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SITE ASSESSMENT PLAN FOR AVGAS PIPELINE SECTION E NAS WHITING FIELD FL
4/25/2002
NAS WHITING FIELD

Site Assessment Plan
for
AVGAS Pipeline – Section E

Naval Air Station Whiting Field
Milton, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO-0200

April 2002

Rev. 1
4/25/02

SITE ASSESSMENT PLAN
FOR
AVGAS PIPELINE – SECTION E

NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

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APRIL 2002

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ACRONYMS

ABB ES	ABB Environmental Services, Inc.
AST	Above Ground Storage Tank
AVGAS	Aviation Gasoline
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CLEAN	Comprehensive Long-term Environmental Action - Navy
CompQAP	Comprehensive Quality Assurance Plan
CTO	Contract Task Order
DAR	Daily Activities Record
DPT	Direct-Push Technology
DOT	Department of Transportation
DRO	Diesel Range Organics
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FID	Flame Ionization Detector
FL-PRO	Florida Petroleum Range Organics
FOL	Field Operations Leader
GC	Gas Chromatograph
ID	Inside diameter
IR	Installation Restoration
mg/kg	milligrams per kilograms
MIP	Membrane Interface Probe
NASWF	Naval Air Station Whiting Field
NSF	National Sanitation Foundation
NTU	Nepelometric Turbidity Unit
OVA	Organic Vapor Analyzer
PID	Photo Ionization Detector
ppm	parts per million
PVC	poly vinyl chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RPM	Remedial Project Manager
SAP	Site Assessment Plan
SAR	Site Assessment Report
SCTL	Soil Cleanup Target Levels
SOP	Standard Operating Procedure
SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
TOM	Task Order Manager
TRAWING FIVE	Training Air Wing Five
TRPH	Total Recoverable Petroleum Hydrocarbon
TTNUS	Tetra Tech NUS, Inc.
µg/kg	micrograms per kilograms
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UTM	Universal Transverse Mercator
VOA	Volatile Organic Aromatics
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Tetra Tech NUS (TTNUS) has prepared this Site Assessment Plan (SAP) for the Aviation Gasoline (AVGAS) Pipeline – Section E, located at the Naval Air Station Whiting Field (NASWF), Milton, Florida. This SAP was prepared for the U.S. Navy Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) under Contract Task Order (CTO) 0200, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888.

The SAP provides the rationale and methodology for performing field activities to evaluate petroleum hydrocarbons in the subsurface at the referenced site(s). Data collected during the site assessments will be used to prepare a Site Assessment Report (SAR) in accordance with Chapter 62-770 of the Florida Administrative Code (F.A.C.).

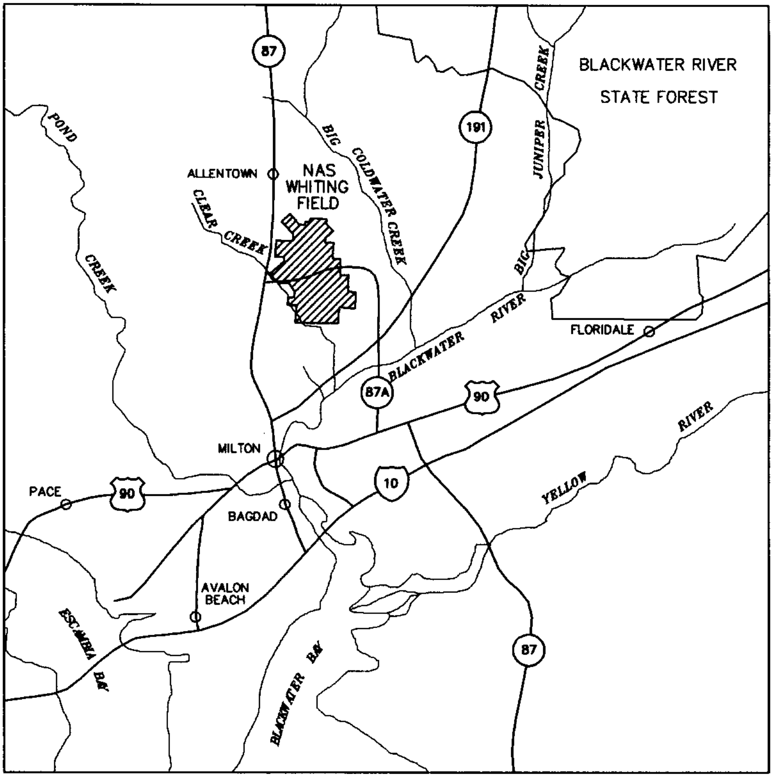
1.1 GENERAL SITE DESCRIPTION

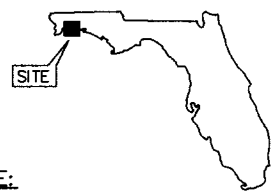
NASWF, home of Training Air Wing Five (TRAWING FIVE), was constructed in the early 1940s. It was commissioned as the Naval Auxiliary Air Station Whiting Field in July 1943 and has served as a naval aviation training facility since its commissioning. The mission of tenant commands at NASWF has been to train student naval aviators in fixed-wing and helicopter operations.

NASWF is located in Santa Rosa County, which is in Florida's northwest coastal area, approximately 7 miles north of Milton, Florida (Figure 1-1) and 20 miles northeast of Pensacola, Florida. The installation is approximately 3,842 acres in size and presently consists of two airfields (North Field and South Field) separated by an industrial area. The North Field is used for fixed-wing aircraft training while the South Field is used for helicopter training. Military quarters and industrial and administrative support facilities are situated between the two airfields. The AVGAS Pipeline – Section E is located in the industrial area between the two airfields (Figure 1-2).

1.2 OBJECTIVE

The objective of the proposed field investigation is to evaluate the extent of petroleum hydrocarbons in subsurface soils and groundwater. The data collected during the investigations will be used to prepare a SAR as required by Chapter 62-770, F.A.C., and to evaluate the need for future remedial action, long term monitoring, or for no further action.





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SCALE IN MILES

NOTE:

NAS = NAVAL AIR STATION

SOURCE: ABB ENVIRONMENTAL SERVICES INC. 1992

DRAWN BY DATE		FACILITY LOCATION MAP NAS WHITING FIELD AVGAS PIPELINE MILTON, FLORIDA	CONTRACT NO. 0409	
CHECKED BY DATE			APPROVED BY	DATE
COST/SCHED-AREA			APPROVED BY	DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1	REV. 0

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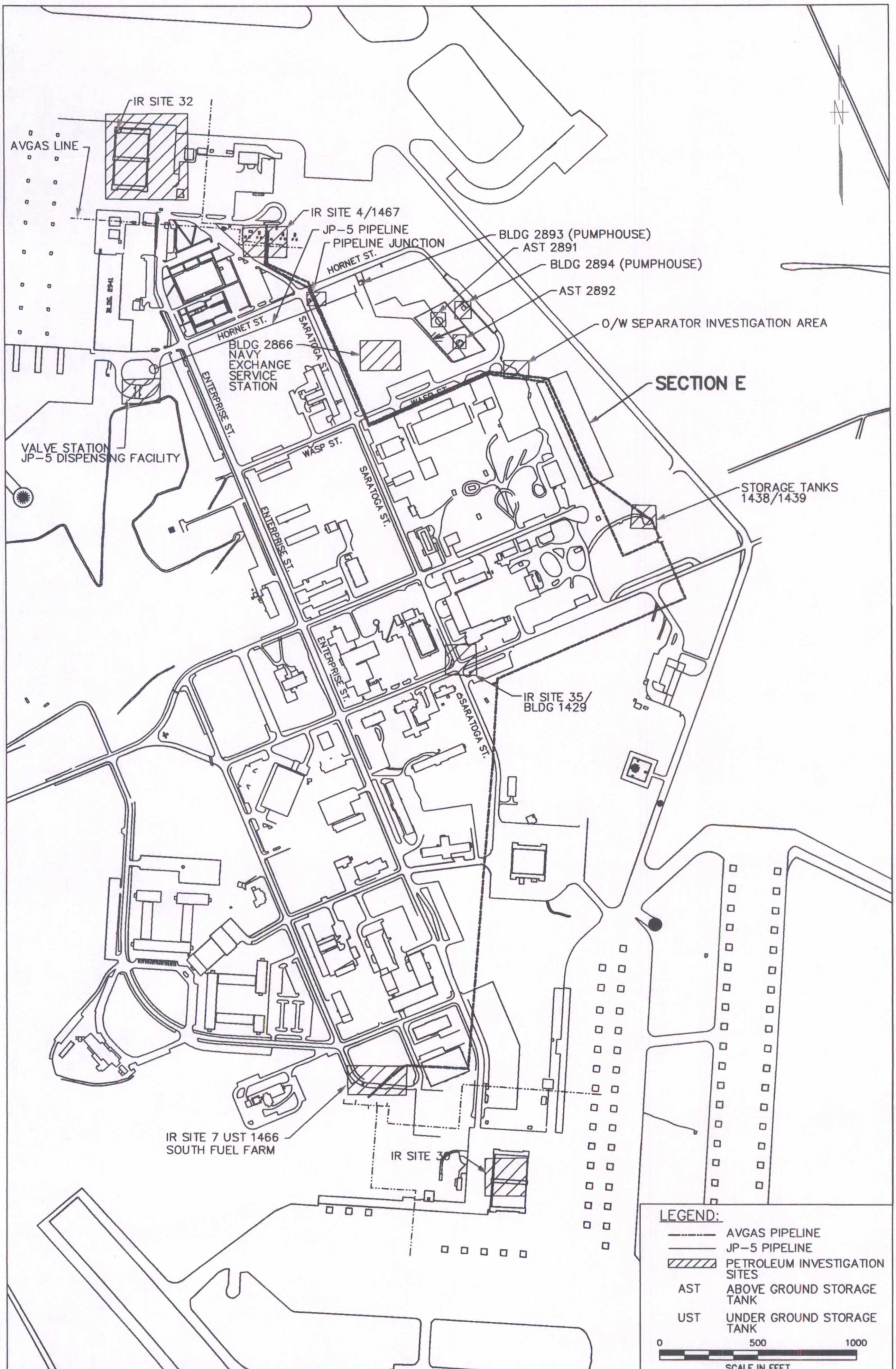


