike recoveries, and blank results, although all required elements of the validation process will be considered. The analytical results for volatile, semivolatile, pesticide, and PCB fractions generated using SW-846 methodology will be validated against method-specific requirements and the National Functional Guidelines to the extent practicable. The analytical results for the remaining non-CLP parameters will be validated versus the applicable analytical methods. Validation of these data will conform to the National Functional Guidelines to the greatest extent practicable.

9.3 DATA REPORTING

9.3.1 Field Measurement Data Reporting

Field data will be reported in the units discussed in Section 9.1.1. The RI Report will include a comprehensive database including all field measurements (specifically organic vapor concentrations, pH, specific conductance, temperature, turbidity, dissolved oxygen, REDOX potential, and divalent iron). Field measurements will be transferred from the site logbook or sample logsheets to the electronic database manually and will be reviewed for accuracy by an independent reviewer. Transcription of field measurements to the electronic database will be completed shortly after completion of the field investigation and prior to receipt of laboratory analytical data.

All records regarding field measurements (i.e., field logbooks, sampling logbooks, and sample logsheets) will be placed in TtNUS's Northern Division central files upon completion of the field effort. Entry of these results in the database will require removal of these results from the files. Outcards will be used to document the removal of any such documentation from the files (date, person, subject matter). Field measurement data will be reported in an appendix of the RI Report at a minimum and may also be reported in summary fashion if they are indicative of the presence of contamination (e.g., high specific conductance readings).

9.3.2 Lab oratory Data Reporting

Data reported by the laboratory will be in accordance with CLP reporting format, including all non-CLP data (to the extent practicable). All pertinent QC data including raw data and summary forms for blanks, standards analysis, calibration information, etc., will be provided for the non-CLP analyses. Case narratives will be provided for each Sample Delivery Group.

All environmental and field QC sample results (trip blanks, field duplicates, rinsate blanks, source water blanks, ambient condition blanks) will be included in the RI Report as an appendix. The database will include pertinent sampling information such as sample number, sampling date, general location, depth, and survey coordinates (if applicable). Sample-specific detection limits will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 9.1.2. The analytical data may also be reported in summary fashion within the body of the RI Report text in tabular and graphic fashion.

Data will be handled electronically pursuant to the electronic deliverable requirements specified in TtNUS's Master Services Agreement with analytical laboratories. This agreement requires the analytical laboratories to provide data in both hardcopy and electronic form. The original electronic diskettes and the original hardcopy analytical data are maintained in TtNUS's Northern Division central files as received.

Validation will be completed using the hard copy data. Upon completion of validation of a Sample Delivery Group and review by the Data Validation Coordinator, the validation qualifiers will be entered in the electronic database and will be subjected to independent review for accuracy. During this review process, the electronic database printout will also be contrasted with the hard copy data (Form 1s) to ensure that the hard copy data and electronic data are consistent.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be performed periodically to ensure that work is being implemented in accordance with the approved Project Plans and in an overall satisfactory manner. Such audits will be performed by various personnel and will include evaluation of field, laboratory, data validation, and data reporting processes. Examples of pertinent audits are as follows:

- The FOL will supervise and check daily that the field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and fieldwork is documented accurately and neatly.
- Performance and system audits of the laboratory will be performed regularly, in accordance with the requirements of the CLP (external), by a Navy Contractor (internal), and in accordance with the Laboratory Quality Assurance Plan (internal).
- Data validators will review (on a timely basis) the chemical analytical data packages submitted by the laboratory. The data validators will check that the data were obtained through use of an approved methodology, that the appropriate level of QC effort and reporting was conducted, and whether or not the results are in conformance with QC criteria. On the basis of these factors, the data validator will generate a report describing data limitations, which will be reviewed internally by the Data Validation Coordinator prior to submittal to the Project Manager.
- A formal audit of the field sampling procedures may be conducted by the TtNUS Quality Assurance Manager (QAM) or designee in addition to the auditing that is an inherent part of the daily project activities. The purpose of this audit is to ensure that sample collection, handling, and shipping protocols, as well as equipment decontamination and field documentation procedures, are being performed in accordance with the approved Project Plans and SOPs.
- A sample tracking system, as further described in Section 1.8.1 of the WP/SAP, will be employed for all environmental samples. This system will allow for early detection of errors made in the field or by the laboratory so that necessary adjustments can be made while the field crew is mobilized.

The Project Manager will maintain contact with the FOL and Data Validation Coordinator to ensure that management of the acquired data proceeds in an organized and expeditious manner. Similarly, the Project Manager will interface with the Risk Assessment and Modeling Coordinators, as applicable.

11.0 PREVENTIVE MAINTENANCE PROCEDURES

Measuring equipment used in environmental monitoring or analysis for the NSB-NLON Basewide Groundwater OU RI shall be maintained in accordance with the manufacturer's operation and maintenance manuals. Equipment and instruments shall be calibrated in accordance with the procedures, and at the frequency, discussed in Section 6.0 (Calibration Procedures and Frequency). Preventive maintenance for field and laboratory equipment is discussed in the remainder of this section.

11.1 FIELD EQUIPMENT PREVENTIVE MAINTENANCE

TtNUS has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The TtNUS equipment manager keeps an inventory of the equipment in terms of items (model and serial number), quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.
- The equipment manager conducts routine checks on the status of equipment and is responsible for stocking spare parts and equipment readiness. The equipment manager also maintains the equipment manual library.
- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions and TtNUS SOPs before being taken to the job site and during field activities.
- During calibration, an appropriate maintenance check is performed on each piece of equipment. Any problems encountered while operating the instrument will be recorded in the field log book including a description of the symptoms and corrective actions taken.
- If problem equipment is detected or should require service, the equipment should be logged, tagged, and segregated from equipment in proper working order. Use of the instrument will not be resumed until the problem is resolved.

11.2 LABORATORY INSTRUMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential to ensuring their readiness when needed. Dependent on manufacturer's recommendations, maintenance intervals are established for each instrument. All instruments must be labeled with a model number and serial number, and a maintenance logbook must be maintained for each instrument. Personnel must be alert to the maintenance status of the equipment they are using at all times.

11.2.1 Major Instruments

Table 11-1 provides a summary of preventive maintenance procedures typically performed for key analytical instruments. Maintenance of key instruments is sometimes covered under service contracts with external firms. These contracts provide for periodic routine maintenance to help guard against unexpected instrument downtime. The contracts also provide for quick response for unscheduled service calls when malfunctions are observed by the operator.

The use of manufacturer recommended grades or better of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the various gas chromatographs and metals instruments should be of sufficient grade to minimize fouling of the instrument. The routine use of septa, chromatographic columns, ferrules, AA furnace tubes, and other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime.

11.2.2 Refrigerators/Ovens

The temperatures of refrigerators used for sample storage and drying ovens will be monitored a minimum of once daily. The acceptable range for refrigerator temperatures is $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Required temperatures of ovens will vary based on the analytical methods for which the ovens are used. The temperatures will be recorded on temperature logs. The logs will contain the following information at a minimum:

- Date
- Temperature
- Initials of person performing the check

Maintenance of the logs is typically the responsibility of the sample custodian. However, assignment of responsibilities for temperature monitoring to specific personnel does not preclude the participation of other laboratory personnel. If unusual temperature fluctuations are noted, it is the responsibility of the observer to immediately notify the person in charge of the discrepancy before the condition of the samples is compromised.

TABLE 11-1

TYPICAL PREVENTIVE MAINTENANCE FOR KEY ANALYTICAL INSTRUMENTS
NSB-NLON, GROTON, CONNECTICUT

Instrument	Preventive Maintenance	Maintenance Frequency
GC/MS	Volatiles: Bake oven, replace septum, check carrier gas. Semivolatiles: Replace the septum, clean injection port, replace liner, bake oven, check carrier gas, clean the source. Replace solvent washes and clean syringe.	As required. As required. Daily.
GC	Replace solvent washes and clean syringe. Clip column, clean injection port, replace liner, and bake oven.	Daily. As required.
ICP	Change sample introduction tubing, clean nebulizer, clean spray chamber, clean torch, manual profile, and automatic profile optics.	As required.
GFAA	Clean contact cylinders, replace/clean tube, check lamp alignment.	As required.
CVAA	Change sample introduction tubing, change drying cell, re-zero detector.	As required.
Spectrophotometer	Check that cuvette has no scratch on its surface. Turn power off at the end of the day and warm up for at least one hour before use.	Daily. Daily

Unstable or fluctuating temperatures may be indicative of malfunctions in the cooling or heating system. On the other hand, the instability may be due to frequent opening of the door. Regardless of the cause, such an observation must be investigated, and modifications must be made to access procedures or repairs to equipment must be made to prevent jeopardizing the integrity of the samples.

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

The purpose of this section is to indicate the methods by which it will be ensured that the data collected for this investigation coincides with the project objectives as specified in Section 1.0 of the WP/SAP. The data assessment will be conducted to evaluate analytical data quality via compliance with the QC objectives addressed in Section 3.0 of this QAPP. Additionally, the data will be reviewed for indications of interferences to results caused by sample matrices, cross contamination during sampling, cross contamination in the laboratory, and sample preservation and storage anomalies.

The data validation process will be used to flag data with quality indicators that fall outside the QC acceptance limits. A summary of the data validation qualifiers for all project samples will be prepared. This summary will include a list of chemicals identified as laboratory and/or field QC blank contaminants, holding time exceedences, samples exhibiting field duplicate/replicate imprecision as well as affected chemicals, rejected results and associated specific causes, and general causes of estimated results. This summary will facilitate the preparation of a summary of the data validation results and completeness assessment for inclusion in the RI Report.

Compliance with the completeness objectives for field and laboratory measurements/data will be calculated by hand (field measurements) and electronically via a database subroutine (laboratory data). Sections 12.1, 12.2, and 12.3 present equations to be used for computing precision, accuracy, and completeness values, respectively. Section 12.4 presents additional data quality considerations that will be evaluated after completion of data validation.

12.1 ACCURACY ASSESSMENT

As described in Section 8.2, to assure the accuracy of the analytical procedures, a minimum of one of every 20 samples is spiked with a known amount of the analyte or analytes to be evaluated. The spiked sample is then analyzed. The increase in concentration of the analyte observed in the spiked sample, because of the addition of a known quantity of the analyte, compared to the reported value of the same analyte in the unspiked sample determines the percent recovery. Control charts are plotted by the laboratory for each commonly analyzed compound and kept on matrix-specific and analyte-specific bases. The %R for a spiked sample is calculated according to the following formula:

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

Section 8.2 also describes the use of surrogate spikes and LCSs as measures of accuracy. The %R for a surrogate spike or LCS is calculated by using the following formula:

$$\%R = \frac{\text{Experimental Concentration}}{\text{Known Amount Added}} \times 100\%$$

12.2 PRECISION ASSESSMENT

As described in Section 8.2, duplicate samples (for inorganic analyses) and MSD samples (for organic analyses) are prepared and analyzed at a minimum frequency of one per every 20 environmental samples. As addressed in Section 3.6, field duplicate samples will also be collected at a minimum frequency of one per 10 environmental samples. The RPD between the sample (or spike) and duplicate (or duplicate spike) is calculated by using the following formula:

$$RPD = \frac{\text{Amount in Sample 1} - \text{Amount in Sample 2}}{0.5 (\text{Amount in Sample 1} + \text{Amount in Sample 2})} \times 100\%$$

12.3 COMPLETENESS ASSESSMENT

As addressed in Section 3.3, completeness is the ratio of the number of valid sample results to the total number of sample results expected to be obtained for the project as a whole. Following the completion of the analytical testing and data validation, the percent completeness will be calculated using the following equation:

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

12.4 DATA ASSESSMENT

The field and laboratory data collected during the NSB-NLON Basewide Groundwater OU RI will be used to meet the objectives presented in Section 1.1 of the WP/SAP. The QC results associated with each analytical parameter for each matrix will be compared with the objectives presented in Sections 3.1 through 3.5 of this QAPP. Only data deemed usable during data validation will be considered usable for quantitative purposes.

In addition, the data obtained will be both qualitatively and quantitatively assessed. The results of this assessment will be presented in the NSB-NLON Basewide Groundwater OU RI Report. Examples of issues to be considered in the data assessment are as follows:

- Were all samples obtained using the methodologies and SOPs specified in the FSP?
- Were samples obtained from all sampling locations for all analyses specified in the FSP?
- Were all field measurements conducted using the methodologies and SOPs specified in the FSP?
- Were all laboratory analyses performed using the methodologies specified in the QAPP?
- Were all field and laboratory data validated as specified in the QAPP?
- Do any analytical results exhibit elevated quantitation limits? If so, what are the causes and what overall impact does this have on the data?
- Were any data points determined to be unusable (qualified as "R") during the data validation process? If so, are these rejected data points critical in meeting the objectives of the project?
- Have sufficient data of appropriate quality been generated to support the objectives described in Section 1.1 of the WP/SAP?

13.0 CORRECTIVE ACTION

Under the TtNUS QA/QC program, it is required that any and all personnel noting conditions adverse to quality report these conditions immediately to the Project Manager and QAM. These parties, in turn, are charged with performing root-cause analyses and implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the QAM to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed.

13.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible so that work integrity or product quality is not compromised. The need for corrective action may arise based on deviations from Project Plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and may involve amending previously approved field procedures. If warranted by the severity of the problem (e.g., if a change in the approved Project Plan documents or SOPs is required), the Navy will be notified in writing via a Field Task Modification Request (FTMR), and Navy (in conjunction with USEPA Region I and CTDEP) approvals will be obtained. The FOL is responsible for initiating FTMRs; an FTMR will be initiated for all deviations from the Project Plan documents, as applicable. An example of an FTMR is provided as Figure 13-1. Copies of all FTMRs will be maintained with the onsite project planning documents and will be placed in the final evidence file.

Minor modifications to field activities such as a slight offset of a boring location will be initiated at the discretion of the FOL, subject to onsite approval by NSB-NLON personnel. Approval for major modifications (e.g., elimination of a sampling point) must be obtained via an FTMR.

FIGURE 13-1

TETRA TECH NUS
FIELD TASK MODIFICATION REQUEST FORM

Client Identification _____ Project Number _____ FTMR Number _____

To _____ Location _____ Date _____

Description:

Reason for Change:

Recommended Disposition:

Field Operations Leader (Signature, if applicable)

Date

Disposition:

Project Manager (Signature, if required)

Date

Distribution:

Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader

Others as required _____

13.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits;
- Method blank analyses yield concentrations of target analytes above acceptable levels;
- Undesirable trends are detected in spike recoveries or in duplicate RPDs;
- There is an unexplained change in compound detection capability;
- Inquiries concerning data quality are received; and
- Deficiencies are detected by laboratory QA staff audits or from performance evaluation sample test results.

Corrective actions are typically documented for out-of-control situations on a corrective action form. Using a corrective action form, any employee may notify the QA/QC Officer of a problem. The QA/QC Officer generally initiates the corrective action by relating the problem to the appropriate Laboratory Manager and/or Internal Coordinator, who then investigates or assigns responsibility for investigating the problem and its cause. Once determined, an appropriate corrective action is approved by the QA/QC Officer. Its implementation is verified and documented on the corrective action form and is further documented through audits.

13.3 CORRECTIVE ACTION DURING DATA VALIDATION AND DATA ASSESSMENT

The need for corrective action may become apparent during data validation, interpretation, or presentation activities, or problems may be identified as a result of oversight findings. The performance of rework, instituting a change in work procedures, or providing additional/refresher training are possible corrective actions relevant to data evaluation activities. The Project Manager will be responsible for approving the implementation of corrective action.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in three primary formats during the course of the NSB-NLON Basewide Groundwater OU RI. Data validation letter reports will be prepared on a Sample Delivery Group-specific basis and will summarize QA issues for the subcontract laboratory data. In addition, daily verbal reports summarizing accomplishments and QA/QC issues during the field investigation will be provided by the FOL. Finally, monthly progress reports are provided by the Project Manager. In addition, a summary of data validation qualifiers and a completeness assessment for all project samples will be included in the RI Report.

14.1 CONTENTS OF PROJECT QUALITY ASSURANCE REPORTS

The contents of the specific QA reports are as follows. The data validation reports address all major and minor laboratory noncompliances as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., holding time exceedances or calibration noncompliances, etc.) the Data Validation Coordinator will notify the Project Manager, the Technical Program Manager, and the Laboratory Services Coordinator. Such notifications (if necessary) are typically provided via internal memoranda and are placed in the project file. Such reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action and compensational adjustments. Corrective actions are initiated at the program level.

The FOL will provide the Project Manager with daily reports via telephone regarding accomplishments, deviations from the WP/SAP, upcoming activities, and a QA summary during the course of the field investigation. In addition, monthly project review meetings are held for all active Navy CLEAN projects. Issues discussed at the project review meeting include all aspects of budget and schedule compliance, and QA/QC problems. The Project Manager provides a monthly progress report to the Navy which addresses the project budget, schedule, accomplishments, planned activities, required revisions of the QAPP, and QA/QC issues and intended corrective actions.

14.2 INDIVIDUALS RECEIVING/REVIEWING QUALITY ASSURANCE REPORTS

Data validation QA Reports are provided to the Project Manager for inclusion in the project files. In the event that major problems are observed for a given laboratory, the Program Manager, Deputy Program Manager, QA Manager, Project Manager, and Laboratory Services Coordinator are provided with copies

of the QA report. Weekly field progress reports are provided to the Project Manager. Monthly progress reports are provided to the Navy CLEAN Program Manager and the Navy CLEAN Contracting Officers Technical Representative.

APPENDIX D

HEALTH & SAFETY PLAN

DRAFT
Health and Safety Plan
for
**BASEWIDE GROUNDWATER
OPERABLE UNIT
REMEDIAL INVESTIGATION**

**Naval Submarine Base – New London
Groton, Connecticut**



**Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0312**

June 1999

**DRAFT
HEALTH AND SAFETY PLAN
FOR
BASEWIDE GROUNDWATER OPERABLE UNIT
REMEDIAL INVESTIGATION**

**NAVAL SUBMARINE BASE – NEW LONDON
GROTON, CONNECTICUT**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:
Northern Division
Environmental Branch, Code 18
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop No. 82
Lester, Pennsylvania 19113-2090**

**Submitted by:
TetraTech NUS, Inc.
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406-1433**

**CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0312**

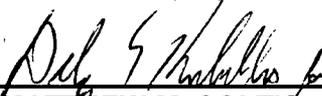
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1.0 INTRODUCTION

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 OU Remedial 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 Northern Division Naval Facilities Engineering Command (NAVFAC), as defined under Contract Number N62472-90-D-1298. 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). Requests for modifications to the HASP will be directed to the PHSO, who will determine if the changes are necessary. The PHSO will notify the Project Manager (PM), who will notify all affected personnel of changes.

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. These duties may include:
 - 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.

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), monitoring well installation, 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 November 1999 and continue until project completion.

Project Team:

TtNUS Management Personnel:

Corey A. Rich, P.E.

TBD

TBD

Matthew M. Soltis, CIH, CSP

Delwyn E. Kubeldis, CIH, CSP

Discipline/Tasks Assigned:

Project Manager (PM)

Field Operations Leader (FOL)

Site Safety Officer (SSO)

CLEAN Health and Safety Manager

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 subcontractor

Prepared by: James K. Laffey

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as 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, Richard Conant. In the event of an emergency that cannot be mitigated using onsite resources, personnel will evacuate to a safe place of refuge and the appropriate emergency response agencies will be notified. It has been determined that the majority of potential emergency situations would be better supported by outside emergency responders. Based on this determination, TtNUS and subcontractor personnel will not provide emergency response support beyond the capabilities of onsite response. Workers who are ill or who have suffered a non-serious injury may be transported by site personnel to nearby medical facilities, provided that such transport does not aggravate or further endanger the welfare of the injured/ill person. The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time. NSB-NLON contact Richard Conant will be notified anytime outside response agencies are contacted. This Emergency Action Plan conforms to the requirements of 29 CFR 1910.38(a), as allowed in 29 CFR 1910.120(l)(1)(ii).

TtNUS will, through necessary services, provide the following emergency action measures:

- Incipient stage fire fighting support and prevention
- Incipient spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Initial medical support for injuries or illnesses requiring basic first-aid
- Site control and security measures as necessary

2.2 PRE-EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, emergencies resulting from chemical, physical, or fire hazards are the types of emergencies that could be encountered during site activities.

To minimize and eliminate the potential for these emergency situations, pre-emergency planning activities will include the following (which are the responsibility of the SSO and/or the FOL):

- Coordinating with local Emergency Response personnel to ensure that TtNUS emergency action activities are compatible with local emergency response procedures. Base Fire Protection and Emergency Services will be notified of scheduled events and activities. This is most imperative in situations where their services may be required.

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:
 - Chemical Inventory of chemicals used onsite, with Material Safety Data Sheets.
 - Onsite personnel medical records (Medical Data Sheets).
 - A log book identifying personnel onsite each day.
 - Hospital route maps with directions (these should also be placed in each site vehicle).
 - Emergency Notification - phone numbers.

The TtNUS FOL will be responsible for the following tasks:

- Identifying a chain of 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.

- Periodically performing practice drills to ensure site workers are familiar with incidental response measures.

- Providing the necessary equipment to safely accomplish identified tasks.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Emergency situations that may be encountered during site activities will generally be recognized by visual observation. To adequately recognize chemical exposures, site personnel must have a clear knowledge of signs and symptoms of exposure associated with site contaminants. This information is provided in Table 6-1. Tasks to be performed at the site, potential hazards associated with those tasks and the recommended control methods are discussed in detail in Sections 5.0 and 6.0. Additionally, early recognition of hazards will be supported by daily site surveys to eliminate any situation predisposed to an

emergency. The FOL and/or the SSO will be responsible for performing surveys of work areas prior to initiating site operations and periodically while operations are being conducted. Survey findings will be documented by the FOL and/or the SSO in the Site Health and Safety logbook, however, all site personnel will be responsible for reporting hazardous situations. Where potential hazards exist, TtNUS will initiate control measures to prevent adverse effects to human health and the environment.

The above actions will provide early recognition for potential emergency situations, and allow TtNUS to instigate necessary control measures. However, if the FOL and the SSO determine that control measures are not sufficient to eliminate the hazard; TtNUS will withdraw from the site and notify the appropriate response agencies listed in Table 2-1.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by following the Health and Safety Guidance Manual and ensuring compliance with the HASP and applicable OSHA regulations. Daily site surveys of work areas, prior to the commencement of that day's activities, by the FOL and/or the SSO will also assist in prevention of illness/injuries when hazards are recognized early and control measures initiated.

2.4 EVACUATION ROUTES, PROCEDURES, AND PLACES OF REFUGE

An evacuation will be initiated whenever recommended hazard controls are insufficient to protect the health, safety or welfare of site workers. Specific examples of conditions that may initiate an evacuation include, but are not limited to the following: severe weather conditions; fire or explosion; monitoring instrumentation readings which indicate levels of contamination are greater than instituted action levels; and evidence of personnel overexposure to potential site contaminants.

In the event of an emergency requiring evacuation, all personnel will immediately stop activities and report to the designated safe place of refuge unless doing so would pose additional risks. When evacuation to the primary place of refuge is not possible, personnel will proceed to a designated alternate location and remain until further notification from the TtNUS FOL. Safe places of refuge will be identified prior to the commencement of site activities by the SSO and will be conveyed to personnel as part of the pre-activities training session. This information will be reiterated during daily safety meetings. Whenever possible, the safe place of refuge will also serve as the telephone communications point for that area. During an evacuation, personnel will remain at the refuge location until directed otherwise by the TtNUS FOL or the on-site Incident Commander of the Emergency Response Team. The FOL or the SSO will perform a

head count at this location to account for and to confirm the location of all site personnel. Emergency response personnel will be immediately notified of any unaccounted personnel. The SSO will document the names of all personnel onsite (on a daily basis) in the site Health and Safety Logbook. This information will be utilized to perform the head count in the event of an emergency.

Evacuation procedures will be discussed during the pre-activities training session, prior to the initiation of project tasks. Evacuation routes from the site and safe places of refuge 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) may dictate evacuation routes. As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed. Evacuation should always take place in an upwind direction from the site.

2.5 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 evacuation 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 first-aid level support. Medical attention above that level will require assistance and support from the designated emergency response agencies. Attachment I provides the procedure to follow when reporting an injury/illness, and the form to be used for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps provided in Figure 2-1.**

2.6 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.

FIGURE 2-1 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, 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 Tetra Tech NUS 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 Continuum Healthcare physician. Continuum Healthcare will contact the medical facility and request specific testing which may be appropriate. The care of the victim will be monitored by Continuum Healthcare physicians. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call Continuum Healthcare at 1-800-229-3674, being 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 MSDS to Continuum Healthcare at (770) 457-1429.
- Contact Corporate Health and Safety Department (Matt Soltis) at 1-800-245-2730.

As environmental data is gathered and the exposure scenario becomes more clearly defined, this information should be forwarded to the Continuum Healthcare Medical Director or Assistant Medical Director.

Continuum Healthcare will compile the results of all 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 Continuum Healthcare.

**FIGURE 2-1 (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 there 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-Medicating: _____ Physician Treated: _____

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) 694-3333
Lawrence & Memorial Hospital	(860) 442-0711
Groton Police:	911 or 445-9721
Groton Fire Department:	911 or 445-5775
Utility Emergencies (electric, gas, water and sewer) NSB-NLON Public Works:	(860) 694-4711
Site Contact Richard "Dick" Conant	(860) 694-5176
NSB-NLON Security:	(860) 694-3444
TtNUS Project Manager Corey A. Rich P.E.	(412) 921-8244
TtNUS Project Health and Safety Officer Delwyn E. Kubeldis, CIH, CSP	(412) 921-8529
TtNUS CLEAN Health and Safety Manager Matthew M. Soltis, CIH, CSP	(412) 921-8912

2.7 ROUTE TO HOSPITAL

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

Exit the base and proceed South on Route 12. 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.

See Figure 2-2 for a map with the route to the hospital highlighted. Prior to the commencement of site activities, a map depicting directions from the site to the hospital shall be posted in the field trailer.

2.8 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

TtNUS personnel will be working in close proximity to each other at NSB-NLON. As a result, hand signals, voice commands, and line of site communication will be sufficient to alert site personnel of an emergency. When project tasks are performed simultaneously on different sites, vehicle horns will be used to communicate emergency situations. If an emergency warranting evacuation occurs, the following procedures are to be initiated:

- Initiate the evacuation via hand signals, voice commands, line of site communication, or vehicle horns. The following signals shall be utilized when communication via vehicle horn is necessary:

HELP	three short blasts	(. . .)
EVACUATION	three long blasts	(- - -)

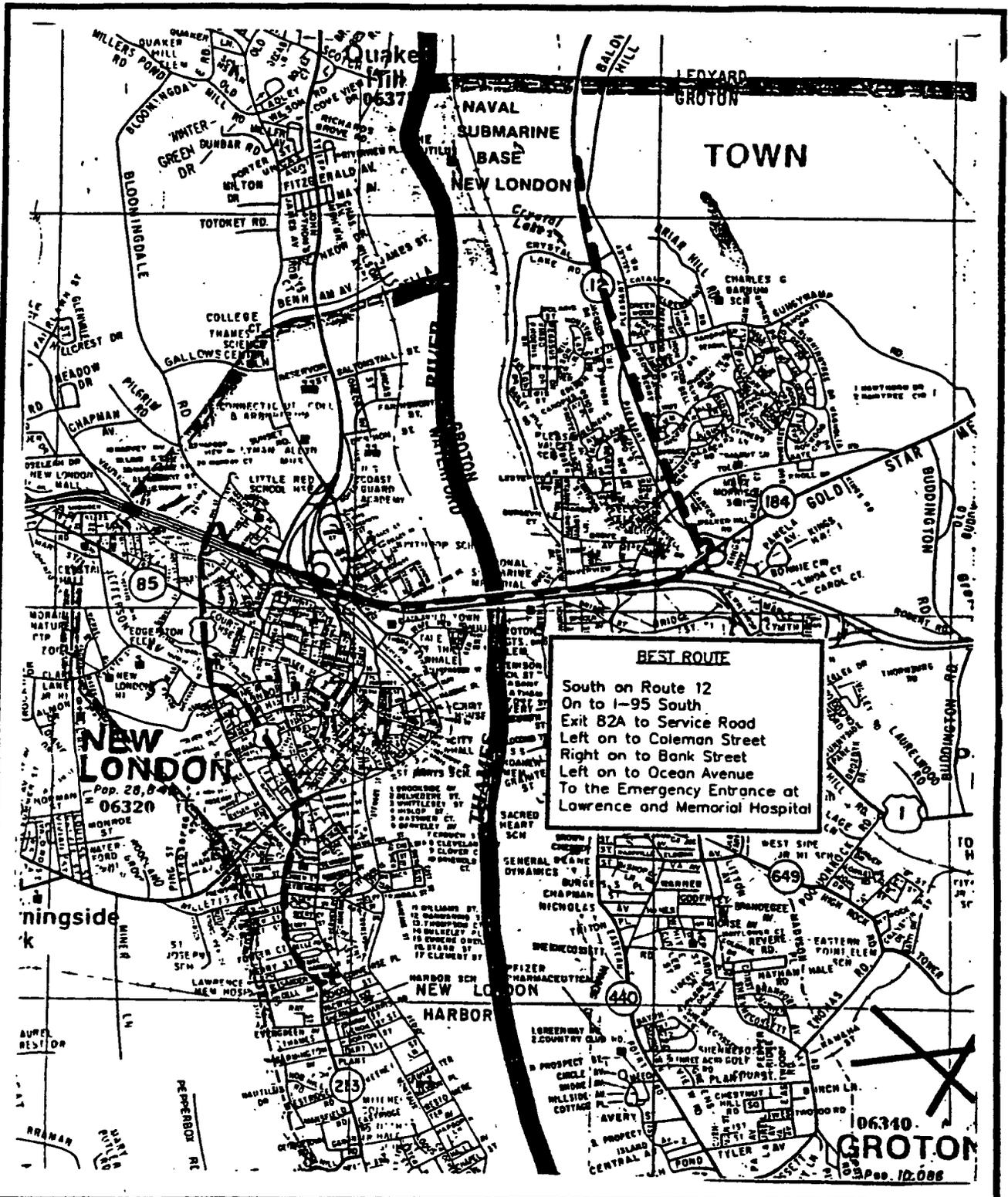
- Report to the designated refuge point.
- Once all non-essential personnel are evacuated, appropriate response procedures will be enacted to control the situation.
- Describe to the FOL (FOL will serve as the Incident Coordinator) pertinent incident details.

In the event that site personnel cannot mitigate the hazardous situation, the FOL and SSO will enact emergency notification procedures to secure additional assistance in the following manner:

- Dial 911 (outside services) and call other pertinent emergency contacts listed in Table 2-1 and report the incident. 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.

2.9 PPE AND EMERGENCY EQUIPMENT

As applicable, a first-aid kit, eye wash units (or bottles of disposable eyewash solution) and/or fire extinguishers (strategically placed) will be maintained onsite and shall be immediately available for use in the event of an emergency. When available, this equipment will be located in the field office as well as in each site vehicle. At least one first aid kit supplied with equipment to protect against bloodborne pathogens will also be available on site. Personnel identified within the field crew with bloodborne pathogen and first-aid training will be the only personnel permitted to offer first-aid assistance.



INSTALLATION RESTORATION STUDY
 NAVAL SUBMARINE BASE - NEW LONDON
 GROTON, CT



Figure 2-2
 ROUTE TO
 LAWRENCE AND MEMORIAL
 HOSPITAL

3.0 SITE BACKGROUND

3.1 SITE HISTORY AND CURRENT OPERATIONS

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 the Basewide Groundwater OU Remedial Investigation. NSB-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. This facility was placed on the National Priorities List by the U.S. EPA on August 28, 1991.

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.

3.2 INVESTIGATION AREAS

The Basewide Groundwater OU Remedial Investigation covers essentially all of NSB-NLON, except for a long narrow strip of land that is adjacent to the Thames River and runs the entire length of the west side of the base. Installation Restoration Program (IRP) sites located in this excluded strip include the Defense Reutilization and Marketing Office (DRMO) and the Lower Subbase. The remaining portion of NSB-NLON included in this investigation is bordered on the east by the Connecticut Route 12, on the south by Crystal Lake Road and Goss Cove, and on the north by a low ridge that trends approximately east-southeast for the Thames River to Baldwin Hill. Within the NSB-NLON, several potential contaminated areas and sources of contamination have been identified. The base is divided into three geographical regions for the purpose of this investigation.

3.2.1 Northern Region

The Northern region is bordered by Perimeter Road to the north and Highway 12 to the east. This region extends to the west to include the Golf Course west of Shark Boulevard. The southern boundary is

represented by an imaginary line extending from the intersection of Corsair Road and Highway 12 to Pier 32 but stopping at the western edge of the Golf Course before the lower Subbase. The following sites will be included in this HASP.

- Site 01 - Central Battalion Unit (CBU) Drum Storage Area - The CBU Drum Storage Area was an unpaved area located in the northern section of NSB-NLON, Adjacent to the deployed personnel parking lot and within the boundary of the Area A Landfill. The site was situated on a flat, open area at the base of a wooded hill side that slopes to the northeast toward the site at a 25% grade. The site has been capped and paved over with asphalt. Because of the low levels of contamination, this site will be monitored as part of the Area A Landfill.
- Site 02A - Area A Landfill - The Area A Landfill encompasses approximately 13 acres in the northeastern and north-central section of NSB-NLON. Access to the landfill is via a dirt road off of Wahoo Avenue. The thickness of the landfill materials is estimated to be 10 to 20 feet based on test boring data. The Area A landfill is a relatively flat area bordered by a steep, wooded hillside that rises to the south, a steep wooded ravine to the west, and the Area A wetland to the north. The landfill extends east along the wetland as far as a recreational area (tennis courts). Most filling occurred within the eastern and western limits of the landfill. Because a cover system and paving have been installed over the Area A Landfill; the release of waste materials to the environment should be minimal. Additional sampling and analysis activities will occur at this site.
- Site 02B - Area A. Wetland - The Area A Wetland is approximately 23.6 acres in size and is adjacent to the northeastern edge of the Area A Landfill. This portion of NSB-NLON was undeveloped, wooded land and possibly wetland until the late 1950s when it was filled in with dredge spoils from the Thames River. There is a small pond at the southern portion of the wetland. A cover system and pavement has minimized the spread of contaminants. Access to this area will be restricted and groundwater will be sampled.
- Site 03 - Area A Downstream Watercourses and the Over Bank Disposal Area (OBDA). - The Area A Downstream Watercourses receive surface water and ground water recharge from the Area A Wetland, Torpedo Shops, OBDA North East, and surrounding areas and convey them to the Thames River. The Area A Downstream Watercourses include North Lake and several small ponds and interconnected streams. Several VOCs, including vinyl chloride, were found in samples collected. Additional groundwater sampling will determine the source and extent of this contamination.

- Site 04 - Rubble Fill Area at Bunker A86 - Bunker A86 is located at the end of a dirt road off Wahoo Avenue in the north-central section of NSB-NLON. The Rubble Fill Area was located south of the Area A Landfill, near the west end. It is north of the dirt road and west of the bunker. The size was approximately 25 feet wide and 60 feet long. It was on a wooded hillside that slopes to the north-northeast at an approximate grade of 40%. A removal action was completed for the soil, sediment and debris at the site in 1997. Because a groundwater monitoring program will be implemented in conjunction with the cover system at the Area A Landfill and that program will include sampling points within and downgradient of the former Rubble Fill Area at Bunker A86, additional sampling activities will occur at this site.
- Site 07 - Torpedo Shops - This site is located in the northern portion of NSB-NLON on the northern side of Triton Avenue. It is bordered on the east and north by 60-foot-high bedrock cliffs. The remainder of the site slopes to the southwest. An earthen berm extends along the base of the eastern portion of the exposed rock face. Buildings 325, 450, and 477 are located here. Methylene chloride and several PAHs were found in approximately 50% of the soil samples. Additional wells are being installed to determine the nature, extent, and migration of organic contamination at this site.
- Site 14 - Over Bank Disposal Area Northeast (OBDANE) - The OBDANE site is located in a heavily wooded area on the edge of a ravine northwest of the Area A Landfill, west of the Area A Weapons Center and south of the Torpedo Shops. The site is circular and approximately 80 feet in diameter. A dirt road provides access to the wooded site. A nearly vertical 20-foot-high bedrock face is located at the eastern edge of the site. The rest of the site slopes to the southwest. A single overburden well will be resampled to verify the extent of contamination migration from the Torpedo Shops.
- Site 20 - Area A Weapons Center - This site consists of Building 524 and the weapons storage bunkers. The site is located at the southeastern end of Triton Avenue and is adjacent to and on the northwestern side of the Area A Wetland. There is little evidence of groundwater and surface water contamination at this site, but it may be a source of contamination for the Area A Wetlands.

3.2.2 Central Region

The central region lies between the northern and southern regions. Site 16 is the only IRP site located within the central region.

- Site 16 - Hospital Incinerator - In the 1980s, the Naval Hospital Groton operated a skid-mounted waste incinerator at two sites adjacent to the hospital. The two sites are located west of Tautog Road,

adjacent to Buildings 449 and 452. The incinerator was used to destroy medical records and medical waste contaminated with pathological agents. Ash was transferred to dumpsters for disposal at the municipal landfill. There is no data available for this site. The data collected will be used to determine the nature and extent of contamination.

3.2.3 Southern Region

The Southern Region extends southward from the southern boundary of the Central Region. It is bordered by Highway 12 to the east, Crystal Lake Road and Goss Cove to the south, and the Thames River or Shark Boulevard to the west. The following sites are located within the Southern Region.

- Site 08 - Goss Cove Landfill - Is located in the southwestern portion of the Base adjacent to the Thames River. It is west of Shark Boulevard and the intersection of Crystal Lake Road and Military Highway, east of the Thames River and north of Goss Cove. The Nautilus Museum and a paved parking lot are directly over the landfill. The landfill was operated from 1946 through 1957. Incinerator ash and inert rubble were disposed at the site. It was reported, however, that several large compressed gas cylinders were uncovered during the excavation of a utility trench in the parking area north of the Nautilus Museum building. One of the cylinders was leaking propane, one was filled with ammonia, and the others were empty. Significant concentrations of Tetrachloroethylene (PCE) were detected. The source of the contamination is from an upgradient, off-site location and not the landfill. Additional investigation is required to determine the extent and source of the contamination.
- Site 15 - Spent Acid Storage and Disposal Area - This area was located in the southeastern sections of the Base between the southern sides of Buildings 409 and 410. This site is a relatively flat area completely covered with concrete or bituminous pavement. It was used before and after World War II for the temporary storage of waste battery acid. While the site has been cleared of all contamination, wells will be sampled to determine chemical concentrations in the groundwater up gradient of the tank farm.
- Site 18 - Solvent Storage Area - This site consists of Building 33 where gas cylinders and 55-gallon drums of solvents such as Trichloroethylene (TCE), and dichloroethene have been stored. It is located north of Site 15 and Site 23. There is no analytical data currently available so information gathered will be used to determine the nature and extent of contamination.
- Site 23 - Tank Farm - Nine 750,000 gallon USTs were used from 1940 to 1991. They stored No. 6 Fuel Oil and diesel fuel exclusively. Evidence of releases of petroleum products was detected in

previous investigations. A number of petroleum spills are documented. Data collected from this site will be used to determine the extent of contamination.

4.0 SCOPE OF WORK

This section describes the project tasks that will be performed at NSB-NLON. Additionally, each task has been evaluated and the associated hazards and recommended control measures are listed in Table 5-1 of this HASP. The planned activities involved in this effort are presented in detail in the Work and Sampling and Analysis Plans developed for the project. If new tasks are to be performed at the site, Table 5-1 and this section will be modified accordingly.

Field investigations to be performed by TtNUS are designed to characterize soil and groundwater conditions at various sites at NSB-NLON. Specific tasks to be conducted include, but are not necessarily limited to, the following:

- Mobilization and demobilization
- Soil borings (hollow stem auger, air rotary and direct push techniques)
- Multi-media sampling:
 - Groundwater
 - Surface Soil
 - Subsurface Soil
- Monitoring well installation, development, and purging
- Decontamination of sampling and heavy equipment
- Surveying
- IDW management

The above listing represents a summarization of the tasks as they apply to the scope and application of this HASP. For more detailed description of the associated tasks, refer to the Work and Sampling and analysis Plan. If additional tasks are determined to be necessary, this HASP will be amended and a hazard evaluation of the additional tasks performed.

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

Table 5-1 of this section serves as the primary portion of the site-specific HASP, and 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, a Health and Safety Guidance Manual accompanies this table and HASP. The manual is designed to further explain supporting programs and elements for other site-specific aspects as required by 29 CFR 1910.120. 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 10.10) will use elements defined in Table 5-1 as it's 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 due to the incorporation of site-specific elements, the Safe Work Permit will be followed.

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TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR
NAVAL SUBMARINE BASE - NEW LONDON (NSB-NLON) GROTON, CONNECTICUT
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment	Decontamination Procedures
<p>Soil borings using Hollow Stem Auger, and Direct-Push Technology (DPT, such as the Geoprobe®)</p> <p>This task also includes monitoring well installation, development, and purging.</p>	<p><i>Chemical Hazards</i></p> <p>1) Primary contaminants include VOCs (including vinyl chloride, methylene chloride, trichloroethene, dichloroethene, benzene, and xylene), SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs), metals (arsenic, chromium and lead), pesticides (represented as DDT), PCBs. Contaminants may vary from location to location. Review text in Section 6.0 of the HASP prior to working in each location. Also, note that these contaminants may be bound to particulates (dusts, soils, etc.) and contact with site dust/dirt should be avoided whenever possible. See Table 6-1 for more information on the chemicals of concern.</p> <p>2) Transfer of contamination into clean areas or onto persons</p> <p><i>Physical hazards</i></p> <p>3) Heavy equipment hazards (pinch/compression points, rotating equipment, hydraulic lines, etc.)</p> <p>4) Noise in excess of 85 dBA</p> <p>5) Energized systems (contact with underground or overhead utilities)</p> <p>6) Lifting (strain/muscle pulls)</p> <p>7) Slip, trips, and falls</p> <p>8) Vehicular and foot traffic</p> <p>9) Ambient temperature extremes (heat or cold stress)</p> <p>10) Eye and foot hazards</p> <p><i>Natural hazards</i></p> <p>11) Insect/animal bites and stings, poisonous plants, etc.</p> <p>12) Inclement weather</p>	<p>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 and contact with dust/dirt should be minimized whenever possible. If airborne dusts are observed, area wetting methods will be used. If area wetting methods are not feasible, termination of activities will be used to minimize exposure to excessive airborne dusts.</p> <p>2) Decontaminate all equipment and supplies between boreholes and prior to leaving the site.</p> <p>3) All equipment to be used will be</p> <ul style="list-style-type: none"> - 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 <p>In addition to the equipment considerations, the following standard operating procedures will be employed:</p> <ul style="list-style-type: none"> - All personnel not directly supporting the drilling/direct push 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 (if necessary) will be established prior to the commencement of 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. - Areas will be inspected prior to the movement of drill/direct push rigs and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. <p>4) Hearing protection will be used during all subsurface activities. Refer to Section 6 of the Guidance Manual for further information.</p> <p>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.</p> <p>6) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques.</p> <p>7) Preview work locations for unstable/uneven terrain.</p> <p>8) Traffic and equipment considerations are to include the following:</p> <ul style="list-style-type: none"> - Establish safe zones of approach. - All activities are to be conducted consistent with Base traffic requirements. <p>9) 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 TINUS Health and Safety Guidance Manual.</p> <p>10) Avoid recognized eye and foot hazards. Wear appropriate PPE.</p> <p>11) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Attachment II of this HASP.</p> <p>12) Suspend or terminate operations until directed otherwise by SSO.</p>	<p>A direct reading Photoionization Detector (PID) with at least a 11.4 eV lamp or Flameionization Detector (FID) will be used to screen samples and to detect the presence of VOCs, SVOCs, and any other detectable contaminants. Source monitoring of the borehole will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location which may impact the field crew will require the following actions:</p> <ul style="list-style-type: none"> - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above background in the breathing zone of the at-risk employees 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 background levels. If elevated readings in the worker's breathing zone persist, the PHSO and HSM will be contacted to determine necessary actions and levels of protection. <p>Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be controlled to minimize the potential for inhalation of contaminated dusts and 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.</p> <p>Where the utility clearance cannot be determined, subsurface activities shall proceed with extreme caution using hand digging to below at least the frost-line depth (no less than 4 feet BGS). Also a magnetometer must be used for periodic down-hole surveys every 2 feet to a depth of at least 10 feet.</p>	<p>All subsurface operations are to be initiated in Level D protection. Level D protection constitutes the following minimum protection</p> <ul style="list-style-type: none"> - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - Safety glasses - Hardhat - Nitrile gloves or leather gloves with surgical style inner gloves - Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential exists for soiling work attire. - Hearing protection during drilling or for other high noise areas as directed by the SSO. - Reflective vest for traffic areas <p><i>(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)</i></p> <p>Note: The Safe Work Permit(s) for this task (see Attachment IV) will be issued and reviewed 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.</p>	<p>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.</p> <p>This decontamination procedure for Level D protection will consist of</p> <ul style="list-style-type: none"> - Equipment drop - Outer coveralls or boot covers removal, as applicable - Soap/water wash and rinse of reusable outer gloves, as applicable - 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 COMPENDIUM FOR
NAVAL SUBMARINE BASE - NEW LONDON (NSB-NLON) GROTON, CONNECTICUT
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment	Decontamination Procedures
<p>Soil borings using air rotary technique.</p> <p>Site 3 and Site 7</p> <p>This task also includes monitoring well installation, development, and purging.</p>	<p><i>Chemical Hazards</i></p> <p>1) Primary contaminants at Site 3 include VOCs (including vinyl chloride) and SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs). Site 7 primary contaminants include VOCs (including methylene chloride), metals (arsenic, chromium and lead) and SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs, and waste oils). Contaminants may vary from well to well. Review text in Section 6.0 of the HASP prior to working in each location. Also, note that these contaminants may be bound to particulates (dusts, soils, etc.) and contact with site dust/dirt should be avoided whenever possible. See Table 6-1 for more information on the chemicals of concern.</p> <p>2) Transfer of contamination into clean areas or onto persons</p> <p><i>Physical hazards</i></p> <p>3) Heavy equipment hazards (pinch/compression points, rotating equipment, hydraulic lines, etc.)</p> <p>4) Flying projectiles associated with air rotary drilling.</p> <p>5) Noise in excess of 85 dBA</p> <p>6) Energized systems (contact with underground or overhead utilities)</p> <p>7) Lifting (strain/muscle pulls)</p> <p>8) Slip, trips, and falls</p> <p>9) Vehicular and foot traffic</p> <p>10) Ambient temperature extremes (heat or cold stress)</p> <p>11) Eye and foot hazards</p> <p><i>Natural hazards</i></p> <p>12) Insect/animal bites and stings, poisonous plants, etc.</p> <p>13) Inclement weather</p>	<p>1) When appropriate use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts and contact with dust/dirt should be minimized whenever possible. If airborne dusts are observed, area wetting methods will be used. If area wetting methods are not feasible, termination of activities will be used to minimize exposure to excessive airborne dusts.</p> <p>2) Decontaminate all equipment and supplies between boreholes and prior to leaving the site.</p> <p>3) All equipment to be used will be</p> <ul style="list-style-type: none"> - 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 <p>In addition to the equipment considerations, the following standard operating procedures will be employed:</p> <ul style="list-style-type: none"> - All personnel not directly supporting the air rotary 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 (if necessary) will be established prior to the commencement of 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. - Areas will be inspected prior to the movement of drill rigs and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. <p>4) Restrict access to non-essential personnel during drilling activities. Utilize appropriate PPE (e.g., safety glasses and face shields) to protect against flying projectiles created by air rotary drilling activities.</p> <p>5) Hearing protection will be used during all subsurface activities. Refer to Section 6 of the Guidance Manual for further information.</p> <p>6) 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.</p> <p>7) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques.</p> <p>8) Preview work locations for unstable/uneven terrain.</p> <p>9) Traffic and equipment considerations are to include the following:</p> <ul style="list-style-type: none"> - Establish safe zones of approach. - All activities are to be conducted consistent with Base traffic requirements. <p>10) 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 TINUS Health and Safety Guidance Manual.</p> <p>11) Avoid recognized eye and foot hazards. Wear appropriate PPE.</p> <p>12) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Attachment II of this HASP.</p> <p>13) Suspend or terminate operations until directed otherwise by SSO.</p>	<p>A direct reading Photoionization Detector (PID) with at least a 11.4 eV lamp or Flameionization Detector (FID) will be used to screen samples and to detect the presence of VOCs, SVOCs, and any other detectable contaminants. Source monitoring of the borehole will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location which may impact the field crew will require the following actions:</p> <ul style="list-style-type: none"> - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above background in the breathing zone (BZ) of the at-risk employees requires site activities to be suspended and site personnel to report to an unaffected area. - Work may only resume if airborne readings in worker BZ return to background levels. If elevated readings in the worker's BZ persist, the PHSO and HSM will be contacted to determine necessary actions and levels of protection. <p>Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be controlled to minimize the potential for inhalation of contaminated dusts and 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, and/or upgrade of PPE.</p> <p>If airborne dusts are generated and cannot be controlled, Level C protection will be required. An air purifying respirator will only be used for protection against particulate contaminants. Respirators will not be used for protection against organic vapors, gases, or other non-particulate respiratory hazards.</p> <p>If PID/FID readings rise above background, operations must be suspended and the site evacuated until the levels return to background.</p> <p>Where the utility clearance cannot be determined, subsurface activities shall proceed with extreme caution using hand digging to below at least the frost-line depth (no less than 4 feet bgs.). Also a magnetometer must be used for periodic down-hole surveys every 2 feet to a depth of at least 10 feet.</p>	<p>All subsurface operations are to be initiated in Level D protection. Level D protection constitutes the following minimum protection</p> <ul style="list-style-type: none"> - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - Safety glasses - Hardhat - Nitrile gloves or leather gloves with surgical style inner gloves - Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential exists for soiling work attire. - Hearing protection during drilling or for other high noise areas as directed by the SSO. - Reflective vest for traffic areas <p><i>(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)</i></p> <p>Upgrade to Level C protection will follow the guidance provided under Hazard Monitoring. Level C protection will consist of a quarter or half-face air purifying respirator (APR) with a protection factor of at least 5. All respirator use will be consistent with the written Respiratory Protection Program.</p> <p>At the discretion of the SSO Tyvek coveralls may be required. When free product is encountered a splash suit made of PVC, Saranex, or PE should be used.</p> <p>Note: The Safe Work Permit(s) for this task (see Attachment IV) will be issued and reviewed 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.</p>	<p>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.</p> <p>This decontamination procedure for Level D protection will consist of</p> <ul style="list-style-type: none"> - Equipment drop - Outer coveralls or boot covers removal, as applicable - Soap/water wash and rinse of reusable outer gloves, as applicable - Removal, segregation, and disposal of non-reusable PPE in bags/containers provided - Wash hands and face, leave contamination reduction zone. <p>For Level C Protection:</p> <ul style="list-style-type: none"> - Equipment drop - Outer coveralls or boot covers removal, as applicable - Respiratory (face mask) protection 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 COMPENDIUM FOR
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment	Decontamination Procedures
<p>Multi-media sampling, including soil, and groundwater sampling.</p>	<p><i>Chemical Hazards</i></p> <p>1) Primary contaminants include VOCs (including vinyl chloride, methylene chloride, trichloroethene, dichloroethene, benzene, and xylene), SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs), metals (arsenic, chromium and lead), pesticides (represented as DDT), PCBs. Contaminants may vary from location to location. Review text in Section 6.0 of the HASP prior to working in each location. Also, note that these contaminants may be bound to particulates (dusts, soils, etc.) and contact with site dust/dirt should be avoided whenever possible. See Table 6-1 for more information on the chemicals of concern.</p> <p>2) Transfer of contamination into clean areas or onto persons</p> <p><i>Physical hazards</i></p> <p>3) Noise in excess of 85 dBA</p> <p>4) Lifting (strain/muscle pulls)</p> <p>5) Pinches and compressions</p> <p>6) Slip, trips, and falls</p> <p>7) Ambient temperature extremes (heat or cold stress)</p> <p>8) Vehicular and foot traffic</p> <p>9) Eye and foot hazards</p> <p><i>Natural hazards</i></p> <p>10) Insect/animal bites and stings, poisonous plants, etc.</p> <p>11) Inclement weather</p>	<p>1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (e.g. air, water, soils). Generation of dusts and contact with dust/dirt should be minimized whenever possible. If airborne dusts are observed, area wetting methods will be used. If area wetting methods are not feasible, termination of activities will be used to minimize exposure to observed airborne dusts.</p> <p>2) Decontaminate all equipment and supplies between sampling locations and prior to leaving the site.</p> <p>3) When sampling at the drill rig or Geoprobe® use hearing protection. The use of hearing protection outside of 25 feet from the drill rig or Geoprobe® should be incorporated under the following condition:</p> <p style="padding-left: 40px;">If you have to raise your voice to talk to someone who is within 2 feet of your location, hearing protection must be worn.</p> <p>Refer to Section 6 of the Guidance Manual for further information.</p> <p>4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques.</p> <p>5) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points.</p> <ul style="list-style-type: none"> - 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. <p>6) Preview work locations for unstable/uneven terrain.</p> <p>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.</p> <p>8) Traffic and equipment considerations are to include the following:</p> <ul style="list-style-type: none"> - Establish safe zones of approach. - All activities are to be conducted consistent with the Base requirements. <p>9) Avoid recognized eye and foot hazards. Wear appropriate PPE.</p> <p>10) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Attachment II of this HASP.</p> <p>11) Suspend or terminate operations until directed otherwise by SSO</p>	<p>A direct reading Photoionization Detector (PID) with at least a 11.4 eV lamp or Flameionization Detector (FID) will be used to screen samples and to detect the presence of VOCs, SVOCs, and any other detectable contaminants. Source monitoring of the borehole will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location which may impact the field crew will require the following actions:</p> <ul style="list-style-type: none"> - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above background in the breathing zone of the at-risk employees requires site activities to be suspended and site personnel to report to an unaffected area. - Work may only resume if airborne readings in the worker breathing zone return to below background levels. If elevated readings in the worker breathing zone persist, the PHSO and HSM will be contacted to determine necessary actions and levels of protection. <p>Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be controlled to minimize the potential for inhalation of contaminated dusts and 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.</p>	<p>Level D protection will be utilized for the initiation of all sampling activities.</p> <p>Level D - (Minimum Requirements)</p> <ul style="list-style-type: none"> - Standard field attire (Sleeved shirt; long pants) - Safety shoes (steel toe/shank) - Safety glasses - Surgical style gloves (double-layered if necessary) - <i>Reflective vest for high traffic areas</i> - <i>Hardhat (when overhead hazards exists, or identified as a operation requirement)</i> - <i>Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential for soiling work attire exists.</i> - <i>Hearing protection for high noise areas, or as directed on an operation by operation scenario.</i> <p><i>(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)</i></p> <p>Note: The Safe Work Permit(s) for this task (see Attachment IV) will be issued and reviewed 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.</p>	<p>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:</p> <ul style="list-style-type: none"> - 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.

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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment	Decontamination Procedures
Mobilization/ Demobilization	<p><i>Physical Hazards</i></p> <ol style="list-style-type: none"> 1) Lifting (muscle strains/pulls) 2) Pinches and compressions 3) Slip, trips, and falls 4) Heavy equipment hazards (rotating equipment, hydraulic lines, etc.) 5) Vehicular and foot traffic 6) Ambient temperature extremes (heat/cold stress) 7) Foot hazards <p><i>Natural hazards</i></p> <ol style="list-style-type: none"> 8) Insect/animal bites and stings, poisonous plants, etc. 9) Inclement weather 	<ol style="list-style-type: none"> 1) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 2) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. 3) Preview work locations for unstable/uneven terrain. 4) All equipment will be <ul style="list-style-type: none"> - Inspected in accordance with OSHA and manufacturer's design. - Operated by knowledgeable operators and ground crew. 5) Traffic and equipment considerations are to include the following: <ul style="list-style-type: none"> - 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. 6) 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 TiNUS Health and Safety Guidance Manual. 7) Avoid recognized foot hazards. Wear appropriate PPE. 8) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Attachment II of this HASP. 9) Suspend or terminate operations until directed otherwise by SSO 	Not required	<p>Level D - (Minimum Requirements)</p> <ul style="list-style-type: none"> - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - 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. <p><i>(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)</i></p>	Not required
Decontamination of Sampling and Heavy Equipment	<p><i>Chemical Hazards</i></p> <ol style="list-style-type: none"> 1) Primary contaminants include VOCs (including vinyl chloride, methylene chloride, trichloroethene, dichloroethene, benzene, and xylene), SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs), metals (arsenic, chromium and lead), pesticides (represented as DDT), PCBs. Contaminants may vary from location to location. Review text in Section 6.0 of the HASP prior to working in each location. Also, note that these contaminants may be bound to particulates (dusts, soils, etc.) and contact with site dust/dirt should be avoided whenever possible. See Table 6-1 for more information on the chemicals of concern. 2) Decontamination fluids - Liquinox (detergent), acetone or isopropanol <p><i>Physical Hazards</i></p> <ol style="list-style-type: none"> 3) Lifting (muscle strains and pulls) 4) Noise in excess of 85 dBA 5) Flying projectiles 6) Vehicular and foot traffic 7) Ambient temperature extremes (heat stress) 8) Slips, trips, and falls 9) Eye and foot hazards <p><i>Natural hazards</i></p> <ol style="list-style-type: none"> 10) Inclement weather 	<ol style="list-style-type: none"> 1) and 2) Employ protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. 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. Refer to Section 6 of the Guidance Manual for further information. 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: <ul style="list-style-type: none"> - Secure all loose articles to avoid possible entanglement. - 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 TiNUS Health and Safety Guidance Manual. 8) Preview work locations for unstable/uneven terrain. 9) Avoid recognized eye and foot hazards. Wear appropriate PPE. 10) Suspend or terminate operations until directed otherwise by SSO 	Use visual observation, and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried. After decon is completed, screen equipment with a PID/FID. If any elevated readings (i.e., above background) are observed, perform decon again and rescreen. Repeat until no elevated PID/FID readings are noted.	<p>For Heavy Equipment This applies to high pressure soap/water, steam cleaning wash and rinse procedures.</p> <p>Level D Minimum requirements -</p> <ul style="list-style-type: none"> - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Chemical resistant boot covers - Nitrile outer gloves - PVC Rainsuits or PE or PVC coated Tyvek - Safety glasses underneath a splash shield - Hearing protection (plugs or muffs) <p><i>Items in italics are at the discretion of the SSO.</i></p> <p>For sampling equipment (trowels, MacroCore Samplers, bailers, etc.), the following PPE is required</p> <p>Level D Minimum requirements -</p> <ul style="list-style-type: none"> - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Nitrile outer gloves - Safety glasses <p>In the event of overspray of chemical decontamination fluids employ PVC Rainsuits or PE or PVC coated Tyvek as necessary.</p>	<p>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:</p> <ul style="list-style-type: none"> - 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. <p>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 be restricted to the exclusion zones, or 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.</p> <p>Sampling Equipment Decontamination</p> <p>Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan.</p> <p>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.).</p> <p>All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site.</p> <p>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.</p>

**TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR
NAVAL SUBMARINE BASE - NEW LONDON (NSB-NLON) GROTON, CONNECTICUT
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DRAFT
Revision 1
June 1999

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment	Decontamination Procedures
IDW management and moving IDW drums to storage areas	<p><i>Chemical Hazards</i></p> <p>1) Primary contaminants include VOCs (including vinyl chloride, methylene chloride, trichloroethene, dichloroethene, benzene, and xylene), SVOCs (including Polynuclear Aromatic Hydrocarbons PAHs), metals (arsenic, chromium and lead), pesticides (represented as DDT), PCBs. Contaminants may vary from location to location. Review text in Section 6.0 of the HASP prior to working in each location. Also, note that these contaminants may be bound to particulates (dusts, soils, etc.) and contact with site dust/dirt should be avoided whenever possible. See Table 6-1 for more information on the chemicals of concern.</p> <p>2) Transfer of contamination into clean areas</p> <p><i>Physical hazards</i></p> <p>3) Noise in excess of 85 dBA 4) Lifting (muscle strains/pulls) 5) Pinches and compressions 6) Slip, trips, and falls 7) Vehicular and foot traffic 8) Ambient temperature extremes (heat/cold stress) 9) Eye and foot hazards</p> <p><i>Natural Hazards</i></p> <p>10) Insect/animal bites and stings, poisonous plants, etc. 11) Inclement weather</p>	<p>1) Employ real-time monitoring instrumentation, action levels, and identify PPE to control exposures to potentially contaminated media (e.g. air, water, soils).</p> <p>2) Decontaminate all equipment and supplies, if they become contaminated, between locations and prior to leaving the site.</p> <p>3) When working near heavy equipment, use hearing protection. Refer to Section 6 of the Guidance Manual for further information.</p> <p>4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques.</p> <p>5) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points.</p> <p>6) Preview work locations for unstable/uneven terrain.</p> <p>7) Traffic and equipment considerations are to include the following: - Secure all loose articles to avoid possible entanglement. - All activities are to be conducted consistent with the Base requirements.</p> <p>8) 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 TINUS Health and Safety Guidance Manual.</p> <p>9) Avoid recognized eye and foot hazards. Wear appropriate PPE.</p> <p>10) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Follow guidance presented in Attachment II of this HASP.</p> <p>11) Suspend or terminate operations until directed otherwise by SSO.</p>	<p>A direct reading Photoionization Detector (PID) with at least a 11.4 eV lamp or Flameionization Detector (FID) will be used to screen samples and to detect the presence of VOCs, SVOCs, and any other detectable contaminants. Source monitoring of the borehole will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location which may impact the field crew will require the following actions:</p> <ul style="list-style-type: none"> - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above background in the breathing zone of the at-risk employees requires site activities to be suspended and site personnel to report to an unaffected area. - Work may only resume if airborne readings in the worker breathing zone return to below background levels. If elevated readings in the worker breathing zone persist, the PHSO and HSM will be contacted to determine necessary actions and levels of protection. - Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be controlled to minimize the potential for inhalation of contaminated dusts and 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. 	<p>Level D protection will be utilized for the initiation of all sampling activities.</p> <p>Level D - (Minimum Requirements)</p> <ul style="list-style-type: none"> - Standard field attire (long sleeve shirt; long pants) - Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential for soiling work attire exists. - Cotton/leather work gloves with surgical style inner gloves - Safety shoes (steel toe/shank) - 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. 	<p>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:</p> <ul style="list-style-type: none"> - 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.
Surveying	<p><i>Physical Hazards</i></p> <p>1) Slip, trips, and falls 2) Insect/animal bites, stings, poisonous plants 3) Inclement weather</p>	<p>1) Preview work locations for unstable/uneven terrain. Barricade all excavations from access closer than two feet from the edge.</p> <p>2) Avoid nesting areas, use repellents (Do NOT use repellents during sampling activities). Report potential hazards to the SSO.</p> <p>3) Suspend or terminate operations until directed otherwise by the SSO.</p>	Not required	<p>Level D - (Minimum Requirements)</p> <ul style="list-style-type: none"> - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - Safety glasses - Hard hat (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. <p><i>(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)</i></p>	Decontamination not required for this task.