DRAWN BY DATE		SITE PLAN AND PETROLEUM INVESTIGATION SITES AVGAS PIPELINE NAS WHITING FIELD MILTON, FLORIDA	CONTRACT NO. 0409
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-2 REV. 0

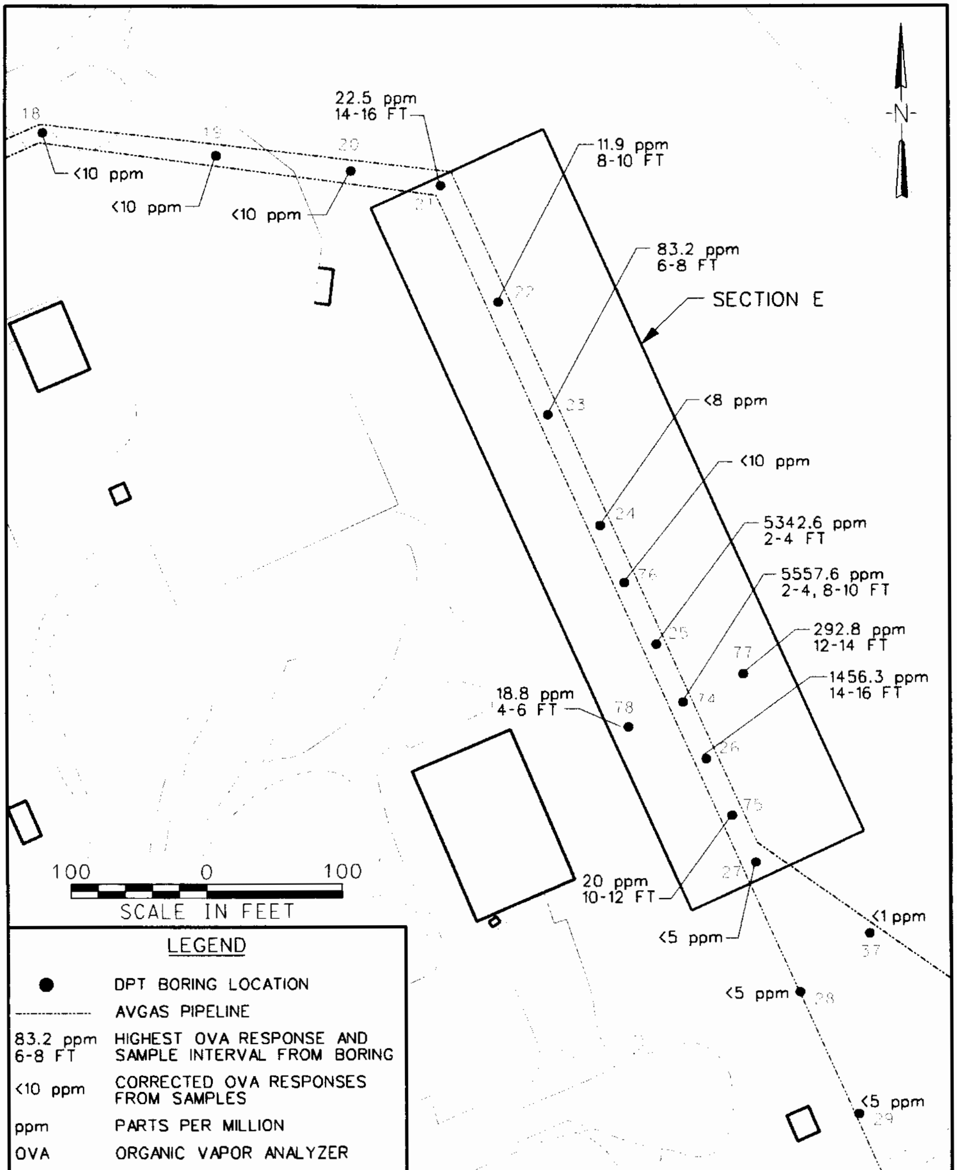
2.0 SITE DESCRIPTION

NASWF is located on the Western Highlands subdivision of the Coastal Plain Physiographic province, which is characterized by a well-drained southward sloping plateau. Elevations range from 150 to 190 feet above sea level. Streams bound NASWF to the west, south, and east. The water table at NASWF occurs at approximately 90 to 100 feet below ground surface (bgs) with localized perched zones occurring various depths above the water table.

Historical information and construction plans provided by NASWF personnel indicate that the AVGAS Pipeline was installed in approximately 1943 for the distribution of AVGAS and continued operation until the late 1970s. Figure 1-2 presents the installation layout and the location of the AVGAS Pipeline. The pipeline consists of one 6-inch diameter steel pipe which runs from the former South Field AVGAS Storage Tank Farm [Underground Storage Tanks (USTs) 1466A through 1466G] to the former pump house (Building 1470), located near the intersection of Langley Street and the aircraft tow road. From this point the pipeline divides and two 6-inch diameter steel pipes run from the former pump house (Building 1470) to the former North Field AVGAS Storage Tank Farm (USTs 1467A through 1467H). The overall length of the AVGAS pipeline is approximately 7,050 feet.

Currently, 13 sites in the vicinity of the AVGAS pipeline are being investigated for petroleum releases under the petroleum storage tank or installation restoration (IR) programs (Figure 1-2). These sites include UST, above ground storage tanks (AST), fuel distribution systems, a JP-5 pipeline, and other facilities.

This SAP addresses assessment activities at Section E of the AVGAS Pipeline (Figure 2-1). Section E of the AVGAS Pipeline is located in the industrial area approximately 150 feet southeast of the oil/water separator investigation area and approximately 300 feet northwest of Site 1438/1439, the former location of two, 218,000 gallon AVGAS storage tanks. The site is currently an open grassed area.



DRAWN BY / DATE		AVGAS PIPELINE SECTION E SITE MAP AND OVA RESPONSES	CONTRACT NO.
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COST/SCHED-AREA			APPROVED BY / DATE
SCALE 1"=100'			DRAWING NO. FIGURE 2-1 / REV. 0

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3.0 SITE HISTORY

During the demolition of the storage tanks at Site 1438/1439 in 1985, free product was reportedly observed in the excavation. In 1994, ABB Environmental Services (ABB ES) advanced 25 TerraProbe™ soil samples to assess the petroleum contamination to a depth of 35 feet. Results indicated that soil contamination extended from the surface to a depth of at least 35 feet. The status of the initial investigation has progressed to the remedial action plan (RAP) phase. Tanks 1438/1439 and the pipeline transmission lines were determined to be one stand-alone tank system.

A closure assessment was conducted on the AVGAS pipeline in October, 2000. The field investigation included locating the buried portions of the AVGAS pipeline using geophysical techniques, collection of soil samples for headspace screening analysis from borings located along the AVGAS pipeline, collection of confirmatory soil samples for fixed-base laboratory analysis, and groundwater sampling at locations where the depth to groundwater was less than 20 feet below grade. During the closure assessment an area of product saturated soil was detected just north of Site 1438/1439 at soil boring B74 Section E (Figure 2-1). A Closure Assessment Report was submitted to the Florida Department of Environmental Protection (FDEP) and the Escambia County Health Department in April, 2001. The Closure Assessment Report recommended that a site assessment be conducted at the location where the product saturated soil was detected. A response letter was subsequently issued by the FDEP concurring with the recommendation to perform a site assessment.

3.1 SOIL INVESTIGATION RESULTS

Section E includes soil borings B21 through B27, and B74 through B78 that were advanced to approximately 20 feet bgs. Corrected organic vapor analyzer (OVA) responses exceeding 10 parts per million (ppm) but below 50 ppm were detected in soil samples from borings B21, B22, B75, and B78 at Section E. OVA responses from soil samples from borings B23, B25, B26, B74, and B77 exceeded the 50 ppm threshold for excessively contaminated soil as defined by Chapter 62-770, F.A.C. The soil borings with the highest corrected OVA responses were B25 at two to four feet bgs (5342 ppm), B26 at 14 to 16 bgs (1456 ppm), and B74 which exceeded the 50 ppm threshold from the surface to 20 feet bgs. The highest corrected OVA responses at Section E, 5,557.6 ppm, was observed in the two to four feet and the eight to ten feet sample intervals at B74. The horizontal and vertical distribution of screening soil samples collected from Section E and the headspace screening results are shown on Figures 2-1 and 3-1, respectively.

Three confirmatory soil samples were collected from Section E for offsite laboratory analysis. These samples were collected at B21, B23, and B74 soil boring locations from the sample interval in each boring with the highest OVA screening response.

The confirmatory soil samples from soil borings B21 and B23 were collected from the 14 to 16 feet and 6 to 8 feet bgs intervals respectively. Analytical results from B21 and B23 indicated that concentrations of petroleum constituents in the soil samples were below the standard laboratory detection limits.

The confirmatory sample from soil boring B74 was collected from the 2 to 4 feet bgs interval. Analytical results from B74 indicated that concentrations of several petroleum constituents in the sample exceeded the soil cleanup target levels (SCTLs) for leachability based on groundwater specified in Chapter 62-770, F.A.C., but not the residential exposure SCTLs.