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical, physical, and natural hazards anticipated to be present during the activities to be conducted. 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), including benzene, dichloroethene, methylene chloride, tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride, and xylene
- Semi-Volatile Organic Compounds (SVOC), including general Polynuclear Aromatic Hydrocarbons (PAHs) and Waste Oils.
- Metals, including arsenic, chromium, and lead
- Pesticides, including DDT

The following contaminants of concern have been identified in soil and groundwater during prior sampling events:

- Site 01 - None
- Site 02A - PAHs, xylene
- Site 02B - None
- Site 03 - PAHs and vinyl chloride
- Site 04 - None
- Site 07 - Arsenic, chromium, lead, PAHs, methylene chloride, and waste oils
- Site 08 - Arsenic, chromium, lead, PAHs, pesticides, tetrachloroethylene, and waste oils
- Site 14 - None
- Site 15 - Lead, PAHs, and waste oils
- Site 20 - PAHs
- Site 23 - Arsenic, benzene, chromium, PAHs, pesticides, waste oils and xylene

Suspected contaminants at areas of first time sampling:

Site 16 - Unknown

Site 18 - Dichloroethene, and trichloroethylene

It is anticipated that the greatest potential for exposure to site contaminants is during intrusive activities (drilling, soil sampling, 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 engineering controls, work practices, and/or PPE where necessary.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT
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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
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/m ³ Inorganic compounds 0.01 mg/m ³ NIOSH: (Ceiling) 0.002 mg/m ³ ACGIH: 0.2 mg/m ³ IDLH: 5 mg/m ³ 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.
Benzene	71-43-2	PID: 1.P 9.24 eV, 100% response with PID and 10.2 eV lamp. FID: 150% relative response ratio with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol in accordance with OSHA 07 or NIOSH Method #1500.	OSHA: 1 ppm ACGIH: 10 ppm NIOSH: 0.1 ppm IDLH: 500 ppm	Inadequate - Odor threshold 34-199 ppm. The use of air-purifying respirators with organic vapor cartridge up to 10 ppm is acceptable despite the inadequate warning properties, providing cartridges are changed at the beginning of each shift. Recommended gloves: Butyl/neoprene blend - >8.00 hrs; Silver shield as a liner - >8.00 hrs; Viton - >8.00 hrs	Boiling Pt: 176°F; 80°C Melting Pt: 42°F; 5.5°C Solubility: 0.07% Flash Pt: 12°F; -11°C LEL/LFL: 1.3% UEL/UFL: 7.9% Vapor Density: 2.77 Vapor Pressure: 75 mmHg Specific Gravity: 0.88 Incompatibilities: Strong oxidizers, fluorides, perchlorates, and acids Appearance and Odor: Colorless to a light yellow liquid with an aromatic odor	Overexposure may result in irritation to the eyes, nose, throat, and respiratory system. CNS effects include giddiness, lightheadedness, headaches, staggered gait, fatigue, and lassitude and depression. Additional effects may include nausea. Long duration exposures may result in respiratory collapse. Regulated as an OSHA carcinogen. May cause damage to the blood forming organs and may cause a form of cancer called leukemia.

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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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/m ³ (Chromium VI) 0.1 mg/m ³ (Ceiling) ACGIH: 0.5 mg/m ³ (Chromium II, III compounds), 0.05 mg/m ³ (Chromium VI compounds) IDLH: 30 mg/m ³ (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/m ³ . 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.
1,1 Dichloroethene See also vinylidene chloride	75-34-4	PID: I.P. 10.00 eV, relative response ratio is 80%. FID: Relative response ratio for detection with the FID is 40%.	Air sample using a charcoal filter tube; carbon disulfide desorption; GC/FID detection in accordance with NIOSH Method #1015.	ACGIH: 5 ppm, STEL 20 ppm NIOSH - as low as possible	Odor threshold - 190 ppm. An air purifying respirator equipped with a organic vapors filter is acceptable for escape purposes only. For exposures greater than the recommended exposures limits should employ supplied air respirators. Recommended glove: Butyl, nitrile, or neoprene.	Boiling Pt: 89°F; 32°C Melting Pt: -188°F; -122°C Solubility: Slight (0.04%) Flash Pt: -2°F; -19°C LEL/LFL: 6.5% UEL/UFL: 15.5% Vapor Density: 3.25 Vapor Pressure: 500 mmHg @ 68°F; 20°C Specific Gravity: 1.21 @ 20°F; 4°C Incompatibilities: Aluminum, air, copper, and heat. Polymerization may occur if exposed to oxidizers. Appearance and Odor: Colorless liquid with a slight sweet chloroform odor.	Overexposure to this substance may result in irritation to the eyes, nose, throat, and respiratory system. Dermal contact with concentrated solutions may cause slight irritation, redness and inflammation. Systemically, headaches, dizziness, nausea, and difficulty in breathing. Chronic effects may include kidney and liver dysfunction, and pneumonitis. This material has expressed cancer causing potential in laboratory animals including liver and kidney tumors.

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
DDT and the major metabolites; DDD and DDE.	50-29-3 72-54-8 72-55-9	Substance is not volatile, I.P. is unknown, detection by PID is unknown. Substance non-combustible, therefore a FID is anticipated to have reduced response to DDT.	Air sample using a binder free, glass fiber filter; isooctane desorption; gas chromatography-electron capture detector. Sampling and analytical protocol will proceed in accordance with NIOSH Method #3(S274).	OSHA; ACGIH: 1 mg/m ³ NIOSH: 0.5 mg/m ³	Adequate - Can use air purifying respirator with high efficiency particulate air filter (HEPA). Recommended glove: Nitrile acceptable for incidental contact.	Boiling Pt: 230°F; 110°C Melting Pt: 226°F; 108°C Solubility: Insoluble Flash Pt: 162-171°F; 72-77°C LEL/LFL: Not available UEL/UFL: Not available Vapor Density: Not available Vapor Pressure: Low Specific Gravity: 0.99 Incompatibilities: Strong oxidizers and alkalis Appearance and Odor: Colorless crystals or off-white powder with a slight aromatic odor	Large doses are followed by vomiting due to gastric irritation, diarrhea may follow. Numbness and paresthesias of the lips tongue and face associated with malaise, headache, sorethroat, fatigue and weakness. Coarse tremors (usually first of the neck, head, and eyelids). This may be accompanied by confusion, apprehension, and depression. Convulsions may result and death may occur from respiratory failure. DDT is absorbed and retained in the fat of humans. Chronic exposure may result in damage to the liver, kidneys and Peripheral Nervous System. DDT is recognized as possessing carcinogenic properties by IARC and NTP.
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 ₂ O ₂ desorption; or Atomic absorption detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7082 or #7300.	OSHA: 0.05 mg/m ³ ACGIH: 0.15 mg/m ³ NIOSH: 0.10 mg/m ³ IDLH: 100 mg/m ³ as lead	The use of a air purifying, full-face respirator with high efficiency particulate air filter for up to 2.5 mg/m ³ . 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.

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT.**

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Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
DDT and the major metabolites; DDD and DDE.	50-29-3	Substance is not volatile, I.P. is unknown, detection by PID is unknown. Substance non-combustible, therefore a FID is anticipated to have reduced response to DDT.	Air sample using a binder free, glass fiber filter; isooctane desorption; gas chromatography-electron capture detector. Sampling and analytical protocol will proceed in accordance with NIOSH Method #3(S274).	OSHA;	Adequate - Can use air purifying respirator with high efficiency particulate air filter (HEPA).	Boiling Pt: 230°F; 110°C Melting Pt: 226°F; 108°C Solubility: Insoluble Flash Pt: 162-171°F; 72-77°C LEL/LFL: Not available UEL/UFL: Not available Vapor Density: Not available Vapor Pressure: Low Specific Gravity: 0.99 Incompatibilities: Strong oxidizers and alkalis Appearance and Odor: Colorless crystals or off-white powder with a slight aromatic odor	Large doses are followed by vomiting due to gastric irritation, diarrhea may follow. Numbness and paresthesias of the lips tongue and face associated with malaise, headache, sorethroat, fatigue and weakness. Coarse tremors (usually first of the neck, head, and eyelids). This may be accompanied by confusion, apprehension, and depression. Convulsions may result and death may occur from respiratory failure. DDT is absorbed and retained in the fat of humans. Chronic exposure may result in damage to the liver, kidneys and Peripheral Nervous System. DDT is recognized as possessing carcinogenic properties by IARC and NTP.
	72-54-8			ACGIH:			
	72-55-9			NIOSH: 0.5 mg/m ³			

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
General PAHs Coal Tar Pitch Volatiles / Creosote / cresol (Fluoranthene, pyrene, benzo(a) anthracene, benzo(a) pyrene, benzo(f)fluoranthene, benzo(k)fluoranthene)	(CAS Numbers vary depending on specific compound)	PID: I.P. of 8.97 eV, relative response ratio unknown. FID: Response factor unknown but given the substances flammability, detection by FID can be anticipated.	Refer to NIOSH methods for each specific compound for appropriate air sampling protocols. Many PAHs can be sampled using <u>NIOSH Method</u> <u>5506 or 5515</u> - Teflon filter with support ring - High pressure liquid chromatography with UV detector. For cresol (a major constituent of creosote) by silica gel or xad-7 sorbent tube; Acetone desorption and analysis by gas chromatography - flame ionization detector or high- pressure liquid chromatography. (NIOSH Method #2001, or OSHA Method #32)	General PAHs: Most PAHs have no established exposure limits. Other Coal Tar Pitch Volatiles / PAHs such as chrysene and benzo(a)pyrene have an exposure limit of 0.2 mg/m ³ (OSHA and ACGIH). 0.1 mg/m ³ - (NIOSH) Creosote / Cresol: OSHA; ACGIH: 5 ppm NIOSH: 2.3 ppm IDLH: 80 mg/m ³	Adequate - use a full-face air- purifying respirator with organic vapor / dust/mist cartridge up to 250 ppm. Cresol has an Odor Threshold of 0.00005-0.0079 ppm. Recommended gloves: Viton >96.00 hrs; butyl rubber >90.00 hrs; neoprene >4.50 hrs	Properties of various PAHs/Coal Tar Pitch Volatiles vary depending upon the specific compound. <i>For Creosote/Cresol:</i> Boiling Pt: 376-397°F; 191-203°C Melting Pt: 52-96°F; 10.9-35.5°C Solubility: Insoluble Flash Pt: 178°F; 81°C LEL/LFL: Not available UEL/UFL: Not available Vapor Density: 3.72 Vapor Pressure: 1 mmHg @ 100- 127°F; 38-53°C Specific Gravity: 1.030-1.038 Incompatibilities: Nitric acid, oleum, chlorosulfonic acid, oxidizers Appearance and Odor: Yellowish or colorless, flammable, oily liquid (often brownish because of impurities or oxidation)	Regulated based on effects on respiratory tract and skin irritation Other effects may include eye irritation and central nervous system, disturbances. Acute exposures may result in difficulty breathing, respiratory failure and skin and eye irritation and burns. Chronic exposure may damage the liver, kidneys, lungs and skin and cause photosensitivity. IARC, NTP, NIOSH, ACGIH, and the EPA list some PAHs such as benzo(a)pyrene as a potential carcinogen (ARC 2A, NTP-2, ACGIH TLV-A2, NIOSH- X, EPA-B2).

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Methylene chloride	75-09-2	PID: I.P. 11.32 eV, High response with PID and 11.7 eV lamp. FID: 100% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detector; Sampling and analytical protocol shall proceed in accordance with OSHA Method #59, 80, or NIOSH Method #1005. OSHA: 25 ppm, 125 ppm (STEL) ACGIH: 50 ppm NIOSH: Lowest feasible concentration IDLH: 2300 ppm	Inadequate - Odor threshold 160 ppm. Use a gas mask with a Type N canister for concentrations up to 25 ppm. In excess of 25 ppm, use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - (SCBA). Recommended gloves: Nitrile rubber latex glove 3.00 hrs (vendor specific); supported Polyvinyl alcohol glove, unsupported 1-8 hrs; Silver shield 1.90 hrs	Boiling Pt: 104°F; 39.8°C Melting Pt: -141°F; -96°C Solubility: 2% Flash Pt: Not available LEL/LFL: 13% UEL/UFL: 12% Vapor Density: 2.93 Vapor Pressure: 380 mmHg @ 72° F; 22°C Specific Gravity: 1.33 Incompatibilities: Strong oxidizers, caustics, metals (i.e. aluminum, magnesium, potassium, sodium, lithium), and concentrated acids Appearance and Odor: Colorless liquid with a chloroform-like odor. (Note: A gas above 104° F; 40°C).	Effects of overexposure may include CNS effects - cause sleepiness, fatigue, weakness, lightheadedness, numbness of the limbs, altered cardiac rate and incoordination. These signs and symptoms may be accompanied by nausea, gastric and pulmonary irritation leading possibly to pulmonary edema. In addition to the narcosis long term effects may include liver injury. Listed as possessing carcinogenic properties by NTP, IARC, and ACGIH.
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: 100 ppm; 200 ppm (Ceiling) ACGIH: 50 ppm; 100 ppm STEL NIOSH: As low as possible 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.

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Tetrachloroethene als kn wn as PCE	79-34-5	PID: I.P. 11.1 eV, relative response ratio unknown. FID: 100% response with FID.	Air sample using charcoal tube; carbon disulfide desorption, GC/FID detection. Sampling and analytical protocol in accordance with OSHA Method #07, or NIOSH Method #1003.	OSHA: 5 ppm (skin) ACGIH; NIOSH: 1 ppm (skin) IDLH: 100 ppm	Odor threshold for this substance is 7.3 ppm. This level in comparison to the TLV is considered poor. Air purifying elements (organic vapor/acid gas) are recommended for escape purposes only. Combination units (APR/airline respirator) are recommended for working in concentrations in excess of the TLV. Recommended glove: Butyl rubber 4.6 hrs; solvent dipped, unsupported. PV alcohol >8.00 hrs; Teflon >15.20 hrs; Viton >8.00 hrs	Boiling Pt: 296°F; 147°C Melting Pt: -33 to -47°F; -36 to -43.8°C Solubility: 0.3% Flash Pt: Not available LEL/LFL: Not available UEL/UFL: Not available Vapor Density: Not available Vapor Pressure: 9 mmHg @ 86°F; 30°C Specific Gravity: 1.59 @ 77°F; 25°C Incompatibilities: Strong oxidizers, alkalis, fuming sulfuric acid, and chemically active metals. When heated to decomposition temperatures will emit toxic fumes of chlorine. Appearance and Odor: Colorless to pale yellow liquid with a pungent chloroform like odor.	Overexposure may result in CNS effects including depression, sleepiness, hallucinations, distorted perceptions, tremors (fingers), and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, abdominal pains, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, enlarged tender liver, jaundice, hepatitis, kidney, and lung damage.
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.

**TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSB-NLON GROTON, CONNECTICUT**

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Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Waste Oils All information is based on mineral oil	Mixture N.E. 8012-95-1 for mineral oil	Varies between fractions however waste oils tend to be less volatile. The FID tends to handle the longer chained aliphatic hydrocarbons more efficiently than its PID counterpart and would be selected as the instrument of choice.	Sampling and analytical protocol shall be in accordance with NIOSH Method #5026 (the recommended method for mineral oil mist).	ACGIH; NIOSH: 5 mg/m ³ (oil mists); 10 mg/m ³ STEL. OSHA; 5 mg/m ³ (Oil mists)	Non-volatile substance, therefore no respiratory protection is required. In an aerosol form, dust and mist respirator would be considered acceptable for up to 500 mg/m ³ . Recommended gloves: Any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances, and will be acceptable). Natural rubber gloves should be avoided. Recommended gloves: Nitrile	Boiling Pt: 680°F; 360°C Melting Pt: Not available Solubility: Insoluble Flash Pt: 275-500°F; 135-260°C depends on the distillation fraction LEL/LFL: Not available UEL/UFL: Not available Vapor Density: Not available Vapor Pressure: <0.5 mmHg Specific Gravity: 0.90 Incompatibilities: None reported Appearance and odor: Colorless, oily, with an odor of burned lubricating oil.	Minor irritation to the eyes, skin, and respiratory system.
Xylene All isomers o-, m-, p-	1330-20-7	PID: I.P. 8.56 eV, High response with PID and 10.2 eV lamp. FID: 110% response with FID.	Air sample using charcoal tube; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol shall proceed in accordance with OSHA 07, or NIOSH Method 1500.	ACGIH, & NIOSH: 100 ppm, 150 ppm STEL OSHA: 100 ppm IDLH: 900 ppm	Adequate - Odor thresholds for the following isomers: 0.6 m-; 5.4 p-; 20 o- ppm. Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm concentrations. Recommended gloves: PV Alcohol >12.67 hrs; Viton >8.00 hrs; CPE >1.00 hr; Butyl 0.87 hrs; Nitrile is acceptable for limited operations and contact (>0.20 hrs)	Boiling Pt: 269-281°F; 132-138°C Melting Pt: -13o/-54m/56p°F; -25o/-48m/13p °C Solubility: 0.02 % Flash Pt: 81-90°F;27-32°C LEL/LFL: 0.9% UEL/UFL: 7.0% Vapor Density: 3.66 Vapor Pressure: 7-9 mmHg @ 70° F; 21°C Specific Gravity: 0.86-0.88 Incompatibilities: Strong oxidizers and strong acids Appearance and odor: Colorless liquid with an aromatic odor.	Effects may of overexposure include irritation at all points of contact, CNS changes (i.e. dizziness, excitement, drowsiness, incoherent, staggering gait), difficulty in breathing, pulmonary edema, and possibly respiratory failure. Chronic effects may include dermatitis and cornea vacuolization.

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)
- Noise in excess of 85 decibels (dBA)
- Ambient temperature extremes
- Eye and foot hazards
- Pinches and compressions
- Vehicular and foot traffic

These physical hazards are discussed in Table 5-1 as applicable to each site task. Further, many of these hazard are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Specific discussion on some of these hazards is 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 and Overhead Utilities)

Underground utilities such as pressurized lines, water lines, telephone lines, buried utility lines, and high voltage power lines may be present throughout the facility. Clearance of underground and overhead utilities for each sample location will be coordinated with NSB-NLON personnel identified in Table 2-1. Additionally, drilling operations will be conducted at a safe distance (>20 feet) from overhead power lines. Whenever underground utilities are suspected to be close to subsurface sampling locations, the borehole will be advanced to a minimum of 5.0 feet with a hand auger prior to drilling. As built drawings may also be utilized for additional clarification. In certain cases, Base personnel may need to de-energize electrical cables using facility lockout/tagout procedures to insure electrical hazards are eliminated.

6.2.3 Ambient Temperature Extremes (Heat Stress)

Overexposure to high ambient temperatures (heat stress) may exist during performance of this work depending on the project schedule. Extremely cold temperatures are not expected to be encountered due to project schedule. Work performed when ambient temperatures exceed 70°F may result in varying levels of heat stress (heat rash, heat cramps, heat exhaustion, and/or heat stroke) depending on variables such as wind speed, humidity, and percent sunshine, as well as physiological factors such as metabolic rate and skin moisture content. Additionally, workload and level of protective equipment will affect the degree of exposure. Site personnel will be encouraged to drink plenty of fluids to replace those lost through perspiration. Additional information such as Work-Rest Regimens and personnel monitoring may be found in and Section 4.0 of the Guidance Manual. The SSO will recommend additional heat stress control measures as they are deemed necessary based on ACGIH guidelines.

6.3 NATURAL HAZARDS

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, especially in Connecticut which is listed as an endemic area for Lyme Disease. 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 Attachment II of this HASP or Section 4.0 of the Health and Safety Guidance Manual.

Contact with poisonous plants and bites or stings from poisonous insects are other natural 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.

6.3.2 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.

7.0 AIR MONITORING

This section presents requirements for the use of real-time air monitoring during site activities. It established the types of instruments to be used. Information on specific instrumentation, the frequency at which they are to be used, techniques for their use, and action levels are established in Table 5-1 pertaining to the hazards and tasks of an identified operation. Additionally, the Health and Safety Guidance Manual, Section 1.0, contains detailed information on the calibration and use of air monitoring instruments.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zones. Whenever a reading above normal background is detected in the workers breathing zone, the area will be evacuated. Work will resume when levels return to normal.

7.1.1 Photoionization Detector or Flame Ionization Detector

In order to accurately monitor for any substances which may present an exposure potential to site personnel, a Photoionization Detector (PID) with a lamp energy of 11.4 eV or higher or a Flame Ionization Detector (FID) will be used. The 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 and noted. Daily background readings will be taken away from any areas of potential contamination. These readings, any influencing conditions (weather, temperature, and 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 in which hazard monitoring will be performed as well as the action levels that will indicate when the site will be evacuated. The SSO may decide to increase these frequencies based on instrument responses and site observations. Reduction in monitoring frequencies is permitted only with the consent of the PHSO and CLEAN 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 according to manufacturer's recommendations. For example, the PID 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 standard operating procedure (found in the Health & Safety Guidance Manual). All calibration efforts must be documented on the Calibration Log Sheet (see Figure 7-1). This information may also be recorded in a field operations logbook, provided that all of the following information is recorded:

- Date of calibration
- 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

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 NSB-NLON. Additionally, TtNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within 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.

TtNUS will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting will be held to discuss the operations completed and any problems encountered. This activity will be supported through the use of a Safe Work Permit System (See Section 10.10).

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) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at NSB-NLON. 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 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, 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 A. Rich, P.E.
Project Manager
Tetra Tech NUS, Inc.
661 Andersen Drive
Pittsburgh, Pennsylvania 15221

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 an 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 hours 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)

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to all site personnel who will perform work on this project. Site-specific training will also be provided to all personnel [U.S. Department of Defense (DOD), 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
- Work practices to minimize risks from hazards
- 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)
- Spill response procedures
- Review of the contents of relevant Material Safety Data Sheets

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.

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" 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 presented in Section 7 of the 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 operation, 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 site-specific training as stipulated in 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 was 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 in accordance with OSHA 29 CFR 1910.134(b)(10) and was 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 that 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 or 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 A Rich, P.E.
Project Manager
Tetra Tech NUS, Inc.
661 Andersen Drive
Pittsburgh, Pennsylvania 15221

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

Dear Mr. Mengel

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: Final Rule." 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 licensed 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, Groton, Connecticut.

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)

9.0 SPILL CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

It is not anticipated that quantities of bulk potentially hazardous materials (greater than 55-gallons) will be handled during some of the site activities conducted as part of the scope of work. Significant quantities of waste water (decontamination, purge and development) and Investigative-Derived Wastes (IDW) may be generated as part of site activities. It is not anticipated, however, that spillage of these materials would constitute a significant danger to human health or the environment. Further, it is possible that as the job progresses disposable PPE and other non-reusable items may be generated. As needed, 55 -gallon drums will be used to contain wastewater, IDW, and other unwanted items generated during investigation activities. These drums will be labeled with the site name and address, the type of contents, and the date the container was filled as well as an identified contact person. Samples will be collected and analyzed to characterize the material and determine appropriate disposal measures. Once characterized they can be removed from the staging area and disposed of in accordance with Federal, State and local regulations. Table 5-1 contains more information about handling IDW at NSB-NLON.

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, there are various areas vulnerable to this hazard including the areas used for central staging and decontamination activities. Additionally, areas designated for handling, loading, and unloading of potentially contaminated soils, waters, and debris present limited potential for leaks or spills. It is anticipated that all IDW generated as a result of this scope of work will be containerized, labeled, and staged to await chemical analyses. The results of these analyses will determine appropriate disposal methods.

9.2.1 Site Drums/Containers

All drums/containers used for containing soils and liquids will be sealed, labeled, and staged within a centralized area awaiting shipment or disposal.

9.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, periodic inspections by the SSO will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected, the first approach will be to transfer the container contents using a hand pump into a new container. Other provisions for the transfer of container contents will be made and appropriate emergency contacts will be notified, if necessary. In most instances, leaks will be collected and contained using absorbents such as Oil-dry, vermiculite, or sand, which will be stored at the staging area in a conspicuously marked drum. This material too, will be containerized for disposal pending analyses. All inspections will be documented in the Project Logbook.

9.4 PERSONNEL TRAINING AND SPILL PREVENTION

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

9.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the types of equipment that may be maintained at the staging area for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Shovels, rakes, and brooms
- Labels

9.6 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 and Subase Fire Department (ext. 3333) immediately.
- 2) Employ the personnel protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the drum or raising the leak to the highest point. Spread the absorbent material in the area of the spill covering completely.

- 3) Transfer the material to a new container, collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment or disposal options.
- 4) Recontainerize spills, including top cover impacted by the spill, and await test results for treatment or disposal options.

It is not anticipated that a spill will occur in which the field crews cannot handle. Should this occur; however, the FOL or SSO will notify appropriate emergency response agencies.

10.0 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. This three-zone approach will utilize 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 the potential for the spread of contaminants, and protect individuals who are not cleared to enter work areas.

10.1 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 present 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 soil boring or sampling operations. Furthermore, once intrusive 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 of the site where active work is being performed plus a designated area surrounding the point of operation (see Table 5-1 for specific operation). When possible, exclusion zones will be delineated using barrier tape, cones and/or drive poles, and postings to inform site personnel.

10.1.1 Exclusion Zone Clearance

Prior to the initiation of site activities, utility locations will be identified by utility companies contacted through the NSB-NLON contact or other responsible party. Additional utility surveys may be conducted by TtNUS through the use of available documentation provided by NSB-NLON and/or local utility companies. The positions of identified utilities will be field located and staked to minimize the potential for damage during intrusive activities. Sample locations can be located to avoid buried utilities. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Table 2-1 will be notified.

Access to work areas will be controlled by TtNUS personnel. No personnel will be permitted to enter site exclusion zones without site-specific training. Site visitors will be provided site-specific training and will be escorted by TtNUS personnel at all times (see section 10.4).

10.2 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. The personnel and equipment decontamination will not take place in this area, but will take place at a central location established for this project. This area instead will serve as a focal point in supporting exclusion zone activities. When applicable, this area will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility personnel.

10.3 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.

10.4 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 (EPA, OSHA, etc.)
- NSB-NLON personnel
- Other authorized visitors

All personnel working on this project are required to gain initial access to the site by coordinating with the TtNUS FOL or designee and following established site access procedures.

Upon gaining access to the site, all site visitors wishing to observe operations in progress will be escorted by a TtNUS representative (arranged for by the FOL) and shall be required to meet the following minimum requirements:

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit.
- All site visitors will be required to produce the necessary information supporting clearance to the site. This shall include information attesting to applicable training (40-hours of HAZWOPER training) and medical surveillance as stipulated in Section 8.0 of this document. In addition, to enter the site 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 HASP.

Once the site visitors have completed the above items, they will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. Any and all visitors not meeting the requirements stipulated in this plan will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause the termination of all onsite activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the FOL, SSO or on-site security personnel.

10.5 SITE SECURITY

Site security will be accomplished using existing base security resources and procedures, supplemented by TtNUS or subcontractor personnel, if necessary. TtNUS will retain control over active operational areas. The first line of security will take place at the base boundaries restricting the general public. The second line of security will take place at the work site referring interested parties to the FOL. The FOL will serve as a focal point for site personnel, and will serve as the final line of security and the primary enforcement contact.

10.6 SITE MAPS

A site map will be generated once access routes, utilities, etc., are determined, and it will be adjusted as site conditions change. These maps will show utility locations, potential points of contact with the public, roadways, and other significant characteristics that may impact site operations and safety. Site maps will be posted to illustrate up-to-date collection of contaminants and adjustment of zones and access points if warranted.

10.7 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to ensure their safety during this operation.

10.8 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 Section 5.0 of the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location and will be available for anyone to review upon request.

10.9 COMMUNICATION

TtNUS personnel will be working in close proximity to each other at NSB-NLON. As a result and since two-way radio communication may or may not be available, hand signals, voice commands, and line of site will provide the initial means of communication. If two-way communication is available, its use will be cleared with Base personnel prior to initiating activities.

External communication will be accomplished by using provided telephones at the site. External communication will primarily be used for the purpose of resource and emergency resource communication.

10.10 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 10-1. The daily meetings conducted during their generation will further support these work permits. This effort will ensure all site-specific considerations and changing conditions are incorporated into the planning effort.

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.

The FOL and/or the SSO will be responsible for completing the safe work permit and issuing them to the appropriate parties. Site personnel at the end of each day's activity will turn in the permit(s) used for that day to the SSO. All permits will be maintained as part of the permanent project files attesting to safety and health measures employed for a given task at a given time and place. Any problems encountered with the protective measures required should be documented on the permit and brought to the attention of the SSO.

**FIGURE 10-1
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 | Respiratory equipment required |
| Level D <input type="checkbox"/> Level B <input type="checkbox"/> | Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/> |
| Level C <input type="checkbox"/> Level A <input type="checkbox"/> | Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/> |
| Detailed on Reverse | SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/> |
| | Skid Rig <input type="checkbox"/> None <input type="checkbox"/> |

Modifications/Exceptions: _____

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

- VI. Additional Safety Equipment/Procedures
- | | |
|--|--|
| Hardhat..... <input type="checkbox"/> Yes <input type="checkbox"/> No | Hearing Protection <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Safety Glasses..... <input type="checkbox"/> Yes <input type="checkbox"/> No | Safety belt/harness <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Chemical/splash goggles.. <input type="checkbox"/> Yes <input type="checkbox"/> No | Radio <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Splash Shield..... <input type="checkbox"/> Yes <input type="checkbox"/> No | Barricades <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Splash suits/coveralls..... <input type="checkbox"/> Yes <input type="checkbox"/> No | Gloves (Type) <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Steel toe/shank..... <input type="checkbox"/> Yes <input type="checkbox"/> No | Work/rest regimen <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Workboots..... <input type="checkbox"/> Yes <input type="checkbox"/> No | |
- Modifications/Exceptions: _____

- | | | | | |
|---|--------------------------|--------------------------|------------------------|---|
| VII. Procedure review with permit acceptors | Yes | NA | Yes | NA |
| Safety shower/eyewash (Location & Use)..... | <input type="checkbox"/> | <input type="checkbox"/> | Emergency alarms..... | <input type="checkbox"/> <input type="checkbox"/> |
| Procedure for safe job completion..... | <input type="checkbox"/> | <input type="checkbox"/> | Evacuation routes..... | <input type="checkbox"/> <input type="checkbox"/> |
| Contractor tools/equipment inspected..... | <input type="checkbox"/> | <input type="checkbox"/> | Assembly points..... | <input type="checkbox"/> <input type="checkbox"/> |

- | | | |
|--|--------------------------|--------------------------|
| VIII. Equipment Preparation | Yes | NA |
| Equipment drained/depressured | <input type="checkbox"/> | <input type="checkbox"/> |
| Equipment purged/cleaned..... | <input type="checkbox"/> | <input type="checkbox"/> |
| Isolation checklist completed..... | <input type="checkbox"/> | <input type="checkbox"/> |
| Electrical lockout required/field switch tested | <input type="checkbox"/> | <input type="checkbox"/> |
| Blinds/misalignments/blocks & bleeds in place | <input type="checkbox"/> | <input type="checkbox"/> |
| Hazardous materials on walls/behind liners considered..... | <input type="checkbox"/> | <input type="checkbox"/> |

- IX. Additional Permits required (Hot work, confined space entry, excavation etc.)..... Yes No

If yes, contact Health Science, Pittsburgh, PA Office

- X. Special instructions, precautions: _____

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

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 confined spaces.** 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 which 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 solutions, fuels, lime, sample preservatives, calibration gases, etc. Copies of all MSDS should be forwarded to the Environmental Department at NSB-NLON prior to the start of work.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- Emergency Reference Information (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED AT THE SITE

The following documentation is to be posted at the site for quick reference purposes. In situations where posting of these documents is not feasible (such as no office trailer), these documents should be filed in a transportable file container and immediately accessible. The file should remain in the FOL's possession.

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

Material Safety Data Sheets (MSDS) - The MSDS 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 - 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 defaced, altered, or covered by other material.

Site Clearance Posting - This list is found within the training section of the HASP (See Figure 8-1). This list identifies all site personnel, dates of training (including site-specific training), and medical surveillance and 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) - This list of emergency numbers and hospital directions will be maintained at all phone communications points and in each site vehicle.

Medical Data Sheets/Cards - Medical Data Sheets will be filled out by all onsite 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.

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

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

13.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
APR	Air Purifying Respirators
C	Celsius
CBU	Central Battalion Unit
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action Navy
CNS	Central Nervous System
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
dBA	Decibels
DDT	Dichlorodiphenyltrichloroethane
DOD	Department of Defense
DOT	Department of Transportation
DPT	Direct Push Technology
DRMO	Defense Reutilization and Marketing Organization
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
eV	electron Volts
F	Fahrenheit
FID	Flame Ionization Detector
FOL	Field Operations Leader
GC	Gas Chromatograph
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HSMr	Health Sciences Manager
IDLH	Immediately Dangerous to Life and Health
IDW	Investigative Derived Waste
IP	Ionization Potential
IRP	Installation Restoration Program
LEL	Lower Explosive Limit
LEL/O ₂	Lower Explosive Limit/Oxygen
Mg/m ³	milligrams per cubic meter
MSDS	Material Safety Data Sheet

N/A	Not Available
NIOSH	National Institute Occupational Safety and Health
NSB-NLON	Naval Submarine Base- New London
OBDA	Over Bank Disposal Area
OBDANE	Over Bank Disposal Area North East
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PE	Professional Engineer
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
PPM	Parts Per Million
SAP	Sampling and Analysis Plan
SCBA	Self Contained Breathing Apparatus
SSO	Site Safety Officer
STEL	Short Term Exposure Limit
SVOC	Semi Volatile Organic Compounds
TCE	Trichloroethylene
TPH	Total Petroleum Hydrocarbons
TiNUS	TetraTech NUS
TWA	Time Weighted Average
UEL	Upper Explosive Limit
UV	Ultraviolet
VOC	Volatile Organic Compounds
WP	Work Plan

ATTACHMENT I

**INJURY/ILLNESS PROCEDURE
AND REPORT FORM**

**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 not 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.
INJURY/ILLNESS REPORT**

Did employee die? Yes No

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 accident report.

Witness(es):

Name:

Address:

Telephone:

Describe the Illness or Injury and Part of Body Affected:

Name the Object or Substance which Directly Injured the Employee:

Medical Treatment Required:

No Yes First Aid Only

Physician's Name: _____

Address: _____

Hospital or Office Name: _____

Address: _____

Telephone No.: _____

Lost Work Days:

No. of Lost Work Days _____

Last Date Worked _____

Time Employee Left Work _____

Date Employee Returned to Work _____

No. of Restricted Work Days _____

None

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:** _____

	Printed Name	Signature	Telephone No.	Date
Project or Office Manager				
Site Safety Coordinator				
Injured Employee				

To be completed by Human Resources:

Date of hire:

Hire date in current job:

Wage information: \$ _____ per _____ (hour, day, week, or month)

Position at time of hire:

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 insurance carrier:

Date reported:

Reported by:

TeleClaim phone number:

TeleClaim account number:

Location code:

Confirmation number:

Name of contact:

Field office of claims adjuster:

ATTACHMENT II

**TICK CONTROL
AND
LYME DISEASE**

TICK CONTROL AND LYME DISEASE

The occurrence of Lyme disease has become a worldwide problem since its identification in 1976. This disease is characteristically recognized as being transmitted by ticks, which may be encountered by field personnel while working at this site. As a result, this discussion has been included with this Health and Safety Plan to provide for adequate recognition, evaluation, and control efforts to minimize the occurrence and effects of this potential hazard.

The discovery of Lyme disease is credited to Dr. Allen Steere of Yale University Medical School, and is named after the community where it was (reportedly) first encountered, Lyme, Connecticut. This disease can be transmitted to man through the bite of ticks that are infected with a cork screw-shaped microbe (spirochete). The spread of this disease has been so rapid that in 1984 it surpassed Rocky Mountain Spotted fever as the most common tick-borne disease in the United States. In this country, most of the incidents of this disease have been recorded in the Northeast, and the tick species most commonly attributed with its spread is the deer tick.

Recognition

This hazard potential exists primarily in the spring and summer months, as these are the seasons that tick populations and activity flourish. In fact, 90 percent of the reported cases have occurred from early June through September. Also, this concern exists primarily in heavily vegetated areas. Therefore, recognition of these factors can aid in the awareness and control of this threat.

To aid in the recognition and identification of these insects, an example illustration of the tick species common to the region where this site is located has been included with this discussion. This species (the American Dog tick) is common in the eastern half of the United States, and typically exists in areas covered with grass or underbrush. These insects will attach themselves to animals (including man) that pass through the area and rub against them. After finding a host, the tick inserts its mouthparts and sucks blood until it is fully engorged. This requires a time period of three to twelve days, then the tick will drop off. In addition to Lyme disease concerns, this tick has also been identified as a transmitter of Rocky Mountain Spotted Fever, and the organisms of tularemia and possibly relapsing fever. The wounds left by tick bites can be painful, and can also have a paralyzing effect commonly referred to as tick paralysis.

The earliest symptom of the onset of this disease is the occurrence of an unusual red skin rash. This is commonly the first indication since it has been evidenced that many persons who have contracted this disease were, in fact, unaware that they had been bitten. This rash can appear at the site of the bite anywhere from several days to a few weeks after the bite. It typically starts as a small red spot, and then expands as the spirochetes expand from the bite location. Rash sizes can vary, but have been most commonly associated in a 2 to 3 inch diameter size range. This rash will fade (with or without treatment) after a few weeks. Close inspection is necessary to detect this symptom as the rashes are easy to miss because they're often very faint. Body sites where rashes frequently occur include the thigh areas, groin, and armpits. Also, it is not uncommon for a rash to develop in more than one place.

Other early symptoms include profound fatigue, a stiff neck, and flu-like symptoms such as headache, chills, fever, and muscle aches. Recognition of the onset of any of these symptoms is important since tick bites do not always produce a rash. If left untreated, the disease will progress to its second stage within weeks or months after the infection. This stage involves affects to the heart and nervous system. A common second stage symptom is a paralysis on one or both sides of the face. Others include severe headache, encephalitis, or meningitis. The third and final stage involves the development of chronic inflammatory arthritis, which can occur up to a year or more after the bite.

Evaluation

Evaluation of this hazard potential principally involves field personnel performing close self-inspections for the presence of ticks each time they leave the site. This should involve careful examination, especially of the individuals' heads. Personnel should be aware that when a tick attaches itself to its host, it inserts its entire head under the surface of the skin.

Control

Control of this threat involves several components. First, field personnel must be aware of the climate and area conditions which are commonly associated with being conducive to tick infestation. Second, when working in or walking through potential infested areas, personnel must ensure that they do not have exposed body parts (i.e. at least long sleeved shirts and long pants, particularly when protective coveralls are not worn). In heavily vegetated areas where infestation is likely, Tyvek coveralls will be required to minimize this hazard potential. Also, several commercial products have been demonstrated as being effective in repelling ticks. Examples include Permanone, Off!, and Cutter. These types of repellents will be used at the direction and discretion of the Tetra Tech NUS Health and Safety Officer, and only in accordance and observation of manufacturer's recommendations. In most instances, however, such repellents are typically applied to the outside surfaces of clothing (and not directly onto the skin), and should be applied also to shoe tops, socks, pants cuffs, and other areas most susceptible to ticks.

Tick Removal

In the event that a tick is discovered to be attached to a member of the field team, timely removal of the insect is critical to reducing the potential for contracting the disease. According to available information and research, there is apparently a grace period of at least a few hours from the time of the bite before the tick transmits the microbe (the spirochetes are not present in the mouth parts of the tick). However, the incident of a tick bite is frequently unnoticed, and the discovery of the tick may not occur until after this suspected grace period has already elapsed. Therefore, timely removal is very important. The preferred method of tick removal is to pull it out using tweezers or small forceps. In this method, the tick should be grasped as close to the mouth as possible, and then pulled steadily upward. Care must be exercised so as not to pull in a jerking motion as this can result in the head becoming detached. After the tick has been removed, disinfect the bite with rubbing alcohol or povidone iodine (Betadine). The tick must not be handled as the microbes can enter the body through any breaks in intact skin. The bite should be checked occasionally for at least a two-week period to see if a rash forms. If it does, medical attention must be promptly sought.

In order to provide for proper and timely response to the occurrence of a tick bite, the SSO will ensure that the site First Aid kit is properly equipped with medical forceps and rubbing alcohol, in addition to the standard kit contents. Also, an adequate supply of commercial insect (tick) repellents will be maintained on-site, and all personnel will be trained in its proper application and will be required to use it, at the direction of FOL.

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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hoses and belts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cab, mirrors, safety glass	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Is the equipment equipped with audible back-up alarms and back-up lights?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Horn and gauges	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Brake condition (dynamic, park, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fire extinguisher (Type/Rating - _____)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fluid Levels:			
- Engine oil	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Transmission fluid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Brake fluid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Cooling system fluid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Windshield wipers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Hydraulic oil	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oil leak/lube	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coupling devices and connectors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exhaust system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Blade/boom/ripper condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Accessways: Frame, hand holds, ladders, walkways (non-slip surfaces), guardrails?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Power cable and/or hoist cable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Steering (standard and emergency)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Safety Guards:

	Yes	No
- Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact? _____	<input type="checkbox"/>	<input type="checkbox"/>
- Hot pipes and surfaces exposed to accidental contact? _____	<input type="checkbox"/>	<input type="checkbox"/>
- All emergency shut offs have been identified and communicated to the field crew? _____	<input type="checkbox"/>	<input type="checkbox"/>
- Have emergency shutoffs been field tested? _____	<input type="checkbox"/>	<input type="checkbox"/>
- Results? _____	<input type="checkbox"/>	<input type="checkbox"/>
- Are any structural members bent, rusted, or otherwise show signs of damage? _____	<input type="checkbox"/>	<input type="checkbox"/>
- Are fueling cans used with this equipment approved type safety cans? _____	<input type="checkbox"/>	<input type="checkbox"/>

- 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? | <input type="checkbox"/> | <input type="checkbox"/> |
| - If so, has an 8-hour noise dosimetry test been performed? | <input type="checkbox"/> | <input type="checkbox"/> |
| - 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 DECONTAMINATION ACTIVITIES

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, backhoe). 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 backhoe.

II. Required Monitoring Instrument(s): FID or PID with at least 11.4 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)

IV. Protective equipment required Level D <input checked="" type="checkbox"/> Level B: <input type="checkbox"/> Level C <input type="checkbox"/> Level A: <input type="checkbox"/> Detailed on Reverse	Respiratory equipment required Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/> Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/> SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/> Skid Rig <input type="checkbox"/> None <input checked="" type="checkbox"/>
---	---

Modifications/Exceptions: Minimum requirement 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.

V. Chemicals of Concern Site contaminants include <u>VOCs, SVOCs, metals,</u> <u>and pesticides</u>	Action Level(s) <u>Any sustained readings</u> <u>above background</u> <u>in worker breathing zones.</u>	Response Measures <u>Suspend site activities and</u> <u>report to an unaffected area.</u>
--	--	---

VI. Additional Safety Equipment/Procedures			
Hard-hat.....	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No	Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Safety Glasses	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Chemical/splash goggles.....	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No	Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Splash Shield.....	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	Barricades <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Splash suits/coveralls	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Gloves (Type - Nitrile) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Steel toe Work shoes or boots	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	Work/rest regimen <input type="checkbox"/> Yes <input checked="" type="checkbox"/> 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.

VII. Procedure review with permit acceptors	Yes	NA	Yes	NA
Safety shower/eyewash (Location & Use)	<input type="checkbox"/>	<input type="checkbox"/>	Emergency alarms	<input type="checkbox"/>
Procedure for safe job completion	<input type="checkbox"/>	<input type="checkbox"/>	Evacuation routes	<input type="checkbox"/>
Contractor tools/equipment/PPE inspected	<input type="checkbox"/>	<input type="checkbox"/>	Assembly points	<input type="checkbox"/>

VIII. Equipment Preparation	Yes	NA
Equipment drained/depressurized.....	<input type="checkbox"/>	<input type="checkbox"/>
Equipment purged/cleaned.....	<input type="checkbox"/>	<input type="checkbox"/>
Isolation checklist completed.....	<input type="checkbox"/>	<input type="checkbox"/>
Electrical lockout required/field switch tested.....	<input type="checkbox"/>	<input type="checkbox"/>
Blinds/misalignments/blocks & bleeds in place	<input type="checkbox"/>	<input type="checkbox"/>
Hazardous materials on walls/behind liners considered.....	<input type="checkbox"/>	<input type="checkbox"/>

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: Other chemical hazards include decontamination fluids such as isopropyl alcohol, methanol, 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 SOIL BORINGS AND WELL INSTALLATION

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

SECTION I: General Job Scope

- I. Work limited to the following (description, area, equipment used): Soil borings using hollow stem auger or direct push techniques. Monitoring well installation, development, and purging is included in this task at the Site 16 Hospital Incinerator.
- II. Required Monitoring Instruments: FID or PID
- III. Field Crew: _____
- IV. On-site Inspection conducted Yes No Initials of Inspector TINUS

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

- | | | |
|--|--|---|
| <p>IV. Protective equipment required</p> <p>Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/></p> <p>Level C <input type="checkbox"/> Level A <input type="checkbox"/></p> <p>Detailed on Reverse</p> | <p>Respiratory equipment required</p> <p>Full face APR <input type="checkbox"/></p> <p>Half face APR <input type="checkbox"/></p> <p>SKA-PAC SAR <input type="checkbox"/></p> <p>Skid Rig <input type="checkbox"/></p> | <p>Escape Pack <input type="checkbox"/></p> <p>SCBA <input type="checkbox"/></p> <p>Bottle Trailer <input type="checkbox"/></p> <p>None <input checked="" type="checkbox"/></p> |
|--|--|---|

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves.

- | | | |
|---|---|--|
| <p>V. Chemicals of Concern</p> <p>Potential site contaminants
<u>are unknown.</u></p> | <p>Action Level(s)</p> <p><u>Any sustained readings above background in worker breathing zones.</u></p> | <p>Response Measures</p> <p><u>Suspend site activities and report to an unaffected area.</u></p> |
|---|---|--|

- | | | | | | |
|---|---|--|----------------------------------|---|--|
| <p>VI. Additional Safety Equipment/Procedures</p> | | | | | |
| Hard-hat..... | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Safety Glasses | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Safety belt/harness | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Chemical/splash goggles..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Radio | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Splash Shield..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Barricades | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Splash suits/coveralls..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Gloves (Type - Nitrile) | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Steel toe Work shoes or boots | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Work/rest regimen | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall and impermeable boots if there is a potential for soiling work clothes.

- | | | | | | |
|---|--|---|--|---|---|
| <p>VII. Procedure review with permit acceptors</p> <p>Safety shower/eyewash (Location & Use)</p> <p>Procedure for safe job completion</p> <p>Contractor tools/equipment/PPE inspected</p> | <p>Yes</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> | <p>NA</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> | <p>Emergency alarms</p> <p>Evacuation routes</p> <p>Assembly points.....</p> | <p>Yes</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input checked="" type="checkbox"/></p> | <p>NA</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> |
|---|--|---|--|---|---|

- | | | |
|---|--|---|
| <p>VIII. Equipment Preparation</p> <p>Equipment drained/depressurized.....</p> <p>Equipment purged/cleaned.....</p> <p>Isolation checklist completed.....</p> <p>Electrical lockout required/field switch tested.....</p> <p>Blinds/misalignments/blocks & bleeds in place.....</p> <p>Hazardous materials on walls/behind liners considered.....</p> | <p>Yes</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> | <p>NA</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> |
|---|--|---|

- 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: Minimize generation of airborne dusts. Pay particular attention to sharps and avoid contact with soil unless certain it does not contain Bio-Waste products.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR SOIL BORINGS AND WELL INSTALLATION

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

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Soil borings using hollow stem auger or direct push techniques. Monitoring well installation, development, and purging is included in this task at the Site 18 Solvent Storage Area.

II. Required Monitoring Instruments: FID or PID

III. Field Crew: _____

IV. On-site Inspection conducted Yes No Initials of Inspector TINUS

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

IV. Protective equipment required Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/> Level C <input type="checkbox"/> Level A <input type="checkbox"/> Detailed on Reverse	Respiratory equipment required Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/> Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/> SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/> Skid Rig <input type="checkbox"/> None <input checked="" type="checkbox"/>
---	---

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves.

V. Chemicals of Concern <u>Potential site contaminants</u> <u>Include TCE, dichloroethene.</u>	Action Level(s) <u>Any sustained readings above</u> <u>background in worker</u> <u>breathing zones.</u>	Response Measures <u>Suspend site activities and</u> <u>report to an unaffected area.</u>
--	--	---

VI. Additional Safety Equipment/Procedures

Hard-hat..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Safety Glasses..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Chemical/splash goggles..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Splash Shield..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Splash suits/coveralls..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Barricades <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No Gloves (Type - Nitrile) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No Work/rest regimen <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
--	--	--

Modifications/Exceptions: 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 Safety shower/eyewash (Location & Use) <input type="checkbox"/> <input type="checkbox"/> Procedure for safe job completion..... <input type="checkbox"/> <input type="checkbox"/> Contractor tools/equipment/PPE inspected..... <input type="checkbox"/> <input type="checkbox"/>	Emergency alarms..... <input type="checkbox"/> <input type="checkbox"/> Evacuation routes..... <input checked="" type="checkbox"/> <input type="checkbox"/> Assembly points..... <input checked="" type="checkbox"/> <input type="checkbox"/>
--	---

VIII. Equipment Preparation Equipment drained/depressurized..... <input type="checkbox"/> <input type="checkbox"/> Equipment purged/cleaned..... <input type="checkbox"/> <input type="checkbox"/> Isolation checklist completed..... <input type="checkbox"/> <input type="checkbox"/> Electrical lockout required/field switch tested..... <input type="checkbox"/> <input type="checkbox"/> Blinds/misalignments/blocks & bleeds in place..... <input type="checkbox"/> <input type="checkbox"/> Hazardous materials on walls/behind liners considered..... <input type="checkbox"/> <input type="checkbox"/>	Yes NA Yes NA Yes NA Yes NA Yes NA Yes NA
--	--

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: Minimize generation of airborne dusts.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR SOIL BORINGS AND WELL INSTALLATION

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 techniques. This permit will be used at the discretion of the SSO if dust levels cannot be controlled by other methods. Monitoring well installation, development, and purging is included in this task at Site 3 - Area A Downstream Watercourses and OBDA, and Site 7 Torpedo Shops.
- II. Required Monitoring Instruments: FID or PID
- 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)

- | | | |
|--|---|--|
| <p>IV. Protective equipment required</p> <p>Level D <input type="checkbox"/> Level B <input type="checkbox"/></p> <p>Level C <input checked="" type="checkbox"/> Level A <input type="checkbox"/></p> <p>Detailed on Reverse</p> | <p>Respiratory equipment required</p> <p>Full face APR <input type="checkbox"/></p> <p>Half face APR <input checked="" type="checkbox"/></p> <p>Quarter face APR <input checked="" type="checkbox"/></p> <p>Skid Rig <input type="checkbox"/></p> | <p>Escape Pack <input type="checkbox"/></p> <p>SCBA <input type="checkbox"/></p> <p>Bottle Trailer <input type="checkbox"/></p> <p>None <input type="checkbox"/></p> |
|--|---|--|

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves. Tyvek, Saranex, or PE coated coveralls at the discretion of the SSO

- | | | |
|---|---|--|
| <p>V. Chemicals of Concern</p> <p>Potential site contaminants</p> <p><u>include PAHs, Vinyl Chloride.</u></p> | <p>Action Level(s)</p> <p><u>Any sustained readings above background in worker breathing zones.</u></p> | <p>Response Measures</p> <p><u>Suspend site activities and report to an unaffected area.</u></p> |
|---|---|--|

- VI. Additional Safety Equipment/Procedures
- | | | |
|---|---|--|
| <p>Hard-hat..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Safety Glasses..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Chemical/splash goggles..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>Splash Shield..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>Splash suits/coveralls..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> | <p>Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>Barricades <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> <p>Gloves (Type - Nitrile) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>Work/rest regimen <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p> | |
|---|---|--|

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall and impermeable boots if there is a potential for soiling work clothes.

- | | |
|--|---|
| <p>VII. Procedure review with permit acceptors Yes NA</p> <p>Safety shower/eyewash (Location & Use)..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Procedure for safe job completion..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Contractor tools/equipment/PPE inspected..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> | <p>Emergency alarms..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Evacuation routes..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Assembly points..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> NA</p> |
|--|---|

- VIII. Equipment Preparation
- | | |
|--|--|
| <p>Equipment drained/depressurized..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Equipment purged/cleaned..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Isolation checklist completed..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Electrical lockout required/field switch tested..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Blinds/misalignments/blocks & bleeds in place..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> <p>Hazardous materials on walls/behind liners considered..... <input type="checkbox"/> Yes <input type="checkbox"/> NA</p> | |
|--|--|

- 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: APR must have a protection factor of at least 5.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR SOIL BORINGS AND WELL INSTALLATION

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

SECTION I: General Job Scope

- I. Work limited to the following. (description, area, equipment used): Soil borings using hollow stem auger or direct push techniques. Monitoring well installation, development, and purging is included in this task at the Site 23 Tank Farm.
- II. Required Monitoring Instruments: FID or PID.
- 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 <input checked="" type="checkbox"/> Level B <input type="checkbox"/> | Respiratory equipment required | Escape Pack <input type="checkbox"/> |
| Level C <input type="checkbox"/> Level A <input type="checkbox"/> | Full face APR <input type="checkbox"/> | SCBA <input type="checkbox"/> |
| Detailed on Reverse | Half face APR <input type="checkbox"/> | Bottle Trailer <input type="checkbox"/> |
| | SKA-PAC, SAR <input type="checkbox"/> | None <input checked="" type="checkbox"/> |
| | Skid Rig <input type="checkbox"/> | |

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves.

- V. Chemicals of Concern
- | | | |
|---|---|--|
| Potential site contaminants | Action Level(s) | Response Measures |
| <u>include Arsenic, Benzene, Chromium, PAHs, Pesticides</u> | <u>Any sustained readings above background in worker breathing zones.</u> | <u>Suspend site activities and report to an unaffected area.</u> |
| <u>Waste Oils, Xylene</u> | | |

- VI. Additional Safety Equipment/Procedures
- | | | | | | |
|-------------------------------|---|--|----------------------------------|---|--|
| Hard-hat..... | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Safety Glasses..... | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Safety belt/harness | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Chemical/splash goggles..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Radio | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Splash Shield..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Barricades | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| Splash suits/coveralls..... | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | Gloves (Type - Nitrile) | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| Steel toe Work shoes or boots | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | Work/rest regimen | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |

Modifications/Exceptions: 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
- | | | | | | |
|--|------------------------------|-----------------------------|-------------------------|---|-----------------------------|
| Safety shower/eyewash (Location & Use) | Yes <input type="checkbox"/> | NA <input type="checkbox"/> | Emergency alarms | Yes <input type="checkbox"/> | NA <input type="checkbox"/> |
| Procedure for safe job completion | <input type="checkbox"/> Yes | <input type="checkbox"/> NA | Evacuation routes | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> NA |
| Contractor tools/equipment/PPE inspected | <input type="checkbox"/> Yes | <input type="checkbox"/> NA | Assembly points | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> NA |

- VIII. Equipment Preparation
- | | | |
|--|------------------------------|-----------------------------|
| Equipment drained/depressurized..... | Yes <input type="checkbox"/> | NA <input type="checkbox"/> |
| Equipment purged/cleaned..... | <input type="checkbox"/> Yes | <input type="checkbox"/> NA |
| Isolation checklist completed..... | <input type="checkbox"/> Yes | <input type="checkbox"/> NA |
| Electrical lockout required/field switch tested..... | <input type="checkbox"/> Yes | <input type="checkbox"/> NA |
| Blinds/misalignments/blocks & bleeds in place..... | <input type="checkbox"/> Yes | <input type="checkbox"/> NA |
| Hazardous materials on walls/behind liners considered..... | <input type="checkbox"/> Yes | <input type="checkbox"/> NA |

- 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: Minimize generation of airborne dusts.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR SOIL BORINGS AND WELL INSTALLATION

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

SECTION I: General Job Scope

- I. Work limited to the following (description, area, equipment used): Soil borings using hollow stem auger or direct push techniques. Monitoring well installation, development, and purging is included in this task at Site 3 - Area A Downstream Watercourses and OBDA
- II. Required Monitoring Instruments: FID or PID
- III. Field Crew: _____
- IV. On-site Inspection conducted Yes No Initials of Inspector TINUS

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

- | | |
|---|---|
| IV. Protective equipment required
Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/>
Level C <input type="checkbox"/> Level A <input type="checkbox"/>
Detailed on Reverse | Respiratory equipment required
Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/>
Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/>
SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/>
Skid Rig <input type="checkbox"/> None <input checked="" type="checkbox"/> |
|---|---|

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves.