Benzene in soil at B74 was reported at a concentration of 264 micrograms per kilogram (μg/kg), which is greater than the leaching SCTL of 7 μg/kg but below the residential direct exposure SCTL of 1,100 μg/kg. Ethylbenzene was reported at a concentration of 5,480 μg/kg, which is greater than the leaching SCTL of 600 μg/kg but below the residential direct exposure SCTL of 1,100,000 μg/kg. Xylene was reported at a concentration of 7,090 μg/kg, which is greater than the leaching SCTL of 200 μg/kg but below the residential direct exposure SCTL of 5,900,000 μg/kg. Methyl Bromide was reported at a concentration of 324 μg/kg, which is greater than the leaching SCTL of 50 μg/kg but below the residential direct exposure SCTL of 2,200 μg/kg. Methyl Chloride was reported at an estimated concentration of 234 μg/kg, which is greater than the leaching SCTL of 10 μg/kg but below the residential direct exposure SCTL of 1,700 μg/kg.

Toluene was reported at a concentration of 264 μg/kg, which is below the leaching SCTL of 500 μg/kg and the residential direct exposure SCTL of 380,000 μg/kg. Total recoverable petroleum hydrocarbons (TRPH) was reported at a concentration of 27.3 milligrams per kilograms (mg/kg), which is below the leaching and residential direct exposure SCTLs of 340 mg/kg.

3.2 GROUNDWATER SAMPLING RESULTS

Observations of soil cores collected from soil borings B25, B26 and B74 indicated the presence of a zone of saturated soil starting at a depth of approximately 16 feet bgs. At the B74 location, a petroleum product sheen was reported on the DPT sampling tools when sampling at depths below 16 feet.

Product saturated soil was observed at boring B74. A groundwater sample was collected from the 16 to 20 feet interval at the B74 location. The sample consisted of groundwater and free petroleum product. Since free product was present in the groundwater sample, the sample was not submitted for analysis.

Two attempts were made to collect a groundwater sample at the B26 location. Initially, the groundwater sampler was deployed in the 16 to 20 feet interval for sampling. When this zone did not produce water, the groundwater sampler was pulled back to the 14 to 18 feet interval and sampling was again attempted. Groundwater could not be collected from this interval either. Since neither attempt to collect a groundwater sample at B26 was successful, a groundwater sample was not submitted for analysis. Groundwater sample collections was not attempted at B25.

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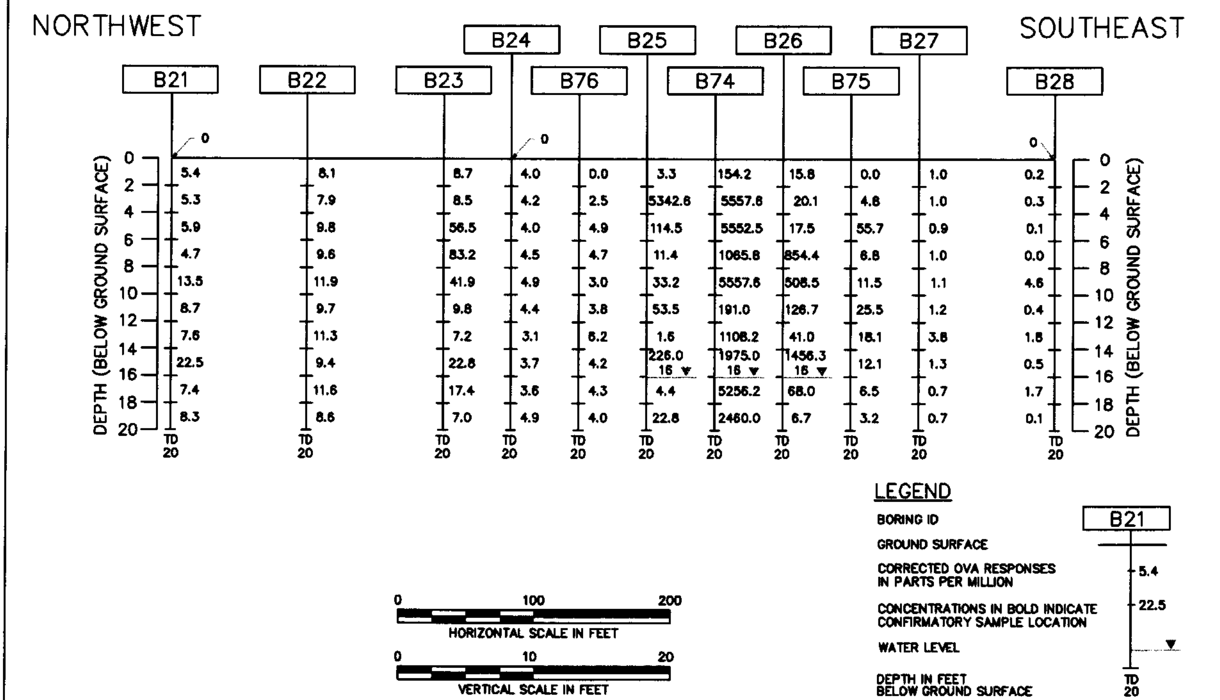


DRAWN BY DATE		OVA RESPONSE CROSS SECTION PIPELINE SECTION E AVGAS PIPELINE NAS WHITING FIELD MILTON, FLORIDA	CONTRACT NO. 0409
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-1 REV. 0

4.0 SCOPE OF PROPOSED ASSESSMENTS

The purpose of this site investigation is to assess an area north of Site 1438/1439 where product saturated soil was detected during a closure assessment conducted on the AVGAS pipeline associated with tanks 1438 and 1439. The product was detected at a depth of approximately 16 to 20 feet bgs. Groundwater in the vicinity of NASWF is typically encountered at a depth of approximately 90 to 100 feet bgs. However, localized intermittent perched water bearing lenses have been encountered at shallower depths. It is likely that the product saturated soil identified during the closure assessment was associated with one of these localized lenses. If the product is associated with one of these lenses it is possible that the contamination has not migrated to the water table aquifer. Therefore, the assessment must be conducted in such way as to ensure that the clay lens is not breached and the underlying water table aquifer inadvertently contaminated. Therefore, the assessment will be conducted in three phases as outlined below:

The first phase (Phase 1) will involve the use of a direct push technology (DPT) rig equipped with a membrane interface probe (MIP) to evaluate the extent of product saturated soil identified during the closure assessment and determine if it is associated with a localized perched lens. By delineating the extent of the product saturated soil and the top and lateral limits of the clay lens, steps can be taken to ensure that the lens is not breached during more comprehensive assessment activities. In addition, the data can aid in determining if a source removal is warranted to address the product saturated soil. Approximately 20 soil borings will be installed during Phase I to a depth of approximately 25 feet bgs using DPT/MIPs.

The second phase (Phase 2) will involve the use of a DPT rig to collect soil samples and a mobile lab to determine the horizontal and vertical extent of petroleum impacted soil. In addition, groundwater samples will be collected for mobile lab screening to determine if the groundwater has been impacted and aid in determining the optimum number and location of permanent monitoring wells. In conjunction with the DPT soil boring installation, OVA screening will be performed on the soil samples and a mobile laboratory will be utilized to screen soil and groundwater samples for benzene, toluene, ethyl-benzene, xylenes (BTEX); naphthalene and Diesel Range Organics (DRO). The soil and groundwater data will be used to determine the optimum location and number of permanent monitoring wells. The following activities will be conducted during Phase 2:

- Install approximately 20 (double-cased, where necessary) soil borings using DPT to determine if the soil below the clay lens has been impacted by petroleum products.

- Collect soil samples for OVA headspace analysis and on-site screening with a mobile laboratory. This data will aid in determining the optimum number and locations to collect soil samples for fixed-base laboratory analysis.

- If contamination is found below the clay lens, the soil borings will be advanced to the water table to determine the vertical extent of contamination.

- If soil borings are extended to the water table, groundwater samples will be collected for on-site screening with a mobile laboratory to aid in determining the optimum number and location of permanent monitoring wells.

The third phase (Phase 3) will involve the mobilization of a drill rig to install approximately six monitoring wells to delineate the horizontal extent of petroleum impacted groundwater. The placement of these wells will be based on soil and/or groundwater field screen results obtained during Phases 1 and 2 of the field investigation. It is estimated that the wells will be installed to a depth of approximately 100 feet bgs. One well located near the area were free product was encountered may be double case in order to prevent possible vertical migration of contaminants. A casing would be in the aquitard beneath the perched interval and the well advanced through the casing to total depth. During drilling for monitor well installation, approximately six confirmatory soil samples will be collected for fixed-base laboratory analysis. Soil sample depths will be determined based on analysis of the MIP and field screening investigations. Six soil samples two each representing high, medium, and low screening results will be collected. Concurrent with this phase of work, groundwater samples will be collected from the newly installed wells for laboratory analysis for constituents of the gasoline and kerosene analytical groups.

The relative top of casing elevation and horizontal location survey of all newly installed monitoring wells, and removal and disposal of investigative-derived waste generated during field investigations, will be performed as part of the Phase 3 field investigation. The horizontal locations of the monitoring wells will be surveyed in accordance with the Florida Plane Coordinate System, Universal Transverse Mercator (UTM), or base coordinator grid system, as deemed appropriate by the Navy's Remedial Project Manager (RPM). The monitoring well top of casing elevations will be surveyed in accordance with USGS NAD'83.

4.1 SOIL INVESTIGATION

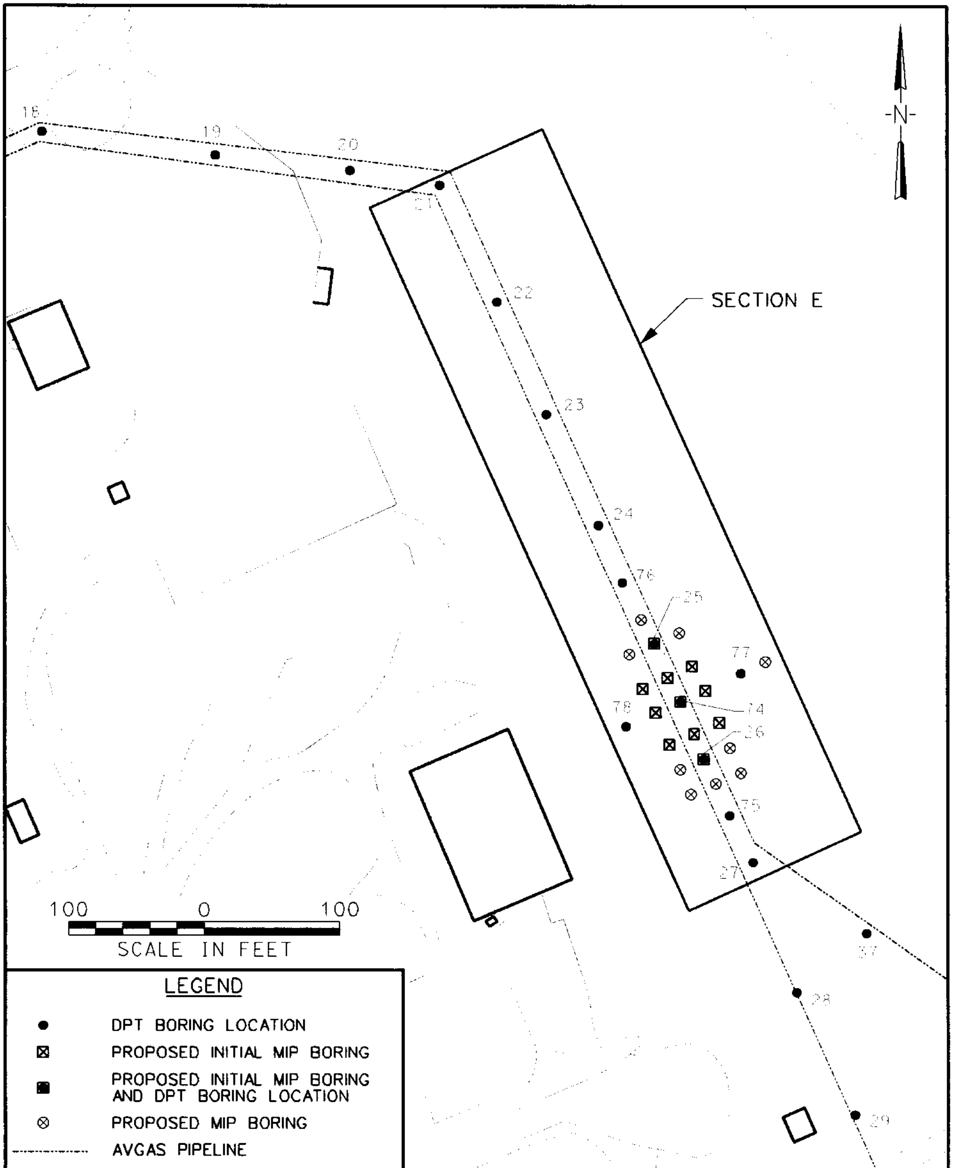
The MIP will be used in conjunction with DPT drilling in Phase 1 to collect real time continuous volatile organic compounds (VOC) data in the vadose and perched groundwater zones. The DPT adapted probe houses a membrane which heats the soil and water up to 250 degrees F, volatilizing the contaminants. The volatiles are then analyzed using a flame ionization detector (FID), a photo ionization detector (PID), and electron capture detector resulting in a continuous vertical profile for VOCs. In addition, the MIP records soil conductivity utilizing a dipole measurement arrangement at one (1) foot intervals. In general, lower soil conductivities will indicate sands while higher conductivities are indicative of silts and clays. Approximately 20 DPT/MIP borings will be drilled to a depth of approximately 25 feet to delineate the extent of the product saturated soil and the clay lens. The approximate boring locations are shown on Figure 4-1. Initial borings will be installed at and near B74 where the product saturated soil was encountered during the pipeline closure assessment investigation. Subsequent borings will be centered on a 20 x 20 foot grid. Additional MIP boring locations indicated on Figure 4-1 may be adjusted as results from the initial borings are evaluated. Prior to beginning each bore hole, the drilling crew will hand auger or post hole from the surface to four feet bgs to ensure that no underground utilities are present.

Approximately 20 DPT soil borings will be installed during the Phase 2 field investigation. The locations of the proposed borings will be determined after evaluating the results of Phase 1. Soil samples will be collected every five feet from the ground surface to the water table. Soil samples will be collected using either a two-foot or four-foot sampler with plastic liners. Vadose zone soil samples will be screened with an OVA following procedures for headspace analysis specified in Chapter 62-770 F.A.C. The soil borings will be advanced until the water table is encountered. It is anticipated that groundwater will be encountered within 90 to 100 feet of the ground surface. One soil sample from each DPT boring will be selected based on OVA headspace screening to be analyzed by the mobile lab. Any DPT borings penetrating areas with free product will have a temporary isolation casing set prior to advancing the boring through any potential aquitard layer.

If soil contamination is identified above the 50 ppm threshold for "excessively contaminated soil" (as defined by Chapter 62-770, F.A.C.) at any proposed Phase 2 boring location, additional soil borings will be positioned to assess the areal extent of soil contamination. It is assumed that 20 soil borings will provide sufficient areal coverage to delineate the soil contamination.

In accordance with Rule 62-770.600(3)(e), soil samples will be collected for fixed base laboratory analysis to confirm the OVA results. The soil sample intervals will be selected to coincide with samples that exhibit high, medium and low field screening results during the Phase 2 OVA survey. Six soil samples two each representing high, medium, and low field screening results will be collected. These samples will be collected during monitoring well installation activities. The samples will be analyzed for constituents of the Kerosene Analytical Group as defined in Chapter 62-770, F.A.C.

Each soil boring will be backfilled with Type 1 Portland Cement. All locations drilled through asphalt or concrete will be completed with similar material and finished flush to existing grade.



DRAWN BY DATE	AVGAS PIPELINE SECTION E PROPOSED MIP BORING LOCATIONS	CONTRACT NO.
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COST/SCHED-AREA		APPROVED BY DATE
SCALE 1"=100'		DRAWING NO. FIGURE 4-1 REV. 0

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A lithologic description will be made of each DPT sample tube and/or grab sample collected and a completed log of each boring will be maintained by the on-site geologist in accordance with Standard Operating Procedure (SOP) GH 1.5 included in Appendix A. At a minimum, the boring log will contain the following information:

- Sample Numbers and Types
- Sample Depths
- Sample Recovery/Sample Interval
- Soil Density or Cohesiveness
- Soil Color
- Unified Soil Classification System (USCS) Material Description

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA readings, drilling methods, and total depth of each borehole, as well as any other pertinent observations, will be included on each log. An example of the boring log form is attached in Appendix B.

The lithology and soil quality will be assessed from soil samples collected during the DPT investigation and from confirmatory soil samples collected during monitoring well installation. No split-spoon samples will be collected during installation of the monitoring wells for lithology as sufficient data should be available from the MIP/DPT investigation. Split spoon samples will only be used for the collection of targeted sample depth for confirmatory laboratory analysis (six samples). Grab samples from the auger flights will be collected and logged during installation of the shallow monitoring wells.

4.2 GROUNDWATER FIELD SCREENING

During the Phase 2 OVA soil screening (DPT investigation), a groundwater sample will be collected at each boring location from the water table for on-site analysis. The samples will be placed into appropriate sample bottles and immediately analyzed for BTEX constituents using a mobile lab equipped with a gas chromatograph (GC). The DPT method for conducting field screening of water samples is the preferred method for delineating groundwater impacts due to the number of groundwater samples that can be collected over a short period of time without installing temporary and/or permanent monitoring wells.

The results from the preliminary investigation will be tabulated and plotted. The summarized data will be sent to the Navy and the FDEP for review. After the data has been reviewed, a conference call will be scheduled to discuss the preliminary data and reach consensus on the optimum number and placement of permanent monitoring wells.

4.3 GROUNDWATER INVESTIGATION

It is anticipated that six monitoring wells installed to approximately 90 to 100 feet bgs will be required to assess the horizontal extent of dissolved hydrocarbons. The installation of the monitoring wells will be completed during the Phase 3 field investigation. The proposed monitoring well locations will be determined based on groundwater quality data and flow directions obtained during the Phase 2 investigation. The Navy and FDEP will be contacted to discuss the locations of the proposed monitoring wells prior to installation.

4.3.1 Monitoring Well Installation

All permanent monitoring wells will be installed in accordance with the *Monitoring Well Design, Installation, Construction and Development Guidelines* (March 27, 1997) provided by SOUTHNAVFACENGCOM. Permanent monitoring wells will be installed using hollow stem auger drilling techniques. These wells will be used to monitor water quality and evaluate the horizontal and vertical extent of contamination. Monitoring wells will be constructed of 2-inch inside diameter (ID) Schedule 40, flush-joint poly vinyl chloride (PVC) riser and flush-joint factory slotted well screen. Each section of casing and screen shall be National Sanitation Foundation (NSF) approved. Screen slot size shall be 0.01 inch. The shallow monitoring wells will be constructed with 10 feet of screen with the top of the screen interval positioned approximately 4 feet above the water table. After the borings are drilled to the desired depth, (6-inch minimum diameter boring for 2-inch ID wells), the well will be installed through the augers.

The lithology has been sufficiently characterized from previous investigations at NASWF such that a sieve analysis of the soils is not needed to determine the type of sand pack and screen slot size for well completion. Clean silica sand of U.S Standard Sieve Size No. 20/30 will be installed into the boring annulus around the well screen as the augers are withdrawn from the boring. The sand pack will be set from the bottom of the hole to approximately two feet above the top of the well screen. A minimum two-foot thick 30/65 fine sand seal will be installed above the sand pack. The remainder of the boring will be backfilled with a Type I Portland cement/bentonite grout. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel or fiberglass tape. The position of the top of the screen interval, sand pack, and fine sand seal may be adjusted as site conditions warrant (elevated water table, etc.)