- | | | |
|---|--|---|
| V. Chemicals of Concern
<u>Potential site contaminants include PAHs, Vinyl Chloride,</u> | Action Level(s)
<u>Any sustained readings above background in worker breathing zones.</u> | Response Measures
<u>Suspend site activities and report to an unaffected area.</u> |
|---|--|---|

- | | | |
|--|---|--|
| VI. Additional Safety Equipment/Procedures | | |
| Hard-hat..... | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Safety Glasses | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Chemical/splash goggles..... | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Splash Shield..... | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Barricades <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Splash suits/coveralls | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Gloves (Type - Nitrile) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Steel toe Work shoes or boots | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Work/rest regimen <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |

Modifications/Exceptions: 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
Safety shower/eyewash (Location & Use) <input type="checkbox"/> <input type="checkbox"/>
Procedure for safe job completion <input type="checkbox"/> <input type="checkbox"/>
Contractor tools/equipment/PPE inspected <input type="checkbox"/> <input type="checkbox"/> | Yes NA
Emergency alarms <input type="checkbox"/> <input type="checkbox"/>
Evacuation routes <input checked="" type="checkbox"/> <input type="checkbox"/>
Assembly points <input checked="" type="checkbox"/> <input type="checkbox"/> |
|---|--|

- | | |
|--|--------------------------------|
| VIII. Equipment Preparation
Equipment drained/depressurized..... <input type="checkbox"/> <input type="checkbox"/>
Equipment purged/cleaned..... <input type="checkbox"/> <input type="checkbox"/>
Isolation checklist completed..... <input type="checkbox"/> <input type="checkbox"/>
Electrical lockout required/field switch tested..... <input type="checkbox"/> <input type="checkbox"/>
Blinds/misalignments/blocks & bleeds in place..... <input type="checkbox"/> <input type="checkbox"/>
Hazardous materials on walls/behind liners considered..... <input type="checkbox"/> <input type="checkbox"/> | Yes NA

 |
|--|--------------------------------|

- 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: Minimize generation of airborne dusts.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR SOIL BORINGS AND WELL INSTALLATION

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

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Soil borings using hollow stem auger or direct push techniques. Monitoring well installation, development, and purging is included in this task at the Site 7 Torpedo Shop.

II. Required Monitoring Instruments: FID or PID

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	Respiratory equipment required
Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/>	Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/>
Level C <input type="checkbox"/> Level A <input type="checkbox"/>	Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/>
Detailed on Reverse	SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/>
	Skid Rig <input type="checkbox"/> None <input checked="" type="checkbox"/>

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, hardhat, hearing protection (during drilling), and nitrile or leather gloves with surgical-style inner gloves.

V. Chemicals of Concern	Action Level(s)	Response Measures
<u>Potential site contaminants include Arsenic, Chromium, lead, PAHs, Methylene chloride, Waste Oils.</u>	<u>Any sustained readings above background in worker breathing zones.</u>	<u>Suspend site activities and report to an unaffected area.</u>

VI. Additional Safety Equipment/Procedures					
Hard-hat.....	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Hearing Protection (Plugs/Muffs)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Safety Glasses	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Safety belt/harness	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		
Chemical/splash goggles.....	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Radio	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		
Splash Shield.....	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Barricades	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		
Splash suits/coveralls	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Gloves (Type - Nitrile)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Steel toe Work shoes or boots	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Work/rest regimen	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No		

Modifications/Exceptions: 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	
Safety shower/eyewash (Location & Use)	<input type="checkbox"/>	<input type="checkbox"/>	Emergency alarms
Procedure for safe job completion	<input type="checkbox"/>	<input type="checkbox"/>	Evacuation routes
Contractor tools/equipment/PPE inspected	<input type="checkbox"/>	<input type="checkbox"/>	Assembly points

VIII. Equipment Preparation	Yes	NA
Equipment drained/depressurized.....	<input type="checkbox"/>	<input type="checkbox"/>
Equipment purged/cleaned.....	<input type="checkbox"/>	<input type="checkbox"/>
Isolation checklist completed.....	<input type="checkbox"/>	<input type="checkbox"/>
Electrical lockout required/field switch tested.....	<input type="checkbox"/>	<input type="checkbox"/>
Blinds/misalignments/blocks & bleeds in place.....	<input type="checkbox"/>	<input type="checkbox"/>
Hazardous materials on walls/behind liners considered.....	<input type="checkbox"/>	<input type="checkbox"/>

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: Minimize generation of airborne dusts.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR MULTI-MEDIA SAMPLING

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 groundwater, and soils. IDW sampling is also included in this task.

II. Required Monitoring Instrument(s): PID or FID

III. Field Crew: _____

IV. On-site Inspection conducted Yes No Initials of Inspector TINUS

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

IV. Protective equipment required Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/> Level C <input type="checkbox"/> Level A <input type="checkbox"/> Detailed on Reverse	Respiratory equipment required Full face APR <input type="checkbox"/> Escape Pack <input type="checkbox"/> Half face APR <input type="checkbox"/> SCBA <input type="checkbox"/> SKA-PAC SAR <input type="checkbox"/> Bottle Trailer <input type="checkbox"/> Skid Rig <input type="checkbox"/> None <input checked="" type="checkbox"/>
---	---

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.

V. Chemicals of Concern Site contaminants include <u>VOCs, SVOCs, metals,</u> <u>and pesticides</u>	Action Level(s) <u>Any sustained readings</u> <u>above background</u> <u>in worker breathing zones.</u>	Response Measures <u>Suspend site activities and</u> <u>report to an unaffected area.</u>
--	--	---

VI. Additional Safety Equipment/Procedures		
Hard-hat <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Hearing Protection (Plugs/Muffs) <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Safety Glasses <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Chemical/splash goggles..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Splash Shield..... <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Barricades <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
Splash suits/coveralls <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Gloves (Type - Nitrile) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	
Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Work/rest regimen <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall if there is a potential for soiling work cloths

VII. Procedure review with permit acceptors <input type="checkbox"/> Yes <input type="checkbox"/> NA	Emergency alarms <input type="checkbox"/> Yes <input type="checkbox"/> NA
Safety shower/eyewash (Location & Use) <input type="checkbox"/> Yes <input type="checkbox"/> NA	Evacuation routes <input checked="" type="checkbox"/> Yes <input type="checkbox"/> NA
Procedure for safe job completion <input type="checkbox"/> Yes <input type="checkbox"/> NA	Assembly points..... <input checked="" type="checkbox"/> Yes <input type="checkbox"/> NA
Contractor tools/equipment/PPE inspected..... <input type="checkbox"/> Yes <input type="checkbox"/> NA	

VIII. Equipment Preparation		Yes	NA
Equipment drained/depressurized.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>
Equipment purged/cleaned.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>
Isolation checklist completed.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>
Electrical lockout required/field switch tested.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>
Blinds/misalignments/blocks & bleeds in place.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>
Hazardous materials on walls/behind liners considered.....	<input type="checkbox"/>		<input checked="" type="checkbox"/>

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: _____

APPENDIX E

SCREENING CRITERIA

- E.1 USEPA Region III Risk Based Concentration Table (April 1999) COC Screening Levels for Residential Soil Ingestion and Tap Water Ingestion**
- E.2 Connecticut Remediation Standard Regulations (RSRs)
Direct Exposure (Residential and Industrial)
Connecticut RSRs for Pollutant Mobility (GB Classified Area)
Connecticut RSRs for the Protection of Groundwater (GA/GAA)**
- E.3 USEPA Generic Soil Screening Levels (SSLs)
Transfers from Soil to Air (Inhalation) Migration to Groundwater**
- E.4 Federal Maximum Contaminant Levels (MCLs)**
- E.5 State Maximum Contaminant Levels (MCLs)**
- E.6 Connecticut Water Quality Standards (WQs)**

APPENDIX E.1

**USEPA REGION III RISK BASED CONCENTRATION TABLE (APRIL 1999)
COC SCREENING LEVELS FOR RESIDENTIAL SOIL INGESTION AND
TAP WATER INGESTION**

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch St
Philadelphia, Pennsylvania 19103

1

SUBJECT: Risk-Based Concentration Table

DATE: 4/12/1999

FROM: Jennifer Hubbard, Toxicologist
Superfund Technical Support Section (3HS41)

TO: RBC Table Users

Attached is the EPA Region III Risk-Based Concentration (RBC) Table, which we prepare and post periodically for all interested parties.

IMPORTANT NOTES: To make the RBC Table more accessible and to minimize paper usage, it is now primarily available through the Internet. The address is <http://www.epa.gov/reg3hwmd/risk/riskmenu.htm>. The Table is available in both Lotus and Excel as "self-extracting" files. These files should be downloaded and then processed with your computer's "run" function. The files can then be viewed in Lotus or Excel. If you have technical questions about the toxicological or risk assessment aspects of the RBCs, please contact Jennifer Hubbard at 215-814-3328 or hubbard.jennifer@epamail.epa.gov. Other questions can be addressed to Vanessa Sizer or Terri Fields at 215-814-3041. You can also consult the Frequently Asked Questions, below.

CONTENTS, USES, AND LIMITATIONS OF THE RBC TABLE

The RBC Table contains Reference Doses (RfDs) and Cancer Slope Factors (CSFs) for 400-500 chemicals. These toxicity factors have been combined with "standard" exposure scenarios to calculate RBCs--chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1, or lifetime cancer risk of 1E-6, whichever occurs at a lower concentration) in water, air, fish tissue, and soil.

The Region III toxicologists use RBCs to screen sites not yet on the NPL, respond rapidly to citizen inquiries, and spot-check formal baseline risk assessments. The primary use of RBCs is for chemical screening during baseline risk assessment (see EPA Regional Guidance EPA/903/R-93-001, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening"). The exposure equations come from EPA's Risk Assessment Guidance for Superfund (RAGS), while the exposure factors are those recommended in RAGS or supplemental guidance from the Superfund program. The attached technical background

document provides specific equations and assumptions. Simply put, RBCs are like risk assessments run in reverse. For a single contaminant in a single medium, under standard default exposure assumptions, the RBC corresponds to the target risk or hazard quotient.

RBCs also have several important limitations. Specifically excluded from consideration are (1) transfers from soil to air and groundwater, 2) cumulative risk from multiple contaminants or media, and (3) dermal risk. Additionally, the risks for inhalation of vapors from water are based on a very simple model, whereas detailed risk assessments may use more detailed showering models. Also, the toxicity information in the Table has been assembled by hand and (despite extensive checking and years of use) may contain errors. It's advisable to cross-check before relying on any RfDs or CSFs in the Table. If you note any errors, please let us know.

It is important to note that this Table uses inhalation RfDs and CSFs rather than RfCs and inhalation unit cancer risks. This is because the latter factors incorporate exposure assumptions and therefore can only be used for one exposure scenario. Because risk assessors need to evaluate risks for many types of scenarios, the factors have been converted to the more traditional RfDs and CSFs. Unless otherwise indicated in the toxicity-factor source, the assumption is that RfCs and unit risks should be adjusted by a 70-kilogram body weight and a 20 m³/day inhalation rate to generate the RfDs and CSFs.

Many users want to know if the RBCs can be used as valid no-action levels or cleanup levels, especially for soils. The answer is a bit complex. First, it is important to realize that the RBC Table does not constitute regulation or guidance, and should not be viewed as a substitute for a site-specific risk assessment. For sites where:

1. A single medium is contaminated;
2. A single contaminant contributes nearly all the health risk;
3. Volatilization, leaching, dermal contact, and other pathways not included in the RBCs are not expected to be significant;
4. The exposure scenarios and assumptions used in the RBC table are appropriate for the site;
5. The fixed risk levels used in the RBC table are appropriate for the site; and
6. Risk to ecological receptors is not expected to be significant;

the RBCs would probably be protective as no-action levels or cleanup goals. However, to the extent that a site deviates from this description, as most do, the RBCs would not necessarily be appropriate.

To summarize, the Table should generally not be used to set cleanup or no-action levels

at CERCLA sites or RCRA Corrective Action sites, to substitute for EPA guidance for preparing baseline risk assessments, or to determine if a waste is hazardous under RCRA.

SPECIAL NOTES

The RBC Table was originally developed by Roy L. Smith, Ph.D., for use by risk assessors in the Region III Superfund program. Dr. Smith is no longer with Region III, and the Table continues to evolve. You may notice some modifications of formatting and conventions used in the Table.

For instance, besides formatting, the following changes are noteworthy:

- As usual, updated toxicity factors have been used wherever available. However, because IRIS and provisional values are updated more frequently than the RBC Table, RBC Table users are ultimately responsible for obtaining the most up-to-date values. The RBC Table is provided as a convenience, but toxicity factors are compiled from the original sources and it is those original sources that should serve as the definitive reference.
- Certain outdated and withdrawn numbers have been removed from the Table.
- Changes to the table have been marked with asterisks (**). Changes may involve a corrected CAS number or a correction in the VOC status, or they may reflect changes of RfDs and CSFs on IRIS.
- RBCs are no longer rounded to 1E6 ppm. For certain low-toxicity chemicals, the RBCs exceed possible concentrations at the target risks. In such cases, Dr. Smith rounded these numbers to the highest possible concentration, or 1E6 ppm. The rounding has been discontinued so that Table users can adjust the RBCs to a different target risk whenever necessary. For example, when screening chemicals at a target HQ of 0.1, noncarcinogenic RBCs may simply be divided by 10. Such scaling is not possible when RBCs are rounded.
- This Table was originally compiled to assist Superfund risk assessors in screening hazardous waste sites. The large number of chemicals made the Table unwieldy and difficult to keep current. Many of the chemicals did not typically (or even occasionally) appear at Superfund sites. Starting with the April 1998 version of the Table, the 600+ chemicals were reduced to some 400-500 chemicals by eliminating many of those atypical chemicals. Through time, the Table may continue to grow or decrease in size. Comments on this issue are appreciated. During the last six months, only one request was received for restoration of a chemical: NuStar has been restored to the Table. (A list of the deleted chemicals is attached.)
- At Region III Superfund sites, noncancer RBCs are typically adjusted downward to correspond to a target HQ of 0.1 rather than 1. (This is done to ensure that chemicals with

additive effects are not prematurely eliminated during screening.) However, some chemicals have RBCs at HQs of 0.1 that are lower than their RBCs at 1E-6 cancer risk. In other words, the screening RBC would change from carcinogenic to noncarcinogenic. A new feature of this Table is that these chemicals are now flagged with a "!" symbol. Therefore, assessors screening with adjusted RBCs will be alerted to this situation.

- Earlier versions of this Table included a substitution of inhalation toxicity factors for oral factors whenever oral factors were unavailable (this applied only to groundwater and air, but not soil or fish). This practice has been discontinued in order to minimize the uncertainty associated with such a conversion. The discontinuation of this practice does not significantly decrease the number of available RBCs.
- The criterion for "VOC status" has been adjusted in accordance with RAGS Part B: chemicals with Henry's Law constants greater than 1E-5 and molecular weight less than 200 are now marked as VOCs. This increases consistency with the national guidance and with other EPA regions that use risk-based screening numbers. The vast majority of the changes on this RBC table are adjustments to meet this criterion. A change in the VOC status only changes the tap water RBC. (Exceptions to the criterion: certain chemicals that are gases at showering temperature are also marked as VOCs, because the purpose of the VOC column is to indicate whether inhalation should be considered as part of the tap water RBC.)
- Earlier versions of this Table included soil screening levels (SSLs), when those values were available in draft form. Since the finalization of the SSL Guidance, risk assessors are urged to consult the final SSL Guidance directly. The Guidance has detailed recommendations on site-specific sampling and site-specific SSL generation. (Soil Screening Guidance: User's Guide, April 1996, Publication 9355.4-23; and Soil Screening Guidance: Technical Background Document, May 1996; EPA/540/R-95/128)
- One user of the Table pointed out that the CAS numbers do not contain the dashes that are part of their format. CAS numbers have always appeared on the Table without dashes, but may be converted to their dashed form by placing a dash before the last number (farthest to the right), then moving two places to the left and placing another dash. For example, "107131" becomes "107-13-1"; "7440360" becomes "7440-36-0"; "25057890" becomes "25057-89-0." Region III could add the dashes directly to the Table, but we do not wish to make this change without feedback from users on whether this would adversely affect them. Therefore, we are soliciting comments on this issue (see box on first page for address). Over the last six months, no comments have been received on this issue.

FREQUENTLY ASKED QUESTIONS

To help you better understand the RBC Table, here are answers to our most often-asked questions:

1. How can the age-adjusted inhalation factor (11.66) be less than the inhalation rate for either a child (12) or an adult (20)?

Age-adjusted factors are not intake rates, but rather partial calculations which have different units from intake rates. (Therefore, they are not directly comparable.) The fact that these partial calculations have values similar to intake rates is really coincidental, an artifact of the similar magnitude of years of exposure and time-averaged body weight.

2. For manganese, IRIS shows an oral RfD of 0.14 mg/kg/day, but the RBC Table uses 2E-2 mg/kg/day. Why?

The IRIS RfD includes manganese from all sources, including diet. The explanatory text in IRIS recommends using a modifying factor of 3 when calculating risks associated with non-food sources, and the Table follows this recommendation. IRIS also recommends subtracting dietary exposure (default assumption in this case 5 mg). Thus, the IRIS RfD has been lowered by a factor of 2×3 , or 6. The Table now reflects manganese RBCs for both "food" and "non-food" (most environmental) sources.

3. What is the source of the child's inhalation rate of 12 m³/day?

The calculation comes from basic physiology. It's a scaling of the mass-specific 20 m³/day rate for adults from a body mass of 70 kg to 15 kg, using the 2/3 power of mass, as follows:

I_{rcm} = mass-specific child inhalation rate (m³/kg/day)

I_{rc} = child inhalation rate (m³/day)

$20 \text{ m}^3/\text{day} / 70 \text{ kg} = 0.286 \text{ m}^3/\text{kg}/\text{day}$ (mass-specific adult inhalation rate)

$0.286 \text{ m}^3/\text{kg}/\text{day} \times (70^{0.67}) = (I_{rcm}) \times (15^{0.67})$

$I_{rcm} = 0.803 \text{ m}^3/\text{kg}/\text{day}$

$I_{rc} = I_{rcm} \times 15 \text{ kg} = 0.803 \text{ m}^3/\text{kg}/\text{day} \times 15 \text{ kg} = 12.04 \text{ m}^3/\text{day}$

4. Can the oral RfDs in the RBC Table be applied to dermal exposure?

Not directly. Oral RfDs are usually based on administered dose and therefore tacitly include a GI absorption factor. Thus, any use of oral RfDs in dermal risk calculations should involve removing this absorption factor. Consult the Risk Assessment Guidance for Superfund, Part A, Appendix A, for further details on how to do this.

5. The exposure variables table in the RBC background document lists the averaging time

for non-carcinogens as "ED*365." What does that mean?

ED is exposure duration, in years, and * is the computer-ese symbol for multiplication. Multiplying ED by 365 simply converts the duration to days. In fact, the ED term is included in both the numerator and denominator of the RBC algorithms for non-cancer risk, canceling it altogether. See RAGS for more information.

6. Why is inorganic lead not included in the RBC Table?

EPA has no consensus RfD or CSF for inorganic lead, so it is not possible to calculate RBCs as we have done for other chemicals. EPA considers lead to be a special case because of the difficulty in identifying the classic "threshold" needed to develop an RfD.

EPA therefore evaluates lead exposure by using blood-lead modeling, such as the Integrated Exposure-Uptake Biokinetic Model (IEUBK). The EPA Office of Solid Waste has also released a detailed directive on risk assessment and cleanup of residential soil lead. The directive recommends that soil lead levels less than 400 mg/kg are generally safe for residential use. Above that level, the document suggests collecting data and modeling blood-lead levels with the IEUBK model. For the purposes of screening, therefore, 400 mg/kg is recommended for residential soils. For water, we suggest 15 ug/l (the EPA Action Level in water), and for air, the National Ambient Air Quality Standard.

7. Where did the CSFs for carcinogenic PAHs come from?

The PAH CSFs are all calculated relative to benzo[a]pyrene, which has an IRIS slope factor. The relative factors for the other PAHs can be found in "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," Final Draft, ECAO-CIN-842 (March, 1993).

8. May I please have a copy of a previous RBC Table?

We do not distribute outdated copies of the RBC Table. Each new version of the Table supersedes all previous versions.

9. Please elaborate on the meaning of the "W" source code in the Table.

The "W" code means that a RfD or CSF is currently not present on either IRIS or HEAST, but that it was once present on either IRIS or HEAST and was removed. Such withdrawal usually indicates that consensus on the number no longer exists among EPA scientists, but not that EPA believes the contaminant to be unimportant.

Withdrawn numbers are shown in the Table because we still need to deal with these contaminants during the long delays before replacement numbers are ready. For the purpose of screening, a "W" value is similar to a provisional value in that neither value

has achieved Agency consensus. The "W" code should serve as a clear warning that before making any serious decision involving that contaminant, you will need to develop an interim value based on current scientific understanding.

If you are assessing risks at a site where a major contaminant is coded "W," consider working with your Region EPA risk assessor to develop a current toxicity constant. If the site is being studied under CERCLA, the EPA-NCEA Regional Technical Support group may be able to assist.

10. Can I get copies of supporting documents for interim toxicity constants which are coded "E" in the RBC Table?

Unfortunately, Region 3 does not have a complete set of supporting documents. The EPA-NCEA Superfund Technical Support Center prepares these interim toxicity constants in response to site-specific requests from Regional risk assessors, and sends the documentation only to the requestor. The RBC Tables contain only the latest interim values that we've either requested or have otherwise received. NCEA maintains the master data base of these chemicals, but will not release documentation of provisional values unless they are recent. Furthermore, since NCEA's Superfund Technical Support Center is mainly for the support of Superfund, it usually cannot develop new criteria unless authorized to do so for a specific Superfund project.

If an "E"-coded contaminant is a chemical of potential concern at your site, we urge you to work with the EPA Regional risk assessor assigned to the project in order to develop or obtain documentation for provisional values. EPA Region 3 furnishes documents only when needed to support Regional risk assessments or recommendations.

11. Why is there no oral RfD for mercury? How should I handle mercury?

IRIS gives oral RfDs for mercuric chloride and for methylmercury, but not for elemental mercury. Therefore, the RBC Table reflects this primary source. Consult your toxicologist to determine which of the available mercury numbers is suitable for the conditions at your site (e.g., whether mercury is likely to be organic or inorganic.)

Attachment

"DISCONTINUED" CHEMICALS

These chemicals may still have toxicity criteria available in IRIS, HEAST, or NCEA provisional values. However, they are not routine chemicals and therefore will not be routinely maintained in the RBC Table, unless our Table users report a significant need for chemicals to be re-added. Some of the chemicals on this Table were deleted because supporting toxicity information has been withdrawn or is unavailable.

acephate	acetone cyanohydrin
acifluorfen	acrylic acid
ally	allyl alcohol
aluminum phosphide	amdro
ametryn	m-aminophenol
amitraz	ammonium sulfamate
antimony potassium tartrate	apollo
aramite	asulam
avermectin B1	barium cyanide
bayleton	benefin
benomyl	benzotrithloride
bidrin	biphenthin
bis(2-chloro-1-methylethyl)ether	
bisphenol A	boron trifluoride
4-bromophenyl phenyl ether	bromoxynil
bromoxynil octanoate	butylphthalyl butylglycolate
cacodylic acid	captafol
captan	carboxin
chloramben	chlorimuron-ethyl
chloroacetaldehyde	2-chloroacetophenone
4-chlorobenzotrifluoride	2-chloroethyl vinyl ether
4-chloro-2-methylaniline hydrochloride	
chlorothalonil	chlorpropham
chlorsulfuron	chlorthiophos
coal tar creosote	
cyclohexylamine	cyromazine
danitol	decabromodiphenyl ether
demeton	diallate
diethylforamide	diflubenzuron
dimethipin	dimethoate
N,N-dimethylformamide	dimethyl terephthalate
diphenamid	direct black 38
direct blue 6	direct brown 95
dodine	1,2-epoxybutane
ethephon	2-ethoxyethanol acetate
ethyl acrylate	EPTC

ethylene cyanohydrin	
ethyl p-nitrophenyl phenylphosphorothioate	
ethylphthalyl ethyl glycolate	express
fluoridone	flurprimidol
flutolanil	fluvalinate
folpet	fosteyl-al
furium	furmecyclox
glufosinate-ammonium	haloxyfop-methyl
harmony	imazalil
imazaquin	iprodione
isoxaben	kepone
lactofen	linuron
londax	
maleic hydrazide	malononitrile
mancozeb	maneb
merphos	merphos oxide
metalaxyl	methamidophos
methomyl	2-methoxyethanol acetate
2-methoxyethanol	2-methoxy-5-nitroaniline
2-methylaniline hydrochloride	methyl chlorocarbonate
4,4-methylene bisbenzeneamine	metribuzin
molinate	2-naphthylamine
napropamide	
nickel subsulfide	nitrapyrin
3-nitroaniline	4-nitroaniline
nitroguanidine	norflurazon
octabromodiphenyl ether	
octamethylpyrophosphoramidate	paclobutrazol
pebulate	pendimethalin
pentabromo-6-chlorocyclohexane	
pentabromodiphenyl ether	phenmedipham
phenylmercuric acetate	phorate
phosmet	picloram
pirimiphos-methyl	prochloraz
profluralin	pronamide
propargyl alcohol	propazine
propham	propiconazole
propylene oxide	pydrin
quinalphos	savey
selenourea	sethoxydim
sodium fluoroacetate	sodium metavanadate
sythane	tebuthiuron
temephos	terbacil
terbufos	terbutryn

tetrachlorovinphos	tetraethyldithiopyrophosphate
thallium selenide	
2-(thiocyanomethylthio)-benzothiazole	
thiofanox	thiophanate-methyl
thiram	tralomethrin
triallate	triasulfuron
2,4,6-trichloroaniline hydrochloride	
tridiphane	triethylamine
trifluralin	vernam

EPA REGION III RISK-BASED CONCENTRATION TABLE
TECHNICAL BACKGROUND INFORMATION
 (Originally developed by Roy L. Smith, Ph.D.)

Development of Risk-Based Concentrations

General

Separate carcinogenic and non-carcinogenic risk-based concentrations were calculated for each compound for each pathway. The concentration in the table is the lower of the two, rounded to two significant figures. The following terms and values were used in the calculations:

Exposure variables	Value	Symbol
<i>General:</i>		
Carcinogenic potency slope oral (risk per mg/kg/d):	*	CPSo
Carcinogenic potency slope inhaled (risk per mg/kg/d):	*	CPSi
Reference dose oral (mg/kg/d):	*	RfDo
Reference dose inhaled (mg/kg/d):	*	RfDi
Target cancer risk:	1e-06	TR
Target hazard quotient:	1	THQ
Body weight, adult (kg):	70	BWa
Body weight, age 1-6 (kg):	15	BWc
Averaging time carcinogens (d):	25550	ATc
Averaging time non-carcinogens (d):	ED*365	ATn
Inhalation, adult (m ³ /d):	20	IRAA
Inhalation, child (m ³ /d):	12	IRAc
Inhalation factor, age-adjusted (m ³ -y/kg-d):	11.66	IFAadj
Tap water ingestion, adult (L/d):	2	IRWa
Tap water ingestion, age 1-6 (L/d):	1	IRWc
Tap water ingestion factor, age-adjusted (L-y/kg-d):	1.09	IFWadj
Fish ingestion (g/d):	54	IRF
Soil ingestion, adult (mg/d):	100	IRSa
Soil ingestion, age 1-6 (mg/d):	200	IRSc
Soil ingestion factor, age adjusted (mg-y/kg-d):	114.29	IFSadj
<i>Residential:</i>		
Exposure frequency (d/y):	350	EFR
Exposure duration, total (y):	30	EDtot
Exposure duration, age 1-6 (y):	6	EDc
Volatilization factor (L/m ³):	0.5	K
<i>Occupational:</i>		
Exposure frequency (d/y):	250	EFO
Exposure duration (y):	25	EDO
Fraction of contaminated soil ingested (unitless)	0.5	FC

* Contaminant-specific toxicological constants. The priority among sources of toxicological constants was as follows: (1) IRIS, (2) HEAST, (3) HEAST alternative method, (4) EPA/NCEA Superfund Health Risk Technical Support Center, (5) withdrawn from IRIS or HEAST, and (6) other EPA documents. Each source was used only if numbers from higher-priority sources were unavailable. The EPA Superfund Health Risk Technical Support Center, part of the EPA National Center for Environmental Assessment in Cincinnati, develops provisional RfDs and CPSs on request for contaminants not in IRIS or HEAST. These provisional values are labeled "E = EPA-NCEA provisional" in the table. It is possible they may be obsolete. If one of the "E" constants is important to a Superfund risk assessment, consider requesting, through a Regional risk assessor, a new provisional value.

Age-adjusted factors

Because contact rates with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximated the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations for two age groups - small children and adults. The age-adjusted factor for soil was obtained from RAGS IB; the others were developed by analogy.

$$(1) \quad \text{Air inhalation} \\ IFAadj \frac{m^3 \cdot y}{kg \cdot d} = \frac{EDc \cdot IRAc}{BWC} + \frac{(EDtot - EDc) \cdot IRAa}{BWa}$$

$$(2) \quad \text{Tap water ingestion} \\ IFWadj \frac{L \cdot y}{kg \cdot d} = \frac{EDc \cdot IRWc}{BWC} + \frac{(EDtot - EDc) \cdot IRWa}{BWa}$$

$$(3) \quad \text{Soil ingestion} \\ IFSadj \frac{mg \cdot y}{kg \cdot d} = \frac{EDc \cdot IRSc}{BWC} + \frac{(EDtot - EDc) \cdot IRSa}{BWa}$$

Residential water

Volatilization terms were calculated only for compounds with a mark in the "VOC" column. Compounds having a Henry's Law constant greater than 10^{-5} were considered volatile. The list may be incomplete, but is unlikely to include false positives. The equations and the volatilization factor (K, above) were obtained from RAGS IB. Oral potency slopes and reference doses were used for both oral and inhaled exposures for volatile compounds lacking inhalation values. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

$$(4) \quad \text{Carcinogens} \\ RBC \frac{\mu g}{L} = \frac{TR \cdot ATc \cdot 1000 \frac{\mu g}{mg}}{Efr \cdot ([K \cdot IFAadj \cdot CPSi] + [IFWadj \cdot CPSo])}$$

$$(5) \quad \text{Non-carcinogens}$$

$$RBC \frac{\mu g}{L} = \frac{THQ \cdot BWa \cdot ATn \cdot 1000 \frac{\mu g}{mg}}{Efr \cdot EDtot \cdot \left(\frac{K \cdot IRAa}{RfDi} + \frac{IRWa}{RfDo} \right)}$$

Ambient air

Oral potency slopes and references were used where inhalation values were not available. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

$$(6) \quad \text{Carcinogens}$$

$$RBC \frac{\mu g}{m^3} = \frac{TR \cdot ATc \cdot 1000 \frac{\mu g}{mg}}{Efr \cdot IFAadj \cdot CPSi}$$

$$(7) \quad \text{Non-carcinogens}$$

$$RBC \frac{\mu g}{m^3} = \frac{THQ \cdot RfDi \cdot BWa \cdot ATn \cdot 1000 \frac{\mu g}{mg}}{Efr \cdot EDtot \cdot IRAa}$$

Edible fish

All RBCs were based on adult exposure.

$$(8) \quad \text{Carcinogens}$$

$$RBC \frac{mg}{kg} = \frac{TR \cdot BWa \cdot ATc}{Efr \cdot EDtot \cdot \frac{IRF}{1000 \frac{g}{kg}} \cdot CPSo}$$

$$(9) \quad \text{Non-carcinogens}$$

$$RBC \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{Efr \cdot EDtot \cdot \frac{IRF}{1000 \frac{g}{kg}}}$$

Commercial/industrial soil ingestion

RBCs were based on adult occupational exposure, including an assumption that only 50% of total soil ingestion is work-related.

$$(10) \quad \text{Carcinogens}$$

$$RBC \frac{mg}{kg} = \frac{TR \cdot BWa \cdot ATc}{EFO \cdot EDO \cdot \frac{IRSa}{10^6 \frac{mg}{kg}} \cdot FC \cdot CPSo}$$

(11) Non-carcinogens

$$RBC \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFO \cdot EDO \cdot \frac{IRSa}{10^6 \frac{mg}{kg}} \cdot FC}$$

Residential soil ingestion

RBCs for carcinogens were based on combined childhood and adult exposure; RBCs for non-carcinogens were based on childhood exposure only.

(12) Carcinogens

$$RBC \frac{mg}{kg} = \frac{TR \cdot ATc}{EFr \cdot \frac{IFSadj}{10^6 \frac{mg}{kg}} \cdot CPSo}$$

(13) Non-carcinogens

$$RBC \frac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWc \cdot ATn}{EFr \cdot EDC \cdot \frac{IRSc}{10^6 \frac{mg}{kg}}}$$

Sources: I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST E = EPA-NCEA provisional value O = other							Basis: C = Carcinogenic effects N = Noncarcinogenic effects * = RBC at HI of 0.1 < RBC-c Risk-based concentrations				
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
**ACETALDEHYDE	75070			2.57E-03 I	7.7E-03 I	y	1.6E+00 C	8.1E-01 C			
ACETOCHLOR	34256821	2E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
**ACETONE	67641	1.00E-01 I				y	6.1E+02 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
**ACETONITRILE	75058			1.7E-02 I		y	1.2E+02 N	6.2E+01 N			
ACETOPHENONE	98862	1.00E-01 I		5.70E-06 W		y	4.2E-02 N	2.1E-02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
ACROLEIN	107028	2.00E-02 H		5.70E-06 I		y	4.2E-02 N	2.1E-02 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
ACRYLAMIDE	79061	2.00E-04 I	4.50E+00 I		4.50E+00 I		1.5E-02 C	1.4E-03 C	7.0E-04 C	1.3E+00 C	1.4E-01 C
**ACRYLONITRILE	107131	1.00E-03 H	5.40E-01 I	5.70E-04 I	2.40E-01 I	y	3.7E-02 C	2.6E-02 C	5.8E-03 C	1.1E+01 C	1.2E+00 C
ALACHLOR	15972608	1.00E-02 I	8.00E-02 H				8.4E-01 C	7.8E-02 C	3.9E-02 C	7.2E+01 C	8.0E+00 C
ALAR	1596845	1.50E-01 I					5.5E+03 N	5.5E+02 N	2.0E+02 N	3.1E+05 N	1.2E+04 N
ALDICARB	116063	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
ALDICARB SULFONE	1646884	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
ALDRIN	309002	3.00E-05 I	1.70E+01 I		1.70E+01 I		3.9E-03 C	3.7E-04 C	1.9E-04 C	3.4E-01 C	3.8E-02 C
ALUMINUM	7429905	1.00E+00 E		1.00E-03 E			3.7E+04 N	3.7E+00 N	1.4E+03 N	2.0E+06 N	7.8E+04 N
AMINODINITROTOLUENES		6.00E-05 E					2.2E+00 N	2.2E-01 N	8.1E-02 N	1.2E+02 N	4.7E+00 N
4-AMINOPYRIDINE	504245	2.00E-05 H					7.3E-01 N	7.3E-02 N	2.7E-02 N	4.1E+01 N	1.6E+00 N
AMMONIA	7884417			2.86E-02 I		y	2.1E+02 N	1.0E+02 N			
**ANILINE	62533	7.00E-03 E	5.70E-03 I	2.90E-04 I			1.2E+01 C	1.1E+00 N	5.5E-01 C	1.0E+03 C	1.1E+02 C I
ANTIMONY	7440360	4.00E-04 I					1.5E+01 N	1.5E+00 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
ANTIMONY PENTOXIDE	1314609	5.00E-04 H					1.8E+01 N	1.8E+00 N	6.8E-01 N	1.0E+03 N	3.9E+01 N
ANTIMONY TETROXIDE	1332816	4.00E-04 H					1.5E+01 N	1.5E+00 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
ANTIMONY TRIOXIDE	1309644	4.00E-04 H		5.70E-05 I			1.5E+01 N	2.1E-01 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
ARSENIC	7440382	3.00E-04 I	1.50E+00 I		1.51E+01 I		4.5E-02 C	4.1E-04 C	2.1E-03 C	3.8E+00 C	4.3E-01 C
ARSINE	7784421			1.40E-05 I		y	1.0E-01 N	5.1E-02 N			
ASSURE	78578146	9.00E-03 I					3.3E+02 N	3.3E+01 N	1.2E+01 N	1.8E+04 N	7.0E+02 N
ATRAZINE	1912249	3.50E-02 I	2.20E-01 H				3.0E-01 C	2.8E-02 C	1.4E-02 C	2.6E+01 C	2.9E+00 C
AZOBENZENE	103333		1.10E-01 I		1.10E-01 I		8.1E-01 C	5.7E-02 C	2.9E-02 C	5.2E+01 C	5.8E+00 C
BARIUM	7440393	7.00E-02 I		1.40E-04 A			2.8E+03 N	5.1E-01 N	9.5E+01 N	1.4E+05 N	5.5E+03 N
BAYGON	114261	4.00E-03 I					1.5E+02 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
BAYTHROID	68359375	2.50E-02 I					9.1E+02 N	9.1E+01 N	3.4E+01 N	5.1E+04 N	2.0E+03 N
BENTAZON	25057890	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
BENZALDEHYDE	100527	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
BENZENE	71432	3.00E-03 E	2.90E-02 I	1.70E-03 E	2.90E-02 I	y	3.6E-01 C	2.2E-01 C	1.1E-01 C	2.0E+02 C	2.2E+01 C
BENZENETHIOL	108985	1.00E-05 H				y	8.1E-02 N	3.7E-02 N	1.4E-02 N	2.0E+01 N	7.8E-01 N
BENZIDINE	92875	3.00E-03 I	2.30E+02 I		2.30E+02 I		2.9E-04 C	2.7E-05 C	1.4E-05 C	2.5E-02 C	2.8E-03 C
BENZOIC ACID	65850	4.00E+00 I					1.5E+05 N	1.5E+04 N	5.4E+03 N	8.2E+06 N	3.1E+05 N
BENZYL ALCOHOL	100516	3.00E-01 H					1.1E+04 N	1.1E+03 N	4.1E+02 N	6.1E+05 N	2.3E+04 N
BENZYL CHLORIDE	100447		0.17 I			y	6.2E-02 C	3.7E-02 C	1.9E-02 C	3.4E+01 C	3.8E+00 C
BERYLLIUM	7440417	2.00E-03 I		5.7E-06 I	8.40E+00 I		7.3E+01 N	7.5E-04 C	2.7E+00 N	4.1E+03 N	1.6E+02 N
BIPHENYL	92524	5.00E-02 I				y	3.0E+02 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
**BIS(2-CHLOROETHYL)ETHER	111444		1.10E+00 I		1.10E+00 I	y	9.6E-03 C	5.7E-03 C	2.9E-03 C	5.2E+00 C	5.8E-01 C
BIS(2-CHLOROISOPROPYL)ETHER	108601	4.00E-02 I	7.00E-02 H		3.50E-02 H	y	2.6E-01 C	1.8E-01 C	4.5E-02 C	8.2E+01 C	9.1E+00 C
BIS(CHLOROMETHYL)ETHER	542881		2.20E+02 I		2.20E+02 I	y	4.8E-05 C	2.8E-05 C	1.4E-05 C	2.6E-02 C	2.9E-03 C
BIS(2-ETHYLHEXYL)PHTHALATE	117817	2.00E-02 I	1.40E-02 I		1.40E-02 E		4.8E+00 C	4.5E-01 C	2.3E-01 C	4.1E+02 C	4.6E+01 C
BORON	7440428	9.00E-02 I		5.70E-03 H			3.3E+03 N	2.1E+01 N	1.2E+02 N	1.8E+05 N	7.0E+03 N
BROMODICHLOROMETHANE	75274	2.00E-02 I	8.20E-02 I			y	1.7E-01 C	1.0E-01 C	5.1E-02 C	9.2E+01 C	1.0E+01 C
BROMOETHENE	593602			8.6E-04 I	1.10E-01 H	y	1.1E-01 C	5.7E-02 C			
**BROMOFORM	75252	2.00E-02 I	7.90E-03 I		3.90E-03 I		8.5E+00 C	1.6E+00 C	4.0E-01 C	7.2E+02 C	8.1E+01 C
BROMOMETHANE	74839	1.40E-03 I		1.40E-03 I		y	8.5E+00 N	5.1E+00 N	1.9E+00 N	2.9E+03 N	1.1E+02 N
**BROMOPHOS	2104963	5.00E-03 H					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
1,3-BUTADIENE	106980				1.80E+00 H	y	7.0E-03 C	3.5E-03 C			
1-BUTANOL	71363	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
BUTYLBENZYLPHTHALATE	85687	2.00E-01 I					7.3E+03 N	7.3E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N
BUTYLATE	2008415	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N

Sources: I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST E = EPA-NCEA provisional value O = other							Basis: C = Carcinogenic effects N = Noncarcinogenic effects I = RBC at HI of 0.1 < RBC-c				
Chemical	CAS	RfDo mg/kg/d	CSF ₀ 1/mg/kg/d	RfDI mg/kg/d	CSF _I 1/mg/kg/d	VOC	Risk-based concentrations				
							Tap water ug/l	Ambient air ug/m ³	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
N-BUTYLBENZENE	104518	1.00E-02 E				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
SEC-BUTYLBENZENE	135988	1.00E-02 E				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
TERT-BUTYLBENZENE	98066	1.00E-02 E				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
CADMIUM-WATER	7440439	5.00E-04 I			6.30E+00 I		1.8E+01 N	9.9E-04 C	6.8E-01 N	1.0E+03 N	3.9E+01 N
CADMIUM-FOOD	7440439	1.00E-03 I			6.30E+00 I		3.7E+01 N	9.9E-04 C	1.4E+00 N	2.0E+03 N	7.8E+01 N
CAPROLACTAM	105602	5.00E-01 I					1.8E+04 N	1.8E+03 N	6.8E+02 N	1.0E+06 N	3.9E+04 N
CARBARYL	63252	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
CARBON DISULFIDE	75150	1.00E-01 I		2.00E-01 I		y	1.0E+03 N	7.3E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
CARBON TETRACHLORIDE	56235	7.00E-04 I	1.30E-01 I	5.71E-04 E	5.30E-02 I	y	1.8E-01 C	1.2E-01 C	2.4E-02 C	4.4E+01 C	4.9E+00 C
CARBOSULFAN	55285148	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
**CHLORAL	75876	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
CHLORANIL	118752		4.00E-01 H				1.7E-01 C	1.6E-02 C	7.9E-03 C	1.4E+01 C	1.6E+00 C
CHLORDANE	57749	5.00E-04 I	3.5E-01 I	2.00E-04 I	3.5E-01 I		1.9E-01 C	1.8E-02 C	9.0E-03 C	1.6E+01 C	1.8E+00 C
CHLORINE	7782505	1.00E-01 I				y	6.1E+02 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
CHLORINE DIOXIDE	10049044			5.70E-05 I		y	4.2E-01 N	2.1E-01 N			
CHLOROACETIC ACID	79118	2.00E-03 H					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
4-CHLOROANILINE	106478	4.00E-03 I					1.5E+02 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
**CHLOROBENZENE	108907	2.00E-02 I		1.7E-02 E		y	1.1E+02 N	6.2E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
CHLOROBENZILATE	510156	2.00E-02 I	2.70E-01 H		2.70E-01 H		2.5E-01 C	2.3E-02 C	1.2E-02 C	2.1E+01 C	2.4E+00 C
P-CHLOROBENZOIC ACID	74113	2.00E-01 H					7.3E+03 N	7.3E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N
2-CHLORO-1,3-BUTADIENE	126998	2.00E-02 A		2.00E-03 H		y	1.4E+01 N	7.3E+00 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
1-CHLOROBUTANE	109693	4.00E-01 H				y	2.4E+03 N	1.5E+03 N	5.4E+02 N	8.2E+05 N	3.1E+04 N
1-CHLORO-1,1-DIFLUOROETHANE	75683			1.40E+01 I		y	1.0E+05 N	5.1E+04 N			
CHLORODIFLUOROMETHANE	75458			1.40E+01 I		y	1.0E+05 N	5.1E+04 N			
CHLOROETHANE	75003	4.00E-01 E	2.90E-03 E	2.90E+00 I		y	3.6E+00 C	2.2E+00 C	1.1E+00 C	2.0E+03 C	2.2E+02 C
CHLOROFORM	67663	1.00E-02 I	6.10E-03 I	6.6E-05 E	8.10E-02 I	y	1.5E-01 C	7.7E-02 C	5.2E-01 C	9.4E+02 C	1.0E+02 C
**CHLOROMETHANE	74873		1.30E-02 H	8.6E-02 E	3.5E-03 E	y	2.1E+00 C	1.8E+00 C	2.4E-01 C	4.4E+02 C	4.9E+01 C
4-CHLORO-2-METHYLANILINE	95692		5.80E-01 H				1.2E-01 C	1.1E-02 C	5.4E-03 C	9.9E+00 C	1.1E+00 C
BETA-CHLORONAPHTHALENE	91587	8.00E-02 I				y	4.9E+02 N	2.9E+02 N	1.1E+02 N	1.6E+05 N	6.3E+03 N
O-CHLORONITROBENZENE	88733		2.50E-02 H			y	4.2E-01 C	2.5E-01 C	1.3E-01 C	2.3E+02 C	2.6E+01 C
P-CHLORONITROBENZENE	100005		1.80E-02 H			y	5.9E-01 C	3.5E-01 C	1.8E-01 C	3.2E+02 C	3.5E+01 C
**2-CHLOROPHENOL	95578	5.00E-03 I				y	3.0E+01 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
2-CHLOROPROPANE	75296			2.90E-02 H		y	2.1E+02 N	1.1E+02 N			
O-CHLOROTOLUENE	95498	2.00E-02 I				y	1.2E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
CHLORPYRIFOS	2921882	3.00E-03 I					1.1E+02 N	1.1E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N
CHLORPYRIFOS-METHYL	5598130	1.00E-02 H					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
CHROMIUM III	18065831	1.50E+00 I					5.5E+04 N	5.5E+03 N	2.0E+03 N	3.1E+06 N	1.2E+05 N
CHROMIUM VI	18540299	3.00E-03 I		3.00E-05 I	4.10E+01 H		1.1E+02 N	1.5E-04 C	4.1E+00 N	6.1E+03 N	2.3E+02 N
COBALT	7440484	6.00E-02 E					2.2E+03 N	2.2E+02 N	8.1E+01 N	1.2E+05 N	4.7E+03 N
**COKE OVEN EMISSIONS (COAL TAR)	8007452				2.2 I			2.8E-03 C			
COPPER	7440508	4.00E-02 H					1.5E+03 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
**CROTONALDEHYDE	123739		1.90E+00 H			y	5.6E-03 C	3.3E-03 C	1.7E-03 C	3.0E+00 C	3.4E-01 C
CUMENE	98828	1.00E-01 I		1.10E-01 I		y	6.8E+02 N	4.0E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
CYANIDE (FREE)	57125	2.00E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
CALCIUM CYANIDE	592018	4E-02 I					1.5E+03 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
COPPER CYANIDE	544923	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
CYANAZINE	21725482	2.00E-03 H	8.40E-01 H				8.0E-02 C	7.5E-03 C	3.8E-03 C	6.8E+00 C	7.8E-01 C
CYANOGEN	460195	4.00E-02 I				y	2.4E+02 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
CYANOGEN BROMIDE	506683	9.00E-02 I					3.3E+03 N	3.3E+02 N	1.2E+02 N	1.8E+05 N	7.0E+03 N
CYANOGEN CHLORIDE	506774	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
HYDROGEN CYANIDE	74908	2.00E-02 I		8.60E-04 I		y	6.2E+00 N	3.1E+00 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
POTASSIUM CYANIDE	151508	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
POTASSIUM SILVER CYANIDE	506616	2.00E-01 I					7.3E+03 N	7.3E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N
SILVER CYANIDE	506649	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N

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Chemical	CAS	RfDo mg/kg/d	CSF0 1/mg/kg/d	RfDi mg/kg/d	CSFI 1/mg/kg/d	VOC	Tap water ug/l	Ambient air, ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
SODIUM CYANIDE	143339	4.00E-02 I					1.5E+03 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
THIOCYANATE		1.00E-01 E					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
ZINC CYANIDE	557211	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
CYCLOHEXANONE	108941	5.00E+00 I					1.8E+05 N	1.8E+04 N	6.8E+03 N	1.0E+07 N	3.9E+05 N
CYHALOTHRIN/KARATE	68085858	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
CYPERMETHRIN	52315078	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
DACTHAL	1861321	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
DALAPON	75990	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
DDD	72548		2.40E-01 I				2.8E-01 C	2.6E-02 C	1.3E-02 C	2.4E+01 C	2.7E+00 C
DDE	72559		3.40E-01 I				2.0E-01 C	1.8E-02 C	9.3E-03 C	1.7E+01 C	1.9E+00 C
DDT	50293	5.00E-04 I	3.40E-01 I		3.40E-01 I		2.0E-01 C	1.8E-02 C	9.3E-03 C	1.7E+01 C	1.9E+00 C
DIAZINON	333415	9.00E-04 H					3.3E+01 N	3.3E+00 N	1.2E+00 N	1.8E+03 N	7.0E+01 N
DIBENZOFURAN	132649	4.00E-03 E				y	2.4E+01 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
**1,4-DIBROMOBENZENE	108376	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
DIBROMOCHLOROMETHANE	124481	2.00E-02 I	8.40E-02 I			y	1.3E-01 C	7.5E-02 C	3.8E-02 C	6.8E+01 C	7.8E+00 C
1,2-DIBROMO-3-CHLOROPROPANE	96128		1.40E+00 H	5.70E-05 I	2.40E-03 H	y	4.7E-02 C	2.1E-01 N	2.3E-03 C	4.1E+00 C	4.6E-01 C
1,2-DIBROMOETHANE	106934		8.50E+01 I	5.70E-05 H	7.60E-01 I	y	7.5E-04 C	8.2E-03 C	3.7E-05 C	6.7E-02 C	7.5E-03 C
DIBUTYLPHTHALATE	84742	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
DICAMBA	1918009	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
1,2-DICHLOROENZENE	95501	9.00E-02 I		9.00E-03 E		y	6.4E+01 N	3.3E+01 N	1.2E+02 N	1.8E+05 N	7.0E+03 N
**1,3-DICHLOROENZENE	541731	9.00E-04 E				y	5.5E+00 N	3.3E+00 N	1.2E+00 N	1.8E+03 N	7.0E+01 N
1,4-DICHLOROENZENE	108467	3.00E-02 E	2.40E-02 H	2.29E-01 I	2.2E-02 E	y	4.7E-01 C	2.8E-01 C	1.3E-01 C	2.4E+02 C	2.7E+01 C
3,3'-DICHLOROENZIDINE	91941		4.50E-01 I				1.5E-01 C	1.4E-02 C	7.0E-03 C	1.3E+01 C	1.4E+00 C
1,4-DICHLORO-2-BUTENE	764410				9.30E+00 H	y	1.3E-03 C	6.7E-04 C			
DICHLORODIFLUOROMETHANE	75718	2.00E-01 I		5.00E-02 A		y	3.5E+02 N	1.8E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N
1,1-DICHLOROETHANE	75343	1.00E-01 H		1.40E-01 A		y	8.0E+02 N	5.1E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
1,2-DICHLOROETHANE	107062	3.00E-02 E	9.10E-02 I	1.40E-03 E	9.10E-02 I	y	1.2E-01 C	6.9E-02 C	3.5E-02 C	6.3E+01 C	7.0E+00 C
1,1-DICHLOROETHENE	75354	9.00E-03 I	6.00E-01 I		1.75E-01 I	y	4.4E-02 C	3.6E-02 C	5.3E-03 C	9.5E+00 C	1.1E+00 C
CIS-1,2-DICHLOROETHENE	156592	1.00E-02 H				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
TRANS-1,2-DICHLOROETHENE	156605	2.00E-02 I				y	1.2E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
TOTAL 1,2-DICHLOROETHENE	540590	9.00E-03 H				y	5.5E+01 N	3.3E+01 N	1.2E+01 N	1.6E+04 N	7.0E+02 N
2,4-DICHLOROPHENOL	120832	3.00E-03 I					1.1E+02 N	1.1E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N
**2,4-D	94757	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
4-(2,4-DICHLOROPHENOXY)BUTYRIC ACID	94826	8E-03 I					2.9E+02 N	2.9E+01 N	1.1E+01 N	1.6E+04 N	6.3E+02 N
1,2-DICHLOROPROPANE	78875		8.80E-02 H	1.14E-03 I		y	1.6E-01 C	9.2E-02 C	4.6E-02 C	8.4E+01 C	9.4E+00 C
2,3-DICHLOROPROPANOL	616239	3.00E-03 I					1.1E+02 N	1.1E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N
1,3-DICHLOROPROPENE	542756	3.00E-04 I	1.80E-01 H	5.71E-03 I	1.30E-01 H	y	7.7E-02 C	4.8E-02 C	1.8E-02 C	3.2E+01 C	3.5E+00 C
DICHLORVOS	62737	5E-04 I	0.29 I	1.43E-04 I			2.3E-01 C	2.2E-02 C	1.1E-02 C	2.0E+01 C	2.2E+00 C
DICOFOL	115322		4.4E-01 W				1.5E-01 C	1.4E-02 C	7.2E-03 C	1.3E+01 C	1.5E+00 C
DICYCLOPENTADIENE	77736	3E-02 H		6.00E-05 A		y	4.4E-01 N	2.2E-01 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
DIELDRIN	60571	5.00E-05 I	1.60E+01 I		1.60E+01 I		4.2E-03 C	3.9E-04 C	2.0E-04 C	3.6E-01 C	4.0E-02 C
DIESEL EMISSIONS				1.40E-03 I				5.1E+00 N			
DIETHYLPHTHALATE	84662	8.00E-01 I					2.9E+04 N	2.9E+03 N	1.1E+03 N	1.6E+06 N	6.3E+04 N
DIETHYLENE GLYCOL, MONOBUTYL ETHER	112345			5.70E-03 H				2.1E+01 N			
DIETHYLENE GLYCOL, MONOETHYL ETHER	111900	2.00E+00 H					7.3E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
DI(2-ETHYLHEXYL)ADIPATE	103231	6.00E-01 I	1.20E-03 I				5.8E+01 C	5.2E+00 C	2.8E+00 C	4.8E+03 C	5.3E+02 C
DIETHYLSTILBESTROL	56531		4.70E+03 H				1.4E-05 C	1.3E-06 C	6.7E-07 C	1.2E-03 C	1.4E-04 C
DIFENZOQUAT (AVERAGE)	43222486	8.00E-02 I					2.9E+03 N	2.9E+02 N	1.1E+02 N	1.6E+05 N	6.3E+03 N
1,1-DIFLUOROETHANE	75376			1.10E+01 I		y	8.0E+04 N	4.0E+04 N			
DIISOPROPYL METHYLPHOSPHONATE (DIMP)	1445756	8.00E-02 I					2.9E+03 N	2.9E+02 N	1.1E+02 N	1.6E+05 N	6.3E+03 N
3,3'-DIMETHOXYENZIDINE	119904		1.40E-02 H				4.8E+00 C	4.5E-01 C	2.3E-01 C	4.1E+02 C	4.6E+01 C
**DIMETHYLAMINE	124403			5.70E-06 W		y	4.2E-02 N	2.1E-02 N			
2,4-DIMETHYLANILINE HYDROCHLORIDE	21436964		5.80E-01 H				1.2E-01 C	1.1E-02 C	5.4E-03 C	9.9E+00 C	1.1E+00 C
2,4-DIMETHYLANILINE	95681		7.50E-01 H				8.9E-02 C	8.3E-03 C	4.2E-03 C	7.6E+00 C	8.5E-01 C

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E = EPA-NCEA provisional value O = other							Risk-based concentrations				
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDI mg/kg/d	CSFI 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
N,N-DIMETHYLANILINE	121697	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
3,3'-DIMETHYLBENZIDINE	119937		9.20E+00 H				7.3E-03 C	6.8E-04 C	3.4E-04 C	6.2E-01 C	6.9E-02 C
1,1-DIMETHYLHYDRAZINE	57147		2.60E+00 W		3.50E+00 W		2.6E-02 C	1.8E-03 C	1.2E-03 C	2.2E+00 C	2.5E-01 C
1,2-DIMETHYLHYDRAZINE	540738		3.70E+01 W		3.70E+01 W		1.8E-03 C	1.7E-04 C	8.5E-05 C	1.5E-01 C	1.7E-02 C
2,4-DIMETHYLPHENOL	105679	2.00E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
2,6-DIMETHYLPHENOL	578261	6.00E-04 I					2.2E+01 N	2.2E+00 N	8.1E-01 N	1.2E+03 N	4.7E+01 N
3,4-DIMETHYLPHENOL	95658	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
DIMETHYLPHthalate	131113	1.00E+01 W					3.7E+05 N	3.7E+04 N	1.4E+04 N	2.0E+07 N	7.8E+05 N
1,2-DINITROBENZENE	528290	4.00E-04 H					1.5E+01 N	1.5E+00 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
1,3-DINITROBENZENE	99650	1.00E-04 I					3.7E+00 N	3.7E-01 N	1.4E-01 N	2.0E+02 N	7.8E+00 N
1,4-DINITROBENZENE	100254	4.00E-04 H					1.5E+01 N	1.5E+00 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
4,8-DINITRO-O-CYCLOHEXYL PHENOL	131895	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
4,8-DINITRO-2-METHYLPHENOL	534521	1.00E-04 E					3.7E+00 N	3.7E-01 N	1.4E-01 N	2.0E+02 N	7.8E+00 N
2,4-DINITROPHENOL	51285	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
DINITROTOLUENE MIX			6.80E-01 I				9.8E-02 C	9.2E-03 C	4.8E-03 C	8.4E+00 C	9.4E-01 C
2,4-DINITROTOLUENE	121142	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
2,6-DINITROTOLUENE	606202	1.00E-03 H					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
**DINOSEB	88857	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
DIOCTYLPHthalate	117840	2.00E-02 H					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
1,4-DIOXANE	123911		1.10E-02 I				6.1E+00 C	5.7E-01 C	2.9E-01 C	5.2E+02 C	5.8E+01 C
DIPHENYLAMINE	122394	2.50E-02 I					9.1E+02 N	9.1E+01 N	3.4E+01 N	5.1E+04 N	2.0E+03 N
1,2-DIPHENYLHYDRAZINE	122667		8.00E-01 I		8.00E-01 I		8.4E-02 C	7.8E-03 C	3.9E-03 C	7.2E+00 C	8.0E-01 C
DIQUAT	85007	2.20E-03 I					8.0E+01 N	8.0E+00 N	3.0E+00 N	4.5E+03 N	1.7E+02 N
**DISULFOTON	298044	4.00E-05 I					1.5E+00 N	1.5E-01 N	5.4E-02 N	8.2E+01 N	3.1E+00 N
1,4-DITHIANE	505293	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
DIURON	330541	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
ENDOSULFAN	115297	6.00E-03 I					2.2E+02 N	2.2E+01 N	8.1E+00 N	1.2E+04 N	4.7E+02 N
ENDRIN	72208	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
**EPICHLOROHYDRIN	106898	2.00E-03 H	9.90E-03 I	2.86E-04 I	4.20E-03 I	y	2.0E+00 N	1.0E+00 N	3.2E-01 C	5.8E+02 C	6.5E+01 C
ETHION	563122	5.00E-04 I					1.8E+01 N	1.8E+00 N	6.8E-01 N	1.0E+03 N	3.9E+01 N
2-ETHOXYETHANOL	110805	4.00E-01 H		5.70E-02 I			1.5E+04 N	2.1E+02 N	5.4E+02 N	8.2E+05 N	3.1E+04 N
ETHYL ACETATE	141786	9.00E-01 I				y	5.5E+03 N	3.3E+03 N	1.2E+03 N	1.8E+06 N	7.0E+04 N
ETHYLBENZENE	100414	1.00E-01 I		2.90E-01 I		y	1.3E+03 N	1.1E+03 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
ETHYLENE DIAMINE	107153	2.00E-02 H					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
ETHYLENE GLYCOL	107211	2.00E+00 I					7.3E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
ETHYLENE GLYCOL, MONOBUTYL ETHER	111762			5.70E-03 H				2.1E+01 N			
**ETHYLENE OXIDE	75218		1.00E+00 H		3.50E-01 H	y	2.3E-02 C	1.8E-02 C	3.2E-03 C	5.7E+00 C	8.4E-01 C
ETHYLENE THIOUREA	96457	8.00E-05 I	1.1E-01 H				6.1E-01 C	5.7E-02 C	2.9E-02 C	5.2E+01 C	5.8E+00 C
ETHYL ETHER	60297	2.00E-01 I				y	1.2E+03 N	7.3E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N
ETHYL METHACRYLATE	97632	9.00E-02 H				y	5.5E+02 N	3.3E+02 N	1.2E+02 N	1.8E+05 N	7.0E+03 N
FENAMIPHOS	22224926	2.50E-04 I					9.1E+00 N	9.1E-01 N	3.4E-01 N	5.1E+02 N	2.0E+01 N
FLUOMETURON	2164172	1.30E-02 I					4.7E+02 N	4.7E+01 N	1.8E+01 N	2.7E+04 N	1.0E+03 N
FLUORINE	7782414	6.00E-02 I					2.2E+03 N	2.2E+02 N	8.1E+01 N	1.2E+05 N	4.7E+03 N
FOMESAFEN	72178020		1.90E-01 I				3.5E-01 C	3.3E-02 C	1.7E-02 C	3.0E+01 C	3.4E+00 C
FONOFOS	944229	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N
FORMALDEHYDE	50000	2.00E-01 I			4.50E-02 I		7.3E+03 N	1.4E-01 C	2.7E+02 N	4.1E+05 N	1.6E+04 N
FORMIC ACID	64186	2.00E+00 H					7.3E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
FURAN	110009	1.00E-03 I				y	6.1E+00 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
FURAZOLIDONE	67458		3.80E+00 H				1.8E-02 C	1.8E-03 C	8.3E-04 C	1.5E+00 C	1.7E-01 C
FURFURAL	98011	3.00E-03 I		1.00E-02 A			1.1E+02 N	3.7E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N
GLYCIDALDEHYDE	785344	4.00E-04 I		2.90E-04 H			1.5E+01 N	1.1E+00 N	5.4E-01 N	8.2E+02 N	3.1E+01 N
GLYPHOSATE	1071836	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
**HEPTACHLOR	76448	5.00E-04 I	4.50E+00 I		4.50E+00 I		1.5E-02 C	1.4E-03 C	7.0E-04 C	1.3E+00 C	1.4E-01 C
**HEPTACHLOR EPOXIDE	1024573	1.30E-05 I	9.10E+00 I		9.10E+00 I		7.4E-03 C	6.9E-04 C	3.5E-04 C	6.3E-01 C	7.0E-02 C