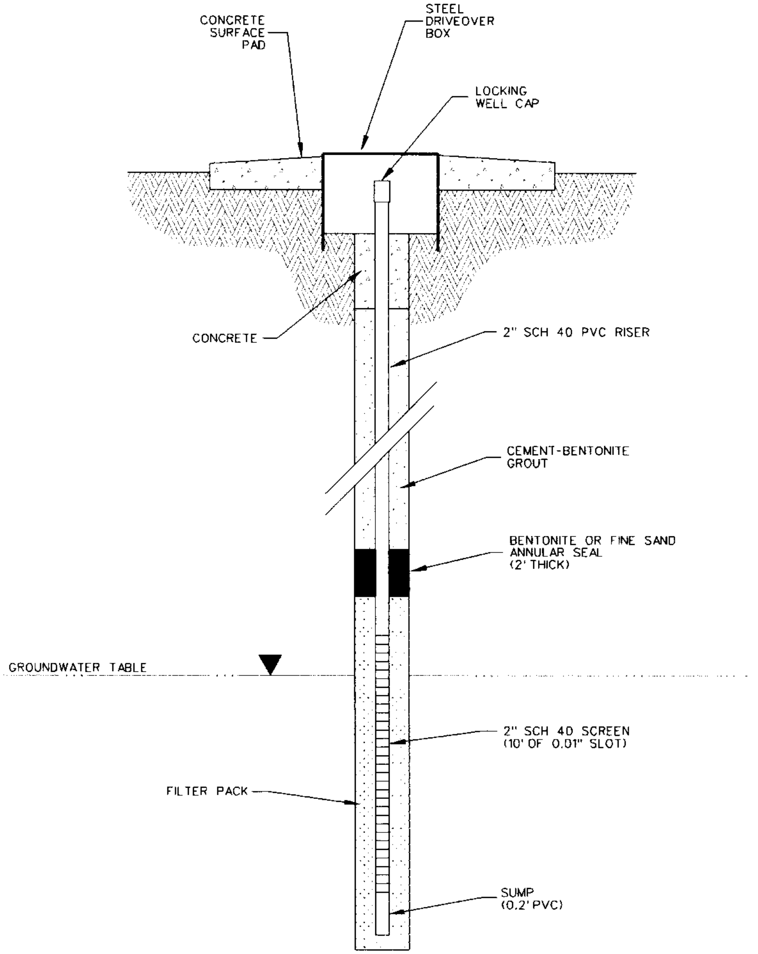
For any monitoring well installations that will potentially pass through contaminated zones or confining layers, an outer casing will be installed to prevent cross contamination of the aquifer below. The outer casing will be installed using hollow stem auger drilling techniques to advance the boring to the confining layer or contaminated zone. Upon completion of the boring the casing will be set to the desired depth and the annular space tremie grouted from total depth to the surface. After allowing the grout to cure for a minimum of 24 hours, the mud-rotary drilling method will be used to drill through the outer casing to install the monitoring well to the desired depth. Double-cased monitoring well construction details will be similar to other wells.

Flush mounted steel well covers and manholes will be installed around the 2-inch ID wells. The manhole will consist of a flush-mounted, 22-gauge steel, water resistant, welded box with 3/8-inch steel lid. A 2-foot by 2-foot by 6-inch thick concrete apron will be constructed around the manhole. The manhole shall be completed 2 inches above existing grade and the apron tapered to be flush with the existing grade at the edges such that water will run off of the apron. A detail of a typical flush-mounted monitoring well is shown on Figure 4-2. All locks supplied for the wells will be keyed alike. After installation, the ground surface, and the top of the PVC riser pipe will be surveyed to within 0.01-foot vertical accuracy using datum points as discussed previously in Section 4.0. A monitor well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix B.

The monitoring wells will be developed no sooner than 24 hours after installation to remove fine material from around the monitored interval of the well. Wells will be developed by bailing and surging, or by pumping, as determined by the field geologist. The pH, temperature, specific conductance and turbidity measurements will be collected from the purge water. Wells will be developed up to a maximum of one hour or until these measurements become stable and the purge water is visibly clear. Water quality stabilization will be determined using the following criteria: temperature +/- 1.0^{o}C (plus or minus one degree Celsius), pH +/- 0.1unit, and specific conductivity +/- 10 percent, and turbidity remains within a 10 Nepelometric Turbidity Unit (NTU) range for 2 consecutive readings. Wells will be developed until approved by the field geologist.

4.3.2 Groundwater Sampling

Groundwater samples will be obtained from monitoring wells in accordance with TTNUS Comprehensive Quality Assurance Plan (CompQAP) (FDEP Comp QA Plan No. 980038 Rev.2). Two groundwater sampling events will occur after monitoring well installation. The first sampling event will occur after the wells are developed and the second event approximately five months later. Prior to obtaining samples, water levels and total well depths will be measured and the wells will be purged using a submersible pump and a low-flow quiescent purging technique. Three to five well volumes will be purged. If wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 80 percent, then a sample will be collected. Field measurements of pH, temperature, specific conductance, and turbidity will be taken after each volume of water is purged.



NOT TO SCALE

DRAWN BY DATE	AVGAS PIPELINE SECTION E TYPICAL FLUSH MOUNT MONITORING WELL CONSTRUCTION	CONTRACT NO.
CHECKED BY DATE		APPROVED BY DATE
COST/SCHED-AREA		APPROVED BY DATE
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4-2 REV. 0

K:\dgn\navy\whiting\4038a\4038a003.dgn 3-13-02

Stabilization of the above parameters is defined in the previous paragraphs. If these parameters do not stabilize after three volumes, up to five volumes will be removed. Before purging, a clear bailer or an oil water interface probe will be used to check for free product. No samples will be collected from a well that exhibits measurable free product. The thickness of the free product will be measured and recorded.

Groundwater samples obtained for laboratory analysis will be collected with a submersible pump and Teflon tubing using a low-flow quiescent sampling technique. The samples will be transferred directly into the appropriate (pre-preserved) sample bottles for analysis. The sample constituents to be analyzed are summarized in Table 4-1.

TABLE 4-1

**FIELD INVESTIGATION
ENVIRONMENTAL SAMPLE SUMMARY
NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA**

Analyte	Proposed Method (1)	Env. Samples	IDW Samples (2)	Duplicate Samples	Rinsate Blanks (Aqueous)	Field Blank (Aqueous)	Trip Blanks (Aqueous)	Total Samples
GROUNDWATER								
VOH	EPA 8260	12		2	0	2	2	**18**
VOA Plus MTBE	EPA 8260	12		2	0	2	2	**18**
PAH	EPA 8310	12		2	0	2	0	**16**
Total Lead	EPA 6010B	12		2	0	2	0	**16**
TRPH		12		2	0	2	0	**16**
EDB	EPA 504.1	12		2	0	2	0	**16**
SOIL								
VOHs only (pre-burn)	EPA 8260 PPL	0	2	0	0	0	0	**2**
BTEX and MTBE	EPA 8260	6	2	1	1	0	0	**10**
PAH	EPA 8310	6	0	1	1	0	0	**8**
TRPH		6	2	1	1	0	0	**10**
Total Arsenic, Cadmium, Chromium, and Lead	6010B	0	2	0	0	0	0	**2**

VOH - Volatile Organic Halocarbons
VOA - Volatile Organic Aromatics
PAH - Polynuclear Aromatic Hydrocarbons
TRPH - Total Recoverable Petroleum Hydrocarbons
EDB - Ethylene Dibromide
(1) Method referenced reflects FDEP requirements.
(2) IDW samples are based on collecting one composite soil sample and one composite liquid sample per site.
All analyses are based on a standard 30-day laboratory turn around time.

4.3.3 Groundwater Level Measurements

Synoptic water level measurements will be taken from all monitoring wells at the sites. Static water level measurements will be measured from the north rim of the top of the PVC riser pipe using an electronic water level indicator. The newly installed wells shall be notched and marked so that the same point will be referenced for all measurements. The depth to water will be measured to the nearest 0.01 foot below the top of the PVC riser pipe. Three consecutive water level readings will be recorded from the well to the nearest 0.01-foot to assure an accurate water level is recorded. Water level measurements will be recorded to the nearest 0.01-foot in the appropriate field log book.

4.4 EQUIPMENT DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drill rigs, downhole tools, augers, well casing and screens, and soil and water sampling equipment.

4.4.1 Major Equipment

All downhole drilling equipment used in the construction and sampling of permanent monitoring wells, including downhole drill and sampling tools shall be steam cleaned prior to beginning work, between boreholes, any time the drill rig leaves the drill site prior to completing a boring, and at the conclusion of the drill program.

These decontamination operations will consist of washing equipment using Alconox and a high-pressure steam wash from a potable water supply. The equipment will be rinsed with potable water. All decontamination activities will take place at a predetermined location. Additional requirements for drilling equipment decontamination can be found in SOP SA-7.1 included in Appendix A.

4.4.2 Sampling Equipment

All equipment such as trowels, bailers, and split spoon samplers used for collecting samples will be decontaminated prior to beginning field sampling and between sample locations. The following decontamination steps will be taken:

- Potable water and Alconox or liquinox detergent wash.
- Potable water rinse.
- Rinse thoroughly with de-ionized, analyte-free water.
- Rinse with isopropanol
- Rinse thoroughly with de-ionized, analyte-free water

- Air dry.
- Wrap equipment in aluminum foil until used.

Field meters such as pH, conductivity and temperature instrument probes will be rinsed first with tap water, then with de-ionized, analyte-free water, and finally with the sample liquid.

4.5 WASTE HANDLING

Drill cuttings from monitoring well installations, well development water, and purge water will be collected and containerized in Department of Transportation (DOT) approved (Specification 17C) 55-gallon drums. Each drum will be sealed and labeled and left at a drum staging area pending groundwater analytical results and/or composite waste sample results for disposal. A waste staging area will be established at the site location to store investigation derived waste generated during the site assessment investigation. A lined decontamination pad will be constructed and used to collect the water from steam cleaning of drilling equipment. All decontamination materials generated during the site investigation will be containerized for proper disposal.

4.6 SAMPLE HANDLING

Sample handling includes the field-related activities such as the selection of sample containers, and preservatives, meeting allowable holding times, and specifying the required analysis. In addition, sample identification, packaging, and shipping are addressed. All sample handling procedures will be in accordance with TTNUS CompQAP (No. 980038 Rev.2) which has been approved by the FDEP. The CompQAP address the topics of containers and sample preservations. A summary of bottleware requirements, preservation requirements, and sample holding times are provided in Table 4-2. The required analysis were specified in Table 4-1.

4.7 SOIL BORING, MONITORING WELL, AND SAMPLE IDENTIFICATION

Each soil boring, monitoring well, soil sample, and groundwater sample will be assigned a unique identification number. The following text describes the nomenclature to be used in generating these numbers and explains the information each number contains.

4.7.1 <u>Base and Site Designations</u>

The base designation for Naval Air Station Whiting Field is WHF. The site designation for the AVGAS Pipeline Section E site will be AVGE.

TABLE 4-2

SUMMARY OF ANALYSIS, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA

Parameter	**Analytical Method**	**Sample Container**	**Volume**	**Preservation**	**Maximum Holding Time (1)**
Aqueous Samples					
VOHs	EPA Method 8260 PPL	Glass Volatile Vial	2 x 40 ml	Add HCl to pH < 2; Chill to 4 degrees Celsius	14 days
VOA Plus MTBE	EPA Method 8260	Glass Volatile Vial	2 x 40 ml	Add HCl to pH < 2; Chill to 4 degrees Celsius	14 days
1,2-Dibromomethane	EPA Method 504	Glass Volatile Vial	40 ml	Add HCl to pH < 2; Chill to 4 degrees Celsius	28 days
PAHs	EPA Method 8310	Amber Glass	1 L	Add .008% Na2S2O3;Chill to 4 degrees Celsius	7 days until extraction; 40 days to analysis
Lead (Total)	EPA Method 6010B	High Density Polyethylene	500 ml	Chill to 4 degrees Celsius	180 days
TRPH	FL-PRO	Glass	1L	Add H2SO4 to pH <2; Chill to 4 degrees Celsius	28 days

TABLE 4-2

**SUMMARY OF ANALYSIS, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA
PAGE 2 OF 2**

Parameter	Analytical Method	Sample Container	Volume	Preservation	Maximum Holding Time
Solid Samples					
VOHs Only (Pre-burn)	EPA Method 8260 PPL	Glass Volatile Vial	3 x 5g	5 ml of appropriate preservative; Chill to 4 degrees Celsius	14 days
BTEX and MTBE	EPA Method 8260	Glass Volatile Vial	3 x 5g	5 ml of appropriate preservative; Chill to 4 degrees Celsius	14
PAHs	EPA Method 8310	Clear Wide Mouth Glass	8 ounces	Chill to 4 degrees Celsius	14 days to extraction;40 days to analysis
TRPH	FL-PRO	Clear Wide Mouth Glass	4 ounces	Chill to 4 degrees Celsius	28 days
Total Arsenic, Cadmium, Chromium, and Lead	SW-846 Method 6010/7000 series	Clear Wide Mouth Glass	4 ounces	Chill to 4 degrees Celsius	28 days

VOHs - Volatile Organic Halocarbons
VOAs - Volatile Organic Aromatics
MTBE - Methyl-tert-butyl-ether
PAHS - Polynuclear Aromatic Hydrocarbons
TRPH - Total Recoverable Petroleum Hydrocarbons
RCRA - Resource Conservation and Recovery Act
H2SO4 - Sulfuric acid
HCl - Hydrochloric acid
(1) - Holding time is measured from date of sample collection to date of sample extraction or analysis.

4.7.2 Soil Boring Identification

Soil boring identification numbers will consist of a three part alpha-numeric code that identifies (1) the base identifier (WHF), (2) the site designation (AVGE), and (3) the discriminator “B” combined with a consecutive numerical value. Thus, the soil boring identification number for the third soil boring installed at the AVGAS Pipeline Section E would be WHF-AVGE-B03.

4.7.3 Monitoring Well Identification

Monitoring well identification numbers will be similar to soil boring identification numbers, except that they use an “M” as a discriminator. For deep wells the discriminator "D" will be added after the consecutive numerical value for the well. For example, The fifth monitoring well installed at the AVGAS Pipeline Section E would be designated WHF-AVGE-M05. If the sixth well installed at the AVGAS Pipeline Section E was a deep well it would be designated WHF-AVGE-M06D.

4.7.4 Soil and Groundwater Sample Identification

A sample tracking number will consist of a five- to six-segment, alphanumeric code that identifies the site number, sample medium, data type, location, the sampling event or sample depth (in case of soil samples) and the QC designation. The QC designation is only used if applicable. Any other pertinent information regarding sample identification will be recorded in the field logbook.

The alphanumeric coding to be used in the sample system and examples of possible sample identification numbers follow:

AAA	-	Site Number
A	-	Medium
A	-	Data Type
ANN	-	Location
NN	-	Sampling Event or Sample Depth
NNN(N)	-	QC Designation (if applicable)

Character Type:

A = Alpha
N = Numeric

Medium:

G = Groundwater	A = Air
W = Surface Water	E = Effluent

S = Soil	D = Sediment
E = Equipment Rinsate	F = Field Blank
T = Trip Blank	X = Other

Data Types:

L = Fixed Base Laboratory Analytical Data

F = Field Laboratory Data

S = Field Screening Data

QC Identifier:

D = Duplicate Sample

M = Matrix Spike Sample

S = Matrix Spike Duplicate

Example 1: The fixed base analytical soil sample collected from WHF-AVGE-B01 at 4 feet bgs would be called AVGESLB0104 and its duplicate would be AVGESLB0104D.

Example 2: The field laboratory groundwater sample collected from WHF-AVGE-B01 at 7 feet bgs would be called AVGEGFB0107.

Example 3: The fixed base analytical groundwater sample collected from WHF-AVGE-P01 during the first sampling event would be called AVGEGLP0101. The sample collected during the next event would be AVGEGLP0102.

Example 4: The fixed base analytical groundwater sample and matrix spike collected from WHF-AVGE-M01 during the first sampling event would be called AVGEGLM0101 and AVGEGLM0101M.

Example 5: The first fixed base analytical trip blank for the first sampling event at the AVGAS Pipeline Section E would be called AVGETL00101, the second trip blank during the same event would be AVGETL00201. The first trip blank collected for the second event would be AVGETL00102.

Information regarding sample labels to be attached before shipment to a laboratory is contained in SOP SA-6.3 included in Appendix A.

4.8 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with the TTNUS CompQAP. The Field Operations Leader (FOL) will be responsible for completion of the following forms when samples are collected for shipping.

- Sample labels
- Chain-of-Custody labels
- Appropriate labels applied to shipping coolers
- Chain-of Custody Forms
- Federal Express Air Bills

4.9 SAMPLE CUSTODY

The chain-of-custody begins with the release of the sample bottles from the laboratory and must be documented and maintained from that point forward. To maintain custody of the sample bottles or samples, they must be in someone's physical possession, in a locked room or vehicle, or sealed with an intact custody seal. When the possession of the bottles or samples is transferred from one person to another it will be documented on the field logbook and on the chain-of-custody. An example of a chain-of-custody record is provided in Appendix B.

4.10 QUALITY CONTROL (QC) SAMPLES

In addition to periodic calibration of field equipment and appropriate documentation, QC samples will be collected or generated during environmental sampling activities. QC samples include field blanks, field duplicates and trip blanks. Each type of field QC sample is defined as follows:

Rinsate Blank - Rinsate blanks are obtained under representative field conditions by running organic free water through sample collection equipment (bailer, split-spoon, etc.) after decontamination and placing it in the appropriate containers for analysis. Rinsate blanks will be used to assess the effectiveness of decontamination procedures. Rinsate blanks will be collected for each type of non-dedicated sampling equipment used. Rinsate blanks will be submitted to the laboratory for analysis as shown in Table 4-1 at the frequencies shown in Table 4-3.

TABLE 4-3

**QUALITY CONTROL SAMPLE FREQUENCY
NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA**

# of Samples	Precleaned Equipment BLK	Field cleaned Equipment BLK	Trip BLK (VOCs)	Duplicate
10+	minimum of one then 5%	Minimum of one then 5%	One per cooler	Minimum one then 10%
5-9	one*	one*	NR	one
< 5	one*	one*	NR	NR

NR = Not required
BLK = Blank

* Note: For nine or fewer samples, a precleaned equipment blank or a field cleaned equipment blank is required. A field cleaned equipment blank must be collected if equipment is cleaned in the field.

Field Duplicate - Field duplicate(s) are two water samples collected independently at a sample location during a single act of sampling under representative field conditions. Field duplicates sample frequencies are provided in Table 4-3**.** The duplicates shall be analyzed for the same parameters in the laboratory as indicated in Table 4-1.

Trip Blanks - Trip blank(s) will be prepared at the laboratory facility and will accompany the Volatile Organic Aromatics (VOA) vials to the sampling site and back to the laboratory. Trip blanks are not required by the FDEP unless 10 or more volatile samples are collected during a given sampling event. Trip blank sample frequencies are provided in Table 4-3.

4.11 FIELD MEASUREMENTS

Certain field measurements will be recorded during sampling activities including groundwater temperature, pH, specific conductance, and turbidity. Instruments used in the field to record this data and additional instruments will be calibrated according to the procedures described below.

4.11.1 Parameters

- Air monitoring - OVA
- Temperature – field meter
- Specific conductance - specific conductance meter
- pH - pH meter
- Turbidity - turbidity meter
- Depth to water table - electronic water level indicator and/or interface probe

4.11.2 Equipment Calibration

The electronic water-level indicator and/or interface probe will be calibrated prior to mobilization and periodically at the discretion of the FOL. The remaining instruments will be calibrated daily and/or according to the manufacturer's operation manual.