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Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
HEXABROMOBENZENE	87821	2.00E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.8E+02 N
**HEXACHLOROBENZENE	118741	8.00E-04 I	1.60E+00 I		1.60E+00 I		4.2E-02 C	3.9E-03 C	2.0E-03 C	3.6E+00 C	4.0E-01 C
**HEXACHLOROBUTADIENE	87883	2.00E-04 H	7.80E-02 I		7.80E-02 I		8.6E-01 C I	8.0E-02 C I	4.0E-02 C I	7.3E+01 C I	8.2E+00 C I
ALPHA-HCH	319846		8.30E+00 I		8.30E+00 I		1.1E-02 C	9.9E-04 C	5.0E-04 C	9.1E-01 C	1.0E-01 C
BETA-HCH	319857		1.80E+00 I		1.80E+00 I		3.7E-02 C	3.5E-03 C	1.8E-03 C	3.2E+00 C	3.5E-01 C
GAMMA-HCH (LINDANE)	58899	3.00E-04 I	1.30E+00 H				5.2E-02 C	4.8E-03 C	2.4E-03 C	4.4E+00 C	4.9E-01 C
TECHNICAL HCH	608731		1.80E+00 I		1.80E+00 I		3.7E-02 C	3.5E-03 C	1.8E-03 C	3.2E+00 C	3.5E-01 C
**HEXACHLOROCYCLOPENTADIENE	77474	7.00E-03 I		2.00E-05 H			2.6E+02 N	7.3E-02 N	9.5E+00 N	1.4E+04 N	5.5E+02 N
HEXACHLORODIBENZODIOXIN MIX	19408743		8.20E+03 I		4.55E+03 I		1.1E-05 C	1.4E-06 C	5.1E-07 C	9.2E-04 C	1.0E-04 C
**HEXACHLOROETHANE	67721	1.00E-03 I	1.40E-02 I		1.40E-02 I		4.8E+00 C I	4.5E-01 C I	2.3E-01 C I	4.1E+02 C I	4.6E+01 C I
HEXACHLOROPHENE	70304	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
1,6-HEXAMETHYLENE DIISOCYANATE	822060			2.90E-06 I				1.1E-02 N			
HEXANE	110543	6.00E-02 H		5.71E-02 I		y	3.5E+02 N	2.1E+02 N	8.1E+01 N	1.2E+05 N	4.7E+03 N
2-HEXANONE	591786	4.00E-02 E		1.4E-03 E			1.5E+03 N	5.1E+00 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
HEXAZINONE	51235042	3.30E-02 I					1.2E+03 N	1.2E+02 N	4.5E+01 N	6.7E+04 N	2.6E+03 N
HMX	2891410	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
HYDRAZINE	302012		3.00E+00 I		1.70E+01 I		2.2E-02 C	3.7E-04 C	1.1E-03 C	1.9E+00 C	2.1E-01 C
HYDROGEN CHLORIDE	7847010			5.70E-03 I				2.1E+01 N			
HYDROGEN SULFIDE	7783064	3.00E-03 I		2.85E-04 I			1.1E+02 N	1.0E+00 N	4.1E+00 N	6.1E+03 N	2.3E+02 N
HYDROQUINONE	123319	4.00E-02 H					1.5E+03 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
IRON	7439896	3.00E-01 E					1.1E+04 N	1.1E+03 N	4.1E+02 N	6.1E+05 N	2.3E+04 N
ISOBUTANOL	78831	3.00E-01 I				y	1.8E+03 N	1.1E+03 N	4.1E+02 N	6.1E+05 N	2.3E+04 N
ISOPHORONE	78591	2.00E-01 I	9.50E-04 I				7.0E+01 C	6.6E+00 C	3.3E+00 C	6.0E+03 C	6.7E+02 C
ISOPROPALIN	33820530	1.50E-02 I					5.5E+02 N	5.5E+01 N	2.0E+01 N	3.1E+04 N	1.2E+03 N
ISOPROPYL METHYL PHOSPHONIC ACID	1832548	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
**TETRAETHYLLEAD	78002	1.00E-07 I					3.7E-03 N	3.7E-04 N	1.4E-04 N	2.0E-01 N	7.8E-03 N
LITHIUM	7439932	2.00E-02 E					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
MALATHION	121755	2.00E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
MALEIC ANHYDRIDE	108316	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N
MANGANESE-NONFOOD	7439965	2.00E-02 I		1.43E-05 I			7.3E+02 N	5.2E-02 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
MANGANESE-FOOD	7439965	1.40E-01 I		1.43E-05 I			5.1E+03 N	5.2E-02 N	1.9E+02 N	2.9E+05 N	1.1E+04 N
MEPHOSFOLAN	950107	9.00E-05 H					3.3E+00 N	3.3E-01 N	1.2E-01 N	1.8E+02 N	7.0E+00 N
MEPIQUAT CHLORIDE	24307264	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
MERCURIC CHLORIDE	7487947	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
MERCURY (INORGANIC)	7439976			8.60E-05 I				3.1E-01 N			
METHYLMERCURY	22987926	1.00E-04 I					3.7E+00 N	3.7E-01 N	1.4E-01 N	2.0E+02 N	7.8E+00 N
METHACRYLONITRILE	126987	1.00E-04 I		2.00E-04 A		y	1.0E+00 N	7.3E-01 N	1.4E-01 N	2.0E+02 N	7.8E+00 N
METHANOL	67561	5.00E-01 I					1.8E+04 N	1.8E+03 N	6.8E+02 N	1.0E+06 N	3.9E+04 N
METHIDATHION	950378	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
METHOXYCHLOR	72435	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
METHYL ACETATE	79209	1.00E+00 H				y	6.1E+03 N	3.7E+03 N	1.4E+03 N	2.0E+06 N	7.8E+04 N
METHYL ACRYLATE	96333	3.00E-02 A				y	1.8E+02 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
2-METHYLANILINE	95534		2.40E-01 H				2.8E-01 C	2.8E-02 C	1.3E-02 C	2.4E+01 C	2.7E+00 C
4-(2-METHYL-4-CHLOROPHENOXY) BUTYRIC ACID	94815	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
2-METHYL-4-CHLOROPHENOXYACETIC ACID (MCPA)	94746	5.00E-04 I					1.8E+01 N	1.8E+00 N	6.8E-01 N	1.0E+03 N	3.9E+01 N
2-(2-METHYL-4-CHLOROPHENOXY)PROPIONIC ACID (MCPA)	93652	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
METHYLCYCLOHEXANE	108872			8.60E-01 H		y	6.3E+03 N	3.1E+03 N			
METHYLENE BROMIDE	74953	1.00E-02 A				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N
METHYLENE CHLORIDE	75092	8.00E-02 I	7.50E-03 I	8.60E-01 H	1.85E-03 I	y	4.1E+00 C	3.8E+00 C	4.2E-01 C	7.6E+02 C	8.5E+01 C
4,4'-METHYLENE BIS(2-CHLOROANILINE)	101144	7.00E-04 H	1.30E-01 H		1.30E-01 H		5.2E-01 C	4.8E-02 C	2.4E-02 C	4.4E+01 C	4.9E+00 C
4,4'-METHYLENE BIS(N,N-DIMETHYL)ANILINE	101811		4.60E-02 I				1.5E+00 C	1.4E-01 C	6.9E-02 C	1.2E+02 C	1.4E+01 C
4,4'-METHYLENEDIIPHENYL ISOCYANATE	101888			1.7E-04 I				6.2E-01 N			
METHYL ETHYL KETONE (2-BUTANONE)	78933	6.00E-01 I		2.86E-01 I		y	1.9E+03 N	1.0E+03 N	8.1E+02 N	1.2E+06 N	4.7E+04 N
METHYL HYDRAZINE	60344		1.10E+00 W				6.1E-02 C	5.7E-03 C	2.9E-03 C	5.2E+00 C	5.8E-01 C

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Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg	
**METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANON)	108101	8.00E-02 H		2.00E-02 A		y	1.4E+02 N	7.3E+01 N	1.1E+02 N	1.6E+05 N	6.3E+03 N	
METHYL METHACRYLATE	80626	1.40E+00 I		2.00E-01 I		y	1.4E+03 N	7.3E+02 N	1.9E+03 N	2.9E+06 N	1.1E+05 N	
2-METHYL-5-NITROANILINE	99558		3.30E-02 H				2.0E+00 C	1.9E-01 C	9.6E-02 C	1.7E+02 C	1.9E+01 C	
METHYL PARATHION	298000	2.50E-04 I					9.1E+00 N	9.1E-01 N	3.4E-01 N	5.1E+02 N	2.0E+01 N	
2-METHYLPHENOL	95487	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
3-METHYLPHENOL	108394	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
4-METHYLPHENOL	106445	5.00E-03 H					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
METHYLSTYRENE MIX	25013154	6.00E-03 A		1.00E-02 A		y	5.5E+01 N	3.7E+01 N	8.1E+00 N	1.2E+04 N	4.7E+02 N	
ALPHA-METHYLSTYRENE	98839	7.00E-02 A				y	4.3E+02 N	2.6E+02 N	9.5E+01 N	1.4E+05 N	5.5E+03 N	
METHYL TERT-BUTYL ETHER	1634044			8.57E-01 I		y	6.3E+03 N	3.1E+03 N				
METOLACHLOR (DUAL)	51218452	1.50E-01 I					5.5E+03 N	5.5E+02 N	2.0E+02 N	3.1E+05 N	1.2E+04 N	
**MIREX	2385855	2.00E-04 I					7.3E+00 N	7.3E-01 N	2.7E-01 N	4.1E+02 N	1.6E+01 N	
MOLYBDENUM	7439987	5E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
**MONOCHLORAMINE	10599903	1E-01 I		1.00E-01 H			3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N	
NALED	300785	2E-03 I					7.3E+01 N	7.3E+00 N	2.7E+00 N	4.1E+03 N	1.6E+02 N	
NICKEL REFINERY DUST					8.4E-01 I			7.5E-03 C				
NICKEL	7440020	2.00E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N	
NITRATE	14797558	1.60E+00 I					5.8E+04 N	5.8E+03 N	2.2E+03 N	3.3E+06 N	1.3E+05 N	
NITRIC OXIDE	10102439	1.00E-01 W				y	6.1E+02 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N	
NITRITE	14797650	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N	
2-NITROANILINE	88744			5.70E-05 H				2.1E-01 N				
NITROBENZENE	98953	5.00E-04 I		6.00E-04 A		y	3.5E+00 N	2.2E+00 N	6.8E-01 N	1.0E+03 N	3.9E+01 N	
NITROFURANTOIN	87209	7.00E-02 H					2.6E+03 N	2.6E+02 N	9.5E+01 N	1.4E+05 N	5.5E+03 N	
NITROFURAZONE	59870		1.50E+00 H				4.5E-02 C	4.2E-03 C	2.1E-03 C	3.8E+00 C	4.3E-01 C	
NITROGEN DIOXIDE	10102440	1.00E+00 W				y	6.1E+03 N	3.7E+03 N	1.4E+03 N	2.0E+06 N	7.8E+04 N	
NITROGLYCERIN	55630		1.4E-02 E				4.8E+00 C	4.5E-01 C	2.3E-01 C	4.1E+02 C	4.6E+01 C	
4-NITROPHENOL	100027	8.00E-03 E					2.9E+02 N	2.9E+01 N	1.1E+01 N	1.6E+04 N	6.3E+02 N	
2-NITROPROPANE	79469			5.70E-03 I	9.40E+00 H	y	1.3E-03 C	6.7E-04 C				
**N-NITROSO-DI-N-BUTYLAMINE	924163		5.40E+00 I		5.60E+00 I	y	1.9E-03 C	1.1E-03 C	5.8E-04 C	1.1E+00 C	1.2E-01 C	
N-NITROSODIETHANOLAMINE	1116547		2.80E+00 I				2.4E-02 C	2.2E-03 C	1.1E-03 C	2.0E+00 C	2.3E-01 C	
N-NITROSODIETHYLAMINE	55185		1.50E+02 I		1.50E+02 I		4.5E-04 C	4.2E-05 C	2.1E-05 C	3.8E-02 C	4.3E-03 C	
N-NITROSODIMETHYLAMINE	82759		5.10E+01 I		5.10E+01 I		1.3E-03 C	1.2E-04 C	8.2E-05 C	1.1E-01 C	1.3E-02 C	
N-NITROSODIPHENYLAMINE	86306		4.90E-03 I				1.4E+01 C	1.3E+00 C	6.4E-01 C	1.2E+03 C	1.3E+02 C	
N-NITROSODIPROPYLAMINE	621647		7.00E+00 I				9.6E-03 C	8.9E-04 C	4.5E-04 C	8.2E-01 C	9.1E-02 C	
N-NITROSO-N-ETHYLUREA	759739		1.40E+02 H				4.8E-04 C	4.5E-05 C	2.3E-05 C	4.1E-02 C	4.6E-03 C	
N-NITROSO-N-METHYLETHYLAMINE	10595956		2.20E+01 I				3.0E-03 C	2.8E-04 C	1.4E-04 C	2.6E-01 C	2.9E-02 C	
N-NITROSOPYRROLIDINE	930552		2.10E+00 I		2.10E+00 I		3.2E-02 C	3.0E-03 C	1.5E-03 C	2.7E+00 C	3.0E-01 C	
M-NITROTOLUENE	99081	2.00E-02 E				y	1.2E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N	
O-NITROTOLUENE	88722	1.00E-02 H				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
P-NITROTOLUENE	99990	1.00E-02 H				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
NUSTAR	85509199	7.00E-04 I					2.6E+01 N	2.6E+00 N	9.5E-01 N	1.4E+03 N	5.5E+01 N	
ORYZALIN	19044883	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
OXADIAZON	19668309	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
OXAMYL	23135220	2.50E-02 I					9.1E+02 N	9.1E+01 N	3.4E+01 N	5.1E+04 N	2.0E+03 N	
OXYFLUORFEN	42874033	3.00E-03 I					1.1E+02 N	1.1E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N	
PARAQUAT DICHLORIDE	1910425	4.50E-03 I					1.6E+02 N	1.6E+01 N	6.1E+00 N	9.2E+03 N	3.5E+02 N	
PARATHION	56382	6.00E-03 H					2.2E+02 N	2.2E+01 N	8.1E+00 N	1.2E+04 N	4.7E+02 N	
**PENTACHLOROBENZENE	608935	8.00E-04 I					2.9E+01 N	2.9E+00 N	1.1E+00 N	1.6E+03 N	6.3E+01 N	
**PENTACHLORONITROBENZENE	82688	3.00E-03 I	2.80E-01 H				2.6E-01 C	2.4E-02 C	1.2E-02 C	2.2E+01 C	2.5E+00 C	
PENTACHLOROPHENOL	87865	3.00E-02 I	1.20E-01 I				5.6E-01 C	5.2E-02 C	2.6E-02 C	4.8E+01 C	5.3E+00 C	
PERMETHRIN	52645531	5.00E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
PHENOL	108952	6.00E-01 I					2.2E+04 N	2.2E+03 N	8.1E+02 N	1.2E+06 N	4.7E+04 N	
M-PHENYLENEDIAMINE	108452	6.00E-03 I					2.2E+02 N	2.2E+01 N	8.1E+00 N	1.2E+04 N	4.7E+02 N	
O-PHENYLENEDIAMINE	95545		4.70E-02 H				1.4E+00 C	1.3E-01 C	6.7E-02 C	1.2E+02 C	1.4E+01 C	

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E = EPA-NCEA provisional value O = other							Risk-based concentrations				
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
P-PHENYLENEDIAMINE	106503	1.90E-01 H					6.9E+03 N	6.9E+02 N	2.6E+02 N	3.9E+05 N	1.5E+04 N
2-PHENYLPHENOL	90437		1.90E-03 H				3.5E+01 C	3.3E+00 C	1.7E+00 C	3.0E+03 C	3.4E+02 C
PHOSPHINE	7803512	3.00E-04 I		8.60E-05 I			1.1E+01 N	3.1E-01 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
PHOSPHORIC ACID	7664382			2.90E-03 I				1.1E+01 N			
PHOSPHORUS (WHITE)	7723140	2.00E-05 I					7.3E-01 N	7.3E-02 N	2.7E-02 N	4.1E+01 N	1.6E+00 N
P-PHTHALIC ACID	100210	1.00E+00 H					3.7E+04 N	3.7E+03 N	1.4E+03 N	2.0E+06 N	7.8E+04 N
PHTHALIC ANHYDRIDE	85449	2.00E+00 I		3.43E-02 H			7.3E+04 N	1.3E+02 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
POLYBROMINATED BIPHENYLS		7.00E-06 H	8.90E+00 H				7.5E-03 C	7.0E-04 C	3.5E-04 C	6.4E-01 C	7.2E-02 C
POLYCHLORINATED BIPHENYLS	1336363		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1016	12674112	7.00E-05 I	7.00E-02 I		7.00E-02 I		9.8E-01 C	8.9E-02 C	4.5E-02 C	8.2E+01 C	5.5E+00 N
AROCLOR-1221	11104282		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1232	11141165		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1242	53469219		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1248	12672296		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1254	11097691	2.00E-05 I	2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
AROCLOR-1260	11096825		2.00E+00 I		2.00E+00 I		3.3E-02 C	3.1E-03 C	1.6E-03 C	2.9E+00 C	3.2E-01 C
POLYCHLORINATED TERPHENYLS	61788338		4.50E+00 E				1.5E-02 C	1.4E-03 C	7.0E-04 C	1.3E+00 C	1.4E-01 C
POLYNUCLEAR AROMATIC HYDROCARBONS:											
**ACENAPHTHENE	83329	6.00E-02 I				y	3.7E+02 N	2.2E+02 N	8.1E+01 N	1.2E+05 N	4.7E+03 N
**ANTHRACENE	120127	3.00E-01 I				y	1.8E+03 N	1.1E+03 N	4.1E+02 N	6.1E+05 N	2.3E+04 N
BENZO[A]ANTHRACENE	56553		7.30E-01 E				9.2E-02 C	8.6E-03 C	4.3E-03 C	7.8E+00 C	8.7E-01 C
BENZO[B]FLUORANTHENE	205992		7.30E-01 E				9.2E-02 C	8.6E-03 C	4.3E-03 C	7.8E+00 C	8.7E-01 C
BENZO[K]FLUORANTHENE	207089		7.30E-02 E				9.2E-01 C	8.6E-02 C	4.3E-02 C	7.8E+01 C	8.7E+00 C
BENZO[A]PYRENE	50328		7.30E+00 I		3.10E+00 E		9.2E-03 C	2.0E-03 C	4.3E-04 C	7.8E-01 C	8.7E-02 C
CARBAZOLE	86748		2.00E-02 H				3.3E+00 C	3.1E-01 C	1.6E-01 C	2.9E+02 C	3.2E+01 C
CHRYSENE	218019		7.30E-03 E				9.2E+00 C	8.6E-01 C	4.3E-01 C	7.8E+02 C	8.7E+01 C
DIBENZO[A,H]ANTHRACENE	53703		7.30E+00 E				9.2E-03 C	8.6E-04 C	4.3E-04 C	7.8E-01 C	8.7E-02 C
DIBENZOFURAN	132649	4.00E-03 E				y	2.4E+01 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
FLUORANTHENE	206440	4.00E-02 I					1.5E+03 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
**FLUORÉNE	86737	4.00E-02 I				y	2.4E+02 N	1.5E+02 N	5.4E+01 N	8.2E+04 N	3.1E+03 N
INDENO[1,2,3-C,D]PYRENE	193395		7.30E-01 E				9.2E-02 C	8.6E-03 C	4.3E-03 C	7.8E+00 C	8.7E-01 C
2-METHYLNAPHTHALENE	91576	2.00E-02 E				y	1.2E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
**NAPHTHALENE	91203	2.00E-02 I		9.00E-04 I		y	6.5E+00 N	3.3E+00 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
**PYRENE	129000	3.00E-02 I				y	1.8E+02 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
PROMETON	1610180	1.50E-02 I					5.5E+02 N	5.5E+01 N	2.0E+01 N	3.1E+04 N	1.2E+03 N
PROMETRYN	7287196	4.00E-03 I					1.5E+02 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
PROPACHLOR	1918167	1.30E-02 I					4.7E+02 N	4.7E+01 N	1.8E+01 N	2.7E+04 N	1.0E+03 N
PROPANIL	709988	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
PROPARGITE	2312358	2.00E-02 I					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
N-PROPYLBENZENE		1.00E-02 E				y	6.1E+01 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E-02 N
PROPYLENE GLYCOL	57556	2.00E+01 H					7.3E+05 N	7.3E+04 N	2.7E+04 N	4.1E+07 N	1.6E+06 N
PROPYLENE GLYCOL, MONOETHYL ETHER	52125538	7.00E-01 H					2.6E+04 N	2.6E+03 N	9.5E+02 N	1.4E+06 N	5.5E+04 N
PROPYLENE GLYCOL, MONOMETHYL ETHER	107982	7.00E-01 H		5.70E-01 I			2.6E+04 N	2.1E+03 N	9.5E+02 N	1.4E+06 N	5.5E+04 N
PURSUIT	81335775	2.50E-01 I					9.1E+03 N	9.1E+02 N	3.4E+02 N	5.1E+05 N	2.0E+04 N
PYRIDINE	110861	1.00E-03 I					3.7E+01 N	3.7E+00 N	1.4E+00 N	2.0E+03 N	7.8E+01 N
QUINOLINE	91225		1.20E+01 H				5.6E-03 C	5.2E-04 C	2.6E-04 C	4.8E-01 C	5.3E-02 C
RDX	121824	3.00E-03 I	1.10E-01 I				6.1E-01 C	5.7E-02 C	2.9E-02 C	5.2E+01 C	5.8E+00 C
RESMETHRIN	10453868	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N
**RONNEL	299843	5.00E-02 H					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N
ROTENONE	83794	4.00E-03 I					1.5E+02 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N
SELENIOS ACID	7783008	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
SELENIUM	7782492	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
SILVER	7440224	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N
SIMAZINE	122349	5.00E-03 I	1.20E-01 H				5.6E-01 C	5.2E-02 C	2.6E-02 C	4.8E+01 C	5.3E+00 C

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Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg	
SODIUM AZIDE	26628228	4.00E-03 I					1.5E+02 N	1.5E+01 N	5.4E+00 N	8.2E+03 N	3.1E+02 N	
SODIUM DIETHYLDIETHIOCARBAMATE	148185	3.00E-02 I	2.70E-01 H				2.5E-01 C	2.3E-02 C	1.2E-02 C	2.1E+01 C	2.4E+00 C	
STRONTIUM, STABLE	7440246	6.00E-01 I					2.2E+04 N	2.2E+03 N	8.1E+02 N	1.2E+06 N	4.7E+04 N	
STRYCHNINE	57249	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N	
STYRENE	100425	2.00E-01 I		2.88E-01 I		y	1.6E+03 N	1.0E+03 N	2.7E+02 N	4.1E+05 N	1.6E+04 N	
2,3,7,8-TETRACHLORODIBENZODIOXIN	1748016		1.50E+05 H		1.50E+05 H		4.5E-07 C	4.2E-08 C	2.1E-08 C	3.8E-05 C	4.3E-06 C	
**1,2,4,5-TETRACHLOROBENZENE	95943	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N	
1,1,1,2-TETRACHLOROETHANE	630206	3.00E-02 I	2.60E-02 I		2.80E-02 I	y	4.1E-01 C	2.4E-01 C	1.2E-01 C	2.2E+02 C	2.5E+01 C	
1,1,2,2-TETRACHLOROETHANE	79345	6.00E-02 E	2.00E-01 I		2.00E-01 I	y	5.3E-02 C	3.1E-02 C	1.8E-02 C	2.9E+01 C	3.2E+00 C	
TETRACHLOROETHENE	127184	1.00E-02 I	5.20E-02 E	1.4E-01 E	2.00E-03 E	y	1.1E+00 C	3.1E+00 C	6.1E-02 C	1.1E+02 C	1.2E+01 C	
2,3,4,6-TETRACHLOROPHENOL	58902	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N	
**P,A,A-A-TETRACHLOROTOLUENE	5216251		2.00E+01 H				3.3E-03 C	3.1E-04 C	1.8E-04 C	2.9E-01 C	3.2E-02 C	
1,1,1,2-TETRAFLUOROETHANE	811972			2.29E+01 I		y	1.7E+05 N	8.4E+04 N				
**TETRAHYDROFURAN	109999	2.00E-02 E	7.6E-03 E	8.6E-02 E	6.8E-03 E		8.8E+00 C	9.2E-01 C	4.2E-01 C	7.5E+02 C	8.4E+01 C	
TETRYL	479458	1.00E-02 H					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
THALLIC OXIDE	1314325	7.00E-05 W					2.8E+00 N	2.6E-01 N	9.5E-02 N	1.4E+02 N	5.5E+00 N	
THALLIUM	7440280	7.00E-05 O					2.8E+00 N	2.6E-01 N	9.5E-02 N	1.4E+02 N	5.5E+00 N	
THALLIUM ACETATE	563688	9.00E-05 I					3.3E+00 N	3.3E-01 N	1.2E-01 N	1.8E+02 N	7.0E+00 N	
THALLIUM CARBONATE	6533739	8.00E-05 I					2.9E+00 N	2.9E-01 N	1.1E-01 N	1.8E+02 N	6.3E+00 N	
THALLIUM CHLORIDE	7791120	8.00E-05 I					2.9E+00 N	2.9E-01 N	1.1E-01 N	1.6E+02 N	6.3E+00 N	
THALLIUM NITRATE	10102451	9.00E-05 I					3.3E+00 N	3.3E-01 N	1.2E-01 N	1.8E+02 N	7.0E+00 N	
THALLIUM SULFATE (2:1)	7446186	8.00E-05 I					2.9E+00 N	2.9E-01 N	1.1E-01 N	1.6E+02 N	6.3E+00 N	
THIOBENCARB	28249776	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
TIN	7440315	6.00E-01 H					2.2E+04 N	2.2E+03 N	8.1E+02 N	1.2E+06 N	4.7E+04 N	
TITANIUM	7440326	4.00E+00 E		8.60E-03 E			1.5E+05 N	3.1E+01 N	5.4E+03 N	8.2E+06 N	3.1E+05 N	
TITANIUM DIOXIDE	13463677	4.00E+00 E		8.60E-03 E			1.5E+05 N	3.1E+01 N	5.4E+03 N	8.2E+06 N	3.1E+05 N	
TOLUENE	108883	2.00E-01 I		1.14E-01 I		y	7.5E+02 N	4.2E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N	
TOLUENE-2,4-DIAMINE	95807		3.20E+00 H				2.1E-02 C	2.0E-03 C	9.9E-04 C	1.8E+00 C	2.0E-01 C	
TOLUENE-2,5-DIAMINE	95705	6.00E-01 H					2.2E+04 N	2.2E+03 N	8.1E+02 N	1.2E+06 N	4.7E+04 N	
TOLUENE-2,6-DIAMINE	823405	2.00E-01 H					7.3E+03 N	7.3E+02 N	2.7E+02 N	4.1E+05 N	1.6E+04 N	
P-TOLUIDINE	106490		1.90E-01 H				3.5E-01 C	3.3E-02 C	1.7E-02 C	3.0E+01 C	3.4E+00 C	
**TOXAPHENE	8001352		1.10E+00 I		1.10E+00 I		6.1E-02 C	5.7E-03 C	2.9E-03 C	5.2E+00 C	5.8E-01 C	
**1,2,4-TRIBROMOBENZENE	615543	5.00E-03 I					1.8E+02 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
TRIBUTYL TIN OXIDE	56359	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N	
2,4,6-TRICHLOROANILINE	634935		3.40E-02 H				2.0E+00 C	1.8E-01 C	9.3E-02 C	1.7E+02 C	1.9E+01 C	
1,2,4-TRICHLOROBENZENE	120821	1.00E-02 I		5.70E-02 H		y	1.9E+02 N	2.1E+02 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
1,1,1-TRICHLOROETHANE	71556	2.00E-02 E		2.86E-01 E		y	5.4E+02 N	1.0E+03 N	2.7E+01 N	4.1E+04 N	1.6E+03 N	
1,1,2-TRICHLOROETHANE	79005	4.00E-03 I	5.70E-02 I		5.60E-02 I	y	1.9E-01 C	1.1E-01 C	5.5E-02 C	1.0E+02 C	1.1E+01 C	
TRICHLOROETHENE	79016	6.00E-03 E	1.10E-02 E		6.00E-03 E	y	1.6E+00 C	1.0E+00 C	2.9E-01 C	5.2E+02 C	5.8E+01 C	
TRICHLOROFLUOROMETHANE	75694	3.00E-01 I		2.00E-01 A		y	1.3E+03 N	7.3E+02 N	4.1E+02 N	6.1E+05 N	2.3E+04 N	
2,4,5-TRICHLOROPHENOL	95954	1.00E-01 I					3.7E+03 N	3.7E+02 N	1.4E+02 N	2.0E+05 N	7.8E+03 N	
2,4,6-TRICHLOROPHENOL	88062		1.10E-02 I		1.00E-02 I		6.1E+00 C	6.3E-01 C	2.9E-01 C	5.2E+02 C	5.8E+01 C	
2,4,5-T	93765	1.00E-02 I					3.7E+02 N	3.7E+01 N	1.4E+01 N	2.0E+04 N	7.8E+02 N	
2-(2,4,5-TRICHLOROPHENOXY)PROPIONIC ACID	93721	8.00E-03 I					2.9E+02 N	2.9E+01 N	1.1E+01 N	1.6E+04 N	6.3E+02 N	
1,1,2-TRICHLOROPROPANE	598776	5.00E-03 I				y	3.0E+01 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
1,2,3-TRICHLOROPROPANE	96184	6.00E-03 I	7.00E+00 H			y	1.5E-03 C	8.9E-04 C	4.5E-04 C	8.2E-01 C	9.1E-02 C	
1,2,3-TRICHLOROPROPENE	96195	5.00E-03 H				y	3.0E+01 N	1.8E+01 N	6.8E+00 N	1.0E+04 N	3.9E+02 N	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	76131	3.00E+01 I		8.60E+00 H		y	5.9E+04 N	3.1E+04 N	4.1E+04 N	6.1E+07 N	2.3E+06 N	
1,2,4-TRIMETHYLBENZENE	95636	5.00E-02 E		1.70E-03 E		y	1.2E+01 N	6.2E+00 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
1,3,5-TRIMETHYLBENZENE	108678	5.00E-02 E		1.70E-03 E		y	1.2E+01 N	6.2E+00 N	6.8E+01 N	1.0E+05 N	3.9E+03 N	
TRIMETHYL PHOSPHATE	512561		3.70E-02 H				1.8E+00 C	1.7E-01 C	8.5E-02 C	1.5E+02 C	1.7E+01 C	
1,3,5-TRINITROBENZENE	99354	3.00E-02 I					1.1E+03 N	1.1E+02 N	4.1E+01 N	6.1E+04 N	2.3E+03 N	
2,4,6-TRINITROTOLUENE	118967	5.00E-04 I	3.00E-02 I				2.2E+00 C	2.1E-01 C	1.1E-01 C	1.9E+02 C	2.1E+01 C	
URANIUM (SOLUBLE SALTS)		3.00E-03 I					1.1E+02 N	1.1E+01 N	4.1E+00 N	6.1E+03 N	2.3E+02 N	

Sources I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST E = EPA-NCEA provisional value O = other							Basis: C = Carcinogenic effects N = Noncarcinogenic effects I = RBC at HI of 0.1 < RBC-c Risk-based concentrations				
Chemical	CAS	RfDo mg/kg/d	CSF _o 1/mg/kg/d	RfDI mg/kg/d	CSF _I 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m ³	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg
VANADIUM	7440622	7.00E-03 H					2.6E+02 N	2.6E+01 N	9.5E+00 N	1.4E+04 N	5.5E+02 N
VANADIUM PENTOXIDE	1314621	9.00E-03 I					3.3E+02 N	3.3E+01 N	1.2E+01 N	1.8E+04 N	7.0E+02 N
VANADIUM SULFATE	16785812	2.00E-02 H					7.3E+02 N	7.3E+01 N	2.7E+01 N	4.1E+04 N	1.6E+03 N
VINCLOZOLIN	50471448	2.50E-02 I					9.1E+02 N	9.1E+01 N	3.4E+01 N	5.1E+04 N	2.0E+03 N
VINYL ACETATE	108054	1.00E+00 H		5.71E-02 I		y	4.1E+02 N	2.1E+02 N	1.4E+03 N	2.0E+06 N	7.8E+04 N
VINYL CHLORIDE	75014		1.90E+00 H		3.00E-01 H	y	1.9E-02 C	2.1E-02 C	1.7E-03 C	3.0E+00 C	3.4E-01 C
WARFARIN	81812	3.00E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
M-XYLENE	108383	2.00E+00 H				y	1.2E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
O-XYLENE	95476	2.00E+00 H				y	1.2E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
P-XYLENE	108423					y					
XYLENES	1330207	2.00E+00 I				y	1.2E+04 N	7.3E+03 N	2.7E+03 N	4.1E+06 N	1.6E+05 N
ZINC	7440666	3.00E-01 I					1.1E+04 N	1.1E+03 N	4.1E+02 N	6.1E+05 N	2.3E+04 N
ZINC PHOSPHIDE	1314847	3E-04 I					1.1E+01 N	1.1E+00 N	4.1E-01 N	6.1E+02 N	2.3E+01 N
ZINEB	12122677	5E-02 I					1.8E+03 N	1.8E+02 N	6.8E+01 N	1.0E+05 N	3.9E+03 N

APPENDIX E.2

**CONNECTICUT REMEDIATION STANDARD REGULATIONS (RSRs)
DIRECT EXPOSURE (RESIDENTIAL AND INDUSTRIAL)
CONNECTICUT RSRs FOR POLLUTANT MOBILITY (GB CLASSIFIED AREA)
CONNECTICUT RSRs FOR THE PROTECTION OF
GROUNDWATER(GA/GAA)**

SUMMARY OF NUMERICAL CRITERIA
Remediation Standard Regulations
Appendices A, B, C, D, E, and F
January 1996

Media	Soil				Groundwater/Surface Water				Soil Vapor	
	RES DE (mg/kg)	IC DE (mg/kg)	GAGAA PM (mg/kg)	GB PM (mg/kg)	GAGAA GP (ug/L)	SWP (ug/L)	RES Vol. (ug/L)	IC Vol. (ug/L)	RES Vol. (ppm)	IC Vol. (ppm)
VOLATILE ORGANIC SUBSTANCES										
Acetone	500	1000	14	140	700	NE	50000	50000	2400	8250
Acrylonitrile	1.1	11	0.01	0.1	0.5	20	NE	NE	NE	NE
Benzene	21	200	0.02	0.2	1	710	215	530	1	113
Bromoform	78	720	0.08	0.8	4	10800	920	3800	1.5	6
2-Butanone (MEK)	500	1000	8	80	400	NE	50000	50000	2400	8285
Carbon tetrachloride	4.7	44	0.1	1	5	132	16	40	1	2.7
Chlorobenzene	500	1000	2	20	100	420000	1800	6150	31	106
Chloroform	100	940	0.12	1.2	6	14100	287	710	4.5	10.4
Dibromochloromethane	7.3	68	0.01	0.1	0.5	1020	NE	NE	NE	NE
1,2-Dichlorobenzene (2 DCB)	500	1000	3.1	3.1	600	170000	30500	50000	240	818
1,3-Dichlorobenzene (3 DCB)	500	1000	12	120	600	26000	24200	50000	240	818
1,4-Dichlorobenzene (4 DCB)	26	240	1.5	15	75	26000	50000	50000	950	3270
1,1,-Dichloroethane (11DCA)	500	1000	1.4	14	70	NE	34800	50000	850	3037
1,2-Dichloroethane (12DCA)	6.7	63	0.02	0.2	1	2970	21	90	1	1
1,1-Dichloroethylene (11DCE)	1	9.5	0.14	1.4	7	96	1	6	1	1
cis-1,2-Dichloroethylene	500	1000	1.4	14	70	NE	NE	NE	NE	NE
trans-1,2-Dichloroethylene	500	1000	2	20	100	NE	NE	NE	NE	NE
1,2-Dichloropropane	9	84	0.1	1	5	NE	14	60	1	1
1,3-Dichloropropane	3.4	32	0.01	0.1	0.5	34000	6	25	1	1
Ethylbenzene	500	1000	10.1	10.1	700	580000	50000	50000	1650	5672
Ethylene dibromide (EDB)	0.007	0.067	0.01	0.1	0.05	NE	4	16	1	1
Methyl-tert-butyl-ether (MTBE)	500	1000	2	20	100	NE	50000	50000	1000	3415
Methyl isobutyl ketone (MIBK)	500	1000	7	14	350	NE	50000	50000	140	480
Methylene chloride	82	780	0.1	1	5	48000	50000	50000	1200	2907
Styrene	500	1000	2	20	100	NE	580	2085	8	28
1,1,1-Tetrachloroethane	24	220	0.02	0.2	1	NE	12	50	1	1.5
1,1,2-Tetrachloroethane	3.1	28	0.01	0.1	0.5	110	23	100	1	1
Tetrachloroethylene (PCE)	12	110	0.1	1	5	88	1500	3820	11	27
Toluene	500	1000	20	67	1000	400000	23500	50000	780	2615
1,1,1-Trichloroethane (TCA)	500	1000	4	40	200	62000	20400	50000	1310	4520
1,1,2-Trichloroethane	11	100	0.1	1	5	1280	8000	19600	40	93
Trichloroethylene (TCE)	56	520	0.1	1	5	2340	219	540	7	16
Vinyl chloride	0.32	3	0.04	0.4	2	15750	2	2	1	1
Xylenes	500	1000	19.5	19.5	530	NE	21300	50000	500	1702
Total Petroleum Hydrocarbons	500	2500	500	2500	500	NE	NE	NE	NE	NE
INORGANIC SUBSTANCES & PCBs										
Antimony (Sb)	27	8200	0.008	0.08	6	86000	NE	NE	NE	NE
Arsenic (Ar)	10	10	0.05	0.5	50	4	NE	NE	NE	NE
Asbestos	NE	NE	NE	NE	7 (mf)	7 (mf)	NE	NE	NE	NE
Barium (Ba)	4700	140000	1	10	1000	NE	NE	NE	NE	NE
Beryllium (Be)	2	2	0.004	0.04	4	4	NE	NE	NE	NE
Cadmium (Cd)	34	1000	0.005	0.05	5	6	NE	NE	NE	NE
Chromium, trivalent (Cr+3)	3900	51000	NE	NE	NE	1200	NE	NE	NE	NE
Chromium, hexavalent (Cr+6)	100	100	NE	NE	NE	110	NE	NE	NE	NE
Chromium, total (Cr)	NE	NE	0.05	0.5	50	NE	NE	NE	NE	NE
Copper (Cu)	2500	76000	1.3	13	1300	48	NE	NE	NE	NE
Cyanide (Cn)	1400	41000	NE	NE	200	52	NE	NE	NE	NE
Cyanide (by SPLP only) (Cn)	NE	NE	0.2	2	NE	NE	NE	NE	NE	NE
Lead (Pb)	500	1000	0.015	0.15	15	13	NE	NE	NE	NE
Mercury (Hg)	20	610	0.002	0.02	2	0.4	NE	NE	NE	NE
Nickel (Ni)	1400	7500	0.1	1	100	880	NE	NE	NE	NE
Selenium (Se)	340	10000	0.05	0.5	50	50	NE	NE	NE	NE
Silver (Ag)	340	10000	0.036	0.36	36	12	NE	NE	NE	NE
Thallium (Tl)	5.4	160	0.005	0.05	5	63	NE	NE	NE	NE
Vanadium (V)	470	14000	0.05	0.5	50	NE	NE	NE	NE	NE
Zinc (Zn)	20000	610000	5	50	5000	123	NE	NE	NE	NE
Polychlorinated Biphenyls (PCBs)	1	10	0.0005	0.005	0.5	0.5	NE	NE	NE	NE

SUMMARY OF NUMERICAL CRITERIA
Remediation Standard Regulations
Appendices A, B, C, D, E, and F
January 1996

Media	Soil				Groundwater/Surface Water				Soil Vapor	
	RES DE (mg/kg)	IC DE (mg/kg)	GA/GAA PM (mg/kg)	GB PM (mg/kg)	GA/GAA GP (ug/L)	SWP (ug/L)	RES Vol. (ug/L)	IC Vol. (ug/L)	RES Vol. (ppm)	IC Vol. (ppm)
SEMI-VOLATILE ORGANICS										
Acenaphthylene	1000	2500	8.4	84	420	0.3	NE	NE	NE	NE
Anthracene	1000	2500	40	400	2000	1100000	NE	NE	NE	NE
Benzo(a)anthracene	1	7.8	1	1	0.06	0.3	NE	NE	NE	NE
Benzo(b)fluoranthene	1	7.8	1	1	0.08	0.3	NE	NE	NE	NE
Benzo(k)fluoranthene	8.4	78	1	1	0.5	0.3	NE	NE	NE	NE
Benzo(a)pyrene	1	1	1	1	0.2	0.3	NE	NE	NE	NE
Bis(2-chloroethyl)ether	1	5.2	1	2.4	12	42	NE	NE	NE	NE
Bis(2-chloroisopropyl)ether	8.8	82	1	2.4	12	3400000	NE	NE	NE	NE
Bis(2-ethyl hexyl)phthalate	44	410	1	11	2	59	NE	NE	NE	NE
Butyl benzyl phthalate	1000	2500	20	200	1000	NE	NE	NE	NE	NE
2-chlorophenol	340	2500	1	7.2	38	NE	NE	NE	NE	NE
Di-n-butyl phthalate	1000	2500	14	140	700	120000	NE	NE	NE	NE
Di-n-octyl phthalate	1000	2500	2	20	100	NE	NE	NE	NE	NE
2,4-Dichlorophenol	200	2500	1	4	20	15800	NE	NE	NE	NE
Fluoranthene	1000	2500	5.6	56	280	3700	NE	NE	NE	NE
Fluorene	1000	2500	5.6	56	280	140000	NE	NE	NE	NE
Hexachloroethane	44	410	1	1	3	89	NE	NE	NE	NE
Hexachlorobenzene	1	3.6	1	1	1	0.077	NE	NE	NE	NE
Naphthalene	1000	2500	5.6	56	280	NE	NE	NE	NE	NE
Pentachlorophenol	5.1	48	1	1	1	NE	NE	NE	NE	NE
Phenanthrene	1000	2500	4	40	200	6000	NE	NE	NE	NE
Phenol	1000	2500	80	800	4000	8200000	NE	NE	NE	NE
Pyrene	1000	2500	4	40	200	110000	NE	NE	NE	NE
PESTICIDES										
Alachlor	7.7	72	0.23	0.4	2	NE	NE	NE	NE	NE
Aldicarb	14	410	1	1	3	NE	NE	NE	NE	NE
Atrazine	2.8	26	0.2	0.2	3	NE	NE	NE	NE	NE
Chlordane	0.49	2.2	0.066	0.066	0.3	0.3	NE	NE	NE	NE
Dieldrin	0.038	0.38	0.007	0.007	0.002	0.1	NE	NE	NE	NE
Endrin	20	610	NE	NE	NE	0.1	NE	NE	NE	NE
2,4 D	680	20000	1.4	14	70	NE	NE	NE	NE	NE
Heptachlor epoxide	0.067	0.63	0.02	0.02	0.2	0.05	NE	NE	NE	NE
Heptachlor	0.14	1.3	0.013	0.013	0.4	0.05	NE	NE	NE	NE
Lindane	20	610	0.02	0.04	0.2	NE	NE	NE	NE	NE
Methoxychlor	340	10000	0.8	8	40	NE	NE	NE	NE	NE
Simazine	NE	NE	0.8	8	4	NE	NE	NE	NE	NE
Toxaphene	0.56	5.2	0.33	0.6	3	1	NE	NE	NE	NE

Abbreviations

RES = Residential
 PM = Pollutant Mobility Criteria
 Vol. = Volatilization Criteria
 ug/L = micrograms per liter or parts per billion
 mg/kg = milligrams per kilogram or ppm

IC = Industrial/Commercial
 SWP = Surface Water Protection Criteria
 GP = Groundwater Protection Criteria
 NE = None Established by DEP
 ppm = parts per million

(1) TCLP or SPLP (mg/L)

Complements of: EPOC

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)				Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC
acenaphthene	1000	2500	8.4	84	420	NE	NE	NE
aldrin	0.036	0.34	In Review	In Review	In Review	NE	NE	NE
benzo(g,h,i)perylene ⁸	1000	2500	4.2	42	210	NE	NE	NE
benzoic acid	1000	2500	1000	10000	50000	NE	NE	NE
BHC(alpha-)	0.097	0.91	In Review	In Review	In Review	NE	NE	NE
BHC(beta-)	0.34	3.2	In Review	In Review	In Review	NE	NE	NE
BHC(delta) ¹	0.097	0.91	In Review	In Review	In Review	NE	NE	NE
bromodichloromethane	9.9	92	0.011	0.11 ²	0.56	NE	NE	NE
bromomethane	95	1000	0.2	2	9.8	NE	NE	NE
4-bromophenyl-phenylether	500	1000	8.2	82	410	NE	NE	NE
n-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE
sec-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE
tert-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)				Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC
carbazole	31	290	1 #	1 #	10 #	NE	NE	NE
carbon disulfide	500	1000	14	140	700	NE	NE	NE
4-chloroaniline	270	2500	1 #	5.6	28	NE	NE	NE
chloromethane	47	440	0.054	0.54	2.7	NE	NE	NE
2-chloronaphthalene	1000	2500	11	110	560	NE	NE	NE
4-chlorophenyl-phenyl ether ²	500	1000	8.2	82	410	NE	NE	NE
chrysene	84	780	1 #	1 #	4.8	NE	NE	NE
m-cresol	1000	2500	7	70	350	NE	NE	NE
p-cresol	340	2500	0.7	7	35	NE	NE	NE
4,4'-DDD	2.6	24	In Review	In Review	0.15	NE	NE	NE
4,4'-DDE	1.8	17	In Review	In Review	0.1	NE	NE	NE
4,4'-DDT	1.8	17	In Review	In Review	0.1	NE	NE	NE
dibenzofuran	270	2500	1 #	5.6	28	NE	NE	NE
dibenz(a,h)anthracene	1 #	1 #	1 #	1 #	0.5 #	NE	NE	NE

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)				Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC
1,2-dibromo-3-chloropropane	0.44	4.1	In Review	In Review	In Review	NE	NE	NE
1,2-dibromoethane	0.0072	0.067	In Review	In Review	In Review	NE	NE	NE
3,3'-dichlorobenzidene	1.4	13	0.33 #	0.33 #	10 #	NE	NE	NE
1,4-dichlorobutene	0.07	0.62	In Review	In Review	In Review	NE	NE	NE
diethyl phthalate	1000	2500	110	1100	5600	NE	NE	NE
2,4-dimethylphenol	1000	2500	2.8	28	140	NE	NE	NE
dimethyl phthalate ¹⁰	1000	2500	110	1100	5600	NE	NE	NE
2,4-dinitrophenol	140	2500	1.65 #	2.8	50 #	NE	NE	NE
2,4-dinitrotoluene	140	2500	1 #	2.8	14	NE	NE	NE
2,6-dinitrotoluene	68	2000	1 #	1.4	10 #	NE	NE	NE
endosulfan I	410	1200	0.84	8.4	42	NE	NE	NE
endosulfan II	410	1200	0.84	8.4	42	NE	NE	NE
endosulfan sulfate ³	410	1200	0.84	8.4	42	NE	NE	NE

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)				Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC
endrin aldehyde ⁴	20	610	NE	NE	NE	NE	NE	NE
endrin ketone ⁵	20	610	NE	NE	NE	NE	NE	NE
hexachlorobutadiene	7.9	73	1 #	1 #	0.45	NE	NE	NE
hexachlorocyclopentadiene	470	2500	1 #	9.8	49	NE	NE	NE
indeno(1,2,3-cd)pyrene	1 #	7.8	1 #	1 #	0.5 #	NE	NE	NE
isophorone	640	2500	1 #	7.4	37	NE	NE	NE
isopropylbenzene (cumene)	500	1000	0.6	132 ¹⁴	30 ¹⁵	NE	NE	NE
4-isopropyltoluene (p-cymene)	500	1000	0.6	41.8	30 ¹⁵	NE	NE	NE
p-isopropyltoluene ⁹	NE	NE	1.4	14	70	NE	NE	NE
2-methylnaphthalene ⁷	474	2500	0.98	9.8	49	NE	NE	NE
2-methylphenol	1000	2500	7	70	350	NE	NE	NE
4-methylphenol	340	2500	1 #	7	35	NE	NE	NE
2-nitroaniline	4.1	1200	1.65 #	1.65 #	50 #	NE	NE	NE

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)				Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC
3-nitroaniline	200	2500	1.65 #	4.2	50 #	NE	NE	NE
4-nitroaniline	200	2500	1 #	4.2	21	NE	NE	NE
nitrobenzene	34	1000	1 #	1 #	10 #	NE	NE	NE
2-nitrophenol	540	2500	1.1	11	56	NE	NE	NE
N-nitrosodiphenylamine	130	1200	1 #	1.4	10 #	NE	NE	NE
N-nitrosodi-n-propylamine	1 #	1 #	1 #	1 #	10 #	NE	NE	NE
n-propylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE
1,2,4-trichlorobenzene	680	2500	1.4	14	70	NE	NE	NE
trichloroflouroethane ¹¹	NE	NE	NE	NE	20000	NE	NE	NE
trichloroflouromethane	500	1000	26	260	1300	NE	NE	NE
2,4,5-trichlorophenol	1000	2500	14	140	700	NE	NE	NE
2,4,6-trichlorophenol	56	520	1 #	1 #	10 #	NE	NE	NE
1,2,4-trimethylbenzene	500	1000	7	70	350	NE	NE	NE
1,3,5-trimethylbenzene	500	1000	7	70	350	NE	NE	NE

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

NE Not Established

Criteria based on detection limits.

Notes: ¹ BCH(alpha) used as surrogate for BCH (delta).

² 4-bromophenyl-phenyl ether used as surrogate for 4-chlorophenyl-phenyl ether.

³ Endosulfan used as surrogate for endosulfan sulfate.

⁴ Endrin used as surrogate for endrin aldehyde.

⁵ Endrin used as surrogate for endrin ketone.

⁷ Based on an interim acceptable exposure level of 0.007 mg/kg developed by DPH. Criteria to be used for screening purposes.

⁸ Pyrene used as surrogate for benzo(g,h,i)perylene.

⁹ Screening level for p-isopropyltoluene is based on isopropylbenzene as a surrogate. Also known as methylisopropylbenzene.

¹⁰ Diethyl phthalate used as surrogate for dimethyl phthalate.

¹¹ Based on odor threshold. Also known as Freon 113 and 1,1,2-trichloro-1,2,2-trifluoroethane.

¹² Based on health based GWPC of 209 µg/l; toxicity is estimated to be three fold greater than cumene.

¹³ GWPC from Region III table which incorporates inhalation and drinking exposure routes.

¹⁴ Based on health based GWPC of 660 µg/l.

¹⁵ GWPC based on odor detection from volatilization during showering.



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C-49-03-8-156

March 20, 1998

Brown & Root Environmental Project Number 7237

Mr. Mark Lewis
Connecticut Department of Environmental Protection
Water Management Bureau
Permitting, Enforcement, and Remediation Division
Federal Remediation Program
79 Elm Street
Hartford, Connecticut 06106-5127

Reference: CLEAN Contract No. N62472-90-D-1298
Contract Task Order No. 0260

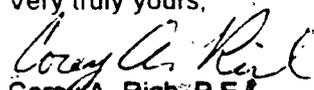
Subject: Responses to CTDEP's Comments on Calculated Remediation Standards
Lower Subbase Remedial Investigation
Naval Submarine Base - New London, Groton, Connecticut

Dear Mr. Lewis:

Brown & Root (B&R) Environmental and the Navy received your February 27, 1998 comment letter regarding the Remediation Standards that were calculated for use in the Lower Subbase Remedial Investigation. Responses to CTDEP's comments have been prepared and the appropriate revisions have been made to Tables 1 and 2, which were previously enclosed in B&R Environmental's December 23, 1997 letter. B&R Environmental, on the behalf of the United States Navy, Northern Division Facilities Engineering Command and Naval Submarine Base - New London, has enclosed the Navy's responses to CTDEP's comments and the revised tables for your review and approval.

If you have any questions regarding the responses or the information provided in the revised tables, please contact Mr. Mark Evans at (610) 595-0567 (ext. 162) or me at (412) 921-8244. It is anticipated that any remaining issues can be resolved during a conference call.

Very truly yours,


Corey A. Rich, P.E.
Project Manager

Enclosure(s)

c: Mr. Roger Boucher, NORTHDIV (letter only)
Mr. Mark Evans, NORTHDIV
Mr. Andy Stackpole, NSB-NLON Environmental
Mr. John Trepanowski, B&R Environmental
Mr. Daryl Hutson, B&R Environmental (letter only)
Ms. Karen Smecker, B&R Environmental
File: CTO 0260

**RESPONSES TO CTDEP'S COMMENTS (2/27/98)
ON THE CALCULATED CTDEP REMEDIATION STANDARDS (12/23/97)
CTO 260 - LOWER SUBBASE REMEDIAL INVESTIGATION
NAVAL SUBMARINE BASE-NEW LONDON, GROTON, CONNECTICUT
MARCH 20, 1998**

I. SURROGATE CHEMICALS USED TO SUPPLY TOXICITY VALUES

Comment:

1. The Navy has used naphthalene as a surrogate to represent the toxicity of benzo(g,h,i)perylene. As noted in Dr. Ginsberg's memorandum, pyrene (RfD 0.03 mg/kg/d) is a more appropriate surrogate. The RfD for naphthalene has been withdrawn from IRIS. Please recalculate the direct exposure, pollutant mobility, and ground water protection criteria for benzo(g,h,i)perylene using this approach. This approach is appropriate for a screening level risk assessment. However, the uncertainties involved with this approach should be acknowledged if these two chemicals are found to be major risk drivers at the site.

Response:

The direct exposure, pollutant mobility, and groundwater protection criteria for benzo(g,h,i)perylene will be recalculated using pyrene as a surrogate. Benzo(g,h,i)perylene was detected in soil and groundwater at the Lower Subbase but was not found to be a major risk driver at any of the zones that were evaluated in the risk assessment. Benzo(g,h,i)perylene was only identified as a COC in groundwater at Zone 4 where it was detected in one sample at a concentration exceeding the State's Ambient Water Quality Criteria (AWQC) for the protection of human health. Consequently, this does not have any impact on the human health risk assessment.

Comment:

2. It is unclear why the Navy calculated criteria for phenanthrene since the regulations list direct exposure, pollutant mobility, and groundwater protection criteria for this compound. Please use the criteria listed in the Regulations for this compound. The Navy should either withdraw their request for approval of criteria for phenanthrene, or, if the Navy is requesting approval of alternative criteria for this compound under the Regulations, the Navy should so state.

Response:

The Navy retracts its request for approval of criteria for phenanthrene. The promulgated criteria for phenanthrene were used in the selection of COCs in the human health risk assessment. Consequently, this does not have any impact on the human health risk assessment.

Comment:

- 3. Bromodichloromethane should be used as a surrogate for bromochloromethane. Please use the criteria calculated for bromodichloromethane in place of those calculated using chloromethane as a surrogate.**

Response:

Bromodichloromethane will be used as a surrogate for bromochloromethane. Bromodichloromethane was not detected in soil and groundwater samples for any of the zones evaluated in the human health risk assessment, consequently this does not have any impact on the analysis.

Comment:

- 4. The Navy's proposal to use 3-methylphenol as a surrogate for 4-chloro-3-methylphenol is not appropriate, due to structural differences between the two compounds. The use of a qualitative risk assessment would be acceptable assuming that concentrations of this chemical do not exceed the low part-per-billion range. Please see Dr. Ginsberg's comments for additional details.**

Response:

No criteria will be developed for 4-chloro-3-methylphenol. Instead, as suggested, 4-chloro-3-methylphenol will be evaluated qualitatively. 4-Chloro-3-methylphenol was only detected in one soil sample at the Lower Subbase and at a low concentration (34 ppb), consequently, this does not have any impact on the human health risk assessment.

II. INCORRECT OR UNSUPPORTED POTENCY VALUES

Comment:

- 5. Several of the CSFs or RfDs used by the Navy appeared to be incorrect, based on a comparison to the values listed in the EPA Region III Risk Based Concentrations table, IRIS, or HEAST. Please recalculate the direct exposure, pollutant mobility, and groundwater protection criteria using correct values for total 1,2-dichloroethene. Please assume that this value pertains to the mixture of *cis* and *trans* isomers. The RfD for the mixture should be $9E-3$ mg/kg/d.**

Response:

The direct exposure, pollutant mobility, and groundwater protection criteria for total 1,2-dichloroethene will be recalculated using an oral reference dose of $9E-3$ mg/kg/day. This revision does not impact the human health risk assessment since all detected concentrations of total 1,2-dichloroethene are less than the recalculated criteria.

Comment:

6. The Department was unable to verify the potency factors listed by the Navy for several chemicals. Please either provide references to support the listed potency factors, or derive criteria using acceptable surrogates for the following compounds: chl roethan , 4,6-dinitro-2-methylphenol, 2-hexanone, and 2-methylnaphthalene. Please note that naphthalene is not an appropriate surrogate for 2-methylnaphthalene as the RfD for naphthalene has been withdrawn from IRIS. Please refer to Dr. Ginsberg's memo for additional guidance.