Calibration will be documented on an Equipment Calibration Log as shown in Appendix B. During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until defective parts are repaired or replaced.

4.11.3 Equipment Maintenance

Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance shall be controlled by established procedures. Measuring equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards.

TTNUS and its suppliers maintains a large inventory of sampling and measurement equipment. In the event that failed equipment cannot be repaired replacement equipment can be shipped to the site by overnight express carrier to minimize downtime.

4.12 FIELD Quality Assurance/Quality Control (QA/QC) PROGRAM

4.12.1 Control Parameters

Field control parameters, which address various field blanks and duplicate samples, are described in Section 4.10, QC Samples. Control checks and their frequency are also presented in Section 4.10.

4.12.2 Control Limits

QA/QC specifications for field measurements are summarized on Table 4-4. This table shows control parameters to be assessed, control limits, and corrective actions to be implemented.

TABLE 4-4

**FIELD QA/QC SPECIFICATIONS
NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA**

Analysis	Control Parameter	Control Limit	Corrective Action
Air monitoring using an photo ionization Detector (PID)	Daily check of calibration of PID	Calibration to manufacturer's specifications	Recalibrate. If unable to calibrate, replace.
PH of water	Continuing calibration check of pH 7.0 buffer	pH = 7.0 ± 0.1	Recalibrate. If unable to calibrate, replace electrode.
Specific conductance of water	Continuing calibration check of standard solution	± 1% of standard	Recalibrate. If unable to calibrate, replace electrode.
Temperature of water	Check against NIST precision thermometer	± 0.1°C at two different temperatures	Reset thermistors in accordance with manufacturer's specifications; dispose of inaccurate thermometer.

NIST – National Institute of Standards and Technology

The TTNUS FOL or designee on site will confirm measurements of total depth of borings and wells, dimensions and placement of well screens and casings, and the volume and placement of filter pack and grout materials by independent measurement. The FOL will examine field laboratory records and field log books on a weekly basis during field activities.

4.12.3 Corrective Actions

The need for corrective actions may become apparent during surveillance of field activities, procurement of services and supplies, or other operations that may affect the quality of work. The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective actions shall be documented and reported to the appropriate levels of management. The TTNUS Task Order Manager (TOM) will have overall responsibility for implementing corrective actions, and must initiate corrective action to remedy any effects of the problem.

The corrective action program includes an analysis of the cause of any negative findings and implementing the corrective actions required. This program includes the investigation of significant or repetitious unsatisfactory conditions relating to the quality of sampling, or the failure to implement and adhere to required quality assurance practices such as SOPs.

4.13 RECORD KEEPING

In addition to chain-of-custody records associated with sample handling and packaging and shipping, certain standard forms will be completed for sample description and documentation. These shall include sample log sheets (for soil and groundwater samples), daily activities record, and logbooks. An example of these forms can be found in Appendix B.

A bound/weatherproof field notebook shall be maintained by each sampling event leader. The field team leader, or designee, shall record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, descriptions of photographs, etc.

A site logbook shall be maintained by the FOL. The requirements of the logbook are referenced in SOP SA-6.3 provided in Appendix A. This book will contain a summary of the day's activities and will reference the field notebooks when applicable.

Each field team leader who is supervising a drilling subcontractor activity must complete a Daily Activities Record (DAR). The DAR documents the activities and progress of the daily drilling activities. The information contained within this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and material used. An example of this form is provided in Appendix B.

At the completion of field activities, the FOL shall submit to the TOM all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc.

4.14 SITE MANAGEMENT AND BASE SUPPORT

TTNUS will perform this project with support from the Navy. This section of the Work Plan describes the project contacts, support personnel, project milestones, and time frames of all major events.

Throughout the duration of the investigation activities, work at NASWF will be coordinated through SOUTHNAVFACENGCOM and NASWF personnel. The primary contacts are as follows:

1. SOUTHNAVFACENGCOM Engineer in Charge
   Ms. Beverly Washington
   (843) 820-5581

2. NASWF Public Works Department
Mr. Jim Holland
(850) 623-7181 ext. 49

4.14.1 Support From NAS Whiting Field

The following support functions will be provided by NASWF personnel

- Assist TTNUS in locating underground utilities prior to the commencement of drilling operations.
- Provide existing engineering plans, drawings, diagrams, files, etc., to facilitate evaluation of the sites under investigation.
- Provide all historical data, background geological and hydrogeological information, and initial site investigation documents.

4.14.2 Assistance From NAS Whiting Field

NASWF personnel will aid in arranging the following:

- Personnel identification badges, vehicle passes, and/or entry permits.
- A secure staging area (approximately 1,000 square feet) for storing equipment and supplies.
- A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water for equipment cleaning etc.
- As required, provide escorts for contract personnel working in secured areas (all contract personnel working at the NASWF will be U.S. citizens).
- Establish a decontamination area and waste staging area located adjacent or near the study area.

4.14.3 Support From TTNUS

The project will be staffed with personnel from the TTNUS Tallahassee, Florida offices. During field activities, TTNUS will provide a senior level geologist and/or staff geologist, and equipment technician.

Mr. Paul Calligan, P.G., is the TOM for CTO 0200 and will be the primary point of contact. He is responsible for cost and schedule control as well as technical performance. Mr. Calligan is a Florida

Licensed Professional Geologist and will serve as the TOM and will provide senior level review and oversight during field activities. Mr. Calligan will be the primary point of contact for the FOL.

4.14.4 Contingency Plan

In the event of problems, which may be encountered during site activities, the point of contact will be notified immediately, followed by the TOM and the NASWF point of contact. The TOM will determine a course of action so as to not interfere with the schedule or budget. All contingency plans will be approved through the SouthDiv point of contact before being enacted.

5.0 PROPOSED LABORATORY ANALYSIS

Soil samples for laboratory analysis will be collected during well installation activities conducted during the Phase 3 field investigation. Groundwater samples for laboratory analysis will be collected from newly installed monitoring wells (Phase 3 field investigation). The groundwater and soil samples will be analyzed in accordance with Chapter 62-770, F.A.C. (see Sections 5.1 and Section 5.2 below for specific sampling requirements regarding soil and groundwater).

5.1 SOIL INVESTIGATION

In accordance with Rule 62-770.600(3)(e), soil samples will be collected from borings for fixed-base laboratory analysis to confirm the OVA results. The boring locations and sample intervals will be selected to coincide with samples that exhibit high, medium and low field screening results during the soil vapor survey. The samples will be analyzed for constituents of the Gasoline and Kerosene Analytical Group, and metals as defined in Rule 62-770.600, F.A.C. The parameters and laboratory methods to be used are summarized in Table 4-1.

5.2 GROUNDWATER INVESTIGATION

Groundwater samples will be collected from each newly installed permanent monitoring well and analyzed for parameters of the Gasoline and Kerosene Analytical Group in accordance with Rule 62-770.600, F.A.C. The parameters and laboratory methods to be used are summarized in Table 4-1.

6.0 PROPOSED SCHEDULE

Phase 1 of the fieldwork is proposed to begin in late April, 2002 and take approximately 5 days to complete. Phase 2 work is anticipated to begin in early June, 2002 and will take approximately 25 days. Phase 3 of the field work will begin following FDEP and Navy review and approval of the Phase 1 and 2 data and proposed permanent monitoring well locations. Upon completion of Phase 3 field activities, a SAR will be prepared for each site and submitted to the Navy for review within 60 days.

7.0 REPORT

Upon completion of all field work and laboratory analysis, a SAR summarizing the results of the investigation will be submitted to the FDEP. The report will include graphical presentations of the screening results and complete summaries of the soil and groundwater analytical results. The locations of the soil samples and monitoring wells will be presented on scaled figures. Boring logs, chain-of-custody forms, field forms, field screening results, and analytical reports will be included in appendices of the report. The report will include a recommendation for no further action, natural attenuation monitoring, or for an active remediation determination if remediation is required in accordance with Chapter 62.770 F.A.C.

REFERENCES

Chapter 62-770 of the Florida Administrative Code. September 23, 1997.

Tetra Tech NUS, Inc., (TTNUS), 1998 Revision 2. Comprehensive Quality Assurance Plan, FDEP COMP QA PLAN#980038.

TTNUS, Inc., 2001. Pipeline Closure Assessment Report for AVGAS Pipeline.

Kasenow, M. and P. Pare, 1995. Using Specific Capacity to Estimate Transmissivity: Field and Computer Methods, Water Resource Publications, pp. 3-11.

APPENDIX A

TETRA TECH NUS, INC.
STANDARD OPERATING PROCEDURES

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number GH-1.5	Page 1 of 20
		Effective Date 06/99	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

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FIGURES

NUMBERS **PAGE**

1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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

5.0 PROCEDURES

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

5.1 Materials Needed

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

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

5.2 Classification of Soils

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

FIGURE 1

BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: ____________________ BORING NUMBER: ____________________
PROJECT NUMBER: ____________________ DATE: ____________________
DRILLING COMPANY: ____________________ GEOLOGIST: ____________________
DRILLING RIG: ____________________ DRILLER: ____________________

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

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: ____________________

Drilling Area Background (ppm): ____

Converted to Well: Yes ______ No ______ Well I.D. #: ____________________

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

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

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.

FINE-GRAINED SOILS
More Than Half of Material is SMALLER Than

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None
	Medium to High	None to Very Slow	Medium
	Slight to Medium	Slow	Slight
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium
	High to Very High	None	High
	Medium to High	None to Very Slow	Slight to Medium
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.		