Response:

The toxicity criteria for chloroethane, 4,6-dinitro-2-methylphenol, 2-hexanone, and 2-methylnaphthalene were obtained from the current U.S. EPA Region III Risk-based Concentration (RBC) Table dated October 22, 1997. The RBC table cites EPA's National Center for Environmental Assessment (NCEA) as the source for the values for chloroethane, 4,6-dinitro-2-methylphenol, and 2-methylnaphthalene. Although not cited in the RBC table, EPA Region III stated in telephone call on March 12, 1998, that NCEA is also the source for the toxicity criteria for 2-hexanone. Therefore, there are no changes necessary to the proposed values.

Comment:

7. The Department was unable to verify the RfD listed by the Navy for 4-nitrophenol (8.00E-3 mg/kg/d). Please either provide a reference for the listed value, or use the default RfD currently listed in the RBC tables (6.2E-2 mg/kg/d).

Response:

The current RBC table lists 8.00E-3 mg/kg/day as the oral RfD for 4-nitrophenol and cites EPA's NCEA as the source for the value. The value of 6.2E-2 mg/kg/day was listed in the previous, outdated version of the RBC table. Therefore, there are no changes necessary to the proposed criteria.

III. POLLUTANT MOBILITY CRITERIA FOR METALS

Comment:

8. The ground water protection criterion for cobalt was calculated correctly by the Navy. However, the approach used by the Navy in calculating pollutant mobility criteria for cobalt is unacceptable. Rather than using the calculated ground water protection criterion (420 µg/l) to establish a pollutant mobility criterion for cobalt, the Navy used the EPA Region III Risk Based Criteria for tap water (2,200 µg/L) as the GAA/GA pollutant mobility criterion. This approach is less conservative than using the calculated ground water protection criterion. The correct pollutant mobility criteria for cobalt, based on the groundwater protection criteria calculated by the Navy, are 420 µg/L for a GAA/GA area, and 4,200 µg/L for a GB area (measurement by TCLP or SPLP).

Response:

The pollutant mobility criteria for cobalt will be changed to 420 µg/L for a GAA/GA area and 4,200 µg/L for a GB area. This revision has no impact on the human health risk assessment because of the following reasons: (1) none of the historical soil samples that were analyzed by TCLP had leachates that were analyzed for cobalt, and (2) only the soil samples from Zone 6 had SPLP leachates that were analyzed for cobalt and all of the results were nondetects.

Comment:

9. The ground water protection criterion for manganese was calculated correctly by the Navy. Rather than using the calculated ground water protection criterion (160 µg/l) to establish a pollutant mobility criterion for manganese, the Navy used the EPA Secondary MCL for drinking water (50 µg/L) as the GAA/GA pollutant mobility criterion. This approach is acceptable as it is more conservative than using the calculated ground water protection criterion.

Response:

No response required.

IV. GB POLLUTANT MOBILITY CRITERIA FOR DIMETHYLPHthalate

Comment:

10. The GB pollutant mobility criteria listed for dimethylphthalate (1,400 mg/kg) in the Navy's Table 2 appears to be a typo. The correct value should be listed as 14,000 mg/kg.

Response:

The GB pollutant mobility criteria for dimethylphthalate will be corrected to 14,000 mg/kg. This revision has no impact on the analysis since dimethylphthalate was not detected in soil samples in any of the zones that were evaluated in the human health risk assessment.

V. BIS(2-CHLOROETHOXY)METHANE

Comment:

11. The Navy proposes a qualitative risk assessment for this compound. This approach is acceptable provided that the compound is not present at concentrations above the 1 w part-per-billion range. As noted by Dr. Ginsberg, if it is present above this range, a more quantitative risk assessment may be required.

Response:

Bis(2-chloroethoxy)methane was not detected in soil or groundwater samples for any of the zones evaluated in the human health risk assessment, consequently this does not have any impact on the analysis.

TABLE 1
 SOURCE OF CONNECTICUT REMEDIATION STANDARDS
 CTO 260 LOWER SUBBASE RI
 NEW LONDON, GROTON, CONNECTICUT
 PAGE 1 OF 4

Chemical	CAS Number	Chemical Fraction	Basis of Value to be Used in RI Report		
			Promulgated Value ⁽¹⁾	Calculated Value ⁽²⁾	Surrogate Calculated Value ⁽³⁾
Acenaphthene	83329	SVOC		X	
Acenaphthylene	208968	SVOC	X		
Anthracene	120127	SVOC	X		
Acetone	67641	VOC	X		
Aldrin	309002	PEST		X	
Aluminum	7429905	INORG	(4)	(4)	(4)
Antimony	7440360	INORG	X		
Arsenic	7440382	INORG	X		
Barium	7440393	INORG	X		
Benzene	71432	VOC	X		
Benz(a)anthracene	56553	SVOC	X		
Benzo(b)fluoranthene	205992	SVOC	X		
Benzo(k)fluoranthene	207089	SVOC	X		
Benzo(g,h,i)perylene	191242	SVOC			X (pyrene)
Benzo(a)pyrene	50328	SVOC	X		
Beryllium	7440417	INORG	X		
BCH (alpha-)	319846	PEST		X	
BCH (beta-)	319857	PEST		X	
BCH (delta-)	319868	PEST			X (alpha-BHC)
BCH (gamma-; Lindane)	58899	PEST	X		
Bis(2-chloroethoxy)methane	111911	SVOC	(5)	(5)	(5)
Bis(2-chloroethyl)ether	111444	SVOC	X		
Bis(2-ethylhexyl)phthalate	117817	SVOC	X		
Bromochloromethane	74975	VOC			X (bromodichloro- methane)
Bromodichloromethane	75274	VOC		X	
Bromoform	75252	VOC	X		
Bromomethane	74839	VOC		X	
4-Bromophenyl-phenylether	101553	SVOC		X	
2-Butanone	78933	VOC	X		
Butylbenzylphthalate	85687	SVOC	X		
Cadmium	7440439	INORG	X		
Calcium	7440702	INORG	(6)	(6)	(6)
Carbazole	86748	SVOC		X	
Carbon disulfide	75150	VOC		X	
Carbon tetrachloride	56235	VOC	X		
Chlordane (alpha-)	57749	PEST	X ⁽⁷⁾		
Chlordane (gamma-)	57749	PEST	X ⁽⁷⁾		
4-Chloroaniline	106478	SVOC		X	
Chlorobenzene	108907	VOC	X		
Chlorodibromomethane	124481	VOC	X		
Chloroethane	75003	VOC		X	
Chloroform	67663	VOC	X		
Chloromethane	74873	VOC		X	
4-Chloro-3-methylphenol	59507	SVOC	(5)	(5)	(5)

TABLE 1
SOURCE OF CONNECTICUT REMEDIATION STANDARDS
CTO 260 LOWER SUBBASE RI
NEW LONDON, GROTON, CONNECTICUT
 PAGE 2 OF 4

Chemical	CAS Number	Chemical Fraction	Basis of Value to be Used in RI Report		
			Promulgated Value ⁽¹⁾	Calculated Value ⁽²⁾	Surrogate Calculated Value ⁽³⁾
2-Chloronaphthalene	91587	SVOC		X	
2-Chlorophenol	95578	SVOC	X		
4-Chlorophenyl-phenylether	7005723	SVOC			X (4-Bromophenyl-phenylether)
Chromium (total)		INORG	X ⁽⁶⁾		
Chrysene	218019	SVOC		X	
Cobalt	7440484	INORG		X	
Copper	7440508	INORG	(4)	(4)	(4)
4,4'-DDD	72548	PEST		X	
4,4'-DDE	72559	PEST		X	
4,4'-DDT	50293	PEST		X	
Dibenzofuran	132649	SVOC		X	
Dibenz(a,h)anthracene	53703	SVOC		X	
1,2-Dibromo-3-chloropropane	96128	VOC		X	
1,2-Dibromoethane	106934	VOC		X	
1,2-Dichlorobenzene	95501	VOC/SVOC	X		
1,3-Dichlorobenzene	541731	VOC/SVOC	X		
1,4-Dichlorobenzene	106467	VOC/SVOC	X		
3,3'-Dichlorobenzidine	91941	SVOC		X	
1,1-Dichloroethane	75343	VOC	X		
1,2-Dichloroethane	107062	VOC	X		
1,1-Dichloroethene	75354	VOC	X		
1,2-Dichloroethene (cis-)	156592	VOC	X		
1,2-Dichloroethene (trans-)	156605	VOC	X		
1,2-Dichloroethene (total)	156605	VOC		X	
2,4-Dichlorophenol	120832	SVOC	X		
1,2-Dichloropropane	78875	VOC	X		
1,3-Dichloropropene (cis-)	542756	VOC	X		
1,3-Dichloropropene (trans-)	542756	VOC	X		
Dieldrin	60571	PEST	X		
Diethyl phthalate	84662	SVOC		X	
2,4-Dimethylphenol	105679	SVOC		X	
Dimethylphthalate	131113	SVOC		X	
Di-n-butylphthalate	84742	SVOC	X		
Di-n-octylphthalate	117840	SVOC	X		
4,6-Dinitro-2-methylphenol	534521	SVOC		X	
2,4-Dinitrophenol	51285	SVOC		X	
2,4-Dinitrotoluene	121142	SVOC		X	
2,6-Dinitrotoluene	606202	SVOC		X	
Endosulfan I	115297	PEST		X ⁽⁹⁾	
Endosulfan II	115297	PEST		X ⁽⁹⁾	
Endosulfan sulfate	1031078	PEST			X (endosulfan)
Endrin	72208	PEST	X		
Endrin aldehyde	7421363	PEST			X (endrin)
Endrin ketone	53494705	PEST			X (endrin)

TABLE 1

SOURCE OF CONNECTICUT REMEDIATION STANDARDS
CTO 260 LOWER SUBBASE RI
NEW LONDON, GROTON, CONNECTICUT
PAGE 3 OF 4

Chemical	CAS Number	Chemical Fraction	Basis of Value to be Used in RI Report		
			Promulgated Value ⁽¹⁾	Calculated Value ⁽²⁾	Surrogate Calculated Value ⁽³⁾
Ethylbenzene	100414	VOC	X		
Fluoranthene	206440	SVOC	X		
Fluorene	86737	SVOC	X		
Heptachlor	76448	PEST	X		
Heptachlor epoxide	1024573	PEST	X		
Hexachlorobenzene	118741	SVOC	X		
Hexachlorobutadiene	87683	SVOC		X	
Hexachlorocyclopentadiene	77474	SVOC		X	
Hexachloroethane	67721	SVOC	X		
2-Hexanone	73663715	VOC		X	
Indeno(1,2,3-cd)pyrene	193395	SVOC		X	
Iron	7439896	INORG	(4)	(4)	(4)
Isophorone	78591	SVOC		X	
Lead	7439291	INORG	X		
Magnesium	7439954	INORG	(6)	(6)	(6)
Manganese	7439965	INORG		X	
Mercury	7439976	INORG	X		
Methoxychlor	72435	PEST	X		
Methylene chloride	75092	VOC	X		
2-Methylnaphthalene	91576	SVOC		X	
4-Methyl-2-pentanone	108101	VOC	X		
2-Methylphenol	95487	SVOC		X	
4-Methylphenol	106445	SVOC		X	
Naphthalene	91203	SVOC	X		
Nickel	7440020	INORG	X		
2-Nitroaniline	88744	SVOC		X	
3-Nitroaniline	99092	SVOC		X	
4-Nitroaniline	100016	SVOC		X	
Nitrobenzene	98953	SVOC		X	
2-Nitrophenol	88755	SVOC			X (4-nitrophenol)
4-Nitrophenol	100027	SVOC		X	
N-Nitrosodiphenylamine	86306	SVOC		X	
N-Nitrosodi-n-propylamine	621647	SVOC		X	
2,2'-Oxybis(1-chloropropane)	108601	SVOC	(5)	(5)	(5)
Pentachlorophenol	87865	SVOC	X		
Phenanthrene	85018	SVOC	X		
Phenol	108952	SVOC	X		
Potassium	7440097	INORG	(6)	(6)	(6)
Pyrene	129000	SVOC	X		
Selenium	7782492	INORG	X		
Silver	7440224	INORG	X		
Sodium	7440235	INORG	(6)	(6)	(6)
Styrene	100425	VOC	X		
1,1,2,2-Tetrachloroethane	79345	VOC	X		
Tetrachloroethylene	127184	VOC	X		
Thallium	6533739	INORG	X		
Toluene	108883	VOC	X		
Toxaphene	8001352	PEST	X		

TABLE 1
SOURCE OF CONNECTICUT REMEDIATION STANDARDS
CTO 260 LOWER SUBBASE RI
NEW LONDON, GROTON, CONNECTICUT
PAGE 4 OF 4

Chemical	CAS Number	Chemical Fraction	Basis of Value to be Used in RI Report		
			Promulgated Value ⁽¹⁾	Calculated Value ⁽²⁾	Surrogate Calculated Value ⁽³⁾
1,2,4-Trichlorobenzene	120821	SVOC		X	
1,1,1-Trichloroethane	71556	VOC	X		
1,1,2-Trichloroethane	79005	VOC	X		
Trichloroethylene	79016	VOC	X		
2,4,5-Trichlorophenol	95954	SVOC		X	
2,4,6-Trichlorophenol	88062	SVOC		X	
Vanadium	7440622	INORG	X		
Vinyl chloride	75014	VOC	X		
Xylene (total)	1330207	VOC	X		
Zinc	7440666	INORG	X		

INORG Inorganic
 PEST Pesticide
 SVOC Semivolatile organic compound
 VOC Volatile organic compound

- 1 State of Connecticut Remediation Standard Regulations, Section 22a-133k (January 1996)
- 2 Published toxicity criteria is available Toxicity criteria from the current USEPA Region III Risk-Based Concentration Table (October 22, 1997) will be used to calculate a value using the methodology presented in the State guidance (January 1996)
- 3 No toxicity criteria is available. Toxicity criteria for a similarly structured chemical (noted in parentheses) will be used to calculate a value
- 4 Region I does not advocate a quantitative evaluation of this chemical. Exposure to this chemical will be addressed in a qualitative fashion
- 5 No promulgated value or published toxicity criteria are available A similarly structured chemical with published toxicity criteria could not be identified Exposure to this chemical will be addressed in a qualitative fashion
- 6 Chemical is an essential nutrient.
- 7 Value for chlordane is used
- 8 Value for hexavalent chromium is used for conservative purposes
- 9 Value for endosulfan is used

TABLE 2

CALCULATED AND SURROGATE CALCULATED VALUES
 CTO 260 LOWER SUBBASE RI
 NEW LONDON, GROTON, CONNECTICUT
 PAGE 1 OF 3

Chemical	Published Toxicological Criteria ⁽¹⁾		Calculated Remediation Standards ⁽²⁾				Groundwater (ug/L)
	RfD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)	Soil (mg/kg)				
			RES DE ⁽³⁾	I/C DE ⁽³⁾	GA/GAA PM	GB PM	GA/GAA GP
Acenaphthene	6.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	8.4	84	420
Aldrin	3.00E-05	1.70E+01	0.036	0.34	0.000041	0.00041	0.0021
Benzo(g,h,i)perylene	NA	NA	1000 ⁽⁵⁾	2500 ⁽⁵⁾	4 ⁽⁵⁾	40 ⁽⁵⁾	200 ⁽⁵⁾
BCH (alpha-)	NA	6.30E+00	0.097	0.91	0.00011	0.0011	0.0056
BCH (beta-)	NA	1.80E+00	0.34	3.2	0.00039	0.0039	0.0194
BCH (delta-)	NA	NA	0.097 ⁽⁶⁾	0.91 ⁽⁶⁾	0.00011 ⁽⁶⁾	0.0011 ⁽⁶⁾	0.0056 ⁽⁶⁾
Bromochloromethane	NA	NA	9.9 ⁽⁷⁾	92 ⁽⁷⁾	0.011 ⁽⁷⁾	0.11 ⁽⁷⁾	0.56 ⁽⁷⁾
Bromodichloromethane	2.00E-02	6.20E-02	9.9	92	0.011	0.11	0.56
Bromomethane	1.40E-03	NA	95	1000 ⁽⁴⁾	0.2	2	9.8
4-Bromophenyl-phenylether	5.80E-02	NA	500 ⁽⁴⁾	1000 ⁽⁴⁾	8.2	82	410
Carbazole	NA	2.00E-02	31	290	0.036	0.36	1.8
Carbon disulfide	1.00E-01	NA	500 ⁽⁴⁾	1000 ⁽⁴⁾	14	140	700
4-Chloroaniline	4.00E-03	NA	270	2500 ⁽⁴⁾	0.56	5.6	28
Chloroethane	4.00E-01	2.90E-03	210	1000 ⁽⁴⁾	0.24	2.4	12
Chloromethane	NA	1.30E-02	47	440	0.054	0.54	2.7
4-Chloro-3-methylphenol	NA	NA	NA ⁽⁸⁾	NA ⁽⁸⁾	NA ⁽⁸⁾	NA ⁽⁸⁾	NA ⁽⁸⁾
2-Chloronaphthalene	8.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	11	110	560
4-Chlorophenyl-phenylether	NA	NA	500 ⁽⁹⁾	1000 ⁽⁹⁾	8.2 ⁽⁹⁾	82 ⁽⁹⁾	410 ⁽⁹⁾
Chrysene	NA	7.30E-03	84	780	0.096	0.96	4.8
Cobalt	6.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	420 ⁽¹⁰⁾	4200 ⁽¹⁰⁾	420
4,4'-DDD	NA	2.40E-01	2.6	24	0.0029	0.029	0.15
4,4'-DDE	NA	3.40E-01	1.8	17	0.0021	0.021	0.1
4,4'-DDT	5.00E-04	3.40E-01	1.8	17	0.0021	0.021	0.1
Dibenzofuran	4.00E-03	NA	270	2500 ⁽⁴⁾	0.56	5.6	28
Dibenz(a,h)anthracene	NA	7.30E+00	0.084	0.78	0.000096	0.00096	0.0048
1,2-Dibromo-3-chloropropane	NA	1.40E+00	0.44	4.1	0.0005	0.005	0.025
1,2-Dibromoethane	NA	8.50E+01	0.0072	0.067	0.0000082	0.000082	0.00041
3,3'-Dichlorobenzidine	NA	4.50E-01	1.4	13	0.0016	0.016	0.078
1,2-Dichloroethene (total)	9.00E-03	NA	500 ⁽⁴⁾	1000 ⁽⁴⁾	1.2	12	63
Diethyl phthalate	8.00E-01	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	110	1100	5600
2,4-Dimethylphenol	2.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	2.8	28	140
Dimethylphthalate	1.00E+01	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	1400	14000	70000

TABLE 2

CALCULATED AND SURROGATE CALCULATED VALUES
CTO 260 LOWER SUBASE RI
NEW LONDON, GROTON, CONNECTICUT
PAGE 2 OF 3

Chemical	Published Toxicological Criteria ⁽¹⁾		Calculated Remediation Standards ⁽²⁾				
	RfD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)	Soil (mg/kg)				Groundwater (ug/L)
			RES DE ⁽³⁾	I/C DE ⁽³⁾	GA/GAA PM	GB PM	GA/GAA GP
4,6-Dinitro-2-methylphenol	1.00E-04	NA	6.8	200	0.014	0.14	0.7
2,4-Dinitrophenol	2.00E-03	NA	140	2500 ⁽⁴⁾	0.28	2.8	14
2,4-Dinitrotoluene	2.00E-03	NA	140	2500 ⁽⁴⁾	0.28	2.8	14
2,6-Dinitrotoluene	1.00E-03	NA	68	2000	0.14	1.4	7
Endosulfan I	6.00E-03	NA	410	1200	0.84	8.4	42
Endosulfan II	6.00E-03	NA	410	1200	0.84	8.4	42
Endosulfan sulfate	NA	NA	410 ⁽¹²⁾	1200 ⁽¹²⁾	0.84 ⁽¹²⁾	8.4 ⁽¹²⁾	42 ⁽¹²⁾
Endrin aldehyde	NA	NA	20 ⁽¹³⁾	610 ⁽¹³⁾	NE ⁽¹³⁾	NE ⁽¹³⁾	NE ⁽¹³⁾
Endrin ketone	NA	NA	20 ⁽¹³⁾	610 ⁽¹³⁾	NE ⁽¹³⁾	NE ⁽¹³⁾	NE ⁽¹³⁾
Hexachlorobutadiene	2.00E-04	7.80E-02	7.9	73	0.009	0.09	0.45
Hexachlorocyclopentadiene	7.00E-03	NA	470	2500 ⁽⁴⁾	0.98	9.8	49
2-Hexanone	4.00E-02	NA	500 ⁽⁴⁾	1000 ⁽⁴⁾	5.6	56	280
Indeno(1,2,3-cd)pyrene	NA	7.30E-01	0.84	7.8	0.00096	0.0096	0.045
Isophorone	2.00E-01	9.50E-04	640	2500 ⁽⁴⁾	0.74	7.4	37
Manganese	2.30E-02	NA	1600	47000	50 ⁽¹⁰⁾⁽¹⁴⁾	500 ⁽¹⁰⁾⁽¹⁴⁾	160
2-Methylnaphthalene	4.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	5.6	56	280
2-Methylphenol	5.00E-02	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	7	70	350
4-Methylphenol	5.00E-03	NA	340	2500 ⁽⁴⁾	0.7	7	35
2-Nitroaniline	6.00E-05	NA	4.1	1200	0.0084	0.084	0.42
3-Nitroaniline	3.00E-03	NA	200	2500 ⁽⁴⁾	0.42	4.2	21
4-Nitroaniline	3.00E-03	NA	200	2500 ⁽⁴⁾	0.42	4.2	21
Nitrobenzene	5.00E-04	NA	34	1000	0.07	0.7	3.5
2-Nitrophenol	NA	NA	540 ⁽¹⁵⁾	2500 ⁽¹⁵⁾	1.1 ⁽¹⁵⁾	11 ⁽¹⁵⁾	56 ⁽¹⁵⁾
4-Nitrophenol	8.00E-03	NA	540	2500 ⁽⁴⁾	1.1	11	56
N-Nitrosodiphenylamine	NA	4.90E-03	130	1200	0.14	1.4	7.1
N-Nitrosodi-n-propylamine	NA	7.00E+00	0.088	0.82	0.0001	0.001	0.005
1,2,4-Trichlorobenzene	1.00E-02	NA	680	2500 ⁽⁴⁾	1.4	14	70
2,4,5-Trichlorophenol	1.00E-01	NA	1000 ⁽⁴⁾	2500 ⁽⁴⁾	14	140	700
2,4,6-Trichlorophenol	NA	1.10E-02	56	520	0.064	0.64	3.2

RfD Reference dose
CSF Cancer slope factor

TABLE 2

CALCULATED AND SURROGATE CALCULATED VALUES
 CTO 260 LOWER SUBBASE RI
 NEW LONDON, GROTON, CONNECTICUT
 PAGE 3 OF 3

RES DE	Direct exposure criteria for residential land use
I/C DE	Direct exposure criteria for industrial/commercial land use
GA/GAA PM	Pollutant mobility criteria for a GA/GAA classified area
GB PM	Pollutant mobility criteria for a GB classified area
GA/GAA GP	Groundwater protection criteria for a GA/GAA classified area
NA	Not available
NE	None established by Connecticut DEP (January 1996)

- 1 Values obtained from current USEPA Region III Risk-Based Concentration Table (October 22, 1997)
- 2 Calculated using methodologies presented in State guidance (January 1996).
- 3 Calculated value for direct exposure for volatile and semivolatile organics is replaced with the appropriate ceiling limit if the calculated value exceeds the ceiling limit. Ceiling limit for volatiles is 500 mg/kg for residential exposure and 1000 mg/kg for industrial/commercial exposure. Ceiling limit for semivolatiles is 1000 mg/kg for residential exposure and 2500 mg/kg for industrial/commercial exposure
- 4 Ceiling limit. Calculated value exceeds the ceiling limit
- 5 Value for pyrene is used.
- 6 Value for alpha-BHC is used
- 7 Value for bromodichloromethane is used
- 8 Chemical will be addressed qualitatively at CTEP's request
- 9 Value for 4-bromophenyl-phenylether is used
- 10 Value is for aqueous units (ug/L) and is based on SPLP or TCLP analytical results
- 11 Value is based on the Region III RBC for tap water (2200 ug/L)
- 12 Value for endosulfan is used.
- 13 Value for endrin is used.
- 14 Value is based on the secondary Federal MCL for drinking water (50 ug/L).
- 15 Value for 4-nitrophenol is used



TETRA TECH NUS, INC.

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PITT-04-9-102

April 14, 1999

Tetra Tech NUS Project Number 7856

Ms. Elsie Patton
Connecticut Department of Environmental Protection
Bureau of Water Management
Permitting, Enforcement, and Remediation Division
Federal Remediation Program
79 Elm Street
Hartford, Connecticut 06106-5127

Reference: CLEAN Contract No. N62472-90-D-1298
Contract Task Order No. 0312

Subject: March 16, 1999 CTDEP Comment Letter Regarding
Calculated Additional Remediation Criteria
EDSR for the Basewide Groundwater OU Remedial Investigation
Naval Submarine Base - New London, Groton, Connecticut

Dear Ms. Patton:

Tetra Tech NUS, Inc. (TtNUS), acting on the behalf of the United States Department of the Navy (i.e., Northern Division Naval Facilities Engineering Command and Naval Submarine Base - New London), reviewed the technical comments included in your March 16, 1999 letter and prepared formal responses to address the comments. In addition, Tables B-1 and B-2, which were included in the December 8, 1998 TtNUS letter, were updated to address the comments received from the CTDEP. The responses and tables are attached.

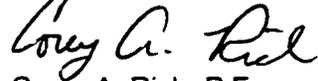
The attached responses and tables should provide the CTDEP with sufficient information to complete the review and approval process of the alternative criteria. Two additional copies of the letter and attachments are enclosed so that you can forward them to the appropriate people at the Connecticut Department of Health.

In order to minimize schedule impacts to this project, the Navy intends to finalize the Existing Data Summary Report for the Basewide Groundwater OU Remedial Investigation (RI) prior to receiving final acceptance of the alternative criteria from the CTDEP. The Navy will address any inconsistencies that could result from this approach during preparation of the Work Plan/Sampling and Analysis Plan for the Basewide Groundwater OU RI.

Ms. Elsie Patton
Connecticut Department of Environmental Protection
April 14, 1999 - Page 2

If you have any questions regarding the information provided in this letter or the attachments please contact Mr. Mark Evans of NORTHDIV at (610) 595-0567 (ext. 162) or me at (412) 921-8244.

Very truly yours,



Corey A. Rich, P.E.
Project Manager

Attachment(s)

c: Mr. Mark Lewis, CTDEP
Mr. Mark Evans, NORTHDIV
Mr. Richard Conant, NSB-NLON Environmental
File: CTO 0312

**RESPONSES TO CTDEP'S MARCH 16, 1999 LETTER OF COMMENTS
REGARDING ADDITIONAL REMEDIATION CRITERIA
BASEWIDE GROUNDWATER OU REMEDIAL INVESTIGATION
NAVAL SUBMARINE BASE - NEW LONDON, GROTON, CONNECTICUT**

April 14, 1999

Comment No. 1

Additional detailed information needs to be submitted regarding toxicity values used to develop criteria for dioxins and furans (i.e., tox values for TCDD and TEF used). While the submission is not detailed enough for a full review, it appears that the Table B-1 values for dioxins/furans are based upon a misapplication of TEFs.

Response to Comment No. 1

A single dioxin and three furans were positively detected in site soil samples. Toxicity criteria for these four analytes were not available. Therefore, toxicity criteria from the USEPA Region III Risk-Based Concentration Table (April 1, 1998) were used to calculate a groundwater protection standard (2.33E-07 ug/L) and a corresponding remediation standard for GB pollutant mobility (4.67E-08 mg/kg) for 2,3,7,8-TCDD using the methodology presented in the CTDEP guidance (CTDEP 1996). A remediation standard was then calculated for each of the positively detected dioxin/furans by dividing the value calculated for 2,3,7,8-TCDD with the associated toxicity equivalency factor (TEF) as shown in the following table.

Analyte	Calculated Remediation Standard for 2,3,7,8-TCDD (mg/kg)	TEF	Calculated Remediation Standard (mg/kg)
1,2,3,4,6,7,8-HPCDF	4.67E-8	0.01	4.67E-6
1,2,3,4,7,8-HXCDF	4.67E-8	0.1	4.67E-7
1,2,3,6,7,8-HXCDF	4.67E-8	0.1	4.67E-7
OCDD	4.67E-8	0.001	4.67E-5

Tetra Tech NUS, Inc. (TtNUS) understands that this application of TEFs varies somewhat from the typical use of TEFs in quantitative human health risk assessments. However, this application was deemed to be appropriate for the purposes of the screening level assessment provided in the Existing Data Summary Report. When performing a quantitative human health risk assessment, TtNUS uses TEFs in conjunction with sample results to convert the concentrations of any detected dioxin/furan congeners into equivalent concentrations of 2,3,7,8-TCDD. The total 2,3,7,8-TCDD equivalent of the dioxins and furans present in each sample is determined by summing the equivalent concentrations of each congener. The total 2,3,7,8-TCDD equivalent concentrations are then used for comparison with 2,3,7,8-TCDD remediation standards during data evaluation and risk assessment.

Comment No. 2

The groundwater protection criteria used to develop the pollutant mobility criteria listed on Table B-1 need to be provided in all cases.

Response to Comment No. 2

The groundwater protection criteria used to develop pollutant mobility criteria have been added to Table B-1. The revised table is attached.

Comment No. 3

Detection limits for each constituent need to be submitted. Remediation criteria may be based on detection limits as is appropriate. Provide additional information from certified labs regarding detection limits in cases where the proposed criteria are based on detection limits are based on detection limits such as dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene.

Response to Comment No. 3

The criteria initially proposed for dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene in Tables B-1 and B-2 of the December 8, 1998 letter were based upon typical reporting limits using SW-846 Method 8270 (i.e., a GC/MS method) because GC/MS methods were primarily used for analysis of samples previously collected at NSB-NLON. The following tables present reporting limits for soil and aqueous samples, respectively, for dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene obtained from three laboratories certified by the state of Connecticut (i.e., Accutest Laboratories, Katahdin Analytical Services, and Ceimic Corporation). Laboratory reporting limits are presented for SW-846 Method 8310 (i.e., an HPLC method) as well as SW-846 Method 8270. The remediation standards calculated using the methodology presented in the CTDEP guidance (CTDEP 1996) are also presented for comparison with laboratory reporting limits.

Analyte	Calculated GB Pollutant Mobility (mg/kg)	Reporting Limits – Soil Samples (mg/kg)					
		Accutest Laboratories		Katahdin Analytical		Ceimic Corporation	
		SW-846 8270	SW-846 8310	SW-846 8270	SW-846 8310	SW-846 8270	SW-846 8310
D(ah)A	0.00096	0.33	0.005	0.33	0.013	0.33	0.003
I(cd)P	0.0096	0.33	0.005	0.33	0.007	0.33	0.002

D(ah)A = Dibenzo(a,h)anthracene

I(cd)P = Indeno(1,2,3-cd)pyrene

Analyte	Calculated Groundwater Protection Std. (ug/L)	Reporting Limits – Aqueous Samples (ug/L)					
		Accutest Laboratories		Katahdin Analytical		Ceimic Corporation	
		SW-846 8270	SW-846 8310	SW-846 8270	SW-846 8310	SW-846 8270	SW-846 8310
D(ah)A	0.0048	10	0.2	10	0.4	10	0.1
I(cd)P	0.048	10	0.2	10	0.2	10	0.05

D(ah)A = Dibenzo(a,h)anthracene

I(cd)P = Indeno(1,2,3-cd)pyrene

Although GC/MS methods (e.g., SW-846 8270) were primarily used for the analysis of historical samples, TtNUS proposes revising the remediation criteria for dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene based upon typical reporting limits for the more sensitive HPLC method (i.e., SW-846 8310). The proposed criteria are presented in the following table. Tables B-1 and B-2 have been revised accordingly and are attached.

Analyte	GB Pollutant Mobility (mg/kg)	Groundwater Protection Standard (ug/L)
Dibenzo(a,h)anthracene	0.005	0.2
Indeno(1,2,3-cd)pyrene	0.005	0.2

TABLE B-1

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - SOLID MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		Groundwater Protection Standard ⁽¹⁴⁾ (ug/L)	CTDEP Remediation Standard GB Pollutant Mobility ⁽²⁾ (mg/kg)
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)		
VOLATILE ORGANICS					
1,1,1-Trichloroethane	71556	2.00E-02	-	--	40
1,1,2,2-Tetrachloroethane	79345	-	2.00E-01	--	0.1
1,1,2-Trichloroethane	79005	4.00E-03	5.70E-02	--	1
1,1-Dichloroethene	75354	9.00E-03	6.00E-01	--	1.4
1,2-Dichloroethene (Total)	540590	9.00E-03	-	63	12 ⁽³⁾
2-Butanone	78933	6.00E-01	-	--	80
4-Methyl-2-pentanone	108101	8.00E-02	-	--	14
Acetone	67641	1.00E-01	-	--	140
Benzene	71432	3.00E-03	2.90E-02	--	0.2
Bromodichloromethane	75274	2.00E-02	6.20E-02	0.56	0.11 ⁽³⁾
Bromomethane	74839	1.40E-03	-	9.8	2 ⁽³⁾
Carbon Disulfide	75150	1.00E-01	-	700	140 ⁽³⁾
Chlorobenzene	108907	2.00E-02	-	--	20
Chloroform	67663	1.00E-02	6.10E-03	--	1.2
Chloromethane	74873	-	1.30E-02	2.7	0.54 ⁽³⁾
cis-1,3-Dichloropropene	10061015	3.00E-04 ⁽⁴⁾	1.80E-01 ⁽⁴⁾	--	0.1
Ethylbenzene	100414	1.00E-01	-	--	10.1
Methylene Chloride	75092	6.00E-02	7.50E-03	--	1
Styrene	100425	2.00E-01	-	--	20
Tetrachloroethene	127184	1.00E-02	5.20E-02	--	1
Toluene	108883	2.00E-01	-	--	67
trans-1,3-Dichloropropene	10061026	3.00E-04 ⁽⁴⁾	1.80E-01 ⁽⁴⁾	--	0.1
Trichloroethene	79016	6.00E-03	1.10E-02	--	1
Vinyl Acetate	108054	1.00E+00	-	7000	1400 ⁽³⁾
Xylenes, Total	1330207	2.00E+00	-	--	19.5
SEMIVOLATILE ORGANICS					
1,4-Dichlorobenzene	106467	3.00E-02	2.40E-02	--	15
2,4-Dimethylphenol	105679	2.00E-02	-	140	28 ⁽³⁾
2-Methylnaphthalene	91576	4.00E-02	-	280	56 ⁽³⁾
2-Methylphenol	95487	5.00E-02	-	350	70 ⁽³⁾
3,3'-Dichlorobenzidine	91941	-	4.50E-01	0.078	0.016 ⁽³⁾
4-Chloro-3-methylphenol	59507	-	-	--	-
4-Methylphenol	106445	5.00E-03	-	35	7 ⁽³⁾
Acenaphthene	83329	6.00E-02	-	420	84 ⁽³⁾
Acenaphthylene	208968	-	-	--	84
Anthracene	120127	3.00E-01	-	--	400
Benzo(a)anthracene	56553	-	7.30E-01	--	1
Benzo(a)pyrene	50328	-	7.30E+00	--	1
Benzo(b)fluoranthene	205992	-	7.30E-01	--	1
Benzo(g,h,i)perylene	191242	-	-	--	40 ⁽⁵⁾
Benzo(k)fluoranthene	207089	-	7.30E-02	--	1
Benzoic Acid	65850	4.00E+00	-	28000	5600 ⁽³⁾
Bis(2-Ethylhexyl)phthalate	117817	2.00E-02	1.40E-02	--	11
Butylbenzyl Phthalate	85687	2.00E-01	-	--	200

TABLE B-1

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - SOLID MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		Groundwater Protection Standard ⁽¹⁴⁾ (ug/L)	CTDEP Remediation Standard GB Pollutant Mobility ⁽²⁾ (mg/kg)
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)		
Carbazole	86748	-	2.00E-02	1.8	0.36 ⁽³⁾
Chrysene	218019	-	7.30E-03	4.8	0.96 ⁽³⁾
Dibenzo(a,h)anthracene	53703	-	7.30E+00	--	0.005 ⁽⁶⁾
Dibenzofuran	132649	4.00E-03	-	28	5.6 ⁽³⁾
Diethyl Phthalate	84662	8.00E-01	-	5600	1100 ⁽³⁾
Dimethyl Phthalate	131113	1.00E+01	-	70000	14,000 ⁽³⁾
Di-n-butyl phthalate	84742	1.00E-01	-	--	140
Di-n-octyl phthalate	117840	2.00E-02	-	--	20
Fluoranthene	206440	4.00E-02	-	--	56
Fluorene	86737	4.00E-02	-	--	56
Indeno(1,2,3-cd)pyrene	193395	-	7.30E-01	--	0.005 ⁽⁶⁾
Isophorone	78591	2.00E-01	9.50E-04	36.8	7.37 ⁽³⁾
Naphthalene	91203	4.00E-02	-	--	56
Pentachlorophenol	87865	3.00E-02	1.20E-01	--	1
Phenanthrene	85018	-	-	--	40
Phenol	108952	6.00E-01	-	--	800
Pyrene	129000	3.00E-02	-	--	40
PESTICIDES/PCBs					
4,4'-DDD	72548	-	2.40E-01	0.146	0.029 ⁽³⁾
4,4'-DDE	72559	-	3.40E-01	0.103	0.021 ⁽³⁾
4,4'-DDT	50293	5.00E-04	3.40E-01	0.103	0.021 ⁽³⁾
Aldrin	309002	3.00E-05	1.70E+01	0.00206	0.00041 ⁽³⁾
alpha-BHC	319846	-	6.30E+00	0.00556	0.0011 ⁽³⁾
Alpha-Chlordane	5103719	5.00E-04 ⁽⁷⁾	3.50E-01 ⁽⁷⁾	--	0.066 ⁽⁷⁾
Aroclor-1242	53469219	-	2.00E+00	--	-
Aroclor-1248	12672296	-	2.00E+00	--	-
Aroclor-1254	11097691	2.00E-05	2.00E+00	--	-
Aroclor-1260	11096825	-	2.00E+00	--	-
beta-BHC	319857	-	1.80E+00	0.0194	0.0039 ⁽³⁾
delta-BHC	319868	-	-	0.00556 ⁽⁸⁾	0.0011 ⁽⁸⁾
Dieldrin	60571	5.00E-05	1.60E+01	--	0.007
Endosulfan I	959988	6.00E-03 ⁽⁹⁾	-	42 ⁽⁹⁾	8.4 ⁽⁹⁾
Endosulfan II	33213659	6.00E-03 ⁽⁹⁾	-	42 ⁽⁹⁾	8.4 ⁽⁹⁾
Endosulfan Sulfate	1031078	6.00E-03 ⁽⁹⁾	-	42 ⁽⁹⁾	8.4 ⁽⁹⁾
Endrin	72208	3.00E-04	-	2.1	0.42 ⁽³⁾
Endrin Aldehyde	7421934	3.00E-04 ⁽¹⁰⁾	-	2.1 ⁽¹¹⁾	0.42 ⁽¹¹⁾
Endrin Ketone	53494705	3.00E-04 ⁽¹⁰⁾	-	2.1 ⁽¹¹⁾	0.42 ⁽¹¹⁾
gamma-BHC (Lindane)	58899	3.00E-04	1.30E+00	--	0.04
Gamma-Chlordane	5103742	5.00E-04 ⁽⁷⁾	3.50E-01 ⁽⁷⁾	--	0.066 ⁽⁷⁾
Heptachlor	76448	5.00E-04	4.50E+00	--	0.013
Heptachlor Epoxide	1024573	1.30E-05	9.10E+00	--	0.02
Methoxychlor	72435	5.00E-03	-	--	8
DIOXINS/FURANS					
1,2,3,4,6,7,8-HPCDF	67562394	-	-	--	4.67E-06 ⁽¹²⁾

TABLE B-1

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - SOLID MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		Groundwater Protection Standard ⁽¹⁴⁾ (ug/L)	CTDEP Remediation Standard GB Pollutant Mobility ⁽²⁾ (mg/kg)
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)		
1,2,3,4,7,8-HXCDF	70648269	-	-	--	4.67E-07 ⁽¹²⁾
1,2,3,6,7,8-HXCDF	57117449	-	-	--	4.67E-07 ⁽¹²⁾
OCDD	3268879	-	-	--	4.67E-05 ⁽¹²⁾
INORGANICS					
Aluminum	7429905	1.00E+00	-	--	-
Antimony	7440360	4.00E-04	-	--	-
Arsenic	7440382	3.00E-04	1.50E+00	--	-
Barium	7440393	7.00E-02	-	--	-
Beryllium	7440417	2.00E-03	-	--	-
Boron	7440428	9.00E-02	-	--	-
Cadmium	7440439	5.00E-04	-	--	-
Calcium	7440702	-	-	--	-
Chromium	7440473	5.00E-3 ⁽¹³⁾	-	--	-
Cobalt	7440484	6.00E-02	-	--	-
Copper	7440508	4.00E-02	-	--	-
Cyanide	57125	2.00E-02	-	--	-
Iron	7439896	3.00E-01	-	--	-
Lead	7439921	-	-	--	-
Magnesium	7439954	-	-	--	-
Manganese	7439965	2.00E-02	-	--	-
Mercury	7439976	-	-	--	-
Nickel	7440020	2.00E-02	-	--	-
Potassium	7440097	-	-	--	-
Selenium	7782492	5.00E-03	-	--	-
Silver	7440224	5.00E-03	-	--	-
Sodium	7440235	-	-	--	-
Thallium	7440280	7.00E-05	-	--	-
Vanadium	7440622	7.00E-03	-	--	-
Zinc	7440666	3.00E-01	-	--	-
TOTAL PETROLEUM HYDROCARBONS					
TPH	-	-	-	--	2500

1 Values obtained from USEPA Region III Risk-Based Concentration Table (April 1, 1998).

2 Unless otherwise noted, value obtained from State of Connecticut Remediation Standard Regulations, Section 22a-133k (January 1996).

3 CTDEP remediation standard not available. Using the methodology presented in the CTDEP guidance (CTDEP 1996) and the toxicity criteria from the USEPA Region III Risk-Based Concentration Table (April 1, 1998), the groundwater protection criterion shown in the previous column is calculated and is then used to calculate a value for GB pollutant mobility.

4 Value for 1,3-dichloropropene is used.

5 Toxicity criteria not available. Published value for pyrene is used.

6 Calculated value less than reliably achievable detection limits. Reliable and accurately achievable detection limit is used.

7 Published value for chlordane is used.

8 Toxicity criteria not available. Toxicity criteria for alpha-BHC is used to calculate a value.

9 Calculated value for endosulfan is used.

10 Value for endrin is used.

11 Calculated value for endrin is used.

TABLE B-1

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - SOLID MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
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12 Toxicity criteria not available. Toxicity criteria for 2,3,7,8-TCDD in conjunction with toxicity equivalent factor (TEF) (EPA/625/ 3-89/016, March 1989) is used to calculate a value.

13 Value for hexavalent chromium is used.

14 Calculated groundwater protection standard used to determine CTDEP remediation standard for GB pollutant mobility. Groundwater protection standards are not directly applicable to solid sample results. They are provided in this table for specific analytes only when used for the calculation of a remediation standard for GB pollutant mobility.

- Not available.

- Groundwater protection standard not provided in this table for this analyte because there is no need to calculate a remediation standard for GB pollutant mobility.

TABLE B-2

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - AQUEOUS MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		State Remediation Standards ⁽²⁾	
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)	Groundwater Protection (ug/L)	Surface Water Protection (ug/L)
VOLATILE ORGANICS					
1,1,1-Trichloroethane	71556	2.00E-02	-	200	62,000
1,1,2,2-Tetrachloroethane	79345	-	2.00E-01	0.5	110
1,1,2-Trichloroethane	79005	4.00E-03	5.70E-02	5	1260
1,1-Dichloroethane	75343	1.00E-01	-	70	-
1,1-Dichloroethene	75354	9.00E-03	6.00E-01	7	96
1,2-Dichloroethane	107062	3.00E-02	9.10E-02	1	2970
1,2-Dichloroethene (Total)	540590	9.00E-03	-	63 ⁽³⁾	14,000 ^(4,5)
2-Butanone	78933	6.00E-01	-	400	-
2-Hexanone	73663715	4.00E-02	-	280 ⁽³⁾	-
4-Methyl-2-pentanone	108101	8.00E-02	-	350	-
Acetone	67641	1.00E-01	-	700	-
Benzene	71432	3.00E-03	2.90E-02	1	710
Bromodichloromethane	75274	2.00E-02	6.20E-02	0.56 ⁽³⁾	660 ⁽⁴⁾
Bromomethane	74839	1.40E-03	-	9.8 ⁽³⁾	80,000 ⁽⁴⁾
Carbon Disulfide	75150	1.00E-01	-	700 ⁽³⁾	-
Chlorobenzene	108907	2.00E-02	-	100	420,000
Chloroform	67663	1.00E-02	6.10E-03	6	14,100
Chloromethane	74873	-	1.30E-02	2.7 ⁽³⁾	9400 ⁽⁴⁾
Ethylbenzene	100414	1.00E-01	-	700	580,000
Methyl Tert-Butyl Ether	1634044	5.00E-03	-	100	-
Methylene Chloride	75092	6.00E-02	7.50E-03	5	48,000
Tetrachloroethene	127184	1.00E-02	5.20E-02	5	88
Toluene	108883	2.00E-01	-	1000	4,000,000
Trichloroethene	79016	6.00E-03	1.10E-02	5	2340
Vinyl Chloride	75014	-	1.90E+00	2	15,750
Xylenes, Total	1330207	2.00E+00	-	530	-
SEMIVOLATILE ORGANICS					
1,2,4-Trichlorobenzene	120821	1.00E-02	-	70 ⁽³⁾	-
1,2-Dichlorobenzene	95501	9.00E-02	-	600	170,000
1,3-Dichlorobenzene	541731	3.00E-02	-	210 ⁽³⁾	26,000
1,4-Dichlorobenzene	106467	3.00E-02	2.40E-02	75	26,000
2,4-Dichlorophenol	120832	3.00E-03	-	20	15,800
2,4-Dimethylphenol	105679	2.00E-02	-	140 ⁽³⁾	-
2,4-Dinitrotoluene	121142	2.00E-03	-	14 ⁽³⁾	270 ⁽⁴⁾
2,6-Dinitrotoluene	606202	1.00E-03	-	7 ⁽³⁾	-
2-Chlorophenol	95578	5.00E-03	-	36	46,000 ⁽⁴⁾
2-Methylnaphthalene	91576	4.00E-02	-	280 ⁽³⁾	-
2-Methylphenol	95487	5.00E-02	-	350 ⁽³⁾	-
4-Methylphenol	106445	5.00E-03	-	35 ⁽³⁾	-
Acenaphthene	83329	6.00E-02	-	420 ⁽³⁾	27,000 ⁽⁴⁾
Acenaphthylene	208968	-	-	420	0.3
Anthracene	120127	3.00E-01	-	2000	1,100,000
Benzo(a)anthracene	56553	-	7.30E-01	0.06	0.3

TABLE B-2

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - AQUEOUS MEDIA
CTO-312, NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		State Remediation Standards ⁽²⁾	
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)	Groundwater Protection (ug/L)	Surface Water Protection (ug/L)
Benzo(a)pyrene	50328	-	7.30E+00	0.2	0.3
Benzo(b)fluoranthene	205992	-	7.30E-01	0.08	0.3
Benzo(g,h,i)perylene	191242	-	-	200 ^(3,6)	0.3 ^(4,6)
Benzo(k)fluoranthene	207089	-	7.30E-02	0.5	0.3
Benzoic Acid	65850	4.00E+00	-	28,000 ⁽³⁾	-
Bis(2-Ethylhexyl)phthalate	117817	2.00E-02	1.40E-02	2	59
Butylbenzyl Phthalate	85687	2.00E-01	-	1000	52,000 ⁽⁴⁾
Carbazole	86748	-	2.00E-02	1.8 ⁽³⁾	29 ⁽⁴⁾
Chrysene	218019	-	7.30E-03	4.8 ⁽³⁾	0.3 ⁽⁴⁾
Dibenzo(a,h)anthracene	53703	-	7.30E+00	0.2 ⁽⁷⁾	0.3 ⁽⁴⁾
Dibenzofuran	132649	4.00E-03	-	28 ⁽³⁾	-
Diethyl Phthalate	84662	8.00E-01	-	5600 ⁽³⁾	2,400,000 ⁽⁴⁾
Dimethyl Phthalate	131113	1.00E+01	-	70,000 ⁽³⁾	58,000,000 ⁽⁴⁾
Di-n-butyl phthalate	84742	1.00E-01	-	700	120,000
Di-n-octyl phthalate	117840	2.00E-02	-	100	-
Fluoranthene	206440	4.00E-02	-	280	3700
Fluorene	86737	4.00E-02	-	280	140,000
Indeno(1,2,3-cd)pyrene	193395	-	7.30E-01	0.2 ⁽⁷⁾	0.3 ⁽⁴⁾
Naphthalene	91203	4.00E-02	-	280	-
N-Nitrosodiphenylamine	86306	-	4.90E-03	7.1 ⁽³⁾	480 ⁽⁴⁾
Phenanthrene	85018	-	-	200	0.3
Phenol	108952	6.00E-01	-	4000	92,000,000
Pyrene	129000	3.00E-02	-	200	110,000
PESTICIDES/PCBs					
Aroclor-1016	12674112	7.00E-05	7.00E-02	0.5 ⁽⁸⁾	0.5
Aroclor-1254	11097691	2.00E-05	2.00E+00	0.5 ⁽⁸⁾	0.5
Aroclor-1260	11096825	-	2.00E+00	0.5 ⁽⁸⁾	0.5
Heptachlor	76448	5.00E-04	4.50E+00	0.4	0.05
INORGANICS					
Aluminum	7429905	1.00E+00	-	-	-
Antimony	7440360	4.00E-04	-	6	86,000
Arsenic	7440382	3.00E-04	1.50E+00	50	4
Barium	7440393	7.00E-02	-	1000	-
Beryllium	7440417	2.00E-03	-	4	4
Boron	7440428	9.00E-02	-	630 ⁽³⁾	-
Cadmium	7440439	5.00E-04	-	5	6
Calcium	7440702	-	-	-	-
Chromium (Total)	7440473	5.00E-03 ⁽⁹⁾	-	50	110 ⁽⁹⁾
Cobalt	7440484	6.00E-02	-	420 ⁽³⁾	-
Copper	7440508	4.00E-02	-	1300	48
Cyanide	57125	2.00E-02	-	200	52
Iron	7439896	3.00E-01	-	-	-
Lead	7439921	-	-	15	13
Magnesium	7439954	-	-	-	-

TABLE B-2

PUBLISHED AND CALCULATED REMEDIATION STANDARDS - AQUEOUS MEDIA
 CTO-312, NSB-NLON, GROTON, CONNECTICUT
 PAGE 3 OF 3

Analyte	CAS Number	Published Toxicological Criteria ⁽¹⁾		State Remediation Standards ⁽²⁾	
		RFD _{oral} (mg/kg/day)	CSF _{oral} (kg/day/mg)	Groundwater Protection (ug/L)	Surface Water Protection (ug/L)
Manganese	7439965	2.00E-02	-	50 ⁽³⁾	-
Mercury	7439976	-	-	2	0.4
Nickel	7440020	2.00E-02	-	100	880
Potassium	7440097	-	-	-	-
Selenium	7782492	5.00E-03	-	50	50
Silver	7440224	5.00E-03	-	36	12
Sodium	7440235	-	-	-	-
Thallium	7440280	7.00E-05	-	5	63
Vanadium	7440622	7.00E-03	-	50	-
Zinc	7440666	3.00E-01	-	5000	123
TOTAL PETROLEUM HYDROCARBONS					
Diesel Range Organics	-	-	-	-	-
Gasoline Range Organics	-	-	-	-	-
Oil & Grease	-	-	-	-	-
TPH	-	-	-	500	-
MISCELLANEOUS PARAMETERS					
Ammonia, as Nitrogen	7664417	-	-	-	-
Biochemical Oxygen Demand	-	-	-	-	-
Chemical Oxygen Demand	-	-	-	-	-
Hardness as CaCO ₃	-	-	-	-	-
Total Organic Carbon	-	-	-	-	-
Total Phosphorus	-	-	-	-	-
Total Suspended Solids	-	-	-	-	-

- 1 Values obtained from USEPA Region III Risk-Based Concentration Table (April 1, 1998).
- 2 Unless otherwise noted, value obtained from State of Connecticut Remediation Standard Regulations, Section 22a-133k (January 1996).
- 3 CTDEP remediation standard not available. Value calculated using methodologies presented in State guidance (January 1996).
- 4 CTDEP remediation standard not available. Value calculated using lower of human health or freshwater aquifer criteria and dilution factors based on methodologies presented in CTDEP guidance (January 1996).
- 5 Value used is for trans-1,2-dichloroethene.
- 6 Calculated value used is for pyrene.
- 7 Calculated value is less than reliably achievable detection limit. Reliably and accurately achievable detection limit is used.
- 8 Value used is for polychlorinated biphenyls (PCBs).
- 9 Hexavalent chromium.
- Not available.

APPENDIX E.3

**USEPA GENERIC SOIL SCREENING LEVELS (SSLs)
TRANSFERS FROM SOIL TO AIR (INHALATION)
MIGRATION TO GROUNDWATER**

Superfund



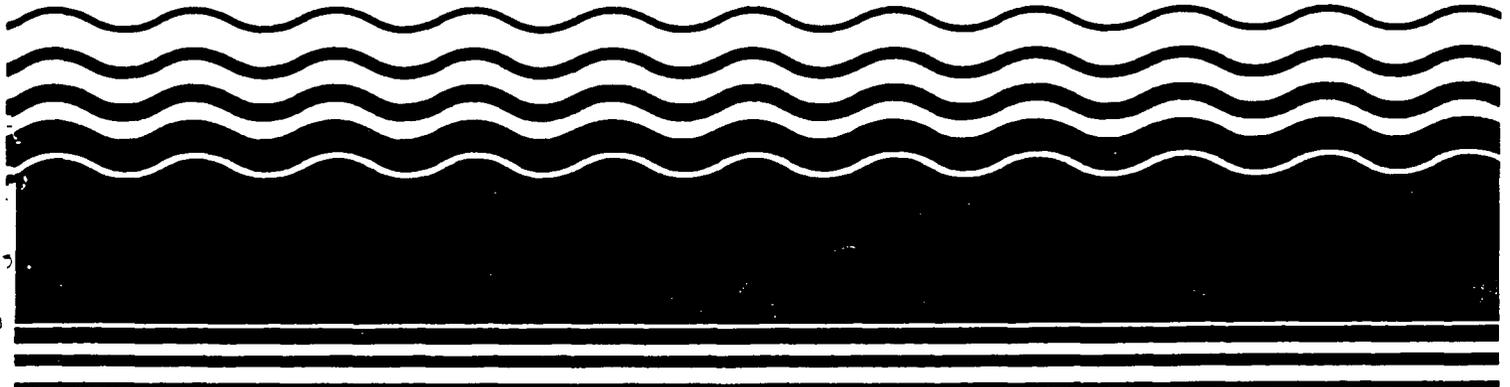
Soil Screening Guidance: Technical Background Document

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APPENDIX A
Generic SSLs

APPENDIX A

Generic SSLs

Table A-1 provides generic SSLs for 110 chemicals. Generic SSLs are derived using default values in the standardized equations presented in Part 2 of this document. The default values (listed in Table A-2) are conservative and are likely to be protective for the majority of site conditions across the nation.

However, the generic SSLs are not necessarily protective of all known human exposure pathways, reasonable land uses, or ecological threats. Thus, before applying generic SSLs at a site, it is extremely important to compare the conceptual site model (see the *User's Guide*) with the assumptions behind the SSLs to ensure that the site conditions and exposure pathways match those used to develop generic SSLs (see Parts 1 and 2 and Table A-2). If this comparison indicates that the site is more complex than the SSL scenario, or that there are significant exposure pathways not accounted for by the SSLs, then generic SSLs are not sufficient for a full evaluation of the site. A more detailed site-specific approach will be necessary to evaluate the additional pathways or site conditions.

Generic SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The first column to the right of the chemical name presents levels based on direct ingestion of soil and the second column presents levels based on inhalation. As discussed in the *User's Guide*, the fugitive dust pathway may be of concern for certain metals but does not appear to be of concern for organic compounds. Therefore, SSLs for the fugitive dust pathway are only presented for inorganic compounds. Except for mercury, no SSLs for the inhalation of volatiles pathway are provided for inorganic compounds because these chemicals are not volatile.

The user should note that several of the generic SSLs for the inhalation of volatiles pathway are determined by the soil saturation concentration (C_{sat}), which is used to address and screen the potential presence of nonaqueous phase liquids (NAPLs). As explained in Section 2.4.4, for compounds that are liquid at ambient soil temperature, concentrations above C_{sat} indicate a potential for free-phase liquid contamination to be present and the need for additional investigation.

The third column presents generic SSL values for the migration to ground water pathway developed using a default DAF (dilution-attenuation factor) of 20 to account for natural processes that reduce contaminant concentrations in the subsurface (see Section 2.5.6). SSLs in Table A-1 are rounded to two significant figures except for values less than 10, which are rounded to one significant figure. Note that the 20 DAF values in Table A-1 are not exactly 20 times the 1 DAF values because each SSL is calculated independently in both the 20 DAF and 1 DAF columns, with the final value presented according to the aforementioned rounding conventions.

The fourth column contains the generic SSLs for the migration to ground water pathway developed assuming no dilution or attenuation between the source and the receptor well (i.e., a DAF of 1). These values can be used at sites where little or no dilution or attenuation of soil leachate concentrations is expected at a site (e.g., sites with shallow water tables, fractured media, karst topography, or source size greater than 30 acres).

Generally, if an SSL is not exceeded for a pathway of concern, the user may eliminate the pathway and areas of the site from further investigation. If more than one exposure pathway is of concern, the lowest SSL should be used.

Table A-1. Generic SSLs *

Organics		Migration to ground water			
CAS No.	Compound	Ingestion (mg/kg)	Inhalation volatiles (mg/kg)	20 DAF (mg/kg)	1 DAF (mg/kg)
83-32-9	Acenaphthene	4,700 ^b	— ^c	570 ^b	29 ^b
67-64-1	Acetone	7,800 ^b	1.0E+05 ^d	16 ^b	0.8 ^b
309-00-2	Aldrin	0.04 ^e	3 ^e	0.5 ^e	0.02 ^e
120-12-7	Anthracene	23,000 ^b	— ^c	12,000 ^b	590 ^b
56-55-3	Benz(a)anthracene	0.9 ^e	— ^c	2 ^e	0.08 ^{ef}
71-43-2	Benzene	22 ^e	0.8 ^e	0.03	0.002 ^f
205-99-2	Benzo(b)fluoranthene	0.9 ^e	— ^c	5 ^e	0.2 ^{ef}
207-08-9	Benzo(k)fluoranthene	9 ^e	— ^c	49 ^e	2 ^e
65-85-0	Benzoic acid	3.1E+05 ^b	— ^c	400 ^{b,j}	20 ^{b,j}
50-32-8	Benzo(a)pyrene	0.09 ^{ef}	— ^c	8	0.4
111-44-4	Bis(2-chloroethyl)ether	0.6 ^e	0.2 ^{ef}	0.0004 ^{ef}	2E-05 ^{ef}
117-81-7	Bis(2-ethylhexyl)phthalate	46 ^e	31,000 ^d	3,600	180
75-27-4	Bromodichloromethane	10 ^e	3,000 ^d	0.6	0.03
75-25-2	Bromoform	81 ^e	53 ^e	0.8	0.04
71-36-3	Butanol	7,800 ^b	10,000 ^d	17 ^b	0.9 ^b
85-68-7	Butyl benzyl phthalate	16,000 ^b	930 ^d	930 ^d	810 ^b
86-74-8	Carbazole	32 ^e	— ^c	0.6 ^e	0.03 ^{ef}
75-15-0	Carbon disulfide	7,800 ^b	720 ^d	32 ^b	2 ^b
56-23-5	Carbon tetrachloride	5 ^e	0.3 ^e	0.07	0.003 ^f
57-74-9	Chlordane	0.5 ^e	20 ^e	10	0.5
106-47-8	p-Chloroaniline	310 ^b	— ^c	0.7 ^b	0.03 ^{bf}
108-90-7	Chlorobenzene	1,600 ^b	130 ^b	1	0.07
124-48-1	Chlorodibromomethane	8 ^e	1,300 ^d	0.4	0.02
67-66-3	Chloroform	100 ^e	0.3 ^e	0.6	0.03
95-57-8	2-Chlorophenol	390 ^b	53,000 ^d	4 ^{b,j}	0.2 ^{b,f,i}
218-01-9	Chrysene	88 ^e	— ^c	160 ^e	8 ^e
72-54-8	DDD	3 ^e	— ^c	16 ^e	0.8 ^e
72-55-9	DDE	2 ^e	— ^c	54 ^e	3 ^e
50-29-3	DDT	2 ^e	— ^g	32 ^e	2 ^e
53-70-3	Dibenz(a,h)anthracene	0.09 ^{ef}	— ^c	2 ^e	0.08 ^{ef}
84-74-2	Di-n-butyl phthalate	7,800 ^b	2,300 ^d	2,300 ^d	270 ^b
95-50-1	1,2-Dichlorobenzene	7,000 ^b	560 ^d	17	0.9
106-46-7	1,4-Dichlorobenzene	27 ^e	— ^g	2	0.1 ^f
91-94-1	3,3-Dichlorobenzidine	1 ^e	— ^c	0.007 ^{ef}	0.0003 ^{ef}
75-34-3	1,1-Dichloroethane	7,800 ^b	1,300 ^b	23 ^b	1 ^b
107-06-2	1,2-Dichloroethane	7 ^e	0.4 ^e	0.02	0.001 ^f
75-35-4	1,1-Dichloroethylene	1 ^e	0.07 ^e	0.06	0.003 ^f
156-59-2	cis-1,2-Dichloroethylene	780 ^b	1,200 ^d	0.4	0.02
156-60-5	trans-1,2-Dichloroethylene	1,600 ^b	3,100 ^d	0.7	0.03
120-83-2	2,4-Dichlorophenol	230 ^b	— ^c	1 ^{b,j}	0.05 ^{b,f,i}

Table A-1 (continued)

Organics		Migration to ground water			
CAS No.	Compound	Ingestion (mg/kg)	Inhalation volatiles (mg/kg)	20 DAF (mg/kg)	1 DAF (mg/kg)
78-87-5	1,2-Dichloropropane	9 ^e	15 ^b	0.03	0.001 ^f
542-75-6	1,3-Dichloropropene	4 ^e	0.1 ^e	0.004 ^e	0.0002 ^e
60-57-1	Dieldrin	0.04 ^e	1 ^e	0.004 ^e	0.0002 ^f
84-66-2	Diethylphthalate	63,000 ^b	2,000 ^d	470 ^b	23 ^b
105-67-9	2,4-Dimethylphenol	1,600 ^b	— ^c	9 ^b	0.4 ^b
51-28-5	2,4-Dinitrophenol	160 ^b	— ^c	0.3 ^{b,f,i}	0.01 ^{b,f,i}
121-14-2	2,4-Dinitrotoluene	0.9 ^e	— ^c	0.0008 ^{ef}	4E-05 ^{ef}
606-20-2	2,6-Dinitrotoluene	0.9 ^e	— ^c	0.0007 ^{ef}	3E-05 ^{ef}
117-84-0	Di- <i>n</i> -octyl phthalate	1,600 ^b	10,000 ^d	10,000 ^d	10,000 ^d
115-29-7	Endosulfan	470 ^b	— ^c	18 ^b	0.9 ^b
72-20-8	Endrin	23 ^b	— ^c	1	0.05
100-41-4	Ethylbenzene	7,800 ^b	400 ^d	13	0.7
206-44-0	Fluoranthene	3,100 ^b	— ^c	4,300 ^b	210 ^b
86-73-7	Fluorene	3,100 ^b	— ^c	560 ^b	28 ^b
76-44-8	Heptachlor	0.1 ^e	0.1 ^e	23	1
1024-57-3	Heptachlor epoxide	0.07 ^e	5 ^e	0.7	0.03
118-74-1	Hexachlorobenzene	0.4 ^e	1 ^e	2	0.1 ^f
87-68-3	Hexachloro-1,3-butadiene	8 ^e	8 ^e	2	0.1 ^f
319-84-6	α-HCH (α-BHC)	0.1 ^e	0.8 ^e	0.0005 ^{ef}	3E-05 ^{ef}
319-85-7	β-HCH (β-BHC)	0.4 ^e	— ^g	0.003 ^e	0.0001 ^f
58-89-9	γ-HCH (Lindane)	0.5 ^e	— ^c	0.009	0.0005 ^f
77-47-4	Hexachlorocyclopentadiene	550 ^b	10 ^b	400	20
67-72-1	Hexachloroethane	46 ^e	55 ^e	0.5 ^e	0.02 ^{ef}
193-39-5	Indeno(1,2,3- <i>cd</i>)pyrene	0.9 ^e	— ^c	14 ^e	0.7 ^e
78-59-1	Isophorone	670 ^e	4,600 ^d	0.5 ^e	0.03 ^{ef}
7439-97-6	Mercury	23 ^{b,j}	10 ^{b,j}	2 ⁱ	0.1 ⁱ
72-43-5	Methoxychlor	390 ^b	— ^c	160	8
74-83-9	Methyl bromide	110 ^b	10 ^b	0.2 ^b	0.01 ^{b,f}
75-09-2	Methylene chloride	85 ^e	13 ^e	0.02 ^e	0.001 ^{ef}
95-48-7	2-Methylphenol	3,900 ^b	— ^c	15 ^b	0.8 ^b
91-20-3	Naphthalene	3,100 ^b	— ^c	84 ^b	4 ^b
98-95-3	Nitrobenzene	39 ^b	92 ^b	0.1 ^{b,f}	0.007 ^{b,f}
86-30-6	<i>N</i> -Nitrosodiphenylamine	130 ^e	— ^c	1 ^e	0.06 ^{ef}
621-64-7	<i>N</i> -Nitrosodi- <i>n</i> -propylamine	0.09 ^{ef}	— ^c	5E-05 ^{ef}	2E-06 ^{ef}
1336-36-3	PCBs	1 ^h	— ^h	— ^h	— ^h
87-86-5	Pentachlorophenol	3 ^{ej}	— ^c	0.03 ^{f,i}	0.001 ^{f,i}
108-95-2	Phenol	47,000 ^b	— ^c	100 ^b	5 ^b
129-00-0	Pyrene	2,300 ^b	— ^c	4,200 ^b	210 ^b
100-42-5	Styrene	16,000 ^b	1,500 ^d	4	0.2
79-34-5	1,1,2,2-Tetrachloroethane	3 ^e	0.6 ^e	0.003 ^{ef}	0.0002 ^{ef}

Table A-1 (continued)

<i>Organics</i>		<u>Migration to ground water</u>			
CAS No.	Compound	Ingestion (mg/kg)	Inhalation volatiles (mg/kg)	20 DAF (mg/kg)	1 DAF (mg/kg)
127-18-4	Tetrachloroethylene	12 ^e	11 ^e	0.06	0.003 ⁱ
108-88-3	Toluene	16,000 ^b	650 ^d	12	0.6
8001-35-2	Toxaphene	0.6 ^e	89 ^e	31	2
120-82-1	1,2,4-Trichlorobenzene	780 ^b	3,200 ^d	5	0.3 ^f
71-55-6	1,1,1-Trichloroethane	— ^c	1,200 ^d	2	0.1
79-00-5	1,1,2-Trichloroethane	11 ^e	1 ^e	0.02	0.0009 ^f
79-01-6	Trichloroethylene	58 ^e	5 ^e	0.06	0.003 ^f
95-95-4	2,4,5-Trichlorophenol	7,800 ^b	— ^c	270 ^{bi}	14 ^{bi}
88-06-2	2,4,6-Trichlorophenol	58 ^e	200 ^e	0.2 ^{e,fi}	0.008 ^{e,fi}
108-05-4	Vinyl acetate	78,000 ^b	1,000 ^b	170 ^b	8 ^b
75-01-4	Vinyl chloride	0.3 ^e	0.03 ^e	0.01 ^f	0.0007 ^f
108-38-3	<i>m</i> -Xylene	1.6E+05 ^b	420 ^d	210	10
95-47-6	<i>o</i> -Xylene	1.6E+05 ^b	410 ^d	190	9
106-42-3	<i>p</i> -Xylene	1.6E+05 ^b	460 ^d	200	10

Table A-1 (continuation)

Inorganics		Migration to ground water			
CAS No.	Compound	Ingestion (mg/kg)	Inhalation fugitive particulate (mg/kg)	20 DAF (mg/kg)	1 DAF (mg/kg)
7440-36-0	Antimony	31 ^b	— ^c	5	0.3
7440-38-2	Arsenic	0.4 ^e	750 ^e	29 ⁱ	1 ⁱ
7440-39-3	Barium	5,500 ^b	6.9E+05 ^b	1,600 ⁱ	82 ⁱ
7440-41-7	Beryllium	0.1 ^e	1,300 ^e	63 ⁱ	3 ⁱ
7440-43-9	Cadmium	78 ^{b,m}	1,800 ^e	8 ⁱ	0.4 ⁱ
7440-47-3	Chromium (total)	390 ^b	270 ^e	38 ⁱ	2 ⁱ
16065-83-1	Chromium (III)	78,000 ^b	— ^c	— ^g	— ^g
18540-29-9	Chromium (VI)	390 ^b	270 ^e	38 ⁱ	2 ⁱ
57-12-5	Cyanide (amenable)	1,600 ^b	— ^c	40	2
7439-92-1	Lead	400 ^k	— ^k	— ^k	— ^k
7440-02-0	Nickel	1,600 ^b	13,000 ^e	130 ⁱ	7 ⁱ
7782-49-2	Selenium	390 ^b	— ^c	5 ⁱ	0.3 ⁱ
7440-22-4	Silver	390 ^b	— ^c	34 ^{bj}	2 ^{bj}
7440-28-0	Thallium	— ^c	— ^c	0.7 ⁱ	0.04 ⁱ
7440-62-2	Vanadium	550 ^b	— ^c	6,000 ^b	300 ^b
7440-66-6	Zinc	23,000 ^b	— ^c	12,000 ^{bj}	620 ^{bj}

DAF = Dilution and attenuation factor.

^a Screening levels based on human health criteria only.

^b Calculated values correspond to a noncancer hazard quotient of 1.

^c No toxicity criteria available for that route of exposure.

^d Soil saturation concentration (C_{sat}).

^e Calculated values correspond to a cancer risk level of 1 in 1,000,000.

^f Level is at or below Contract Laboratory Program required quantitation limit for Regular Analytical Services (RAS).

^g Chemical-specific properties are such that this pathway is not of concern at any soil contaminant concentration.

^h A preliminary remediation goal of 1 mg/kg has been set for PCBs based on *Guidance on Remedial Actions for Superfund Sites with PCB Contamination* (U.S. EPA, 1990) and on EPA efforts to manage PCB contamination.

ⁱ SSL for pH of 6.8.

^j Ingestion SSL adjusted by a factor of 0.5 to account for dermal exposure.

^k A screening level of 400 mg/kg has been set for lead based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (U.S. EPA, 1994).

^l SSL is based on RfD for mercuric chloride (CAS No. 007487-94-7).

^m SSL is based on dietary RfD.

Table A-2. Generic SSLs: Default Parameters and Assumptions

Parameter	SSL pathway		Default
	Inhalation	Migration to ground water	
Source Characteristics			
Continuous vegetative cover	●		50 percent
Roughness height	○		0.5 cm for open terrain; used to derive U_{L7}
Source area (A)	●	○	0.5 acres (2,024 m ²); used to derive L for MTG
Source length (L)		●	45 m (assumes square source)
Source depth		○	Extends to water table (i.e., no attenuation in unsaturated zone)
Soil Characteristics			
Soil texture	○	○	Loam; defines soil characteristics/parameters
Dry soil bulk density (ρ_b)	●	●	1.5 kg/L
Soil porosity (n)	●	○	0.43
Vol. soil water content (θ_w)	●	●	0.15 (INH); 0.30 (MTG)
Vol. soil air content (θ_a)	●	●	0.28 (INH); 0.13 (MTG)
Soil organic carbon (f_{oc})	●	●	0.006 (0.6%, INH); 0.002 (0.2%, MTG)
Soil pH	○	○	6.8; used to determine pH-specific K_d (metals) and K_{oc} (ionizable organics)
Mode soil aggregate size	○		0.5 mm; used to derive U_{L7}
Threshold windspeed @ 7 m (U_{L7})	●		11.32 m/s
Meteorological Data			
Mean annual windspeed (U_m)	●		4.69 m/s (Minneapolis, MN)
Air dispersion factor (Q/C)	●		90th percentile conterminous U.S.
Volatilization Q/C	●		68.81; Los Angeles, CA; 0.5-acre source
Fugitive particulate Q/C	●		90.80; Minneapolis, MN; 0.5-acre source
Hydrogeologic Characteristics			
Hydrogeologic setting		○	Generic (national); surficial aquifer
Dilution/attenuation factor (DAF)		●	20

● Indicates input parameters directly used in SSL equations.

○ Indicates parameters/assumptions used to develop SSL input parameters.

INH = Inhalation pathway.

MTG = Migration to ground water pathway.

APPENDIX E.4

FEDERAL MAXIMUM CONTAMINANT LEVELS (MCLs)



Drinking Water Regulations and Health Advisories



DRINKING WATER REGULATIONS

AND HEALTH ADVISORIES

by

**Office of Water
U.S. Environmental Protection Agency
Washington, D.C.**

October 1996



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These regulations and health advisory tables are revised approximately every 6 months by EPA's Office of Water. Although no permanent mailing list is kept, copies may be ordered free of charge from the:

SAFE DRINKING WATER HOTLINE
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The Health Advisories available and their ERIC order numbers are included at the end of this publication. For further information regarding the Drinking Water Regulations and Health Advisories, call Barbara Corcoran in EPA's Office of Water at (202) 260-1332.

LEGEND

Abbreviations column descriptions are:

- MCLG:** Maximum Contaminant Level Goal. A non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.
- MCL:** Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system.
- RfD:** Reference Dose. An estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime.
- DWEL:** Drinking Water Equivalent Level. A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.

The codes for the Status Reg and Status HA columns are as follows:

- F** final
- D** draft
- L** listed for regulation
- P** proposed
- T** tentative (not officially proposed)

Other codes found in the table include the following:

- NA** not applicable
- PS** performance standard 0.5 NTU-1.0 NTU
- TT** treatment technique

Large discrepancies between Lifetime and Longer-term HA values may occur because of the Agency's conservative policies, especially with regard to carcinogenicity, relative source contribution, and less-than-lifetime exposures in chronic toxicity testing. These factors can result in a cumulative UF (uncertainty factor) of up to 5 to 5000 when calculating a Lifetime HA.

The scheme for categorizing chemicals according to their carcinogenic potential is as follows:*

Group A: Human carcinogen	Sufficient evidence in epidemiologic studies to support causal association between exposure and cancer
Group B: Probable human carcinogen	Limited evidence in epidemiologic studies (Group B1) and/or sufficient evidence from animal studies (Group B2)
Group C: Possible human carcinogen	Limited evidence from animal studies and inadequate or no data in humans
Group D: Not classifiable	Inadequate or no human and animal evidence of carcinogenicity
Group E: No evidence of carcinogenicity for humans	No evidence of carcinogenicity in at least two adequate animal tests in different species <i>or</i> in adequate epidemiologic and animal studies

Drinking Water Health Advisories (HAs) are defined as follows:

One-day HA:	The concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for up to 5 consecutive days of exposure, with a margin of safety.
Ten-day HA:	The concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects up to 14 consecutive days of exposure, with a margin of safety.
Long-term HA:	The concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects up to approximately 7 years (10% of an individual's lifetime) of exposure, with a margin of safety.
Lifetime HA:	The concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects over a lifetime of exposure, with a margin of safety.

*EPA is in the process of revising the Cancer Guidelines.

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group	
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult						
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	Rf (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk		
ORGANICS														
Acenaphth n	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-
Acifluorfen	T	zero	-	F	2	2	0.1	0.4	0.01	0.4	-	-	0.1	B2
Acrylamide	F	zero	TT	F	1.5	0.3	0.02	0.07	0.0002	0.007	-	-	0.001	B2
Acrylonitril	T	zero	-	D	-	-	-	-	-	-	-	-	0.006	B1*
Adipate (diethylhexyl)	F	0.4	0.4	-	20	20	20	60	0.6	20	0.4	-	3	C
Alachlor	F	zero	0.002	F	0.1	0.1	-	-	0.01	0.4	-	-	0.04	B2
Aldicarb**	D	0.007	0.007	D	-	-	-	-	0.00	0.035	0.007	-	-	D
Aldicarb sulfone**	D	0.007	0.007	D	-	-	-	-	0.00	0.035	0.007	-	-	D
Aldicarb sulfoxide**	D	0.007	0.007	D	-	-	-	-	0.00	0.035	0.007	-	-	D
Aldrin	-	-	-	D	0.0003	0.0003	0.0003	0.0003	0.0003	0.001	-	-	0.0002	B2
Ametryn	-	-	-	F	9	9	0.9	3	0.00	0.3	0.06	-	-	D
Ammonium sulfamate	-	-	-	F	20	20	20	80	0.28	8	2	-	-	D
Anthracene (PAH)***	-	-	-	-	-	-	-	-	0.3	-	-	-	-	D
Atrazine	F	0.003	0.003	F	0.1	0.1	0.05	0.2	0.03	0.2*	0.003*	-	-	C
Baygon	-	-	-	F	0.04	0.04	0.04	0.1	0.00	0.1	0.003	-	-	C
Bentazon	T	0.02	-	F	0.3	0.3	0.3	1.0	0.03	1.0	0.2**	-	-	D
Benz(a)anthracene (PAH)	-	-	-	-	-	-	-	-	-	-	-	-	-	B2
Benzene	F	zero	0.005	F	0.2	0.2	-	-	-	-	-	-	0.1	A
Benzo(a)pyrene (PAH)	F	zero	0.0002	-	-	-	-	-	-	-	-	-	0.0002	B2*
Benzo(b)fluoranthene (PAH)	-	-	-	-	-	-	-	-	-	-	-	-	-	B2
Benz (g,h,i)perylene (PAH)	-	-	-	-	-	-	-	-	-	-	-	-	-	D
Benzo(k)fluoranthene (PAH)	-	-	-	-	-	-	-	-	-	-	-	-	-	B2
bis-2-Chloroisopropyl ether	-	-	-	F	4	4	4	13	0.04	1	0.3	-	-	D
Bromacil	L	-	-	F	5	5	3	9	0.13	5	0.09	-	-	C
Bromobenzen	L	-	-	D	-	-	-	-	-	-	-	-	-	-

* Under review.

**NOTE: The HA value or the MCLG/MCL value for any two or more of these three chemicals should remain at 0.007 mg/L because of similar mode of action.

***PAH = Polyaromatic hydrocarbon

*See 40CFR Parts 141 and 142

**Revised value based on change in RID

NOTE: Anthracene and Benz (g,h,i)perylene — not proposed in Phase V.

NOTE: Changes from the last version are noted in *italic* and **Bold Face** print.

T to Fed register - Only action levels listed for Pb + Cu
 if the PAH includes both if MCLG=MCL
 = 0.001 = MCLG start

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group	
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult						
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	Rf1 (mg/l: g/da)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk		
Br mochloroacetonitrile	T	-	-	D	-	-	-	-	-	-	-	-	-	-
Bromochloromethane	-	-	-	F	0.1	1	0.1	0.5	0.012	0.05	0.01	-	-	-
Bromodichloromethane (THM)	P	zero	0.1*/0.08*	D	6	6	4	13	0.02	0.7	-	0.06	B2	
Br m form (THM)	P	zero	0.1*/0.08*	D	5	2	2	6	0.02	0.7	-	0.4	B2	
Bromomethane	T	-	-	F	0.1	0.1	0.1	0.5	0.001	0.05	0.01	-	D	
Butyl benzyl phthalate (PAE)***	-	-	-	-	-	-	-	-	0.2	7	-	-	C	
Butylate	-	-	-	F	2	2	1	4	0.05	2	0.35	-	D	
-Butylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	-	
-Butylbenzene sec-	-	-	-	D	-	-	-	-	-	-	-	-	-	
-Butylbenzene tert-	-	-	-	D	-	-	-	-	-	-	-	-	-	
Carbaryl	-	-	-	F	1	1	1	1	0.1	4	0.7	-	D	
Carbofuran	F	0.04	0.04	F	0.05	0.05	0.05	0.2	0.005	0.2	0.04	-	E	
Carbon tetrachloride	F	zero	0.005	F	4	0.2	0.07	0.3	0.0007	0.03	-	0.03	B2	
Carboxin	-	-	-	F	1	1	1	4	0.1	4	0.7	-	D	
-Chloral hydrate	P	0.04	0.06**	D	7	0.2	0.2	0.6	0.0002	0.06	0.06	-	C	
Chloramben	-	-	-	F	3	3	0.2	0.5	0.015	0.5	0.1	-	D	
Chlordan	F	zero	0.002	F	0.06	0.06	-	-	0.00036	0.002	-	0.003	B2	
Chlorodibromomethane (THM)	P	0.06	0.1*/0.08*	D	6	6	2	8	0.02	0.7	0.06	-	C	
Chloroethane	L	-	-	D	-	-	-	-	-	-	-	-	B	
Chloroform (THM)	P	zero	0.1*/0.08*	D	4	4	0.1	0.4	0.01	0.4	-	0.6	B2	
Chloromethane	L	-	-	F	9	0.4	0.4	1	0.004	0.1	0.003	-	C	
Chlorophenol (2-)	-	-	-	D	0.5	0.5	0.5	2.0	0.005	0.2	0.04	-	D	
-p-Chlorophenyl methyl sulfide/sulfone/sulfoxide	-	-	-	**	-	-	-	-	-	-	-	-	D	
-Chloropicrin	L	-	-	-	-	-	-	-	-	-	-	-	-	
Chlor thalonil	-	-	-	F	0.2	0.2	0.2	0.5	0.015	0.5	-	0.15	B2	
Chlorotoluene o-	L	-	-	F	2	2	2	7	0.02	0.7	0.1	-	D	
-Chlor toluene p-	L	-	-	F	2	2	2	7	0.02	0.7	0.1	-	D	
Chlorpyrifos	-	-	-	F	0.03	0.03	0.03	0.1	0.003	0.1	0.02	-	D	
Chrysene (PAH)	-	-	-	-	-	-	-	-	-	-	-	---	B2	
Cyanazine****	T	0.001	-	D	0.1	0.1	0.02	0.07	0.002	0.07	0.001****	-	C	

* Database Deficiency Report has been published.

* Current MCL. ** A HA will not be developed due to insufficient data.

* 1994 Proposed Rule for Disinfectants and Disinfection By-products: Total for all THMs combined must not exceed the 0.08 level.

** Total for all chlorinated acetic acids cannot exceed 0.06 level. *** PAE = phthalate acid ester **** Draft updated for the Phase VIB regulation, which has been postponed. It includes the change of the cancer classification from D to C, thus justifying the use of an additional 10-fold safety factor for the lifetime HA.

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Chemicals	Standards			Status HA	Health Advisories							Cancer Group		
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult						
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	RfD (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)		mg/l at 10 ⁻⁴ Cancer Risk	
Cyanogen chloride	T	-	-	-	-	-	-	-	-	-	-	-	-	-
-Cymene p-	-	-	-	D	-	-	-	-	-	-	-	-	-	-
2,4-D	F	0.07	0.07	F	1	0.3	0.1	0.4	0.0	0.4	0.07	-	-	D
DCPA (Dacthal)	L	-	-	F	80	80	5	20	0.0	-	-	-	-	D
Dalapon	F	0.2	0.2	F	3	3	0.3	0.9	0.06	0.9	0.2	-	-	D
Di[2-ethylhexyl]adipate	F	0.4	0.4	-	20	20	20	60	0.6	20	0.4	3	-	C
Diazinon	-	-	-	F	0.02	0.02	0.005	0.02	0.0009	0.003	0.0006	-	-	E
-Dibromoacetonitrile	L	-	-	D	2	2	2	8	0.0	0.8	0.02	-	-	C
-Dibromochloropropane (DBCP)	F	zero	0.0002	F	0.2	0.05	-	-	-	-	-	0.003	-	B2
Dibromomethane	L	-	-	-	-	-	-	-	-	-	-	-	-	D
Dibutyl phthalate (PAE)	-	-	-	-	-	-	-	-	0.1	4	-	-	-	D
Dicamba	L	-	-	F	0.3	0.3	0.3	1	0.0	1	0.2	-	-	D
-Dichloroacetaldehyde	L	-	-	D	-	-	-	-	-	-	-	-	-	-
-Dichloroacetic acid *	P	zero	0.06**	D	1	1	1	4	0.04	0.1	-	-	-	B2
-Dichloroacetonitrile	L	-	-	D	1	1	0.8	3	0.08	0.3	0.006	-	-	C
Dichlorobenzene o-	F	0.6	0.6	F	9	9	9	30	0.0	3	0.6	-	-	D
Dichlorobenzene m-	-	-	-	F	9	9	9	30	0.0	3	0.6	-	-	D
Dichlorobenzene p-	F	0.075	0.075	F	10	10	10	40	0.1	4	0.075	-	-	C
Dichlorodifluoromethane	L	-	-	F	40	40	9	30	0.2	5	1	-	-	D
Dichloroethane (1,2-)	F	zero	0.005	F	0.7	0.7	0.7	2.6	-	-	-	0.04	-	B2
Dichloroethylene (1,1-)	F	0.007	0.007	F	2	1	1	4	0.09	0.4	0.007	-	-	C
Dichloroethylene (cis-1,2-)	F	0.07	0.07	F	4	3	3	11	0.0	0.4	0.07	-	-	D
Dichloroethylene (trans-1,2-)	F	0.1	0.1	F	20	2	2	6	0.0	0.6	0.1	-	-	D
Dichloromethane	F	zero	0.005	F	10	2	-	-	0.0	2	-	0.5	-	B2
Dichlorophenol (2,4-)	-	-	-	D	0.03	0.03	0.03	0.1	0.03	0.1	0.02	-	-	D
-Dichloropropane (1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-	-
Dichloropropane (1,2-)	F	zero	0.005	F	-	0.09	-	-	-	-	-	0.06	-	B2
-Dichloropropane (1,3-)	L	-	-	D	-	-	-	-	-	-	-	-	-	-

* The values for m-dichlorobenzene are based on data for o-dichlorobenzene.

** A quantitative risk estimate has not been determined.

** Total for all haloacetic acids cannot exceed 0.06 level.

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Chemicals	Standards			Status HA	Health Advisories								Cancer Gr up
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult					
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	RfD (mg/ kg/ da)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk	
- Dichloropropane (2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
- Dichloropropane (1,1-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (1,3-)	T	zero	-	F	0.03	0.03	0.03	0.09	0.0003	0.01	-	0.02	B2
Dieldrin	-	-	-	F	0.0005	0.0005	0.0005	0.002	0.00035	0.002	-	0.0002	B2
Diethyl phthalate (PAE)	-	-	-	D	-	-	-	-	0.8	30	5	-	D
Diethylene glycol dinitrate	-	-	-	*	-	-	-	-	-	-	-	-	-
Di(2-ethylhexyl)phthalate (PAE)	F	zero	0.006	D	-	-	-	-	0.02	0.7	-	0.3	B2
Diisopropyl methylphosphonate	-	-	-	F	8	8	8	30	0.08	3	0.6	-	D
-Dimethrin	-	-	-	F	10	10	10	40	0.3	10	2	-	D
-Dimethyl methylphosphonate	-	-	-	F	2	2	2	6	0.2	7	0.1	0.7	C
Dimethyl phthalate (PAE)	-	-	-	-	-	-	-	-	-	-	-	-	D
1,3-Dinitrobenzene	-	-	-	F	0.04	0.04	0.04	0.14	0.0001	0.005	0.001	-	D
Dinitrotoluene (2,4-)	L	-	-	F	0.50	0.50	0.30	1	0.002	0.1	-	0.005	B2
Dinitrotoluene (2,6-)	L	-	-	F	0.40	0.40	0.40	1	0.001	0.04	-	0.005	B2
tg 2,6 & 2,4 dinitrotoluene **	-	-	-	-	-	-	-	-	-	-	-	0.005	B2
Dinoseb	F	0.007	0.007	F	0.3	0.3	0.01	0.04	0.001	0.04	0.007	-	D
Dioxane p-	-	-	-	F	4	0.4	-	-	-	-	-	0.7	B2
Diphenamid	-	-	-	F	0.3	0.3	0.3	1	0.03	1	0.2	-	D
Diphenylamine	-	-	-	F	1	1	0.3	1	0.03	1	0.2	-	D
Diquat	F	0.02	0.02	-	-	-	-	-	0.0022	0.08	0.02	-	D
Disulfoton	-	-	-	F	0.01	0.01	0.003	0.009	0.00034	0.001	0.0003	-	E
Dithiane (1,4-)	-	-	-	F	0.4	0.4	0.4	1	0.01	0.4	0.08	-	D
Diuron	-	-	-	F	1	1	0.3	0.9	0.002	0.07	0.01	-	D
Endothall	F	0.1	0.1	F	0.8	0.8	0.2	0.2	0.02	0.7	0.1	-	D
Endrin	F	0.002	0.002	F	0.02	0.02	0.003	0.01	0.0003	0.01	0.002	-	D
Epichlorohydrin	F	zero	TT	F	0.1	0.1	0.07	0.07	0.002	0.07	-	0.4	B2
Ethylbenzene	F	0.7	0.7	F	30	3	1	3	0.1	3	0.7	-	D
Ethylene dibromide (EDB)	F	zero	0.00005	F	0.008	0.008	-	-	-	-	-	0.00004	B2
Ethylene glycol	-	-	-	F	20	6	6	20	2	40	7	-	D
ETU	L	-	-	F	0.3	0.3	0.1	0.4	0.00038	0.003	-	0.03	B2
Fenamiphos	-	-	-	F	0.009	0.009	0.005	0.02	0.00025	0.009	0.002	-	D

* An HA will not be developed due to insufficient data; a "Database Deficiency Report" has been published.

** tg = technical grade

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult					
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	RTL (mg/l g/ day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk	
Fluometron	-	-	-	F	2	2	2	5	0.012	0.4	0.09	-	D
Fluorene (PAH)	-	-	-	-	-	-	-	-	0.04	-	-	-	D
Fluorotrichloromethane	L	-	-	F	7	7	3	10	0.3	10	2	-	D
Fog Oil	-	-	-	D	-	-	-	-	-	-	-	-	-
Fonofos	-	-	-	F	0.02	0.02	0.02	0.07	0.002	0.07	0.01	-	D
Formaldehyd	D	-	-	D	10	5	5	20	0.15	5	1	-	B1**
Gasoline, unleaded (benzene)	-	-	-	D	-	-	-	-	-	-	0.005	-	-
Glyphosate	F	0.7	0.7	F	20	20	1	1	0.1	4	0.7	-	E
Heptachlor	F	zero	0.0004	F	0.01	0.01	0.005	0.005	0.0005	0.02	-	0.0008	B2
Heptachlor epoxide	F	zero	0.0002	F	0.01	-	0.0001	0.0001	1E-4	0.0004	-	0.0004	B2
Hexachlorobenzene	F	zero	0.001	F	0.05	0.05	0.05	0.2	0.0003	0.03	-	0.002	B2
Hexachlor butadiene	T	0.001	-	F	0.3	0.3	0.1	0.4	0.002	0.07	0.001	-	C
Hexachlorocyclopentadiene	F	0.05	0.05	-	-	-	-	-	0.007	0.2	-	-	D
Hexachloroethane	L	-	-	F	5	5	0.1	0.5	0.001	0.04	0.001	-	C
Hexane (n-)	-	-	-	F	10	4	4	10	-	-	-	-	D
Hexazinone	-	-	-	F	3	3	3	9	0.033*	1*	0.2*	-	D
HMX	-	-	-	F	5	5	5	20	0.05	2	0.4	-	D
Indeno(1,2,3,-c,d)pyrene (PAH)	-	-	-	D	-	-	-	-	-	-	-	***	B2
Isophorone	L	-	-	F	15	15	15	15	0.2	7	0.1	4	C
Isopropyl methylphosphonate	-	-	-	D	30	30	30	100	0.1	4.0	0.7	-	D
Isopropylbenzene	-	-	-	D	-	-	-	-	-	-	-	-	-
Lindane	F	0.0002	0.0002	F	1	1	0.03	0.1	0.0003	0.01	0.0002	-	C
Malathion	-	-	-	F	0.2	0.2	0.2	0.8	0.02	0.8	0.2	-	D
Maleic hydrazide	-	-	-	F	10	10	5	20	0.5	20	4	-	D
MCPA	-	-	-	F	0.1	0.1	0.1	0.4	0.0015	0.05	0.01	-	E
Methomyl	L	-	-	F	0.3	0.3	0.3	0.3	0.025	0.9	0.2	-	D
Methoxychlor	F	0.04	0.04	F	0.05	0.05	0.05	0.2	0.005	0.2	0.04	-	D
Methyl ethyl ketone*	-	-	-	F	-	-	-	-	-	-	-	-	D
Methyl parathion	-	-	-	F	0.3	0.3	0.03	0.1	0.00025	0.009	0.002	-	D

* Under review.

** Carcinogenicity based on inhalation exposure.

*** See 40CFR Parts 141 and 142

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Chemicals	Standards			Status HA	Health Advisories								Cancer Gr up
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult					
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	RfD (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk	
Methyl tert butyl ether	L	-	-	D	24	24	3	12	0.03	1.0	0.02-0.2*	-	C***
Metolachlor	L	-	-	F	2	2	2	5.0	0.1	3.5	0.07	-	C
Metribuzin	L	-	-	F	5	5	0.3	0.5	0.013***	0.5	0.1	-	D
-Monochloroacetic acid	L	-	-	D	-	-	-	-	-	-	-	-	-
-Monochlor benzene	F	0.1	0.1	F	2	2	2	7	0.02	0.7	0.1	-	D
Naphthalene	-	-	-	F	0.5	0.5	0.4	1	0.004	0.1	0.02	-	D
-Nitrocellulose (non-toxic)	-	-	-	F	-	-	-	-	-	-	-	-	-
Nitroguanidine	-	-	-	F	10	10	10	40	0.1	4	0.7	-	D
Nitr phenol p-	-	-	-	F	0.8	0.8	0.8	3	0.008	0.3	0.06	-	D
Oxamyl (Vydate)	F	0.2	0.2	F	0.2	0.2	0.2	0.9	0.025	0.9	0.2	-	E
Paraquat	-	-	-	F	0.1	0.1	0.05	0.2	0.0045	0.2	0.03	-	E
-Pentachloroethane	-	-	-	D	-	-	-	-	-	-	-	-	-
Pentachlorophenol	F	zero	0.001	F	1	0.3	0.3	1	0.03	1	-	0.03	B2
Phenanthrene (PAH)	-	-	-	-	-	-	-	-	-	-	-	-	-
Phen I	-	-	-	D	6	6	6	20	0.6	20	4	-	D
Picloram	F	0.5	0.5	F	20	20	0.7	2	0.07	2	0.5	-	D
Polychlorinated biphenyls (PCBs)	F	zero	0.0005	P	-	-	-	-	-	-	-	0.0005	B2
Prom ton *	L	-	-	F	0.2	0.2	0.2	0.5	0.015*	0.5*	0.1*	-	D
Pronamide	-	-	-	F	0.8	0.8	0.8	3	0.075	3	0.05	-	C
Propachlor	-	-	-	F	0.5	0.5	0.1	0.5	0.013	0.5	0.09	-	D
Pr pazin	-	-	-	F	1	1	0.5	2	0.02	0.7	0.01	-	C
Propham	-	-	-	F	5	5	5	20	0.02	0.6	0.1	-	D
-Pr pylbenzene n-	-	-	-	D	-	-	-	-	-	-	-	-	-
Pyrene (PAH)	-	-	-	-	-	-	-	-	0.03	-	-	-	D
RDX	-	-	-	F	0.1	0.1	0.1	0.4	0.003	0.1	0.002	0.03	C
Simazine	F	0.004	0.004	F	0.07	0.07	0.07	0.07	0.005	0.2	0.004	-	C
Styrene	F	0.1	0.1	F	20	2	2	7	0.2	7	0.1	-	C
2,4,5-T	L	-	-	F	0.8	0.8	0.8	1	0.01	0.35	0.07	-	D
2,3,7,8-TCDD (Dioxin)	F	zero	3E-08	F	1E-06	1E-07	1E-08	4E-08	1E-06	4E-08	-	2E-08	B2

* Und r r view. NOTE: Phenanthrene — not proposed.

** The RfD for metribuzin was revised Dec. 1994 to 0.013 mg/kg/day. Based on this revised RfD the Lifetime HA would be 0.1 mg/l assuming a 20% relative source contribution for drinking water. This information has not been incorporated in the Health Advisory document.

*** Tentative.

* If the cancer classification C is accepted, the Lifetime HA is 0.02; otherwise it is 0.200 mg/L

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult					
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	Rf (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁶ Cancer Risk	
T buthiuron	-	-	-	F	3	3	0.7	2	0.07	2	0.5	-	D
Terbacil	-	-	-	F	0.3	0.3	0.3	0.9	0.01	0.4	0.09	-	E
Terbufos	-	-	-	F	0.005	0.005	0.001	0.005	0.0013	0.005	0.0009	-	D
Tetrachloroethane (1,1,1,2-)	L	-	-	F	2	2	0.9	3	0.03	1	0.07	0.1	C
Tetrachloroethane (1,1,2,2-)	L	-	-	D	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	F	zero	0.005	F	2	2	1	5	0.01	0.5	-	0.07	-
-Tetranitromethane	-	-	-	**	-	-	-	-	-	-	-	-	-
Toluene	F	1	1	F	20	2	2	7	0.2	7	1	-	D
Toxaphene	F	zero	0.003	F	-	-	-	-	0.1	-	-	0.003	B2
2,4,5-TP	F	0.05	0.05	F	0.2	0.2	0.07	0.3	0.005	0.3	0.05	-	D
1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-	-	-
-Trichloroacetic acid	P	0.3	0.06**	D	4	4	4	13	0.1	4.0	0.3	-	C
-Trichloroacetonitrile	L	-	-	D	0.05	0.05	-	-	-	-	-	-	-
Trichlorobenzene (1,2,4-)	F	0.07	0.07	F	0.1	0.1	0.1	0.5	0.01	0.04	0.07	-	D
-Trichlorobenzene (1,3,5-)	-	-	-	F	0.6	0.6	0.6	2	0.001	0.2	0.04	-	C
Trichloroethane (1,1,1-)	F	0.2	0.2	F	100	40	40	100	0.03	1	0.2	-	D
Trichloroethane (1,1,2-)	F	0.003	0.005	F	0.6	0.4	0.4	1	0.001	0.1	0.003	-	C
-Trichloroethanol (2,2,2-)	L	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	F	zero	0.005	F	-	-	-	-	-	0.3	-	0.3	B2
Trichlorophenol (2,4,6-)	L	-	-	D	-	-	-	-	-	-	-	0.3	B2
-Trichloropropane (1,1,1-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trichloropropane (1,2,3-)	L	-	-	F	0.6	0.6	0.6	2	0.001	0.2	0.04	0.5	B2
Trifluralin	L	-	-	F	0.08	0.08	0.08	0.3	0.005	0.3	0.005	0.5	C
Trimethylbenzene (1,2,4-)	-	-	-	D	-	-	-	-	-	-	-	-	-
Trimethylbenzene (1,3,5-)	-	-	-	D	-	-	-	-	-	-	-	-	-
-Trinitroglycerol	-	-	-	F	0.005	0.005	0.005	0.005	-	-	0.005	-	-
-Trinitrotoluene	-	-	-	F	0.02	0.02	0.02	0.02	0.005	0.02	0.002	0.1	C
Vinyl chloride	F	zero	0.002	F	3	3	0.01	0.05	-	-	-	0.0015	A
Xylenes	F	10	10	F	40	40	40	100	2	60	10	-	D

* Under review.

** A HA will not be developed due to insufficient data; a "Database Deficiency Report" has been published.

** Total for all haloacetic acids cannot exceed 0.06 mg/l vel.

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult					
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	FFD (mg/kg/day)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk	
INORGANICS													
Aluminum	L	-	-	D	-	-	-	-	-	-	-	-	-
Ammonia	-	-	-	D	-	-	-	-	-	-	30	-	D
Antimony	F	0.006	0.006	F	0.01	0.01	0.01	0.015	0.004	0.01	0.003	-	D
Arsenic	*	-	0.05	D	-	-	-	-	-	-	-	0.002	A
Asbestos (fibers/l >10µm length)	F	7 MFL	7 MFL	D	-	-	-	-	-	-	-	700 MFL	A
Barium	F	2	2	F	-	-	-	-	0.0 ¹	2	2	-	D
Beryllium	F	0.004	0.004	D	30	30	4	20	0.0 ¹⁵	0.2	-	0.0008	B2
Boron	L	-	-	D	4	0.9	0.9	3	0.0 ¹	3	0.6	-	D
Bromate	L	zero	0.01	-	-	-	-	-	-	-	-	-	-
Cadmium	F	0.005	0.005	F	0.04	0.04	0.005	0.02	0.0 ¹⁰⁵	0.02	0.005	-	D
Chloramine	P	4 ^{***}	4	D	1	1	1	1	0.1	3.3	3/4 ^{***}	-	-
Chlorate	L	-	-	D	-	-	-	-	-	-	-	-	-
Chlorine	P	4	4	D	-	-	-	-	0.1	-	-	-	D
Chlorine dioxide	T	0.3	0.8	D	-	-	-	-	0.0	0.35	0.3	-	D
Chlorite	L	0.08	1	D	-	-	-	-	0.0 ¹³	0.1	0.08	-	D
Chromium (total)	F	0.1	0.1	F	1	1	0.2	0.8	0.0 ¹⁵	0.2	0.1	-	D
Copper (at tap)	F	1.3	TT ^{**}	-	-	-	-	-	-	-	-	-	D
Cyanide	F	0.2	0.2	F	0.2	0.2	0.2	0.8	0.0 ²	0.8	0.2	-	D
Fluoride [*]	F	4	4	-	-	-	-	-	0.1 ²	-	-	-	-
Hypochlorite	P	4 ¹	-	-	-	-	-	-	-	-	-	-	-
Hypochlorous acid	P	4 ¹	-	-	-	-	-	-	-	-	-	-	-
Lead (at tap)	F	zero	TT ^{**}	-	-	-	-	-	-	-	-	-	B2
Manganese	L	-	-	-	-	-	-	-	0.1 ²	-	-	-	-
Mercury (inorganic)	F	0.002	0.002	F	-	-	-	0.002	0.0 ¹⁰³	0.01	0.002	-	D
Molybdenum	L	-	-	D	0.02	0.02	0.01	0.05	0.0 ⁵	0.2	0.04	-	D
Nickel	F	0.1 ⁴	0.1 ⁴	F	1	1	0.5	1.7	0.0 ¹	0.6	0.1	-	D
Nitrate (as N)	F	10	10	F	-	10 [*]	-	-	1.6	-	-	-	-

* Under review.

** Copper — action level 1.3 mg/L, Lead — action level 0.015 mg/L

*** Measured as free chlorine.

¹ Regulated as chlorine.

² In food.

³ In water.

⁴ Being re-

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Chemicals	Standards			Status HA	Health Advisories								Cancer Group	
	Status Reg.	MCLG (mg/l)	MCL (mg/l)		10-kg Child			70-kg Adult						
					One-day (mg/l)	Ten-day (mg/l)	Longer-term (mg/l)	Longer-term (mg/l)	R D (mcg/kg/d; y)	DWEL (mg/l)	Lifetime (mg/l)	mg/l at 10 ⁻⁴ Cancer Risk		
Nitrite (as N)	F	1	1	F	-	1*	-	-	0.1*	-	-	-	-	-
Nitrate + Nitrite (both as N)	F	10	10	F	-	-	-	-	-	-	-	-	-	-
Selenium	F	0.05	0.05	-	-	-	-	-	0.05	-	-	-	-	-
Silver	-	-	-	D	0.2	0.2	0.2	0.2	0.05	0.2	0.1	-	-	D
Sodium	-	-	-	D	-	-	-	-	-	20**	-	-	-	-
Strontium	L	-	-	D	25	25	25	90	0.6	90	17	-	-	D
Sulfate	P	500	500	D	-	-	-	-	-	-	-	-	-	-
Thallium	F	0.0005	0.002	F	0.007	0.007	0.007	0.02	0.0007	0.0023	0.0005	-	-	-
Vanadium	T	-	-	D	-	-	-	-	-	-	-	-	-	D
White phosphorous	-	-	-	F	-	-	-	-	0.0002	0.0005	0.0001	-	-	D
Zinc	L	-	-	D	6	6	3	10	0.3	10	2	-	-	D
Zinc chloride (measured as Zinc)	L	-	-	F	6	6	3	10	0.3	10	2	-	-	D
RADIONUCLIDES														
Beta particle and photon activity (formerly man-made radionuclides)	F	++	4 mrem	-	-	-	-	-	-	-	-	-	4 mrem/y	A
Gross alpha particle activity	F	++	15 pCi/L	-	-	-	-	-	-	-	-	-	15 pCi/L	A
Combined Radium 226 & 228	F	++	5 pCi/L	-	-	-	-	-	-	-	-	-	20 pCi/L	A
Radon*	P	zero	300 pCi/L	-	-	-	-	-	-	-	-	-	150 pCi/L	A
Uranium*	P	zero	20 µg/L	-	-	-	-	-	0.3	-	-	-	-	A

* Under review. ** Guidance.
 + 1991 Proposed National Primary Drinking Water Rule for Radionuclides
 ++No final MCLG, but zero proposed in 1991.

Secondary Maximum Contaminant Levels

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Chemicals	Status	SMCLs (mg/L)
Aluminum	F	0.05 to 0.2
Chloride	F	250
Color	F	15 color units
Copper	F	1.0
Corrosivity	F	non-corrosive
Fluoride*	F	2.0
Foaming agents	F	0.5
Iron	F	0.3
Manganese	F	0.05
Odor	F	3 threshold odor numbers
pH	F	6.5 — 8.5
Silver	F	0.1
Sulfate	F	250
Total dissolved solids (TDS)	F	500
Zinc	F	5

Status Codes: P — proposed, F — final

* Under review.

Secondary Drinking Water Standards are unenforceable federal guidelines regarding taste, odor, color and certain aesthetic effects of drinking water. EPA recommends them to the States as reasonable goals, but federal law does not require water systems to comply with them. States may, however, adopt their own enforceable regulations governing these concerns. To learn more, check your State's drinking water rules.

Microbiology

October 1996

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	Status	MCLG	MCL
Cryptosporidium	L	-	-
<i>Giardia lamblia</i>	F	zero	TT
<i>Legionella</i>	F*	zero	TT
Standard Plate Count	F*	NA	TT
Total Coliforms	F	zero	**
Turbidity	F	NA	PS
Viruses	F*	zero	TT

Key: PS, TT, F, defined as previously stated.

- * Final for systems using surface water; also being considered for regulation under groundwater disinfection rule.

11/95 EPA HEALTH ADVIS.

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	BC	D	E	F	G	H	I	J	K	L	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	All	
05																									2.50
06																									1.75
07																									1.25
08																									3.00
09																									2.50
10																									1.50
11																									2.25
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D-223																										1.75
D-224																										1.50
D-225																										1.75
D-226																										1.50
D-227																										3.50
D-228																										2.25
D-229																										2.25
D-230																										2.00
D-231																										2.25
D-232																										2.00
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D-060	Methyl-t-Butyl Ether Drinking Water Health Advisory (Draft)	3.50 Jan-92
D-A10	Methyl-t-Butyl Ether Drinking Water Health Advisory (Draft)	3.50 Jan-92
G-045	Zinc Health Advisory (Draft)	4.50 Dec-90

35.25

Total charge: \$495.50

APPENDIX E.5

STATE MAXIMUM CONTAMINANT LEVELS (MCLs)

§19-13-B102. Standards for quality of public drinking water

The following standards for the quality of drinking water, minimum treatment methods, and requirements for the design and operation of treatment works and water sources shall be met by all public water systems.

(a) Definitions. As used in Section 19-13-B102:

(1) "Action Level" means the concentration of lead or copper in water specified in subsection (j)(6)(B) of this section which determines, in some cases, the treatment requirements contained in subsection (j) (6) of this section that a water system is required to complete.

(2) "Active Source Of Supply" means all springs, streams, watercourses, brooks, rivers, lakes, ponds, wells, or underground water from which water is taken on a regular or periodic basis for water supply purposes. A number of wells drawing water from a single aquifer or more than one surface water body or a combination of surface water and groundwater sources connected to a common distribution system may, at the discretion of the department, be considered a single source of supply.

(3) "CFR" means code of federal regulations.

(4) "Certified Distribution System Operator" means an operator who has met the education, experience, and examination requirements specified in Section 25-32-11 of the regulations of Connecticut State agencies.

(5) "Certified Treatment Plant Operator" means an operator who has met the education, experience, and examination requirements of Section 25-32-9 of the regulations of Connecticut State agencies.

(6) "Coagulation" means a process using coagulant chemicals and mixing by which colloidal and suspended materials are destabilized and agglomerated into flocs.

(7) "Community Water System" means a public water system that serves at least twenty-five (25) residents throughout the year.

(8) "Complete Conventional Treatment" means coagulation, sedimentation, rapid granular filtration, and disinfection unless approved otherwise by the department.

(9) "Compliance Period" means a three (3) calendar-year period within a compliance cycle. Each compliance cycle has three (3) three-year compliance periods. Within the first compliance cycle, the first compliance period runs from January 1, 1993 to December 31, 1995; the second from January 1, 1996 to December 31, 1998; the third from January 1, 1999 to December 31, 2001.

(10) "Compliance Cycle" means the nine (9) calendar-year cycle during which public water systems shall monitor. Each compliance cycle consists of three (3) three-year compliance periods. The first calendar year cycle begins January 1, 1993 and ends December 31, 2001; the second begins January 1, 2002 and ends December 31, 2010; the third begins January 1, 2011 and ends December 31, 2019.

(11) "Confluent Growth" means a continuous bacterial growth covering the entire filtration area of a membrane filter, or a portion thereof, in which bacterial colonies are not discrete.

(12) "Consecutive Public Water System" means a public water system that purchases all of its water from another public water system and does not operate or control any other sources of supply.

(13) "Consumer" means one that meets the requirements of section 25-32a of the Connecticut General Statutes.

(14) "Contaminant" means any physical, chemical, biological, or radiological substance or matter in water as in section 1401 Title XIV of the Federal Public Health Service Act.

(15) "Conventional Filtration Treatment" means a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal.

(16) "Corrosion Inhibitor" means a substance capable of reducing the corrosivity of water toward metal plumbing materials, especially lead and copper, by forming a protective film on the interior surface of those materials.

(17) "CT" or "CT CALC" means the product of the "residual disinfectant concentration" (C) in milligrams per liter (mg/l) determined before or at the first customer, and the corresponding "disinfectant contact time" (T) in minutes (i.e., "C" X "T"). If a public water system applies disinfectants at more than one point prior to the first customer, it shall determine the CT of each disinfectant sequence before or at the first customer to determine the total percent inactivation.

(18) "Department" means Connecticut Department of Public Health.

(19) "Diatomaceous Earth Filtration" means a process resulting in substantial particulate removal in which a precoat cake of diatomaceous earth filter media is deposited on a support membrane (septum), and while the water is filtered by passing through the cake on the septum, additional filter media known as body feed is continuously added to the feed water to maintain the permeability of the filter cake.

(20) "Direct Filtration" means a series of processes including coagulation and filtration but excluding sedimentation resulting in substantial particulate removal.

(21) "Disinfectant Contact Time" ("T" in CT calculations) means the time in minutes that it takes for water to move from the point of disinfectant application or the previous point of disinfectant residual measurement to a point before or at the point where residual disinfectant concentration ("C") is measured.

(A) Where only one "C" is measured (single application point), "T" is the time in minutes that it takes for water to move from the point of disinfectant application to a point before or at which residual disinfectant concentration ("C") is measured.

(B) Where more than one "C" is measured (multiple application points), "T" is:

(i) for the first measurement of "C," the time in minutes that it takes for water to move from

the first point of disinfectant application to a point before or at the point where the first "C" is measured, and

(ii) for subsequent measurements of "C," the time in minutes that it takes for water to move from the previous "C" measurement point to the "C" measurement point for which the subsequent "T" is being calculated.

(C) Disinfectant contact time in pipelines shall be calculated by dividing the internal volume of the pipe by the maximum hourly flow rate through that pipe (plug flow).

(D) Disinfectant contact time within mixing basins, clear wells, and storage reservoirs shall be determined by tracer studies or an equivalent demonstration.

(22) "Disinfection" means a process which inactivates pathogenic organisms in water by chemical oxidants or equivalent agents.

(23) "Domestic Or Other Non-Distribution System Plumbing Problem" means a coliform contamination problem in a public water system with more than one service connection that is limited to the specific service connection from which the coliform-positive sample was taken.

(24) "EC Medium/Mug Tests" means analytical tests for waterborne bacteria as specified in 40 CFR 141.21(f).

(25) "Effective Corrosion Inhibitor Residual" means a concentration sufficient to form a passivating film on the interior walls of a pipe.

(26) "End Of Distribution System" means the last service connection on a dead-end water main.

(27) "EPA" means the United States Environmental Protection Agency.

(28) "Filtration" means a process for removing particulate matter from water by passage through porous media.

(29) "First Draw Sample" means a one-liter sample of tap water, collected in accordance with subsection (e) (8) (B) (ii) of this section, that has been standing in plumbing pipes at least six (6) hours and is collected without flushing the tap.

(30) "Flocculation" means a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable particles through gentle stirring by hydraulic or mechanical means.

(31) "Groundwater Under The Direct Influence Of Surface Water" means any water beneath the surface of the ground with either significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as giardia lamblia, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence shall be determined for individual sources in accordance with criteria established by the department. The department determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation

according to "Department of Health Services criteria - determination of groundwater under the direct influence of surface water."

(32) "Initial Compliance Period" means the first full three-year compliance period which begins at least eighteen (18) months after promulgation. Initial compliance period runs from January 1, 1993 to December 31, 1995.

(33) "Large Water System" means a water system that serves more than fifty thousand (50,000) persons.

(34) "Lead Service Line" means a service line made of lead that connects the water main to a building inlet and any lead pigtail, gooseneck or other fitting connected to such lead line.

(35) "Legionella" means a genus of bacteria, some species of which have caused a type of pneumonia called legionnaires' disease.

(36) "Local director of health" means a city, town, borough, or district director of health or his authorized agent.

(37) "mg/l" means milligrams per liter.

(38) "Maximum Contaminant Level (MCL)" means the maximum permissible level of a contaminant in water that is delivered to any consumer of a public water system.

(39) "Maximum Contaminant Level Goal" or "MCLG" means the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. Maximum Contaminant Level Goals are non-enforceable health goals.

(40) "Medium-Size Water System" means a water system that serves greater than three thousand three hundred (3,300) and less than or equal to fifty thousand (50,000) persons.

(41) "Method Detection Limit (MDL)" means the minimum concentration of a substance that can be measured and reported with ninety-nine percent (99%) confidence that the true value is greater than zero (0).

(42) "Near The First Service Connection" means at one of the twenty percent (20%) of all service connections in the entire system that are nearest the water supply treatment facility, as measured by water transport time within the distribution system.

(43) "Non-Community Water System" means a public water system that serves at least twenty-five (25) persons at least sixty (60) days out of the year and is not a community or a seasonal water system.

(44) "Non-Transient Non-Community Water System" (NTNC) means a public water system that is not a community system and that regularly serves at least twenty-five (25) of the same persons over six (6) months per year.

(45) "Notification Level" means the level of a contaminant that if exceeded shall require public notification by a public water system to its consumers.

(46) "Optimal Corrosion Control Treatment" means the corrosion control treatment that minimizes the lead and copper concentrations at users' taps while ensuring that the treatment does not cause the water system to violate any drinking water statutes or regulations.

(47) "Other Unregulated Contaminants" means contaminants that meet or exceed the departments action level or contaminant level for which the maximum contaminant goal has been proposed for drinking water by EPA.

(48) "Physical Parameters" means color, turbidity, pH and odor.

(49) "Point Of Disinfectant Application" is the point where the disinfectant is applied and water downstream of that point is not subject to recontamination by surface water.

(50) "Point Of Entry" means a location on an active source of supply that is after any treatment and before entrance to the distribution system.

(51) "Public Water System" or "System" means any water company supplying water to fifteen (15) or more consumers or twenty-five (25) or more persons, based on the "Design Population" as defined in Section 16-262m-8(a)(3) of the regulations of Connecticut State Agencies, jointly administered by the department and the Department of Public Utility Control, daily at least sixty days (60) of the year.

(52) "Practical Quantification Level (PQL)" means the lowest concentration that can be reliably measured within specific limits of precision and accuracy during routine laboratory operating conditions.

(53) "Repeat Compliance Period" means any subsequent compliance period after the initial compliance period.

(54) "Repeat Sample" means a sample that is collected as a result of a total coliform-positive routine sample.

(55) "Residual Disinfectant Concentration" ("C" in CT calculations) means the concentration of disinfectant measured in mg/l in a representative sample of water.

(56) "Routine Sample" means a sample that is collected at a location and frequency as specified in the approved sample siting plan.

(57) "Sanitarian" means a person who is trained in environmental health and who is qualified to carry out educational and investigational duties in the fields of environmental health such as investigation of air, water, sewage, foodstuffs, housing and refuse by observing, sampling, testing and reporting; and who is licensed pursuant to section 20-361 of the Connecticut General Statutes.

(58) "Sanitary Survey" means an onsite inspection of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(59) "Seasonal Water System" means a public water system that operates on a seasonal basis for six (6) months or less per calendar year.

(60) "Second Compliance Period" means the second full three-year compliance period in the first compliance cycle. Second compliance period runs from January 1, 1996 to December 31, 1998.

(61) "Sedimentation" means a process for removal of solids before filtration by gravity or separation.

(62) "Service Line Sample" means a one (1) liter sample of water, collected in accordance with subsection (e) (8) (B) (iii) of this section, that has been standing for at least six (6) hours in a service line.

(63) "Single Family Structure" means a building constructed as a single-family residence that is currently used as either a residence or a place of business.

(64) "Slow Sand Filtration" means a process involving passage of raw water through a bed of sand at low velocity (generally less than 0.16 gallons per minute per square foot, gpm/sq. ft.) resulting in substantial particulate removal by physical and biological mechanisms.

(65) "Small Water System" means a water system that serves three thousand three hundred (3,300) persons or fewer.

(66) "Source Water" means raw water before any kind or type of treatment at the source of supply.

(67) "Special Purpose Sample" means a sample that is taken to determine whether disinfection practices are sufficient following routine maintenance work on the distribution system.

(68) "Surface Water" means all water that is open to the atmosphere and subject to surface runoff.

(69) "System With A Single Service Connection" means a system that supplies drinking water to consumers via a single service line.

(70) "Tier I Violation" means a public water system has failed to comply with requirements for any of the following:

(A) an applicable maximum contaminant level (MCL) or Action Level;

(B) regulations concerning quality and quantity of drinking water ready for consumption with the exception of odor, color, pH and sodium content;

(C) applicable treatment technique or any schedule prescribed pursuant to a variance or exemption.

(71) "Tier II Violation" means a public water system which:

- (A) has failed to perform monitoring requirements according to this section; or
- (B) has failed to comply with a current testing procedure established by EPA; or
- (C) is subject to a variance or an exemption.

(72) "Too Numerous To Count" means that the total number of bacterial colonies exceeds two hundred (200) on a forty-seven (47) mm diameter membrane filter used for coliform detection.

(73) "Transient Non-Community Water System" means a non-community water system that does not meet the definition of a non-transient non-community water system.

(74) "Virus" means a microorganism of fecal origin which is infectious to humans by waterborne transmission.

(75) "Water Company" means one that meets the requirements of Section 25-32a of the Connecticut General Statutes.

(76) "Water System" means all community water systems, non-transient non-community water systems and seasonal water systems.

(77) "Waterborne Disease Outbreak" means the significant occurrence of acute infectious illness, epidemiologically associated with the ingestion of water from a public water system as determined by the department.

(78) "Zone of Influence" means the land area that directly overlies and has the same horizontal extent as the part of the water table or other potentiometric surface that is perceptibly lowered by the withdrawal of water. The zone of influence delineated by the use of modeling is that area of land in which the water table or potentiometric surface is lowered by at least one-half (0.5) foot. In the event of inadequate information and data to delineate the zone of influence, a radius of one (1) mile shall be utilized for unconsolidated aquifer groundwater sources and a radius of one thousand (1000) feet shall be utilized for confined and bedrock aquifer groundwater sources.

(b) Watershed survey. A water utility having an active surface water source of supply under its control shall make a sanitary survey of the watershed to the intake at least annually. A report on the survey shall be submitted to the State Health Department by March 1 each year covering the preceding calendar year.

(c) Standards for quality of untreated water prior to treatment. All parameters shall be tested for each surface source at least annually, except bacteriological and physical tests which shall be done quarterly.

Groundwater sources shall be tested for these parameters when the department determines that the source is vulnerable to contamination.

Connecticut Final Regulations

Parameter	Degree of Treatment	
	Disinfection and Chemical Treatment	Filtration
(1) BACTERIOLOGICAL Coliform Organisms* (1)	Not to exceed 100/100 ml monthly average, based on a running arithmetic average for the most recent twelve month period. No individual sample is to exceed 500/100 ml	Not to exceed 20,000 measured by a monthly mean
(2) PHYSICAL Color	Not to exceed twenty (20) standard units in more than ten percent (10%) of samples for most recent twelve (12) month period	Not to exceed two hundred (250) standard units by a monthly geometric mean
Turbidity	The turbidity level as specified in 40 CFR 141.74 (a)(4), in a representative sample of the source water immediately prior to the first or only point of disinfection application shall not exceed (5) Nephelometric Turbidity Units (NTU).	Not to exceed two hundred (250) standard units by a monthly geometric mean

* If coliform organisms are demonstrated to be not associated with a fecal source on t

Parameter	Degree of Treatment	
	Disinfection and Chemical Treatment Level mg/l	Filtration Level mg/l
(3) INORGANIC CHEMICALS		
Arsenic	.05	.05
Barium	1	1
Cadmium	.01	.01
Chloride	250	250
Chromium	.05	.05
Copper	.05	1.0
Cyanide	.01	0.2
Fluoride	2.0	2.0
Lead	.05	.05
MBAS (methylene blue active substance)	0.5	0.5
Mercury	.002	.005
Nitrate plus Nitrite as N	10	10

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Selenium	.01	.01
Silver	.05	.05
(4) PESTICIDES	All Degrees of Treatment Level	
	mg/l	
Endrin		0.002
Lindane		0.0002
Methoxychlor		0.04
Toxaphene		0.003
2, 4-D		0.07
2, 4, 5-TP (silvex)		0.05

(d) Facility location. Such as but not limited to treatment plants, pumping stations, storage tanks, etc., but not including water intakes and connecting pipelines.

(1) New facilities are to be located: (A) Above the level of the one hundred year flood. (B) Where chlorine gas will not be stored or used within three hundred feet of any residence. (C) Where the facility is not likely to be subject to fires or other natural or manmade disasters.

(2) The state health department must be notified before entering into a financial commitment for a new public water system or increasing the capacity of an existing public water system, and the approval of the state health department must be obtained before any construction is begun. This includes construction of supply and treatment works, transmission lines, storage tanks, pumping stations and other works of sanitary significance. It does not include the routine extension of laterals or tapping of new service connections.

(e) Water ready for consumption.

(1) Physical Tests. Color is not to exceed fifteen (15) standard units leaving the treatment plant nor at representative sampling points in the distribution system.

Turbidity is not to exceed five (5) standard units at representative sampling points in the distribution system.

Odor is not to exceed a value of two (2) in the treatment plant effluent on a scale of 0-5 as follows:

0-None

1-Very Faint

2-Faint

3-Distinct

4-Decided

5-Strong

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For systems that are not required to install optimal corrosion control treatment under subsection (j)(7) of this section, the pH value is not to be less than 6.4 nor to exceed 10.0 entering the distribution system.

(2) Inorganic Chemicals

Community, non-transient non-community and seasonal water systems shall test for inorganic chemicals specified below. Transient non-community water systems shall test for nitrate and nitrite only.

Inorganic chemicals^{a(2)} and their limits

Chemical	Maximum Contaminant Level (mg/l)	Maximum Contaminant Level Goal (mg/l)
Antimony	0.006	
Arsenic	0.05	
Asbestos	7.0 MFL ¹ (3)	
Barium	2.0	
Beryllium	0.004	
Cadmium	0.005	
Chromium	0.1	
Cyanide	0.2	
Fluoride	4.0	
Mercury	0.002	
Nickel	0.1	
Nitrate nitrogen	10.0 (as N)	
Nitrite nitrogen	1.0 (as N)	
Nitrate nitrogen plus nitrite nitrogen	10.0 (as N)	
Selenium	0.05	
Silver	0.05	
Sulfate	** (4)	
Chloride	250	
Thallium	0.002	
Lead	*** (5)	(0)
Copper	*** (6)	1.3
	Notification Level (mg/l)	
Sodium	28.0	

Notes

** MCL has not been established for this chemical.

*** See Section 19-13-B102(j) (6).

¹ MFL = million fibers per liter longer than ten (10) micrometers.

(3) Pesticides, Herbicides and PCBs. Community, non-transient non-community and seasonal

water systems shall test for pesticides, herbicides and PCB specified below.

Pesticides, Herbicides, PCB, and their limits

Chemical ¹ (7)	Maximum Contaminant Level (mg/l)
Alachlor	0.002
Aldicarb	** (8)
Aldicarb sulfoxide	** (9)
Aldicarb sulfone	** (10)
Aldrin	** (11)
Atrazine	0.003
Benzo(A)pyrene	0.0002
Butachlor	** (12)
Carbaryl	** (13)
Carbofuran	0.04
Chlordane	0.002
Dalapon	0.2
Di(2-ethylhexyl)adipate	0.4
Di(2-ethylhexyl)phthalates	0.006
Dicamba	** (14)
Dieldrin	** (15)
Dinoseb	0.007
Diquat	0.02
Dibromochloropropane (DBCP)	0.0002
2, 4-D	0.07
Ethylene dibromide (EDB)	0.00005
Endrin	0.002
Endothall	0.1
Glyphosate	0.7
Heptachlor	0.0004* (16)
Heptachlor epoxide	0.0002* (17)
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
3-Hydroxycarbofuran	** (18)
Lindane	0.0002
Methoxychlor	0.04
Methomyl	** (19)
Metolachlor	** (20)
Metribuzin	** (21)
Oxamyl (vydate)	0.2
Picloram	0.5
Propachlor	** (22)
Simazine	0.004
2, 3, 7, 8-TCDD (dioxin)	0.00000003
Polychlorinated biphenyls (PCB)	0.0005
Pentachlorophenol	0.001
Toxaphene	0.003

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2, 4, 5-TP (silvex) 0.05

Notes:

- ¹ The method detection limits for all pesticides, herbicides and PCB shall conform to
- ** MCL has not been established for this chemical.
- * If monitoring results in detection of one (1) or more of these contaminants, then su

(4) Organic Chemicals. Community, non-transient non-community (NTNC) and seasonal water systems shall test for organic chemicals specified below.

Organic chemicals^(c) and their limits.

Chemical ^(b)	Maximum Contaminant Level (mg/l)
Benzene	0.005
Bromobenzene	** (23)
Bromomethane	** (24)
n-Butyl Benzene	** (25)
Carbon Tetrachloride	0.005
Chlorobenzene	0.1
Chloroethane	** (26)
Chloromethane	** (27)
o-Chlorotoluene	** (28)
p-Chlorotoluene	** (29)
Dibromomethane	** (30)
m-Dichlorobenzene	** (31)
o-Dichlorobenzene	0.6
p-Dichlorobenzene	0.075
1, 1-Dichloroethane	** (32)
1, 2-Dichloroethane (EDC)	0.005
1, 1-Dichloroethylene	0.007
cis-1, 2-Dichloroethylene	0.07
Trans-1, 2-Dichloroethylene	0.1
Dichloromethane (Methylene chloride)	0.005
1, 2-Dichloropropane	0.005
1, 3-Dichloropropane	** (33)
2, 2-Dichloropropane	** (34)
1, 1-Dichloropropene	** (35)
1, 3-Dichloropropene	** (36)
Ethylbenzene	0.7

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Methyl Tert Butyl Ether (MTBE)	** (37)
Naphthalene	** (38)
n-Propyl Benzene	** (39)
Styrene	0.1
1, 1, 1, 2-Tetrachloroethane	** (40)
1, 1, 2, 2-Tetrachloroethane	** (41)
Tetrachloroethylene	0.005
Toluene	1.0
Total Trihalomethanes (TTHM)	0.100
Bromodichloromethane	* (42)
Bromoform	* (43)
Chlorodibromomethane	* (44)
Chloroform	* (45)
1, 1, 1-Trichloroethane	0.200
1, 1, 2-Trichloroethane	0.005
1, 2, 4-Trichlorobenzene	0.07
Trichloroethylene	0.005

Chemical§(b) <	Maximum Contaminant Level (mg/l)
1, 2, 3-Trichloropropane	** (46)
1, 2, 4-Trimethylbenzene	** (47)
1, 3, 5-Trimethylbenzene	** (48)
Vinyl Chloride§(c) <	0.002
Xylenes (total)	10.0
m-Xylene	*** (49)
o-Xylene	*** (50)
p-Xylene	*** (51)

Notes:

- * The MCL for Total Trihalomethanes (TTHM) is 0.100 mg/l, this is the sum of the four
- ** MCL has not been established for this chemical.
- *** The MCL for Xylenes (total) is 10.0 mg/l, this is the sum of the three (3) constit

(i) The method detection limit (MDL) for all organic chemicals is 0.0005 mg/l with the exception of MTBE which has an MDL of 0.002 mg/l.

(ii) The department may require the testing of other chemicals for which a Maximum Contaminant Level Goal has been proposed by EPA or which the department has reason to believe may be health threatening.

(iii) Quarterly analysis for vinyl chloride is required for ground water systems only when one

or more of the following compounds are detected: trichloroethylene, 1, 2 Tetrachloroethylene, 1, 2 Dichloroethane, 1, 1, 1 Trichloroethane, Cis 1, 2 Dichloroethylene, Trans 1, 2 Dichloroethylene, or 1, 1 Dichloroethylene. If the first analysis does not detect vinyl chloride, the Department may reduce the frequency of vinyl chloride monitoring to once every three (3) years.

(5) Radioactivity.

Natural Radioactivity	
Contaminant	Maximum Allowable Level Picocuries Per Liter (pCi/l)
Combined radium-226 and radium-228	5
Gross alpha particle activity (including radium-226 but excluding radon and uranium)	15

Procedure. Community systems are to test gross alpha by June 1, 1979. They are to test a composite sample of four (4) quarterly samples, or tests may be made on each of four (4) quarterly samples and the results averaged for reporting purposes.

When gross alpha is more than five (5) pCi/l, the sample is to be tested for radium-226 also. When radium-226 exceeds three (3) pCi/l, the sample shall then be tested for radium-228 in addition.

Tests are to be repeated every four (4) years for ground water supplies and every four (4) years for surface water supplies.

Non-community supplies are not required to test.

Man-Made Radioactivity	
Contaminant	Annual Average Maximum Allowable Level
Dose equivalent of beta particles plus photon radioactivity	4 millirems
or	
Gross beta particle activity	50 pCi per liter
Tritium	20,000 pCi per liter
Strontium-90	8 pCi per liter
Dose equivalent of Tritium plus Strontium-90	4 millirems

Systems utilizing surface water and serving more than 100,000 persons are to test a composite of four (4) quarterly samples or are to average the results of individual tests on four (4) quarterly samples by June 1, 1979. Tests are to be repeated every four (4) years.

Systems using only groundwater shall not test. Systems serving less than 100,000 persons shall not test.

(6) Total coliforms.

(A) The MCLG for microbiological contaminants which includes *E. coli* and fecal coliforms is zero (0).

(B) The maximum contaminant level (MCL) is based on the presence or absence of total coliforms in a sample, rather than coliform density. Compliance shall be based on a monthly MCL for total coliforms.

(i) For a system which collects at least forty (40) samples per month, if more than five percent (5.0%) of the samples collected during a month are total coliform-positive, the system is in violation of the MCL for total coliforms.

(ii) For a system which collects fewer than forty (40) samples per month, if more than one (1) sample collected during a month is total coliform-positive, the system is in violation of the MCL for total coliforms.

(C) A system shall determine compliance with the MCL for total coliforms for each month in which it is required to monitor for total coliforms.

(D) Analytical methodology.

(i) Analytical methods for total coliform. The analysis for total coliform should be conducted using either the membrane filter (MF) technique, or the 10-tube multiple tube fermentation (MTF) technique (five (5) tubes may be utilized provided they collectively equal one hundred (100) ml), or the presence-absence (P-A) coliform test, or the colilert system as approved and specified in 40 CFR 141.21(f). The standard sample volume required for total coliform analysis, regardless of analytical method used, is one hundred (100) ml.

(ii) Analytical methods for fecal coliforms. The use of EC medium for determining the presence of fecal coliform in a total coliform-positive culture is required. The procedure for fecal coliform analysis shall conform to those approved by EPA.

(iii) Analytical methods for *E. Coli*. The analysis for *E. Coli* shall be conducted using either the EC medium plus MUG (4-methylumbelliferyl-B-D-glucuronide), the nutrient agar plus MUG test or other testing methods which conform to those approved by EPA.

(7) Monitoring requirements

(A) The monitoring frequency for total coliforms and physical parameters for a community

water system (CWS) is based on the population served by the system, and the frequency is as follows:

Table 1

Population Served	Minimum Number of Routine Samples Per Month
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3
3,301 to 4,100	4
4,101 to 4,900	5
4,901 to 5,800	6
5,801 to 6,700	7
6,701 to 7,600	8
7,601 to 8,500	9
8,501 to 12,900	10
12,901 to 17,200	15
17,201 to 21,500	20
21,501 to 25,000	25
25,001 to 33,000	30
33,001 to 41,000	40
41,001 to 50,000	50
50,001 to 59,000	60
59,001 to 70,000	70
70,001 to 83,000	80
83,001 to 96,000	90
96,001 to 130,000	100
130,001 to 220,000	120
220,001 to 320,000	150
320,001 to 450,000	180
450,001 to 600,000	210
600,001 to 780,000	240
780,001 to 970,000	270

If a CWS serving twenty five (25) to one thousand (1,000) persons has no history of total coliform violation in its current configuration, and a sanitary survey conducted in the past five (5) years shows that the system is supplied solely by a protected ground water source, and is free of sanitary defects pursuant to sections 19-13-B51a through 19-13-B51m of the Regulations of Connecticut State Agencies; the department may, if it is satisfied that this water is safe for consumption, reduce the monitoring frequency specified to no less than one (1) sample per quarter. Department approval of the reduced monitoring frequency shall be in writing. Water samples shall be collected by technical personnel employed by an environmental laboratory approved by the department under section 25-40 of the Connecticut General Statutes, or a certified distribution system operator, or a certified treatment plant operator, or a sanitarian, or an employee of the department, or a person under the direct supervision of either a certified

distribution system, or a certified treatment plant operator.

(B) The monitoring frequency for total coliforms and physical parameters for non-community water systems is as follows:

(i) A non-community water system using only ground water sources that are not under the direct influence of surface water and serving one thousand (1,000) persons or fewer shall monitor during each calendar quarter that the system provides water to the public, except that the department may reduce this monitoring frequency, in writing, to no less than once a year if a sanitary survey shows that the system is free of sanitary defects pursuant to sections 19-13-B51a through 19-13-B51m of the Regulations of Connecticut State Agencies.

(ii) A non-community water system using only ground water sources that are not under the direct influence of surface water and serving more than one thousand (1,000) persons shall monitor as specified in Table 1. Monitoring shall begin no later than December 31, 1990.

(iii) A non-community water system using surface water, in total or in part, shall monitor at the frequency specified in Table 1, regardless of the number of persons it serves. Monitoring shall begin no later than December 31, 1990.

(iv) A non-community water system using groundwater under the direct influence of surface water, shall monitor at the frequency specified in Table 1. Monitoring shall begin six (6) months after the department determines that the ground water is under direct influence of surface water.

(C) Community, non-transient non-community and seasonal water systems shall conduct monitoring beginning in the initial compliance period to determine compliance with the MCLs specified in subdivisions 2, 3, and 4 of subsection 19-13-B102(e) of the regulations of Connecticut State Agencies. Systems serving fewer than one hundred and fifty (150) service connections shall begin monitoring in the second compliance period for the following chemicals: Benzo(a)pyrene, Dalapon, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl)phthalate, Dinoseb, Diquat, Endothall, Endrin, glyphosate, Hexachlorobenzene, Hexachlorocyclopentadiene, oxamyl(vydate), Picloram, Simazine, 2, 3, 7, 8-TCDD (Dioxin).

(i) Monitoring frequency for community, non-transient non-community and seasonal water systems

Contaminant	BASE SAMPLING REQUIREMENT		REDUCED SAMPLING
	Ground water systems	Surface water ⁽⁴⁾ (53)) systems	Ground water systems
Asbestos	Every 9 yrs.	Every 9 yrs.	Not Applicable
Nitrate ⁽¹⁾ (55) & Nitrite ⁽¹⁾ (56))	Annually	Quarterly	Not Applicab

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Inorganic Chemicals	Every 3 yrs.	Annually	Not Applicable
Organic Chemicals	Quarterly ⁽⁶⁾ (58))	Quarterly ⁽⁶⁾ (59))	Annually
Pesticides, Herbicides, and PCBs,	Quarterly ⁽⁶⁾ (64))	Quarterly ⁽⁶⁾ (65))	Systems serving two quarters per Systems serving every 3

¹ Each transient non-community water system shall monitor annually for nitrate and nit

² Applicable only if all analytical results from four consecutive quarters are less th

³ Applicable only if no single contaminant is detected in the results of the base samp

* Reduce to once every three (3) years after three (3) years of no detection of any co

⁴ Or groundwater under the influence of surface water systems.

⁵ Applicable only if granted in writing by the department.

⁶ See sections 19-13-B102(e) (7) (C) (x), (xiv) and (xvi) for exception.

Notes:

(ii) A system shall monitor quarterly beginning in the next quarter, if in any one sample: inorganic chemical, with the exception of nitrate and nitrite, exceeds the MCL; organic chemical, pesticide, herbicide or PCB is detected at a level exceeding the MDL; or nitrate or nitrite exceeds or equals fifty percent (50%) of the MCL.

Endnotes

1 (Popup)

* If coliform organisms are demonstrated to be not associated with a fecal source on the basis sanitary survey and differential tests, exception may be made.

2 (Popup)

a

(a) The method detection limits for inorganic chemicals shall conform to those accepted and approved by EPA.

3 (Popup)

¹ MFL = million fibers per liter longer than ten (10) micrometers.

4 (Popup)

** MCL has not been established for this chemical.

5 (Popup)

*** See Section 19-13-B102(j)(6).

6 (Popup)

*** See Section 19-13-B102(j)(6).

7 (Popup)

¹ The method detection limits for all pesticides, herbicides and PCB shall conform to those accepted and approved by EPA.

8 (Popup)

** MCL has not been established for this chemical.

9 (Popup)

** MCL has not been established for this chemical.

10 (Popup)

** MCL has not been established for this chemical.

11 (Popup)

** MCL has not been established for this chemical.

12 (Popup)

** MCL has not been established for this chemical.

13 (Popup)

** MCL has not been established for this chemical.

14 (Popup)

** MCL has not been established for this chemical.

15 (Popup)

** MCL has not been established for this chemical.

16 (Popup)

* If monitoring results in detection of one (1) or more of these contaminants, then subsequent monitoring shall analyze for all these contaminants.

17 (Popup)

* If monitoring results in detection of one (1) or more of these contaminants, then subsequent monitoring shall analyze for all these contaminants.

18 (Popup)

** MCL has not been established for this chemical.

19 (Popup)

** MCL has not been established for this chemical.

20 (Popup)

** MCL has not been established for this chemical.

21 (Popup)

** MCL has not been established for this chemical.

22 (Popup)

** MCL has not been established for this chemical.

23 (Popup)

** MCL has not been established for this chemical.

24 (Popup)

** MCL has not been established for this chemical.

25 (Popup)

** MCL has not been established for this chemical.

26 (Popup)

** MCL has not been established for this chemical.

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** MCL has not been established for this chemical.

28 (Popup)

** MCL has not been established for this chemical.

29 (Popup)

** MCL has not been established for this chemical.

30 (Popup)

** MCL has not been established for this chemical.

31 (Popup)

** MCL has not been established for this chemical.

32 (Popup)

** MCL has not been established for this chemical.

33 (Popup)

** MCL has not been established for this chemical.

34 (Popup)

** MCL has not been established for this chemical.

35 (Popup)

** MCL has not been established for this chemical.

36 (Popup)

** MCL has not been established for this chemical.

37 (Popup)

** MCL has not been established for this chemical.

38 (Popup)

** MCL has not been established for this chemical.

39 (Popup)

** MCL has not been established for this chemical.

40 (Popup)

** MCL has not been established for this chemical.

41 (Popup)

** MCL has not been established for this chemical.

42 (Popup)

* The MCL for Total Trihalomethanes (TTHM) is 0.100 mg/l, this is the sum of the four (4) constituent Trihalomethanes.

43 (Popup)

* The MCL for Total Trihalomethanes (TTHM) is 0.100 mg/l, this is the sum of the four (4) constituent Trihalomethanes.

44 (Popup)

* The MCL for Total Trihalomethanes (TTHM) is 0.100 mg/l, this is the sum of the four (4) constituent Trihalomethanes.

45 (Popup)

* The MCL for Total Trihalomethanes (TTHM) is 0.100 mg/l, this is the sum of the four (4) constituent Trihalomethanes.

46 (Popup)

** MCL has not been established for this chemical.

47 (Popup)

** MCL has not been established for this chemical.

48 (Popup)

** MCL has not been established for this chemical.

49 (Popup)

*** The MCL for Xylenes (total) is 10.0 mg/l, this is the sum of the three (3) constituent Xylenes.

50 (Popup)

*** The MCL for Xylenes (total) is 10.0 mg/l, this is the sum of the three (3) constituent Xylenes.

51 (Popup)

*** The MCL for Xylenes (total) is 10.0 mg/l, this is the sum of the three (3) constituent Xylenes.

52 (Popup)

⁵ Applicable only if granted in writing by the department.

53 (Popup)

⁴ Or groundwater under the influence of surface water systems.

54 (Popup)

⁴ Or groundwater under the influence of surface water systems.

55 (Popup)

¹ Each transient non-community water system shall monitor annually for nitrate and nitrite beginning January 1, 1993.

56 (Popup)

¹ Each transient non-community water system shall monitor annually for nitrate and nitrite beginning January 1, 1993.

57 (Popup)

² Applicable only if all analytical results from four consecutive quarters are less than fifty percent (50%) of the MCL.

58 (Popup)

⁶ See sections 19-13-B102(e) (7) (C) (x), (xiv) and (xvi) for exception.

59 (Popup)

⁶ See sections 19-13-B102(e) (7) (C) (x), (xiv) and (xvi) for exception.

60 (Popup)

* Reduce to once every three (3) years after three (3) years of no detection of any contaminant in annual sampling.

61 (Popup)

³ Applicable only if no single contaminant is detected in the results of the base sampling requirement.

62 (Popup)

³ Applicable only if no single contaminant is detected in the results of the base sampling requirement.

63 (Popup)

³ Applicable only if no single contaminant is detected in the results of the base sampling requirement.

64 (Popup)

⁶ See sections 19-13-B102(e) (7) (C) (x), (xiv) and (xvi) for exception.

65 (Popup)

⁶ See sections 19-13-B102(e) (7) (C) (x), (xiv) and (xvi) for exception.

66 (Popup)

³ Applicable only if no single contaminant is detected in the results of the base sampling requirement.

APPENDIX E.6

CONNECTICUT WATER QUALITY STANDARDS (WQSs)



STATE OF CONNECTICUT
DEPARTMENT OF
ENVIRONMENTAL PROTECTION
79 Elm Street
Hartford, CT 06106-5127

Sidney J. Holbrook, Commissioner

Water Quality Standards



Surface Water Quality Standards Effective April 3, 1997
Ground Water Quality Standards Effective April 12, 1996

For further information contact:

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PREFACE

The Water Quality Standards and Criteria (WQS) set forth in this publication are an important element in Connecticut's clean water program. The WQS set an overall policy for management of water quality in accordance with the directive of Section 22a-426 of the General Statutes. In simple terms the policies can be summarized by saying that the Department of Environmental Protection shall:

- Protect surface and ground waters of high quality from degradation.
- Segregate waters used for drinking from those that play a role in waste assimilation.
- Restore surface waters that have been used for waste assimilation to conditions suitable for fishing and swimming.
- Restore degraded ground water to protect existing and designated uses.
- Provide a framework for establishing priorities for pollution abatement and State funding for clean up.
- Adopt standards that promote the State's economy in harmony with the environment.

There are three elements that make up the WQS. The first of these are the Standards themselves. This is the text of the policy statements (pages 5 through 10) which discuss issues such as classification of different water resources according to the desirable use, anti-degradation, allowable types of discharges, the fundamental principles of waste assimilation, and a variety of other subjects. The second element, also contained in this document, are the Criteria (pages 10 through 21). These are descriptive and numerical standards that describe the allowable parameters and goals for the various water quality classifications. The final elements are the WQS and Classification Maps which show the classification assigned to each surface and groundwater resource throughout the State. These maps also show the goals for the water resources, and in that manner provide a blueprint and set of priorities for our efforts to restore water quality.

These three elements comprise the WQS and are adopted using the public participation procedures contained in Section 22a-426 of the General Statutes. The Standards, Criteria and Maps are reviewed and revised roughly every three years. Any change is considered a revision requiring public participation. The public participation process consists of public meetings held at various locations around the State, notification of all chief elected officials, notice in the Connecticut Law Journal and a public hearing. The Classification Maps are the subject of separate public hearings which are held for the adoption of the map covering each major drainage basin in the State.

As with any complex program, it is always difficult to anticipate the questions that the public may have about either proposed or adopted standards. The staff of the Planning and Standards Division of the Bureau of Water Management are the best source of information about these WQS and are always willing to provide answers to your questions. They may be contacted by writing to:

Assistant Director
Planning and Standards Division
Bureau of Water Management
Department of Environmental Protection
79 Elm Street
Hartford, Connecticut 06106-5127

The WQS do not stand alone; rather, they are one critical element in our program to protect and improve water quality. The WQS are written in response to, and in concert with, the principles of Connecticut's Clean Water Act, which is in Chapter 446k of the General Statutes. The Statutes set the broad outline and legal framework for our entire program. They establish the authorities and procedures for the WQS, for permitting discharges to the waters of the State and for the abatement of pollution. Within the framework of the Statutes, the WQS establish broad policy and objectives to meet the statutory goals. These objectives are then carried out by means of specific procedures and requirements of

statutory sections and even more detailed regulations. These include Statutes and Regulations for the permitting of discharges to the waters of the State, hazardous materials management, solid waste management, water diversions, structures, dredging, wetlands and others.

As an example of how these pieces fit together the following may be of assistance.

- Section 22a-430 of the General Statutes allows and sets procedures for the permitting of discharges of treated wastewater to the waters of the State.
- The WQS set forth the types of treated wastewater discharges that can be allowed in various water quality classifications in order to meet the statutory goals. In addition, the WQS provide the principles of waste assimilation and the goals for the receiving waters.
- If the type of discharge is allowed, then the details of application procedures and requirements for treatment, monitoring and reporting of the specific discharge are provided by Sections 22a-430-1 through 4 of the Regulations of Connecticut State Agencies.

The WQS provide policy guidance in many different areas, all of which are subject to detailed statutory and regulatory requirements. Some examples are as follows:

- Decisions on the acceptability of a type of discharge to a specific water resource.
- Any decision on the siting of a landfill.
- Decisions on the type of remediation and priority for the cleanup of hazardous waste sites.
- Decisions on the priority assigned to improvements of municipal sewerage systems and the priority for funding such projects.
- Decisions on Water Quality Certification pursuant to Section 401 of the Federal Clean Water Act, which are required for any federally permitted activity which results in a point or nonpoint source discharge to a surface water resource.

If you have further questions about the Water Quality Standards please do not hesitate to contact the staff.

I. INTRODUCTION

Section 22a-426 of the General Statutes requires that the Commissioner of Environmental Protection adopt standards of water quality for all the State's waters. The purpose of these standards is to provide clear and objective statements for existing and projected water quality and the general program to improve Connecticut's water resources. They also serve to qualify the state and its municipalities for available federal grants for water pollution control.

Section 22a-426 mandates these standards shall:

- (1) Apply to interstate waters or portions thereof within the State.
- (2) Apply to such other waters within the State as the Commissioner may determine is necessary.
- (3) Protect the public health and welfare and promote the economic development of the State.
- (4) Preserve and enhance the quality of State waters for present and prospective future use for public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes and agricultural, industrial and other legitimate uses.

- (5) Be consistent with the health standards as established by the Department of Public Health Services.

Water Quality Classifications, based on the adopted Water Quality Standards (WQS), establish designated uses for surface and ground waters and identify the criteria necessary to support those uses. The designated use and criteria goals serve to focus the department's water quality management activities, including establishment of water quality based treatment controls and strategies required by the Federal Clean Water Act.

Section 303 of the Federal Clean Water Act requires state adoption of surface WQS and their review and modification at least once every three years. Federal law defines WQS as the identification of water quality goals of a water resource through the assignment of designated uses to be made of the water and by setting criteria necessary to protect the uses.

Federal regulations specify that WQS should, wherever attainable, provide water quality for the protection and propagation of fish, shellfish and wildlife and for recreation in and on the water, taking into consideration their use and value for public water supplies, propagation of fish, shellfish and wildlife, recreation in and on the water and agricultural, industrial and other purposes including navigation.

Although federal law requires adoption of WQS for surface waters, WQS for ground waters are not subject to federal review and approval. Connecticut's WQS recognize that surface and ground waters are interrelated and address the issue of competing use of ground waters for drinking and for waste water assimilation. These standards specifically identify ground water quality goals, designated uses and those measures necessary for protection of public and private drinking water supplies; the principal use of Connecticut's ground waters.

II. SURFACE WATERS STANDARDS

1. It is the State's goal to restore or maintain all surface water resources, including wetlands, to a quality consistent with their existing and designated uses and supportive criteria.
2. Existing water uses and the level of water quality necessary to protect the existing and designated uses shall be maintained and protected.
3. Surface waters with a classification goal of B or SB and with an existing quality better than established standards shall be maintained at their existing high quality, unless the Commissioner finds, after adequate opportunity for intergovernmental review and public participation, that allowing lower water quality is necessary to accommodate overriding statewide economic or social development, and that existing and designated uses will be fully protected. The implementation procedures for the anti-degradation provisions of the State Water Quality Standards are provided in full in Appendix A.
4. For new or expanded discharges to high quality waters, the Commissioner shall, at a minimum, require of discharge permit applicants a level of treatment meeting the highest applicable standards of performance promulgated pursuant to the Federal Clean Water Act as well as Sections 22a-426, 22a-430 and 22a-436 of the General Statutes, and require additional treatment measures deemed necessary to prevent pollution and maintain high water quality. The Commissioner shall also require the use of appropriate Best Management Practices for control of point and nonpoint source discharges to high quality waters.
5. Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and forests and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected. The lowering of water quality is prohibited for such waters except where limited activities will result in only temporary and insignificant changes in water quality.
6. Standard (1) shall be met except where a Use Attainability Analysis demonstrates that the water resource has been irreparably altered to the extent certain designated uses have been permanently lost. The determination of where these exceptions exist, including identification of the specific uses which have been permanently lost and designation of quality criteria necessary to protect all other existing, designated and potential future uses

of the water resource, shall be made by the Commissioner as a revision to the Water Quality Standards in accordance with Section 22a-426 and shall be subject to the approval of the Federal Environmental Protection Agency.

7. Any person or municipality requesting a change in Water Quality Classification shall demonstrate to the Commissioner that the proposed new Class designation is consistent with all existing or designated uses made of, or presently possible in, such waters. Any such change in a water quality classification shall be considered a revision of the Water Quality Standards and subject to the public participation requirements of Section 22a-426 of the General Statutes. With regard to any such change in Water Quality Classification the provisions of Standards (3) and (4) of this Standard shall be met.
8. Water quality criteria do not apply to conditions brought about by natural causes. Natural hydrologic and geologic conditions may cause excursions from established criteria. The meaning of the word 'natural' is not limited to only those conditions which would exist in water draining from pristine land. Conditions which exist in the water, in part due to normal uses of the land, may be considered natural. It shall not be considered normal use of the land if excursions from established criteria result in the loss of an existing or designated use.
9. Discharges to surface waters shall be limited as follows:
 - (A) Class AA, A and SA surface waters: discharges may be permitted by the Commissioner from public or private drinking water treatment systems, dredging and dredge material dewatering operations and other clean water discharges. In Class AA surface waters such discharges shall be subject to the approval of the Commissioner of Health Services. The Commissioner may authorize other discharges to waters with a water quality goal of SA, A or AA provided the Commissioner finds such discharge will be of short duration and is necessary to remediate surface water or ground water pollution. Any such discharge must be treated or controlled to a level which in the judgement of the Commissioner, protects aquatic life and public health.
 - (B) Class B and SB surface waters: discharges may be permitted for all those allowed in Class AA, A and SA waters, cooling water discharges, discharges from municipal and industrial wastewater treatment systems and other discharges subject to the provisions of Section 22a-430.
 - (C) The designation of surface waters as Class C/B, D/B, SC/SB or SD/SB shall not be a reason for authorizing a new discharge that would not allow the receiving surface waters to attain Class B or Class SB designated uses and quality criteria.
 - (D) The designation of surface waters as Class B/AA, B/A, C/A, SB/SA, or SC/SA shall not be a reason for authorizing a new discharge that would be inconsistent with Class AA, A or SA water quality goals.
10. The Commissioner may, on a case-by-case basis, establish zones of influence when permitting discharges to surface waters to allocate a portion of the receiving water resource for mixing and assimilation of a discharge effluent. Unless otherwise indicated in these Standards, the water quality criteria for a given class apply outside a zone of influence for a discharge permitted pursuant to Section 22a-430 of the General Statutes. The zone of influence shall not preclude attainment of any existing or designated uses of the receiving water resource. The spatial dimensions and/or volume of receiving water allocated to zones of influence will be established based on the unique physical, chemical and biological characteristics of the receiving waterbody. The Commissioner may require Permit applicants to provide information on receiving water and waste water characteristics including the volume of flow and spatial dimensions required for mixing and assimilation of waste. Considerations to be used in establishing zones of influence include, but are not limited to:
 - (A) Characteristics of the discharge, such as the volume, strength and persistence of any substances in the discharge effluent, potential bioaccumulation or bioconcentration of these substances in aquatic

organisms, the temperature of the discharge and the potential for any substances, either singly or in combination with other substances present in the effluent or receiving waterbody, to result in an unacceptable risk to human health or the environment.

- (B) Allowance for a continuous zone of passage for free swimming and drifting organisms.
- (C) Impingement upon spawning grounds or nursery areas of sensitive aquatic organisms or areas utilized by aquatic organisms for shelter and living space to the extent that the environmental value of the receiving waterbody is significantly reduced.
- (D) The location of other discharges to the receiving waterbody to insure that the cumulative effect of adjacent zones of influence will not significantly reduce the environmental value or preclude any existing or designated uses of the receiving waterbody.

Assessment of environmental value will be based on a number of receiving water characteristics, including but not limited to: type of waterbody, velocity, depth, number and type of aquatic habitats, migration patterns, nature of the food chain, level of productivity, water temperature, ability of tributaries to provide recruitment, presence of endangered species and value to human uses (aesthetic, commercial and sport fishing and recreational uses). As a guideline, zones of influence for assimilation of thermal discharges shall be limited to no more than 25% of the cross-sectional area or volume of flow.

11. The minimum average daily flow for seven consecutive days that can be expected to occur once in ten years under natural conditions (7Q10) is the minimum flow to which the standard for surface waters apply, except when a stream has been historically regulated to result in low flows below that level, in which case the standards apply to that low flow determined by the Department of Environmental Protection's Minimum Flow Regulations as amended (Connecticut General Statutes Section 26-141a); the Department's Diversion Permit Program (Section 22a-365 through 22a-378); or the Federal Energy Regulatory Commission's hydropower licensing process (Federal Power Act 18 USC SEC 791). Maintaining a long-term flow of 7Q10 or less may result in significant stress on the physical and biological quality of surface waters. In those surface waters having regulated flows at, near or below the naturally occurring 7Q10 flow, more stringent water quality criteria may be required to achieve and maintain existing and designated uses. The Commissioner may approve limitations based on minimum average daily flow in excess of 7Q10 conditions, provided the Commissioner is satisfied that special measures will be implemented during low flow conditions which provide protection to the environment at least as effective as that protection which would pertain if limitations were based on 7Q10 conditions alone.

Water resources which are influenced by tidal forces or which experience short-term variation in flow due to periodic or irregular water release from upstream diversions or other causes may require special consideration with regard to protecting existing and designated uses: including consideration of the minimum flow to which Standards apply.

12. The Commissioner, pursuant to Chapter 446k of the Connecticut General Statutes and regulations adopted thereunder, will regulate discharges to the waters of the State to assure that such discharges do not cause pollution due to acute or chronic toxicity to aquatic and marine life, impair the biological integrity of aquatic or marine ecosystems or result in an unacceptable risk to human health.

(A) In making a determination under Chapter 446k of the Connecticut General Statutes as to whether a discharge or other activity will or can reasonably be expected to cause pollution of the waters of the State, the Commissioner shall consider the numeric criteria for the toxic pollutants listed in Appendix D.

(B) The Commissioner may amend the numeric criteria for the toxic pollutants listed in Appendix D of these Water Quality Standards in accordance with the procedures specified in Section 22a-426 of the

Connecticut General Statutes on his or her own initiative, or upon request of any person or municipality that site-specific criteria be adopted, provided such request is supported by sound scientific and technical evidence demonstrating the following:

1. Local conditions at the site differ significantly from those used in establishing the statewide criteria.
 2. The site-specific criteria will be sufficiently stringent to protect all existing and designated uses of the waterbody.
 3. The site-specific criteria were derived consistent with sound scientific and technical principles, giving consideration to all applicable federal guidance.
13. Surface waters and sediments shall be free from chemical constituents in concentrations or combinations which will or can reasonably be expected to result in acute or chronic toxicity to aquatic organisms or impair the biological integrity of aquatic or marine ecosystems outside of any allocated zone of influence or which will or can reasonably be expected to bioconcentrate or bioaccumulate in tissues of fish, shellfish and other aquatic organisms to levels which will impair the health of aquatic organisms or wildlife or result in unacceptable tastes, odors or health risks to human consumers of aquatic life. In determining consistency with this Standard, the Commissioner shall at a minimum consider the specific numeric criteria listed in Appendix D and any other information he or she deems relevant.
 14. Benthic invertebrate criteria may be utilized where appropriate for assessment of the biological integrity of surface waters. The criteria apply to the fauna of erosional or riffle habitats in flowing waters which are not subject to tidal influences.
 15. The discharge of radioactive materials in concentrations or combinations which would be harmful to human, animal or aquatic life shall not be allowed. The applicable criteria can be found in Title 10 Part 20 of the Code of Federal Regulations.
 16. Reasonable controls or Best Management Practices for control of nonpoint source pollutants may be required by the Commissioner on a case-by-case basis.
 17. Controls on point and nonpoint sources of phosphorus and nitrogen which contribute to the eutrophication of any surface water including streams, rivers, lakes, ponds, impoundments and Long Island Sound may be required on a case-by-case basis.
 18. Use of Best Management Practices and other reasonable controls of nonpoint sources of nutrients and sediment is preferable to the use of biocides for correction of eutrophic conditions.
 19. Potential drinking water supplies identified in the Long Range Plan for Management of Water Resources prepared and adopted pursuant to Section 22a-352 or in an individual water supply plan approved in accordance with Section 22a-32d of the Connecticut General Statutes shall be designated as Class AA surface waters.
 20. Section 22a-417 of the Connecticut General Statutes imposes an absolute restriction on the discharge of sewage to Class AA reservoirs and their tributaries. A discharge outside the State shall not be a valid reason for either relaxing the restriction in Connecticut or changing the Class AA designation. It is a State policy to pursue the adoption of compatible Water Quality Standards in neighboring states to assure the protection of Connecticut drinking water supplies.
 21. Disinfection shall be required for all treated domestic sewage discharges to surface waters. The period of disinfection shall vary depending on the nature of the receiving waterbody as described below:

1. Continuous disinfection shall be required at all domestic sewage treatment plants located south of Interstate Highway 95 (I-95) to protect the sanitary quality of shellfish resources.
2. Disinfection shall be required during the period from May 1 to October 1 at all domestic sewage treatment plants located north of I-95. Seasonal disinfection is intended to protect the sanitary quality of bathing waters and minimize adverse impacts to aquatic life associated with disinfection. An alternative schedule, including continuous disinfection, may be required if found necessary by the Commissioner to protect existing and designated uses.

It is recognized that criteria for indicator bacteria may not be met during periods when disinfection of sewage treatment plant effluent is not required.
22. The discharge of sewage, sink and galley wastes from boats, whether or not treated by any marine sanitation device, is prohibited in all inland freshwaters not capable of interstate navigation and in marine waters identified in accordance with Regulations developed through the authority of Public Act 90-173.
23. Indicator bacteria are used to detect the presence of contamination by human or animal wastes. Due to the inherent uncertainty involved in sampling and analytical determination of bacteria levels, excursions from established ambient criteria should be investigated by means of a field survey of sanitary conditions or other appropriate means to determine sanitary quality (see also Appendix B).
24. Physical obstructions such as dams, which prevent fish reaching an area suitable for spawning and growth, shall not be considered a valid reason for not achieving and maintaining water quality conditions necessary to support all existing and designated uses for a waterbody unless the Commissioner has approved a Use Attainability Analysis in accordance with all applicable State and Federal statutes and regulations, consistent with the Department's anti-degradation policy.
25. In the estuarine segments (Class SB) of the Housatonic, Connecticut and Thames Rivers, the allowable temperature increase from discharges shall be consistent with the criteria for the non-tidal segments (Class B).
26. Except within designated dredged material disposal areas or areas approved by the Commissioner for placement of fill under the authority of Section 22a-32, surface waters and sediments shall be substantially free of pollutants that: a) unduly affect the composition of bottom fauna; b) unduly affect the physical or chemical nature of the bottom; or c) interfere with the propagation and habitats of shellfish, finfish and wildlife. Dredged materials dumped at approved disposal areas shall not pollute the waters of the state and shall not result in: a) floating residues of any sort; b) release of any substance which may result in long-term or permanent degradation of water quality in waters overlying or adjacent to the disposal areas; c) dispersal of sediments outside a zone of influence enclosing the designated disposal points; or d) biological mobilization and subsequent transport of toxic substances to food chains.
27. Surface water quality monitoring methods shall conform to the Department of Environmental Protection, Water Management Bureau's Quality Assurance Project Plan, consistent with 40 CFR Part 30. Other different but equivalent or better methods may be utilized if they have received the Commissioner's prior approval.
28. As part of the Commissioner's continuing efforts to further define WQS, other criteria will be considered. The Commissioner reserves the right to amend or extend the criteria for each Class of waters as new information or improved or more stringent criteria relative to water quality impacts are developed and justified subject to the legal and procedural requirements of State and Federal laws or regulations.
29. Surface waters, including wetlands which are not otherwise designated, shall be considered as Class A or Class SA.

30. Watercourses which are fully enclosed in drainage conduits or pipes and not assigned a specific Class may be considered, on a case-by-case basis, to be the Class of the stream segment to which they discharge.
31. Where existing water quality does not meet the designated use and quality criteria goals, the existing quality will be identified, followed by the use goal (e.g., C/B).
32. Revisions to the WQS, including but not limited to the following, shall be subject to the public participation process provided for in Section 22a-426 of the General Statutes:
 - (A) The adoption of a map which depicts the Water Quality Goals and Classifications assigned to any water resource.
 - (B) Any decisions regarding the lowering of water quality in existing high quality Class B or SB waters or a change in the Water Quality Classification of any water resource.
 - (C) The adoption of any Use Attainability Analysis.
33. The surface WQS shall apply to all tidal waters, harbors, estuaries, rivers, brooks, watercourses, waterways, lakes, ponds, marshes, bogs, those portions of inland wetlands which are inundated or saturated by surface or ground waters at a frequency and duration sufficient to support, and that under normal circumstances do support, prevalence of vegetation typically adapted for life in saturated soil conditions and those portions of tidal wetlands below mean high water.

III. SURFACE WATER CLASSIFICATIONS

INLAND SURFACE WATERS

CLASS AA

Designated Use - Existing or proposed drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other purposes, (recreational uses may be restricted).

		<u>CRITERIA</u>
<u>Parameter</u>		<u>Standard</u>
1.	Aesthetics	Uniformly excellent
2.	Dissolved oxygen	Not less than 5 mg/l at any time.
3.	Sludge deposits-solid refuse-floating solids-oils and grease-scum	None other than of natural origin.
4.	Color	None other than of natural origin.
5.	Suspended and settleable solids	None in concentrations or combinations which would impair the most sensitive designated use; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; none which would adversely impact aquatic organisms living in or on the bottom substrate.

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| 6. | Silt or sand deposits | None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity or dredging provided all reasonable controls or Best Management Practices are used. |
| 7. | Turbidity | Shall not exceed 5 NTU over ambient levels. All reasonable controls or Best Management Practices are to be used. |
| 8. | Indicator bacteria | Total coliform organisms (MF) shall not exceed a monthly moving arithmetic mean of 100/100 ml for the most recent 12 months. No individual sample shall exceed 500/100 ml. Refer to Standard number 23 and Appendix B. |
| 9. | Taste and odor | None other than of natural origin. |
| 10. | pH | As naturally occurs. |
| 11. | Allowable temperature increase | None other than of natural origin except when it can be demonstrated that fish spawning and growth will not be impaired, in which case Class B Standards and Criteria apply. |
| 12. | Chemical constituents | None in concentrations or combinations which would be harmful to the most sensitive designated water use. Refer to Standards numbers 10, 11, 12, 13, and 17. |
| | (a) Phosphorus | None other than of natural origin |
| | (b) Sodium | Not to exceed 20 mg/l |
| 13. | Benthic Invertebrates which inhabit lotic waters | A wide variety of macroinvertebrate taxa should normally be present and all functional feeding groups should normally be well represented. Presence and productivity of aquatic species is not limited except by natural conditions, permitted flow regulation or irreversible cultural impacts. Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. Taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Coleoptera (beetles) and Trichoptera (caddisflies) should be well represented. |

CLASSIFICATIONS

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|------------------------------|---|
| - <u>AA</u> | Known or presumed to meet Water Quality Criteria which support the designated uses. |
| - <u>B/AA</u> or <u>C/AA</u> | May not be meeting Class AA Water Quality Criteria or designated uses. The water quality goal is achievement of Class AA Criteria and attainment of Class AA designated uses. |

INLAND SURFACE WATERS

CLASS A

- | | |
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| Designated Uses - | Potential drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other legitimate uses, including navigation. |
|-------------------|--|

CRITERIA

<u>Parameter</u>	<u>Standard</u>
1. Aesthetics	Uniformly excellent
2. Dissolved oxygen	Not less than 5 mg/l at any time.
3. Sludge deposits-solid refuse - floating solids -oils and grease-scum.	None other than of natural origin.
4. Color	None other than of natural origin
5. Suspended and settleable solids	None in concentrations or combinations which would impair the most sensitive designated use; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; none which would adversely impact aquatic organisms living in or on the bottom substrate.
6. Silt or sand deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity or dredging provided all reasonable controls or Best Management Practices are used.
7. Turbidity	Shall not exceed 5 NTU over ambient levels. All reasonable controls or Best Management Practices to be used.
8. Indicator Bacteria	Total coliform organisms (MF) shall not exceed a monthly moving arithmetic mean of 100/100 ml for the most recent 12 months. No individual sample shall exceed 500/100 ml. For established bathing waters, enterococcal organisms shall not exceed a geometric mean of 33/100 ml and no sample shall exceed 61/100 ml. Refer to Standard number 23 and Appendix B.
9. Taste and odor	None other than of natural origin.
10. pH	As naturally occurs.
11. Allowable temperature increase	None other than of natural origin except when it can be demonstrated that fish spawning and growth will not be impaired, in which case Class B Standards and Criteria apply.
12. Chemical constituents	None in concentrations or combinations which would be harmful to the most sensitive designated water use. Refer to Standards numbers 10, 11, 12, 13 and 17.
(a) Phosphorus	None other than of natural origin.
13. Benthic Invertebrates which inhabit lotic waters.	A wide variety of macroinvertebrate taxa should normally be present and all functional feeding groups should normally be well represented. Presence and productivity of aquatic species is not limited except by natural conditions, permitted flow regulation or irreversible cultural impacts. Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. Taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Coleoptera (beetles) and Trichoptera (caddisflies) should be well represented.

CLASSIFICATIONS

- A Known or presumed to meet Water Quality Criteria which support designated uses.
- B/A or C/A May not be meeting Water Quality Criteria or one or more designated uses. The water quality goal is achievement of class A Criteria and attainment of Class A designated uses.

INLAND SURFACE WATERS

CLASS B

- Designated Use - Recreational use; fish and wildlife habitat; agricultural and industrial supply and other legitimate uses including navigation.

CRITERIA

<u>Parameter</u>	<u>Standard</u>
1. Aesthetics	Good to excellent
2. Dissolved oxygen	Not less than 5 mg/l at any time.
3. Sludge deposits - solid refuse - floating solids - oil and grease - scum	None except for small amounts that may result from the discharge from a waste treatment facility providing appropriate treatment.
4. Color	None which causes visible discoloration of the receiving stream outside of any designated zone of influence.
5. Suspended and settleable solids	None in concentrations or combinations which would impair the most sensitive designated use; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; and none which would adversely impact aquatic organisms living in or on the bottom sediments; shall not exceed 10 mg/l over ambient concentrations.
6. Silt or sand deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity or dredging activity provided all reasonable controls or Best Management Practices are used.
7. Turbidity	Shall not exceed 5 NTU over ambient levels. All reasonable controls and Best Management Practices to be used.
8. Indicator bacteria	As an indicator of general sanitary quality Fecal coliform shall not exceed a geometric mean of 200 organisms/100 ml in any group of samples nor shall 10% of the samples exceed 400 organisms/100 ml. For established bathing waters, enterococcal organisms shall not exceed a geometric mean of 33 organisms/100 ml, and no single sample shall exceed 61/100 ml. Refer to Standard number 23 and Appendix B.
9. Taste and odor	None that would impair any usages specifically assigned to this Class.
10. pH	6.5 - 8.0
11. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85°F, or in any case raise the normal temperature of the receiving water more than 4°F.

12. Chemical constituents None in concentrations or combinations which would be harmful to the most sensitive designated water use. Refer to Standards numbers 10, 11, 12, 13, and 17.
13. Benthic Invertebrates which inhabit lotic waters Water quality shall be sufficient to sustain a diverse macroinvertebrate community of indigenous species. All functional feeding groups and a wide variety of macroinvertebrate taxa shall be present, however one or more may be disproportionate in abundance. Waters which currently support a high quality aquatic community shall be maintained at that high quality. Presence and productivity of taxa within the Orders Plecoptera (stoneflies), Ephemeroptera (mayflies); and pollution intolerant Coleoptera (beetles) and Trichoptera (caddis-flies) may be limited due to cultural activities. Macroinvertebrate communities in waters impaired by cultural activities shall be restored to the extent practical through implementation of the department's procedures for control of pollutant discharges to surface waters and through Best Management Practices for non-point sources of pollution.

CLASSIFICATIONS

- B Known or presumed to meet Water Quality Criteria which support designated uses.
- C/B or D/B Due to point or nonpoint sources of pollution, certain Water Quality Criteria or one or more designated uses assigned to Class B waters are not currently met. The water quality goal is achievement of Class B Criteria and attainment of Class B designated uses.

INLAND SURFACE WATERS

CLASS C

Present water quality conditions preclude the full attainment of one or more designated uses for Class B waters some or all of the time. One or more Water Quality Criteria for Class B waters are not being consistently achieved. Class C waters may be suitable for certain fish and wildlife habitat, certain recreational activities, industrial use and other legitimate uses, including navigation. Class C waters may have good aesthetic value. Class C water quality results from conditions which are usually correctable through implementation of established water quality management programs to control point and nonpoint sources of pollution. Examples of conditions which warrant a Class C designation include; combined sewer overflows, urban runoff, inadequate municipal or industrial wastewater treatment, and community-wide septic system failures. The minimum acceptable class goal is Class B unless a DEP and EPA approved Use Attainability Analysis demonstrates that one or more uses are not attainable. In those situations, site-specific Quality Criteria will be employed in the analysis to insure that all existing uses are maintained. Refer to Standard Number 6.

CLASSIFICATIONS

- C/B, C/A or C/AA Presently not meeting Water Quality Criteria or not supporting one or more assigned designated uses due to pollution. The goal for such waters may be Class AA, A or Class B.

INLAND SURFACE WATERS

CLASS D

Present water quality conditions persistently preclude the attainment of one or more designated uses for Class B waters. One or more Water Quality Criteria for Class B waters are not being achieved most or all of the time. Class D waters may be suitable for bathing or other recreational purposes, certain fish and wildlife habitat, industrial or other legitimate uses, including navigation. Class D waters may have good aesthetic value. Class D water quality results from sources

of pollution which are not readily correctable. Examples of conditions which warrant a Class D designation include contamination of bottom sediments, contamination of fish or shellfish with toxic compounds, and pollution caused by out-of-state sources. The water quality goal is restoration to Class B or Class A conditions. The minimum acceptable class goal is Class B unless a DEP and EPA approved Use Attainability Analysis demonstrates that one or more uses are not attainable. In those situations, site-specific Quality Criteria will be employed in the analysis to insure that all existing uses are maintained. Refer to Standard Number 6.

CLASSIFICATIONS

D/B, D/A - Presently not meeting Water Quality Criteria or not supporting one or more assigned designated uses due to severe pollution. The goal for such waters may be Class A or Class B.

LAKE TROPHIC CLASSIFICATIONS

OLIGOTROPHIC

May be Class AA, Class A, or Class B water. Low in plant nutrients. Low biological productivity characterized by the absence of nuisance macrophyte beds. Excellent opportunities for water contact recreation.

CRITERIA

Parameters

Standard

- | | |
|-----------------------------|------------------------------|
| 1. Total Phosphorus | 0-10 ug/l spring and summer |
| 2. Total Nitrogen | 0-200 ug/l spring and summer |
| 3. Chlorophyll-a | 0-2 ug/l mid-summer |
| 4. Secchi Disk Transparency | 6 + meters mid-summer |

MESOTROPHIC

May be Class AA, Class A, or Class B water. Moderately enriched with plant nutrients. Moderate biological productivity characterized by occasional nuisance blooms of algae and/or small areas of nuisance macrophyte beds. Good opportunities for water contact recreation.

CRITERIA

Parameters

Standard

- | | |
|-----------------------------|--------------------------------|
| 1. Total Phosphorus | 10-30 ug/l spring and summer |
| 2. Total Nitrogen | 200-600 ug/l spring and summer |
| 3. Chlorophyll-a | 2-15 ug/l mid-summer |
| 4. Secchi Disk Transparency | 2-6 meters mid-summer |

EUTROPHIC

May be Class AA, Class A, or Class B water. Highly enriched with plant nutrients. High biological productivity characterized by frequent nuisance blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation opportunities may be limited.

CRITERIA

<u>Parameters</u>	<u>Standard</u>
1. Total Phosphorus	30-50 ug/l spring and summer
2. Total Nitrogen	600-1000 ug/l spring and summer
3. Chlorophyll-a	15-30- ug/l mid-summer
4. Secchi Disk Transparency	1-2 meters mid-summer

HIGHLY EUTROPHIC

May be Class AA, Class A, or Class B water. Excessive enrichment with plant nutrients. High biological productivity, characterized by severe nuisance blooms of algae and/or extensive areas of dense macrophyte beds. Water contact recreation may be extremely limited.

CRITERIA

<u>Parameters</u>	<u>Standard</u>
1. Total Phosphorus	50 + ug/l spring and summer
2. Total Nitrogen	1000 + ug/l spring and summer
3. Chlorophyll-a	30 + ug/l mid-summer
4. Secchi Disk Transparency	0-1 meters mid-summer

TROPHIC CLASSIFICATION OF LAKES

OLIGOTROPHIC LAKES

<u>Lake</u>	<u>Location</u>
Bashan	East Haddam
Beach	Voluntown
Billings	North Stonington
Mashapaug	Union
Riga	Salisbury
Uncas	Lyme
West Hill	New Hartford

MESOTROPHIC LAKES

<u>Lake</u>	<u>Location</u>
Alexander	Killingly
Anderson's Pond	North Stonington
Ball	New Fairfield
Beseck	Middlefield
Bigelow	Union
Black	Meriden and Middlefield
Black	Woodstock
Burr	Torrington
Candlewood	N. Fairfield, Sherman, Danbury, N. Milford, Brookfield
Cedar	Chester
Columbia	Columbia

Cream Hill
Crystal
Dodge
East Twin
Fitchville
Gardner
Glasgo
Gorton
Green Falls
Halls
Hatch Pond
Hayward
Higganum Reservoir
Highland
Hitchcock
Killingly Pond
Little Schoolhouse
Long
Lower Bolton
Mamasasco
Middle Bolton
Mohawk Pond
Moodus
Morey
Mount Tom
Norwich
Mudge
Pachaug
Park
Pataganset
Pattaconk Reservoir
Pocotopaug
Powers
Quaddick
Quonnipaug
Rogers
Shenipsit
South Spectacle
Squantz
Taunton
Terramuggus
Tyler
Wangumbaug
Waramaug
Wauregan Reservoir
West Side
Winchester
Wononscopomuc
Wright's Pond
Wyassup

Cornwall
Ellington, Stafford
East Lyme
Salisbury
Fitchville
Salem, Bozrah, Montville
Griswold
East Lyme
Voluntown
Eastford
Kent
East Haddam
Haddam
Winchester
Wolcott
Killingly
Thompson
Ledyard, North Stonington
Bolton, Vernon
Ridgefield
Vernon
Goshen
East Haddam
Ashford
Litchfield, Morris, Goshen
Lyme
Sharon
Griswold
Winchester
East Lyme
Chester
East Hampton
East Lyme
Thompson
Guilford
Lyme, Old Lyme
Vernon, Ellington, Tolland
Kent
New Fairfield, Sherman
Newtown
Marlborough
Goshen
Coventry
Warren, Washington, Kent
Killingly
Goshen
Winchester
Salisbury
Westbrook, Essex, Deep River
North Stonington

EUTROPHIC LAKES

<u>Lake</u>	<u>Location</u>
Amos	Preston
Aspinook	Lisbon and Canterbury
Avery	Preston
Bantam	Litchfield, Morris
Batterson Park	Farmington, New Britain
Crystal	Middletown
Dog	Goshen
Eagleville	Mansfield
Housatonic	Shelton
Howell	Hartland
Kenosia	Danbury
Leonard	Kent
Lillinonah	Bridgewater, Brookfield
Linsley	Branford, North Branford
Long Meadow	Bethlehem
Moosup	Plainfield
Rainbow Reservoir	Windsor
Red Cedar	Lebanon
Roseland	Woodstock
Wononpakook	Salisbury
Zoar	Newtown, Monroe, Oxford, Southbury

HIGHLY EUTROPHIC LAKES

<u>Lake</u>	<u>Location</u>
Beachdale	Voluntown
Cedar	North Branford
Dooley's	Middletown
1860 Reservoir	Wethersfield
Hanover Pond	Meriden
Holbrook	Hebron
Hopeville	Griswold
Lake of Isles	North Stonington
Lantern Hill	Ledyard, North Stonington
Messerschmidt's	Westbrook, Deep River
North Farms	Wallingford
Pickerel	Colchester
Silver	Berlin, Meriden
West Thompson	Thompson
Winnemaug	Watertown
Wood Creek	Norfolk

COASTAL AND MARINE SURFACE WATERS

CLASS SA

Designated Use - Marine fish, shellfish and wildlife habitat, shellfish harvesting for direct human consumption, recreation, and all other legitimate uses including navigation.

CRITERIA

<u>Parameter</u>	<u>Standard</u>
1. Aesthetics	Uniformly excellent
2. Dissolved oxygen	Not less than 6.0 mg/l at any time.
3. Sludge deposits-solid refuse-floating solids-oils and grease-scum	None other than of natural origin
4. Color	None other than of natural origin
5. Suspended and settleable solids	None other than of natural origin
6. Silt or sand deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, or dredge material disposal provided all reasonable controls and Best Management Practices are used.
7. Turbidity	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, or dredging provided all reasonable controls and Best Management Practices are used.
8. Indicator bacteria	Fecal coliform organisms shall not exceed a geometric mean of 14 MPN/100 ml nor shall greater than 10% of samples exceed 43 MPN/100 ml. For established bathing waters enterococcal organisms shall not exceed a geometric mean of 33/100 ml and no single sample shall exceed 61/100 ml. Refer to standard number 23 and Appendix B.
9. Taste and odor	As naturally occurs.
10. pH	6.8 - 8.5
11. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83°F or in any case raise the normal temperature of the receiving water more than 4°F. During the period including July, August and September, the normal temperature of the receiving water shall not be raised more than 1.5°F unless it can be shown that spawning and growth of indigenous organisms will not be significantly affected.
12. Chemical constituents	None in concentrations or combinations which would be harmful to the most sensitive designated water use. Refer to Standards numbers 10, 11, 12, 13 and 17.

CLASSIFICATIONS

- SA Know or presumed to meet Water Quality Criteria which support designated uses.
- SB/SA or SC/SA Presently not meeting Water Quality Criteria or one or more designated uses. The water quality goal is achievement of Class SA Criteria and attainment of Class SA designated uses.

COASTAL AND MARINE SURFACE WATERS

CLASS SB

Designated Uses - Marine fish, shellfish and wildlife habitat, shellfish harvesting for transfer to a depuration plant or relay (transplant) to approved areas for purification prior to human consumption, recreation, industrial and other legitimate uses including navigation.

CRITERIA

<u>Parameter</u>	<u>Standard</u>
1. Aesthetic	Good to excellent
2. Dissolved oxygen	Not less than 5.0 mg/l at any time.
3. Sludge deposits - solid refuse	None except for small amounts that floating solids-oils and may result from the discharge from a grease-scum-waste treatment facility providing appropriate treatment.
4. Color	None resulting in obvious discoloration of the receiving water outside of any designated zone of influence.
5. Suspended and settleable solids	None in concentrations or combinations which would impair the most sensitive designated use; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of bottom sediments; none which would adversely impact organisms living in or on the bottom sediments.
6. Sand or silt deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, or dredging provided all reasonable controls and Best Management Practices are used.
7. Turbidity	None other than of natural origin except for small amounts that may result from the discharge from a waste treatment facility providing appropriate treatment. All reasonable controls and Best Management Practices to be used.
8. Indicator bacteria	As an indicator of general sanitary quality, Fecal coliform shall not exceed a geometric mean of 200 organisms/100ml nor shall 10% of the samples exceed 400 organisms/100 ml. For designated shellfish harvesting areas fecal coliform organisms shall not exceed a geometric mean of 88 MPN/100 ml nor shall greater than 10% of samples exceed 260 MPN/100 ml. For established bathing waters, enterococcal organisms shall not exceed a geometric mean of 33/100 ml and no single sample shall exceed 61/100 ml. Refer to Standard number 23 and Appendix B.
9. Taste and odor	As naturally occurs. None that would impair any usages specifically assigned to this Class.
10. pH	6.8 - 8.5
11. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83°F or in any case raise the normal temperature of the receiving water more than 4°F. During the period including July, August and September, the normal temperature of the receiving water shall not be raised more than 1.5°F unless it can be shown that spawning and growth of indigenous organisms will not be significantly affected.

12. Chemical constituents None in concentrations or combinations which would be harmful to the most sensitive designated water use. Refer to Standards numbers 10, 11, 12, 13 and 17.

CLASSIFICATIONS

- SB Known or presumed to meet Water Quality Criteria which support designated uses.
- SC/SB or SD/SB Due to point or nonpoint sources of pollution, certain Water Quality Criteria or one or more designated uses assigned to Class SB waters are not currently met. The water quality goal is achievement of Class SB criteria and attainment of Class SB designated uses.

COASTAL AND MARINE SURFACE WATERS

CLASS SC

May be suitable for fish, shellfish, and wildlife habitat, certain aquaculture operations, recreational uses, industrial and other legitimate uses including navigation. Present water quality conditions preclude the full attainment of one or more designated uses some of all of the time. One or more Water Quality Criteria are not being consistently achieved. Examples of conditions which warrant a Class SC designation include conditions such as combined sewer overflows, urban runoff, inadequate municipal or industrial wastewater treatment, or community-wide septic system failures which can be corrected through implementation of established water quality management programs. Where the water quality goal is Class SA or SB, a DEP and EPA approved Use Attainability Analysis may be performed to demonstrate that one or more uses are not attainable. In those situations, site specific Quality Criteria will be employed in the analysis to insure that all existing uses are maintained. Refer to Standard Number 6.

CLASSIFICATIONS

- SC/SB or SC/SA Presently not meeting Water Quality Criteria or not supporting one or more assigned designated uses due to pollution. The goal for such waters may be Class SB, or Class SA.

COASTAL WATERS

CLASS SD

Present water quality conditions persistently preclude the attainment of one or more designated uses for Class SB waters. One or more Water Quality Criteria for Class SB waters are not being achieved most or all of the time. Class SD waters may be suitable for bathing or other recreational purposes, certain fish and wildlife habitat, industrial or other legitimate uses, including navigation, may have good aesthetic value. Class SD water quality results from sources of pollution which are not readily correctable through implementation of established State water quality management programs to control point and nonpoint sources of pollution. Examples of conditions which warrant a Class SD designation include contamination of bottom sediments, contamination of fish or shellfish with toxic compounds, and pollution caused by out-of-state sources. The water quality goal is restoration to Class SB or Class SA conditions. Where the water quality goal is Class SA or SB, a DEP and EPA approved Use Attainability Analysis may be performed to demonstrate that one or more uses are not attainable. In those situations, site specific Quality Criteria will be employed in the analysis to insure that all existing uses are maintained. Refer to Standard Number 6.

CLASSIFICATIONS

- SD/SB, SD/SA Presently not meeting Water Quality Criteria or not supporting one or more assigned designated uses due to severe pollution. The goal for such waters may be Class SA or Class SB

IV. GROUND WATER QUALITY STANDARDS

- GW1.** The policy of the Department in areas that are classified as GAA, GAA,, or GA is to maintain or restore all ground water in such areas to its natural quality.
- GW2.** If the Commissioner determines that, with respect to a particular pollutant, restoring or maintaining natural quality at a GAA, GAA,, or GA level is not technically practicable, the Department's policy is to:
- (A) Maintain or restore quality such that the ground water is suitable for drinking and other domestic uses without treatment, and
 - (B) Maintain or restore quality such that the ground water will not adversely affect surface water quality or prevent the maintenance or attainment or any designated uses of surface waters to which that ground water discharges, and
 - (C) Eliminate sources of pollution to such ground water to the extent that the Commissioner determines to be technically practicable, and regulate discharges to such groundwater so as to prevent pollution.
- GW3.** Ground water is deemed suitable for drinking and other domestic uses without treatment when no pollutant in such groundwater (A) exceeds a level which the Commissioner of Public Health has determined, pursuant to Section 22a-471 of the General Statutes, creates or reasonably can be expected to create an unacceptable risk of injury to the health or safety of persons using such ground water for drinking or other personal or domestic use, (B) is a carcinogen present at a concentration associated with a 1×10^{-6} excess cancer risk, (C) is a non-carcinogen present at a level exceeding that to which the human population, including sensitive subgroups, can be exposed on a daily basis with appreciable risk of adverse health effects during a lifetime, or (D) exceeds a level which the Commissioner determines, in consultation with the Commissioner of Public Health, renders the ground water so aesthetically impaired that a person cannot reasonably be expected to consume or otherwise use it.
- GW4.** The policy of the Department in areas classified as GB is:
- (A) To eliminate or reduce in the ground water any pollutant which presents a hazard of fire, explosion, or toxic or hazardous emission to the environment or otherwise poses a threat to public safety or an unacceptable risk to public health, and
 - (B) To maintain the ground water at a quality that will not adversely affect the quality of surface waters to which such ground water discharges or prevent the maintenance or attainment of any designated or existing uses in such surface waters, and
 - (C) To maintain a quality consistent with all designated and existing uses of the ground water, including its use for drinking without treatment if such ground water has, prior to the adoption of these Water Quality Standards, been utilized for, and continues to be utilized, for drinking water, and
 - (D) To regulate discharges to the ground water in order to prevent further degradation of ground water quality.
- GW5.** The policy of the Department in areas classified as GC is:
- (A) To eliminate or reduce in the ground water any pollutant which presents a hazard of fire, explosion or toxic or hazardous emission to the air or otherwise poses a threat to public safety or an unacceptable threat to public health, and

- (B) To maintain the ground water at a quality that will not adversely affect the quality of surface waters to which such ground water discharges or prevent the maintenance or attainment of any designated or existing uses in such surface waters, and
 - (C) To limit the impacts of waste discharges on ground water quality to those which, despite the use of treatment technology, cannot be avoided and which result from a discharge which is authorized by a permit under Section 22a-430 of the General Statutes.
- GW6.** With respect to ground water whose quality is actually higher than that reflected by the assigned classification, the Department's policy is that such ground water should be maintained at its existing high quality. To maintain such quality, the Commissioner may require that:
- (A) A new, increased, or otherwise modified discharge to such ground water shall be given treatment such that, notwithstanding such classification, the actual higher quality is maintained.
 - (B) If after the adoption of these Water Quality Standards there is an unpermitted release of pollutants to ground water which is classified GB but whose quality is actually GA or GAA, such groundwater shall be remediated to the standards for Class GA or GAA.
- GW7.** The Commissioner may raise the ground water classification of any area if he finds that such ground water meets the standards for the higher classification.
- GW8.** (A) The Commissioner may consider an application to lower a ground water classification to GB. Such application shall be subject to the public participation requirements of Section 22a-426 of the General Statutes and shall:
- (i) describe the nature and extent and date of commencement of pollution of the ground water proposed to be reclassified,
 - (ii) identify all sources of drinking water in the area whose ground water is proposed to be reclassified and identify all existing uses of ground water within and down gradient of such area,
 - (iii) assess the potential of the subject area to produce ground water in an amount suitable for a public water supply,
 - (iv) describe all past and present land uses in the subject area, with dates, and
 - (v) provide such other information the Commissioner may reasonably require to determine the most appropriate ground water classification.
- (B) A ground water classification shall not be lowered to GB unless the applicant has satisfactorily demonstrated that: any person within or down gradient of the area to be reclassified and extending to an area previously classified as GB or to a surface water body to which the groundwater discharges will be provided with an adequate public water supply, and that lowering of a ground water classification will not prevent attainment of adjacent surface water quality goals or present unacceptable health risks, and
- (i) That the ground water to be reclassified is polluted as a result of intense urban, commercial, or industrial development which occurred prior to 1981, and the hydrologic conditions of the subject area are not suitable for the development of a significant public water supply, or

- (ii) The ground water proposed to be reclassified is polluted and remediation of such ground water to a quality suitable for drinking without treatment is not technically practicable, or
- (iii) There is an overriding social or economic justification for reclassifying the ground water to GB and the proposed reclassification is supported by the affected municipality or municipalities, as affirmed, in writing, by the chief executive officer(s) of the municipality or municipalities. For the purpose of this Standard an "affected municipality" is one in which ground water classifications are to be altered, "social justification" means a specific social need of the affected municipality or the state and "economic justification" means avoidance of an economic impact that would substantially impair or otherwise detrimentally affect the economy of the community or the state. The applicant must also demonstrate that the purposes for the reclassification will not result in development that is inconsistent with the State Policies Plan for Conservation and Development as adopted pursuant to Section 16a-30 of the General Statutes.

GW9. The Commissioner may consider an application to lower a ground water classification to GC. Any such application shall be subject to the public participation requirements of Section 22a-426 of the General Statutes and:

(A) Such application shall be accompanied by a completed application under Section 22a-430 of the General Statutes for a permit to discharge leachate from a solid waste land disposal facility to the subject ground water.

(B) A ground water classification shall not be lowered to GC unless the applicant has satisfactorily demonstrated that:

- (i) there is an overriding social or economic justification for reclassifying the ground water to GC and the affected municipality or municipalities have been notified of the proposed reclassification; and
- (ii) the ground water proposed to be reclassified is not suitable for development of a significant public water supply and is suitable for waste treatment; and
- (iii) the subject area is adjacent to and hydraulically connected with a surface water body classified B or SB; and
- (iv) in a Section 22a-430 permit application the applicant has delineated the zone of influence (see standard GW10) of the ground water proposed to be reclassified as extending from the proposed solid waste land disposal facility to the receiving surface water body, and the applicant owns the land overlying such zone of influence, or has an easement with respect to such land which easement is properly recorded and provides protections, as described in subsection D(1) and D(2) of Standard GW10, or otherwise controls the zone of influence to the satisfaction of the Commissioner.

GW10. Zones of influence. The Commissioner may establish zones of influence when, in the course of permitting discharges to the ground water under Section 22a-430 of the General Statutes, he allocates ground water and soil resources for the treatment of pollutants. Within that zone of influence the Section 22a-430 permittee will be allowed to degrade the ground water such that it may not meet the standards for the assigned classification or be suitable for uses designated by these Water Quality Standards for such classification.

A. For a subsurface sewage disposal system permitted under authority delegated pursuant to Section 22a-430-1 of the Regulations of Connecticut State Agencies to the Commissioner of Health and Addiction Services, the zone of influence shall be that area required by the minimum separating distances established in Section 19-13-B103d of the Regulations of Connecticut State Agencies.

- B. For discharges to ground water of treated domestic sewage other than discharges of domestic sewage identified in subparagraph GW10(A), agricultural wastes, and storm water, the zone of influence shall be the area in which such discharge causes the ground water to be 1) altered in quality from its natural condition, or 2) lowered in quality from that which is suitable for drinking and other domestic uses without treatment. The Commissioner may require the applicant for a permit under Section 22a-430 of the General Statutes to submit for the Commissioner's approval an engineering plan showing the areal extent of any such zone of influence.
- C. The applicant for a permit under Section 22a-430 of the General Statutes authorizing a discharge other than a discharge of treated domestic sewage, agricultural waste, or storm water shall delineate the zone of influence associated with the proposed discharge. Such zone of influence shall include all areas beneath which the ground water which is or may be affected in quality by such discharge. The Commissioner may require that such zone of influence extend to a receiving water body with a classification of B or SB.
- D. The Commissioner may require the applicant for a permit under Section 22a-430 of the General Statutes to demonstrate that he has acquired rights to the zone of influence of the proposed discharge. Acquisition of such rights means that the applicant owns the land overlying such zone, has obtained an easement with respect to such land and has recorded such easement in the applicable Town Clerk's office, or otherwise controls such zone to the Commissioner's satisfaction. Any such easement or other control mechanism shall: 1) provide the applicant with the exclusive right to use the ground water in such zone and such right to enter the land overlying such zone as the Commissioner deems necessary to accommodate monitoring or remediation, and 2) assure that the ground water within such zone will not be used for potable water supply.
- E. The delineation by a Section 22a-430 permit applicant of the zone of influence of a proposed waste discharge indicates that the underlying ground water may not be suitable for human consumption or other uses. Installation of a withdrawal well in or near such a zone of influence may result in an induced flow of polluted ground water to such well. When reviewing an application to withdraw groundwater pursuant to Connecticut's Water Diversion Policy Act, General Statutes Sections 22a-365 et seq., the Commissioner considers the potential impacts on water quality attributable to induced flow of polluted water from a zone of influence associated with a waste discharge.

GW11. The Department's classification of ground water, whether as GB, GC, or otherwise, conveys no right to degrade that ground water or to utilize less effective treatment measures than those utilized for discharges to groundwater designated for use as potable water. Domestic sewage shall be given the same treatment regardless of the classification of the groundwater to which such sewage is discharged.

GW12. The Commissioner applies the following policies in reviewing applications under Section 22a-430 of the General Statutes to discharge waste to ground water:

- A. *Class GAA Ground Waters:* The Commissioner does not issue permits authorizing a discharge to class GAA ground water unless such discharge is of treated domestic sewage as defined in Section 22a-430-1 of the Regulations of Connecticut State Agencies, waste generated by certain agricultural practices, certain water treatment waste waters from public water supply treatment systems, or certain minor cooling waters or clean waters. If a GAA area is within an Aquifer Protection Area designated in accordance with Section 22a-354 of the General Statutes, the Commissioner does not issue permits authorizing a groundwater discharge that conflicts with any regulation adopted pursuant to Section 22a-354(i) of the General Statutes.
- B. *Class GAA, Ground Waters:* The Commissioner does not issue permits authorizing a discharge to class GAA, ground water unless such discharge is of treated domestic sewage as defined in Section 22a-430-1 of the Regulations of Connecticut State Agencies, waste generated by certain agricultural

practices, certain water treatment waste waters from public water supply treatment systems, or certain minor cooling waters or clean waters. If a GAA area is within an Aquifer Protection Area designated in accordance with Section 22a-354 of the General Statutes, the Commissioner does not issue permits authorizing a groundwater discharge that conflicts with any regulation adopted pursuant to Section 22a-354(i) of the General Statutes.

- C. *Class GA Ground Waters:* The Commissioner does not issue permits authorizing a discharge to class GA ground water unless such discharge is allowed under subparagraph (A) of this standard or is a discharge from a septage treatment system or of other wastes that are predominantly human, plant, or animal in origin so long as any such wastes are of natural origin, easily biodegradable and, if properly managed, pose no threat of pollution to the ground water. The ground water plume generated by a discharge of septage treatment system must terminate in a stream with classification of B or SB unless the permittee treats the discharge in a manner which the Commissioner determines is adequate to maintain class A water in the receiving stream.
- D. *Class GB Ground Waters:* The Commissioner may issue permits authorizing a waste discharge to class GB ground water if such discharge would be allowable in a GA area under subparagraph (C) of this standard or if such discharge meets all of the following criteria:
 - (i) The Commissioner has determined that such waste is generated by a source which is unlikely to produce persistent pollutants or pollutants that do not biodegrade in soil.
 - (ii) The waste will be treated as necessary to render it amenable to attenuation by the receiving soil so that the groundwater will not be impaired.
 - (iii) Such discharge otherwise conforms with all applicable legal requirements and standards.
- E. *Class GC Ground Waters:* The Commissioner may issue permits authorizing a discharge to class GC ground water of any material, provided such discharge otherwise conforms with all applicable legal requirements and standards.

GW13. The Commissioner may issue a permit authorizing a discharge of material to ground water, even if such discharge would be inconsistent with subparagraph (A), (B), (C), or (D) of Standard GW12, provided such discharge otherwise conforms with all applicable legal requirements and standards, is necessary to remediate groundwater pollution, and is treated or managed such that, to the maximum extent practicable, the discharge does not impair public health or the environment.

V. GROUND WATER CLASSIFICATIONS AND CRITERIA

CLASS GAA

Designated Uses: Existing or potential public supply of water suitable for drinking without treatment; baseflow for hydraulically-connected surface water bodies.

<u>Parameter</u>	<u>CRITERIA</u>
	<u>Criterion</u>
1. Dissolved Oxygen	As naturally occurs.
2. Oils and grease	None other than of natural origin.
3. Color and turbidity	None other than of natural origin.
4. Coliform bacteria	None other than of natural origin.
5. Taste and odor	None other than of natural origin.
6. pH	As naturally occurs.
7. Chemical constituents	As naturally occurs.

Sub-Classifications of Class GAA

GAA Ground water used or which may be used for public supplies of water suitable for drinking without treatment; ground water in the area that contributes to a public drinking water supply well; and ground water in areas that have been designated as a future water supply in an individual water utility supply plan or in the Area wide Supplement prepared by a Water Utility Coordinating Committee pursuant to Title 25 of the General Statutes.

GAA Ground water that is tributary to a public water supply reservoir.

CLASS GA

Designated Uses: Existing private and potential public or private supplies of water suitable for drinking without treatment; baseflow for hydraulically-connected surface water bodies.

CRITERIA

<u>Parameter</u>	<u>Criterion</u>
1. Dissolved oxygen	As naturally occurs.
2. Oils and grease	None other than of natural origin.
3. Color and turbidity	None other than of natural origin.
4. Coliform bacteria	None other than of natural origin.
5. Taste and odor	None other than of natural origin.
6. pH	As naturally occurs.
7. Chemical constituents	As naturally occurs.

CLASSIFICATIONS

GA Ground water within the area of existing private water supply wells or an area with the potential to provide water to public or private water supply wells. The Department presumes that ground water in such an area is, at a minimum, suitable for drinking or other domestic uses without treatment.

CLASS GB

Designated Uses: Industrial process water and cooling waters; baseflow for hydraulically-connected surface water bodies; presumed not suitable for human consumption without treatment.

CRITERIA

Ground waters of this class are assumed by the Department to be degraded due to a variety of pollution sources. No specific groundwater quality criteria apply except those that may be promulgated as part of the Site Remediation Regulations required by Section 22a-133k of the General Statutes

CLASSIFICATIONS

GB Ground water within a historically highly urbanized area or an area of intense industrial activity and where public water supply service is available. Such ground water may not be suitable for human consumption without treatment due to waste discharges, spills or leaks of chemicals or land use impacts.

CLASS GC

Designated Uses: Assimilation of discharges authorized by the Commissioner pursuant to Section 22a-430 of the General Statutes.

CRITERIA

No quantitative criteria are specifically determined until such time as a person applies to the Department under Section 22a-430 of the General Statutes to discharge leachate to ground water. The most important consideration in making a determination to classify ground water as GC is the impact of any authorized ground water discharges on adjacent surface waters.

CLASSIFICATIONS

GC Ground water to which the Commissioner has authorized a discharge under Section §22a-430 of the General Statutes. In the course of applying for Section §22a-430 authorization, the permittee performed all necessary hydrogeologic studies, secured legal rights to all affected ground waters, and complied with all other requirements of Connecticut's Water Quality Standards and any other applicable law. Ground waters classified as GC are not suitable for development of public supplies of potable water.

APPENDIX A

CONNECTICUT ANTI-DEGRADATION IMPLEMENTATION POLICY

I. PURPOSE. The purpose of this document is to establish implementation procedures to carry out Connecticut's anti-degradation policy as required by the Federal Clean Water Act (40 CFR 131.12) and stated in Connecticut Water Quality Standards 2 through 5. The anti-degradation policy requires the maintenance and protection of water quality in high quality waters.

II. APPLICABILITY. The procedures outlined in this policy would apply to any proposed new or increased discharge to the surface waters of the state or any activity requiring a permit pursuant to Chapters 440, 446i-k, and 368 of the Connecticut General Statutes or requiring Water Quality Certification pursuant to Section 401 of the Clean Water Act.

III. SURFACE WATER RESOURCES TO BE MAINTAINED AT EXISTING HIGH QUALITY. No permit or certification may be issued for any discharge or activity in the following waters:

1) Outstanding National Resource Waters

Where high quality waters constitute an outstanding National resource, such as waters of National and State parks, wildlife refuges, and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected. The lowering of water quality is prohibited in Outstanding National Resource Waters except where limited activities will result in only temporary or short term insignificant changes in water quality.

2) Class A or AA waters

unless:

(a)(1) a temporary discharge is necessary to remediate an existing surface or groundwater pollution pr
or

- (a)(2) the discharge consists of clean water, treated backwash waters from public or private drinking water treatment systems or dredging and dredged material dewatering operations and does not result in violation of Class A or AA standards;
 - (b) for nonpoint source discharges, appropriate Best Management Practices as determined by the Commissioner are employed; and
 - (c) in all cases the Commissioner finds that existing or designated uses will be protected fully. Existing uses are defined in 40 CFR 131.12 those which have occurred on or after November 28, 1975.
- 3) High quality Class B or SB water resources are those with existing quality better than established standards for that class and which meet all designated use goals. These waters will be maintained at their existing high quality,

unless

- (a) the Commissioner finds, after adequate opportunity for intergovernmental and public participation, that allowing lower water quality is necessary to accommodate overriding State economic or social development in accordance with paragraph IV.2 of this document or
- (b) the Commissioner finds that the resulting change in water quality is not significant in accordance with paragraph IV.1 of this document; and,
- (c) in all cases, the Commissioner finds that existing and designated uses will be protected fully.

IV. ANTI-DEGRADATION EVALUATION PROCEDURES FOR CLASS B AND SB WATER RESOURCES

- 1) Determination of significant lowering of water quality - The Commissioner will make a determination of whether a proposed discharge or activity will result in a significant change in water quality by utilizing all available data and the best professional judgement of Department staff. Factors to be considered in making this determination include, but are not limited to:
- (a) percent change in a water quality parameter;
 - (b) quality and value of the resource;
 - (c) cumulative impact of discharges and/or activities on water quality;
 - (d) impact on aquatic biota and habitat;
 - (e) eutrophic impacts;
 - (f) impact on existing, designated, and potential uses; and
 - (g) percent of remaining assimilative capacity for the water resource.
- 2) Determination that allowing lower water quality is necessary to accommodate overriding economic and social development - If it is determined that a proposed discharge or activity will result in a significant lowering of water quality in a high quality Class B or SB water resource, no permit or certification will be issued unless the Commissioner finds that allowing lower water quality is necessary to accommodate overriding economic and social development which the Commissioner has determined is clearly in the public interest, and that existing uses will be protected fully.

(a) The proposed lowering of water quality will be found to be necessary only if the applicant demonstrates to the satisfaction of the Commissioner that:

- alternatives are not technologically feasible, or
- applicable pollution control alternatives are prohibitively expensive.

Alternatives studied should include but are not necessarily limited to:

- alternative discharge locations
- reduction in scale of the project
- pollution prevention measures
- water recycle or reuse
- process changes and/or innovative technology
- improved operation and maintenance of existing facilities

(b) The burden of proof is on the applicant to show the overriding economic or social benefits to the State which will result from the proposed activity, including any mitigation. The applicant shall also discuss the loss or reduction of natural resource benefits associated with lower water quality. These benefits include but are not limited to active and passive recreation, aquatic life, aquatic habitat including riparian vegetation and intrinsic values such as aesthetic appreciation of the water resource.

- 3) As required by WQS (4), the Commissioner shall require the highest statutory and regulatory requirements for all new and existing point sources. All cost-effective and reasonable Best Management Practices for nonpoint source discharges must be utilized.
- 4) The Commissioner may periodically review available treatment technology and reconsider any prior decisions in accordance with Section 22a-431 of the General Statutes.
- 5) Public Participation - Anti-degradation issues will be evaluated in conjunction with permit or certification issuance described in Section II above. For activities where anti-degradation applies, the Public Notice for the proposed activity will contain the Commissioner's finding regarding compliance with the anti-degradation policy.
- 6) The Commissioner may take into consideration all other mitigating factors not included within these procedures in making a decision.

APPENDIX B

GUIDELINES FOR USE OF CRITERIA FOR INDICATOR BACTERIA

The indicator bacteria criteria established in Connecticut Water Quality Standards identify the minimum requirements for sanitary quality necessary to support the uses designated for each Class of waters. Three uses in particular are sensitive to bacterial contamination; drinking water supply, shellfish harvesting, and contact recreation (bathing). Three groups of indicator bacteria, total coliform, fecal coliform, and Enterococci, are used in Connecticut Water Quality Standards to establish the sanitary quality of waters relative to the support of these designated uses. The results of bacteriological analysis of a water sample also depends to a degree on the methodology used to determine bacterial densities. In practice, both the indicator organism and the method of measurement must be known to make valid assessments of sanitary quality.

Water Quality Classifications for individual waterbodies are reviewed approximately every three years at which time all available water quality monitoring data is considered. Public input is also solicited and considered in determining the appropriate Classification to identify current quality and future quality goals. Nevertheless, the Water Quality Classification may not be an accurate representation of the current water quality conditions at any particular site. For this reason, the Water Quality Classification should not be considered as a certification of quality by the State or an approval to engage in certain activities such as swimming or shellfish harvesting.

Total coliform bacteria have traditionally been widely used as surrogates for pathogenic organisms normally associated with sewage to indicate the possible contamination of surface and ground waters including evaluation of the sanitary quality of drinking water. However, total coliform bacteria also originate in the intestines of other warm blooded animals, as well as sources which have little sanitary significance such as plants and soils (see also Standard 22). The Public Health Code, adopted pursuant to Section 19-13 of the Connecticut General Statutes, establishes sanitary criteria for untreated drinking water supplies based on total coliform densities determined using the Membrane Filter method described in the most recent edition of Standard Methods. The Connecticut Department of Health Services is designated as the lead agency with the authority to regulate the sanitary quality of public drinking water supplies and certify laboratories for analysis of the sanitary quality of surface and ground waters.

Fecal coliform bacteria comprise a portion of the total coliform group and may be more specific to bacteria of sanitary significance. Fecal coliform density as determined using the Multiple Tube Fermentation method has been designated as the preferred means of assessing the sanitary quality of marine waters with respect to shellfish harvesting. Public Act 89-321 assigns to the Department of Agriculture, Aquaculture Division (DA/AD) the responsibility for regulating the harvesting of shellfish in Connecticut waters. Consistent with this authority, the DA/AD has begun the process of classifying shellfish growing areas with respect to authorized use and sanitary quality in accordance with Federal regulations. The DA/AD has established shellfish growing area classifications (following table) based in part on monitoring of fecal coliform densities consistent with Interstate Shellfish Sanitation Conference (ISSC) National Shellfish Sanitation Program Manual of Operations, Parts I and II.

Additional information on the shellfish growing area classifications used by DA/AD for regulation of shellfish harvesting is provided in the tables which follow. Due to differences in the procedures used to classify waters, some inconsistencies may exist between the Connecticut Water Quality Classification adopted by DEP and the DA/AD Classification of shellfish growing areas. For example, the DA/AD may classify an area as PROHIBITED due to a lack of sufficient monitoring data to satisfy federal/ISSC mandates when, in fact, actual water quality would not result in contamination of the shellfish resource. In this instance, the shellfish classification does not accurately reflect true water quality conditions but rather indicates a shortfall in State and local resources to conduct monitoring. Situations may also arise in which monitoring to verify sanitary quality conducted by DA/AD and local authorities may uncover an area of previously unknown contamination. Here the DEP Water Quality Classification must be revised to reflect actual quality and corrective actions implemented to restore the use of the area for shellfishing. Each triennial revision of the Water Quality Classifications for marine waters will reduce the number of both types of inconsistencies as more direct and intensive monitoring data for Long Island Sound waters is available.

Enterococci have been adopted by the DEP and the Department of Health Services (DHS) as the preferred indicator for evaluation of the sanitary quality of established bathing waters. Enterococci are a subgroup of the fecal streptococci group and are more fecal specific than other commonly used indicators such as total coliform or fecal coliform bacteria. However, they also can be found in domestic animals and birds as well as humans. The local Director of Health is responsible for determining the sanitary quality of bathing waters and closure of waters found not to meet minimum criteria. Enterococci densities are determined using the Membrane filter method using mE agar as described in Test Methods for Escherichia coli and Enterococci in Water by the Membrane Filter Procedure (USEPA 600/4-85/076). Procedures for monitoring and closure of bathing areas by Local Health Authorities are specified in Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by DEP and DHS in May 1989.

Prior to this revision, the Water Quality Standards included a fecal coliform criteria for evaluation of the sanitary quality of fresh waters as related to use for contact recreation. This criteria is now being replaced with a criteria for established bathing areas which utilizes Enterococci as indicator organism. The old fecal coliform criteria, however, is being retained as a guideline for evaluation of the general sanitary quality of waters relative to maintaining all designated uses for Class B waters:

Fecal coliform shall not exceed a geometric mean indicator density of 200/100ml in any group of samples nor shall greater than 10% of samples exceed 400/100ml.

A fecal coliform guideline is desirable for several reasons. First, fecal coliform is a more general, broad-based indicator of sanitary quality than Enterococci and may be more useful in identifying and locating sources of sewage contamination in certain situations. Also, there exists a large body of historical monitoring data for fecal coliform densities in surface waters which can be useful in monitoring trends in surface water quality. Facilities which treat sanitary waste use fecal coliform density as a measure of disinfection efficiency. Currently the NPDES discharge permits for all sewage treatment plants in Connecticut include limits on fecal coliform density in the effluent as a means of ensuring that adequate disinfection has taken place prior to discharge. Finally, due to the more widespread past use of the fecal coliform analysis in comparison to the Enterococcal test, the Fecal coliform guideline provides a useful monitoring device during the transition period to greater reliance on the Enterococcal test for sanitary quality.

**BACTERIAL INDICATORS OF SANITARY QUALITY FOR DESIGNATED USES
ESTABLISHED IN CONNECTICUT WATER QUALITY STANDARDS**

<u>DESIGNATED USE</u>	<u>CLASSES</u>	<u>INDICATOR</u>	<u>INDICATOR BACTERIA CRITERIA</u>
Drinking Water Supply Suitable for drinking following disinfection and chemical treatment.	AA A	Total Coliform (MF)	Shall not exceed a monthly moving average of 100/100 ml for the most recent 12 months. No individual sample shall exceed 500/100 ml.
Contact Recreation Established bathing waters	A B SA SB	Enterococci (MF)	Shall not exceed a geometric mean indicator density of 33/100 ml. No single sample shall exceed 61/100 ml.
Shellfish Growing Areas for Direct Consumption (DA/AD Classified as APPROVED)	SA	Fecal Coliform (MPN)	Shall not exceed a geometric mean of 14 MPN/100 ml. No more than 10% of samples shall exceed 43 MPN/100 ml.
Shellfish Growing Areas for Indirect Consumption following transfer to a Depuration Plant or DA/AD approved Area for purification. (DA/AD Classified as RESTRICTED-DEPURATION)	SB SB/SA	Fecal Coliform (MPN)	Shall not exceed a geometric mean of 88 MPN/100 ml. No more than 10% of samples shall exceed 260 MPN/100 ml.

<u>DESIGNATED USE</u>	<u>CLASSES</u>	<u>INDICATOR</u>	<u>INDICATOR BACTERIA CRITERIA</u>
Shellfish Growing Areas for Indirect Consumption following transfer to an DA/AD Approved area for purification. (DA/AD Classified as RESTRICTED-RELAY)	SB SB/SA	Fecal Coliform (MPN)	Criteria established on a site-specific basis by DA/AD following a sanitary survey.
Shellfish Growing Areas for certain aquaculture operations only. (DA/AD Classified as PROHIBITED)	SC/SA SC/SB SD/SA SD/SB	Fecal Coliform (MPN)	Does not meet SB criteria. Sanitary survey indicates that transfer of shellfish to DA/AD Approved Area will not be an effective means of protecting human health from possible adverse effects.

**SHELLFISH GROWING AREA CLASSIFICATIONS
ESTABLISHED BY**

THE CONNECTICUT DEPARTMENT OF AGRICULTURE / AQUACULTURE DIVISION

- Approved Approved by the DA/AD for growing or harvesting shellfish for direct marketing as licensed by DA/AD and recreational shellfishing. Classification is determined through a sanitary survey conducted by DA/AD with local assistance. May be temporarily closed during a public health emergency is declared resulting from, for example, a hurricane or flooding.
- Restricted-Depuration Use is restricted to harvesting of shellfish by DA/AD licensed operators for transfer to a Depuration Plant or to an Approved Area for purification. These shellfish may not be directly marketed or consumed prior to the purification process. These areas require sanitary surveys and must meet specified bacteriological standards.
- Restricted-Relay Use is restricted to harvesting of shellfish by DA/AD licensed operators. Shellfish must be transferred to an Approved Area for natural purification prior to marketing and consumption. Transfer to a depuration plant is not allowed. A sanitary survey is required.
- Prohibited Harvesting of shellfish is prohibited except for certain aquaculture operations licensed by DA/AD such as harvesting of seed oysters for transplant to clean growing areas. This classification results from the presence of conditions that could pose a health hazard such as severe pollution or marine biotoxins. The DA/AD may also prohibit shellfishing in areas where insufficient sanitary survey and water quality information exist to establish an appropriate classification.

Conditional Use

The DA/AD may classify certain shellfishing areas as Conditionally Approved or Conditionally Restricted if it is determined by the DA/AD that the area will meet the criteria established for an Approved or Restricted classification for a predictable period. A conditional classification may be based on seasonal, meteorological or wastewater treatment plant performance characteristics which can be related in a predictable way to the sanitary quality of the shellfish growing area. If the conditions established by DA/AD are met, the area can be used for shellfish harvesting (either Approved or Restricted as Classified); if the conditions are not met, shellfish harvesting in the area would be prohibited until conditions improve. Water Quality Classifications for marine waters which are conditionally classified by DA/AD are determined on a case-by-case basis by DEP taking into consideration the cause and frequency of any restrictions on use.

- A sanitary survey, as referenced here, consists of a shoreline survey to identify and assess potential pollution sources, meteorological effects, water quality examination and assessment using prescribed standards, and corrective action where necessary. Sanitary surveys are required for all shellfish growing area classifications with the exception of PROHIBITED.

APPENDIX C

DEFINITIONS

Acute Toxicity	Adverse effect such as mortality or debilitation caused by a brief exposure to a relatively high concentration of a toxic substance.
Ambient	Normally occurring conditions in a waterbody.
Anti-degradation	A statement of practice required by federal law which prohibits a state from lowering surface water quality classifications or standards in order to accommodate new or increased wastewater discharges or land use practices which impact a particular water course. The state must attain, and maintain the most sensitive existing and potential use for a respective waterbody.
Arithmetic Mean	The average, calculated by dividing the sum of all values by the number of values to be averaged.
Benthic	Refers to organisms or material associated with the bottom of watercourses.
Benthic Macroinvertebrates	Animals large enough to be seen by the unaided eye and can be retained by a U. S. standard No. 30 sieve (28 meshes per inch, 0.595 mm openings). They must live at least part of their life cycle within or upon submerged substrates in a body of water. These animals usually consist of the aquatic life stages of various insects and arthropods, molluscs, leeches and worms. The benthic community is widely used for the environmental assessment of flowing waters. The structure of this community is a function of environmental conditions during the life span of the organisms. Consequently, community structure can be altered by the effects of pollution, including intermittent events which could be easily missed by conventional chemical/physical indicators. The well-being of the benthic community is frequently reflected in the well-being of higher forms of aquatic life, such as fish.
Best Management Practices	Those practices which reduce pollution of the waters of the state and which have been determined by the Commissioner to be acceptable based on, but not limited to, technical, economic and institutional feasibility.
Bioaccumulate	The uptake and retention of substances by an organism from its surrounding medium and/or from food.
Bioconcentrate	The uptake and retention of substances by an organism from its surrounding medium to levels which exceed the concentration of that substance in the medium.
Chronic Toxicity	Adverse effect, such as reduced reproductive success or growth, poor survival of sensitive life stages which occurs as a result of exposure to relatively low concentrations of a toxic substance.

Classifications	Designation of the proposed uses of surface and ground waters with alphabetic character. Where classifications appear in two sections separated by a diagonal line, the first classification indicates existing use or general quality and the second classification indicates the water use goal.
Clean Water	Water, which in the judgement of the Commissioner, is of a quality substantially similar to that occurring naturally in the receiving stream under consideration; e.g., Clean water may include minor cooling waters, residential swimming pool water, and stormwater. Best Management Practices or other treatment may be required.
Coastal and Marine Waters	Those waters generally subject to the rise and fall of the tide and as defined by Section 22a-93 of the Connecticut General Statutes as amended.
Commissioner	Commissioner of Environmental Protection
Criteria	Elements of Connecticut's Water Quality Standards, expressed in parameters and their constituent concentrations, levels, or by narrative statements, representing a quality of water that supports a particular designated use.
Department	The Connecticut Department of Environmental Protection.
Depuration	Controlled shellfish purification process where a controlled environment is used to reduce the level of bacteria and viruses in shellfish. The process usually includes a fixed structure having a specified water circulation and disinfection system, together with designed tanks and racks.
Designated Use	Those uses specified in Connecticut's Water Quality Standards for each surface watercourse or ground water area, whether or not they are being attained.
Discharge	Defined in Sec. 22a-423 as "... the emission of any water, substance or material into the waters of the state, whether or not such substance causes pollution."
Discharge Toxicity Evaluation	A structured scientific analysis of the toxic strength and discharge rate of a treated wastewater effluent relative to available dilution in the receiving water. Prepared as described in the Department's guidance document, <u>Guidelines for Preparation of Discharge Toxicity Evaluations</u> . An analysis typically contains data and supporting information on receiving waterbody characteristics and recommendations regarding possible approaches to reduce effluent toxicity and in-stream toxic impacts resulting from the discharge.
Domestic Sewage	Waste water which consists of water and human excretions or other waterborne wastes incidental to the occupancy of a residential building or a non-residential building but not including manufacturing process water, cooling water, wastewater from water softening equipment, commercial laundry wastewater, blowdown from heating or cooling equipment, water from cellar or floor drains or surface water from roofs, paved surfaces, or yard drains.
Dredging	The excavation, removal or dispersal of sediments.
Effluent	Treated waste process waters or cooling waters discharged from a waste treatment or manufacturing facility.
Eutrophication	The process of enrichment of surface waters with plant nutrients which may cause nuisance algae blooms and excessive growth of aquatic weeds.

Existing Uses	Those uses actually attained in the water body on or after November 28, 197 whether or not they are included in the Water Quality Standards.
Functional Feeding Group	General category of benthic macroinvertebrates based on feeding mechanisms.
Geometric Mean	Also referred to as the log mean, it is a measure of central tendency calculated by taking the anti-log of the mean of the logarithms of the values to be averaged.
Ground Waters	Waters flowing through earth materials, beneath the ground surface.
Ground Water of Natural Quality	Means ground water which is free from pollution by solid waste, wastewater discharges, chemical spills and leaks, pesticides or other anthropogenic sources of water pollution except for acid rain.
High Quality Waters	Waters of a quality which exceed established standards for the respective Class. May sustain a sensitive use which is designated for a higher Class. Refer to Standard number 2.
Indigenous	Animal or plant life which are naturally occurring inhabitants of a certain geographic region.
Invertebrates	Animals lacking a backbone.
Lentic	Standing water environments, such as lakes and ponds.
Lotic	Refers to flowing water habitats, as in streams or rivers.
Most Sensitive Use	The water use (drinking, swimming, boating, fish and aquatic life propagation, irrigation etc.) which is most susceptible to degradation by a specific pollutant (e.g. Bacterial contamination can preclude swimming but not fish production, copper concentrations as low as 20 parts per billion (ppb) may adversely affect sensitive species of fish and aquatic life while drinking water quality is not affected until copper concentrations approach the secondary drinking water Maximum Concentration Level (MCL) of 1,000 parts per billion).
Moving Average	Mean of consecutive values in a time series of a specified duration. For example, a 12 month moving average is calculated by averaging the monthly values for a parameter for the most recent 12 consecutive months. It is called a moving average since as time progresses and more new values are available, old values are dropped resulting in an average which is always based on 12 consecutive monthly values.
MSD	Marine Sanitation Device. Devices installed or used on watercraft for the collection, treatment and disposal of human wastes.
Natural Origin	The natural ambient background level that has been measured.
Non-point Source	Wastewaters, leachate or runoff which originate from diffuse sources or widespread areas. For example; soil erosion from construction sites.
Point Sources	Treated or untreated wastewater discharges from manufacturing or sewage treatment works which are conveyed to their discharge point within discrete, readily identifiable pipes or conduits or are emitted through some other similar single point. For example, an outfall pipe from a sewage treatment plant.
Prudent	Means reasonable, after taking into consideration cost, in light of the social environmental benefits.

Recreational Use	Water use which involves active or passive leisure activities such as fishing, swimming, boating, and aesthetic appreciation.
Sediments	Any natural or artificial materials which constitute all or part of the banks, bed or bottom of an intermittent or perennial watercourse.
Sewage	Defined in Sec. 22a-423 as, "human and animal excretions and all domestic and such manufacturing wastes as may tend to be detrimental to the public health."
Streamflow Regulation	Control of the rate of stream discharge by means of dams withdrawals, or diversion of water which might otherwise impede the flow of water in a watercourse.
Taxon (pl. Taxa)	Refers to a biological classification category, usually the finest division attainable in current taxonomy. Most benthic organisms are identified to genus or species.
Technically Practicable	Means, with respect to remediation, the greatest degree of remediation that can be achieved using sound engineering and hydro geologic practices.
Based Treatment	301(b) and 304(b) of the Federal Water Pollution Control (Clean Water) Act. The level and type of treatment required is based on the manufacturing process used and type of waste generated.
Tidal Wetlands and Creeks	Defined in Section 22a-29 of the Connecticut General Statutes as those areas which border on or lie beneath tidal waters.
Toxic Substance	Any substance which can adversely affect the survival, growth or reproduction of fish, other forms of aquatic life or humans exposed to the substance either by direct contact or through consumption of aquatic organisms.
Transplantation	Harvesting shellfish from designated closed areas, transporting and placing the shellfish onto other designated areas for propagation, growth, purification or transfer to an approved depuration plant.
Trophic Conditions	The state of enrichment of a waterbody with plant nutrients.
Use Attainability Analysis	A structured scientific assessment of the factors affecting the attainment of a watercourse designated use which may include physical, chemical, biological and economic factors. The analysis process is defined in: the Revised Water Quality Standards Regulations published in the Federal Register (48 FR 5 1400, November 8, 1983). Additional guidance regarding preparation of Use Attainability Analyses is contained in Chapter 3 of the Water Quality Standards Handbook (EPA - 1983) and Technical Support Manual: Water Body Surveys and Assessments for Conducting Use Attainability Analyses (EPA Office of Water, November 1983).
Waters of the State	Defined in Sec. 22a-423 as, ". . . all tidal waters, harbors, estuaries, rivers, brooks, watercourses, waterways, wells, springs, lakes, ponds, marshes, drainage systems, and all other surface or underground streams, bodies or accumulations of water, natural or artificial, public or private, which are contained within, flow through or border upon this state or any portion thereof."
Water Quality	A statement of the physical, chemical and biological characteristics of surface or ground waters.

Water Quality Based Treatment

Additional waste treatment defined under the provisions of Section 302 of the Clean Water Act when technology based treatment is not sufficient to protect water quality.

Water Quality Limited Segment

Any segment of a watercourse where it is known that water quality does not meet applicable standards and/or is not expected to meet applicable water quality standards even after the application of technology based effluent limitations.

Water Quality Standards

Provisions of state and federal law which consist of designated use or uses for the state's waters and water quality criteria which will support those uses.

Zone of Influence

Spatial area or volume of receiving water flow within which some degradation of water quality or use impairment is anticipated to occur as a result of a pollutant discharge. May be used to describe an area impacted by thermal, conventional, or toxic pollutants.

Zone of Passage

Spatial area or volume of flow within which the concentration of toxic chemicals and/or temperature elevations are below levels which would impede or prohibit the passage of free swimming and drifting aquatic organisms.

7Q10

(Seven-day, Ten-year low flow) - lowest 7 consecutive day mean stream discharge with a recurrence interval of ten (10) years.

APPENDIX D

NUMERICAL CRITERIA FOR TOXIC POLLUTANTS

REVISED APRIL 1997

APPENDIX D
 NUMERICAL WATER QUALITY CRITERIA FOR CHEMICAL CONSTITUENTS ⁽¹⁾

Compound	Concentrations in ug/L				Consumption of:		
	Aquatic Life Criteria				Human Health Criteria		
	Freshwater		Saltwater		Organisms Only	Water and Organisms	Health Designation ⁽⁴⁾
	Acute ⁽²⁾	Chronic ⁽³⁾	Acute ⁽²⁾	Chronic ⁽³⁾			
Toxic Metals ⁽⁵⁾, Cyanides							
Antimony	---	---	---	---	4300	14	TT
Arsenic (Tri)	360	190	69	36	.14	.018	A
Beryllium	---	---	---	---	.13	.0077	TT
Cadmium	1.80	.62	42	9.3	170	16	TT
Chromium (hex)	15	10	1100	50	3,400	170	TT
Chromium (tri)	310	103	---	---	670,000	33,000	TT
Copper	14.3 ⁽⁶⁾	4.8 ⁽⁷⁾	2.4	2.4	---	1300	TT
Copper (site-specific) ⁽⁸⁾	25.7	18.1	---	---	---	1300	TT
Cyanide (HCN + CN ⁻)	22	5.20	1	1	220,000	700	TT
Lead	30	1.2	210	8.1	---	50	TT
Mercury	2.1	.012 (total)	1.8	.025 (total)	.15	.14	TT-11B
Nickel	788	88	74	8.2	4,600	610	TT
Selenium	20 (total)	5 (total)	290	71	6,800	100	TT
Silver	1.02	---	1.96	---	65,000	105	TT
Thallium	---	---	---	---	6.3	1.7	TT
Zinc	63.6	58.2	90	81	---	---	TT

Compound	<u>Aquatic Life Criteria</u>		<u>Human Health Criteria</u>				
	Freshwater	Saltwater	Consumption of:		Organisms Only	Water and Organisms	Health Designation
	Acute	Chronic	Acute	Chronic			
Volatiles							
Acrolein	---	---	---	---	780	320	TT
Acrylonitrile	---	---	---	---	.66	.059	C
Benzene	---	---	---	---	71	1.2	A
Bromoform	---	---	---	---	360	4.3	C
Carbon Tetrachloride	---	---	---	---	4.4	.25	C
Chlorobenzene	---	---	---	---	21,000	680	TT
Chlorodibromomethane	---	---	---	---	34	.41	C
Chloroethane	---	---	---	---	---	---	---
Chloroform	---	---	---	---	470	5.7	C
Dichlorobromomethane	---	---	---	---	22	.27	C
1,1 Dichloroethane	---	---	---	---	---	---	---
1-2-Dichloroethane	---	---	---	---	99	.38	C
1,1-Dichloroethylene	---	---	---	---	3.2	0.057	C
1,2,T-Dichloroethylene	---	---	---	---	---	700	TT
1,2-Dichloropropane	---	---	---	---	39	0.52	TT
1,3-Dichloropropylene	---	---	---	---	1,700	10	TT
Ethylbenzene	---	---	---	---	29,000	3,100	TT
Methyl Bromide	---	---	---	---	4,000	48	TT
Methyl Chloride	---	---	---	---	470	5.7	TT
Methylene Chloride	---	---	---	---	1,600	4.7	C
1,1,2,2-Tetrachloroethane	---	---	---	---	11	.17	C-HB
Tetrachloroethylene	---	---	---	---	8.85	.8	TT

Compound	Aquatic Life Criteria				Human Health Criteria		
	Freshwater		Saltwater		Consumption of:		
	Acute	Chronic	Acute	Chronic	Organisms Only	Water and Organisms	Health Designation
Volatiles (continued)							
Trichloroethylene	---	---	---	---	81	2.7	C
Vinyl Chloride	---	---	---	---	525	2	C
GC/MS: Acid Compounds							
2-Chlorophenol	---	---	---	---	2300	540	TT
2,4-Dichlorophenol	---	---	---	---	790	93	TT
2,4-Dimethylphenol	---	---	---	---	---	---	---
3-Methyl-4-chlorophenol	---	---	---	---	---	---	---
2-Methyl-4,6-Dinitrophenol (=4,6 Dinitro-o-cresol)	---	---	---	---	765	13.4	TT
2,4-Dinitrophenol	---	---	---	---	14,000	70	TT
2-Nitrophenol	---	---	---	---	---	---	---
Pentachlorophenol	9.07	5.73	13	7.9	8.2	.28	C-HB
Phenol	---	---	---	---	4,600,000	21,000	TT
2,4,6-Trichlorophenol	---	---	---	---	6.5	2.1	C-HB
Base Neutral Compounds							
Acenaphthene	---	---	---	---	2700	1200	TT-HB
Acenaphthylene	---	---	---	---	.031	.0028	C-HB
Anthracene	---	---	---	---	110,000	9,600	C-HB
Benzidine	---	---	---	---	.00054	.00012	A
Benzo(a)anthracene	---	---	---	---	.031	.0028	C-HB
Benzo(a)pyrene	---	---	---	---	.031	.0028	C-HB
Benzo(b)fluoranthene	---	---	---	---	.031	.0028	C-HB
Benzo(k)fluoranthene	---	---	---	---	.031	.0028	C-HB

Compound	Aquatic Life Criteria				Human Health Criteria		
	Freshwater		Saltwater		Consumption of:		
	Acute	Chronic	Acute	Chronic	Organisms Only	Water and Organisms	Health Designation
Base Neutral Compounds (continued)							
1,2-Diphenylhydrazine	---	---	---	---	.54	.04	C
Fluoranthene	---	---	---	---	370	300	TT-HB
Fluorene	---	---	---	---	14,000	1,300	C-HB
Hexachlorobenzene	---	---	---	---	.00077	.00075	C-HB
Hexachlorobutadiene	---	---	---	---	50	.44	C-HB
Hexachlorocyclopentadiene	---	---	---	---	17,000	240	TT-HB
Hexachloroethane	---	---	---	---	8.9	1.9	C-HB
Indeno(1,2,3-cd)pyrene	---	---	---	---	.031	.0028	C-HB
Isophorone	117,000	---	---	---	600	8.4	TT
Naphthalene	---	---	---	---	---	---	---
Nitrobenzene	---	---	---	---	1,900	17	TT
N-Nitrosodimethylamine	---	---	---	---	8.1	.00069	C
N-Nitrosodi-n-propylamine	---	---	---	---	1.4	0.005	C
N-Nitrosodiphenylamine	---	---	---	---	16	5	C
Phenanthrene	---	---	---	---	.031	.0028	C-HB
Pyrene	---	---	---	---	11,000	960	C-HB
1,2,4-Trichlorobenzene	---	---	---	---	---	---	---
Pesticides:							
Aldrin	1.50	---	.65	---	.00014	.00013	C-HB
Chlordane	1.20	.0043	.045	.004	.00059	.00057	C-HB
DDT	.55	.001	.065	.001	.00059	.00059	C-HB
DDD	---	---	---	---	.00084	.00083	C

Aquatic Life Criteria

Human Health Criteria

Freshwater

Saltwater

Consumption of:

Compound	Aquatic Life Criteria		Human Health Criteria			
	Freshwater	Saltwater	Organisms Only	Water and Organisms	Health Designation	
	Acute	Chronic	Acute	Chronic		
Pesticides (continued)						
Dieldrin	1.25	.0019	.355	.0019	.00014	.00014 C
Endosulfan(alpha)	.11	.056	.017	.0087	2.0	.93 TT
Endosulfan (beta)	.11	.056	.017	.0087	2.0	.93 TT
Endosulfan Sulfate	---	---	---	---	2.0	.93 TT
Endrin	.09	.0023	.0185	.0023	.81	.76 TT
Endrin Aldehyde	---	---	---	---	.81	.76 TT
Heptachlor	.26	.0038	.0265	.0036	.00021	.00021 C
Heptachlor epoxide	.26	.0038	.0265	.0036	.00011	.00010 C
Hexachlorocyclohexane (Alpha)	---	---	---	---	.013	.0039 C-HB
Hexachlorocyclohexane (Beta)	---	---	---	---	.046	.014 C-HB
Hexachlorocyclohexane (delta)	---	---	---	---	---	---
Hexachlorocyclohexane (Gamma) 'Lindane'	1.0	.08	.08	---	.063	.019 TT-HB
Polychlorinated Biphenyls	---	.014	---	.03	.00017	.00017 C-HB
2,3,7,8-TCDD	---	---	---	---	.000000014	.000000013 C-HB
Toxaphene	.73	.0002	.21	.0002	.00075	.00073 C-HB
Other Substances:						
Ammonia	See Table ⁽⁹⁾	See Table ⁽⁹⁾	See Table ⁽⁹⁾	See Table ⁽⁹⁾	---	---
Asbestos	---	---	---	---	---	7,000,000 fibers/liter A
Chlorine	19	11	13	7.5	---	---

TABLE NOTES:

1. The minimum data necessary to determine consistency with Connecticut Water Quality Standards shall be subject to the Commissioner's discretion and may not be limited to or include chemical analysis results for all of the constituents listed in Appendix D.
2. Biological integrity is impaired by an exposure of one hour or longer to a concentration which exceeds the acute criteria more frequently than once every three years on average.
3. Biological integrity is impaired when the four-day average concentration exceeds the chronic criteria more frequently than once every three years on average.
4. The Commissioner will consider the following human health designations in allocating zones of influence for point source discharges:
 - A: Class A carcinogen (known human carcinogen)
 - TT: Threshold Toxicant, not carcinogenic
 - C: Carcinogenic (probable or possible carcinogen)
 - HB: High potential to bioaccumulate or bioconcentrate.
5. Criteria apply to the dissolved fraction unless otherwise noted.
6. Biological integrity is impaired when the ambient concentration exceeds this value on more than 5% of days in any year.
7. Biological integrity is impaired when the ambient concentration exceeds this value on more than 50% of days in any year.
8. Site specific criteria for copper apply for the following waters:

Bantam River	Litchfield POTW to confluence with Shepaug River
Blackberry River	Norfolk POTW to confluence with Roaring Brook
	North Canaan POTW to confluence with Housatonic River
Factory Brook	Salisbury POTW to mouth
Five Mile River	New Canaan POTW to mouth
Hockanum River	Vernon POTW to confluence with Connecticut River
Mill Brook	Plainfield Village POTW to mouth
Naugatuck River	Torrington POTW to confluence with Housatonic River
Norwalk River	Ridgefield Brook to Branchville
Pequabuck River	Plymouth POTW to confluence with Farmington River
Quinnipiac River	Southington POTW to Broadway, North Haven
Still River	Winsted POTW to confluence with Farmington River
Still River	Limekiln Brook to confluence with Housatonic River
Williams Brook	Ledyard POTW to mouth
Willimantic River	Stafford Springs POTW to Trout Management Area (Willington)
	Eagleville Dam to confluence with Housatonic River

9. Criteria for ammonia may be adjusted to account for seasonal variation in temperature as indicated below. Criteria values are expressed in mg/L NH₃-N.

Acute Toxicity

	Temperature °C						
	0	5	10	15	20	25	30
Freshwater (general)	23.1	21.4	20.6	19.8	18.9	13.2	9.9
Freshwater (Salmon spawning)	23.1	21.4	20.6	19.8	18.9	13.2	9.9
Estuarine (20 mg/Kg salinity)	29.0	20.0	14.0	9.8	6.7	4.8	3.3
Marine (30 mg/Kg salinity)	31.0	21.0	15.0	10.0	7.3	5.0	3.5

Chronic Toxicity

	Temperature °C						
	0	5	10	15	20	25	30
Freshwater (general)	2.47	2.30	2.22	2.14	2.06	1.43	1.01
Freshwater (Salmon spawning)	2.47	2.30	2.22	2.14	1.45	1.01	0.72
Estuarine (20 mg/Kg salinity)	4.40	3.00	2.10	1.50	1.00	0.72	0.31
Marine (30 mg/Kg salinity)	4.70	3.10	2.20	1.60	1.10	0.75	0.53