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	
Very Soft	Less than 0.25	0 to 2	Easily penetra
Soft	0.25 to 0.50	2 to 4	Easily penetra
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetr
Stiff	1.0 to 2.0	8 to 15	Readily indent
Very Stiff	2.0 to 4.0	15 to 30	Readily indent
Hard	More than 4.0	Over 30	Indented with

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

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

ROCK BROKENNESS

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

LEGEND:

SOIL SAMPLES - TYPES
S-2" Split-Barrel Sample
ST-3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES
X-NX (Conventional) Core (~2-1/8" O.D.)
Q-NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

12/18
12/18

WATER LEVELS
12.6' Initial Level w/Date & Depth
12.6' Stabilized Level w/Date & Depth

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).
This method of classification identifies soil types on the basis of grain size and cohesiveness.

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

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

5.2.2 Color

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

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

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

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

5.2.3 Relative Density and Consistency

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

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

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

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

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

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Examples:

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

5.2.5 Moisture

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

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

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

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

5.2.8 Summary of Soil Classification

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

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

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

5.3 Classification of Rocks

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

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

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

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

5.3.1 Rock Type

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

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

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

5.3.2 Color

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

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

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

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

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

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

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

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

5.3.5 Fracturing

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

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

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

Method of Calculating RQD
(After Deere, 1964)

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

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

l = Total length of the coring run.

5.3.6 Weathering

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

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

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

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone – few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

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

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

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

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

5.4 Abbreviations

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

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

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB- SITE BORING NUMBER: SB/MW 1
PROJECT NUMBER: 9594 DATE: 3/8/96
DRILLING COMPANY: SOILTEST CO. GEOLOGIST: SJ CONTI
DRILLING RIG: CME-55 DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ORG.	5	0	0	0
@ 0800	2.0	9/10				TO BLK	ROCK FR.: TR BRICKS		ODOR				
							(FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 @		5/7	2.9/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-
0810	6.0	9/8					GRAVEL		NAT. MATL. TOOK SAMPLE				
	•			7'± ▽					SB01-0406 FOR ANALYSIS				
	8.0			8.0									
S-3 @		6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0
0820	10.0	17/16					TR. F. GRAVEL		HIT WATER = 7'±				
	12.0			12.0									
S-4 @		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
0830	14.0	5/8											
	15.0			15.0					AUGER REF @ 15'				
				[illegible]	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
				16					LO ∠ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STNNS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±				
							SILTSTONE		SET TEMP 6" CAS TO 15.5				
4.9/5.0	②		5.0/5.0						SET 2" Ø PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 RIG, 4¼" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min. RUN ② = 15 min

Converted to Well: Yes ✓ No ____ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.

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

  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent

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

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

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

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

  - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

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

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak, or strong.

- Additional comments:

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

  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.

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

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

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

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

5.5.2 Rock Classification

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

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

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

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

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

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

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

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

- Remarks at the bottom of Boring Log shall include:

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

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

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

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

5.5.3 Classification of Soil and Rock from Drill Cuttings

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

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

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

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

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

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

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

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

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

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

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

7.0 RECORDS

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

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		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject FIELD DOCUMENTATION		Approved D. Senovich	

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

ATTACHMENTS (EXAMPLES) **PAGE**

1.0 PURPOSE

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

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

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

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

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

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

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

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

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

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

5.1.2 Photographs

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

5.2 <u>Field Notebooks</u>

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

5.3 <u>Sample Forms</u>

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

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

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

5.3.1.2 Sample Label

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

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager, while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

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

5.3.1.5 Field Analytical Log Sheets for Geochemical Parameters

Field Analytical Log Sheets (Attachment B-8) are used to record geochemical and/or natural attenuation field test results. Attachments B-8 (3-page form) should be used when applicable.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

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

5.3.2.2 Data Sheet for Pumping Test

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

5.3.2.3 Packer Test Report Form

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

5.3.2.4 Summary Log of Boring

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

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions.

5.3.2.6 Test Pit Log

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

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance (Attachment C-11) should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record (Attachment C-12) should be used as the project directs to document all well development activities.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

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

5.4 Field Reports

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

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

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

5.4.1.2 Responsibilities

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

5.4.1.3 Submittal and Approval

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

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required. Attachment F is an example of a Field Trip Summary Report form.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment B-8	FIELD ANALYTICAL LOG SHEET
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-9	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-10	EXAMPLE TEST PIT LOG
Attachment C-11	MONITORING WELL MATERIALS CERTIFICATE OF CONFORMANCE
Attachment C-12	MONITORING WELL DEVELOPMENT RECORD
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ____________________ DATE: ____________________

SITE LEADER: ____________________

PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
________	________	________
________	________	________
________	________	________

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

ACTIVITIES:

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

____

Field Operations Leader

ATTACHMENT B-1

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________________
Project No.: ____________________

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: ____________________
[] QA Sample Type: ____________________

Sample ID No.: ____________________
Sample Location: ____________________
Sampled By: ____________________
C.O.C. No.: ____________________
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS/NOTES:

Circle if Applicable:

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

ATTACHMENT B-2

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________________
Project No.: ____________________

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: ____________________
[] QA Sample Type: ____________________

Sample ID No.: ____________________
Sample Location: ____________________
Sampled By: ____________________
C.O.C. No.: ____________________

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date:								
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-3

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name:	______________	Sample ID No.:	______________
Project No.:	______________	Sample Location:	______________
		Sampled By:	______________
[] Surface Soil		C.O.C. No.:	______________
[] Subsurface Soil			
[] Sediment		Type of Sample:	
[] Other:	______________	[] Low Concentration	
[] QA Sample Type:	______________	[] High Concentration	

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:				
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:	MAP:

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

ATTACHMENT B-4

Tetra Tech NUS, Inc.

CONTAINER SAMPLE & INSPECTION SHEET

Page____ of ____

Project Site Name: ____________
Project Number: ____________
Site Identification: ____________
Container Number(s): ____________
Sample Type: 0 Grab
0 Composite

Sample ID No. ____________
Sampled By: ____________
C.O.C. No. ____________
Concentration: 0 High
0 Medium
0 Low

CONTAINER SOURCE

DRUM:
0 Bung Top
0 Lever Lock
0 Bolted Ring
0 Other ____________

TANK:
0 Plastic
0 Metal
0 Other ____________

OTHER: ____________

CONTAINER DESCRIPTION

COLOR: ____________

CONDITION: ____________

MARKINGS: ____________

VOL. OF CONTENTS: ____________

OTHER: ____________

CONTAINER DISPOSITION

SAMPLED: ____________

OPENED BUT NOT SAMPLED:
Reason ____________
____

NOT OPENED:
Reason ____________
____

CONTENTS DESCRIPTION

SINGLE PHASED: ____________
____

MULTIPHASE :

	Layer 1	Layer 2	Layer 3
Phase (Sol. or Liq.)	______	______	______
Color	______	______	______
Viscosity	L, M or H	L, M or H	L, M orH
% of Total Volume	______	______	______

MONITOR READINGS

SAMPLING/INSPECTION TIME

____________HRS.
METHOD:____________

SAMPLER(S)/ INSPECTOR(S) SIGNATURE

ANALYSIS

ATTACHMENT B-5

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:	
Sample No:		Matrix:
Date:	Time:	Preserve:
Analysis:		
Sampled by:	Laboratory:	

ATTACHMENT B-6

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE ___ OF ___

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER AND PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER	CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR ___	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS									COMMENTS

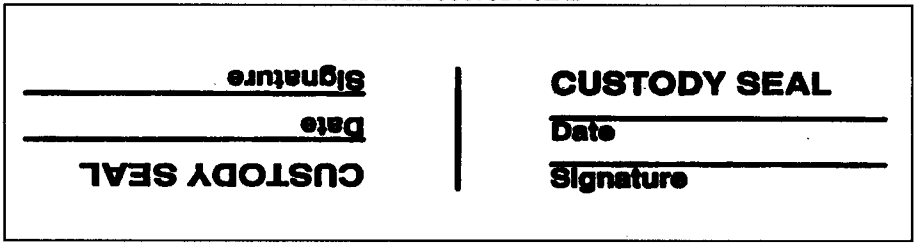
1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME
COMMENTS					

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

3/99
FORM NO. TtNUS-001

ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL



ATTACHMENT B-8

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ______ Sample ID No.: ______
Project No.: ______ Sample Location: ______
Sampled By: ______ Duplicate: ☐
Field Analyst: ______ Blank: ☐
Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv): ______ Electrode Make & Model: ______
Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:
Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: ______ mg/L) Analysis Time: ______

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier	Concentration
______	x 0.01	= mg/L
______	x 0.02	= mg/L

CHEMetrics: ______ mg/L
Notes:

Alkalinity:
Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range: ______ mg/L) Analysis Time: ______ Filtered: ☐

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	______ & ______	x 0.1	= mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	______ & ______	x 0.4	= mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	______ & ______	x 1.0	= mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	______ & ______	x 2.0	= mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	______ & ______	x 5.0	= mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	______ & ______	x 10.0	= mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: ______ mg/L
Notes:
Standard Additions: ☐ Titrant Molarity: ______ Digits Required: 1st.: ______ 2nd.: ______ 3rd.: ______

Carbon Dioxide:
Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: ______ mg/L) Analysis Time: ______

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count		Concentration
______	x 0.1	= mg/L
______	x 0.2	= mg/L
______	x 1.0	= mg/L
______	x 2.0	= mg/L

CHEMetrics: ______ mg/L
Notes:
Standard Additions: ☐ Titrant Molarity: ______ Digits Required: 1st.: ______ 2nd.: ______ 3rd.: ______

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ____________ Sample ID No.: ____________

Project No.: ____________ Sample Location: ____________

Sampled By: ____________ Duplicate: ☐

Field Analyst: ____________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Sulfide (S^{2-}):

Equipment: DR-700 DR-8 __ HS-WR Color Wheel Other: ________ Analysis Time: ________

Program/Module: 610nm 93

Concentration: ________ mg/L Filtered: ☐

Notes: ____________

Sulfate (SO_4^{2-}):

Equipment: DR-700 DR-8 __ Other: ________ Analysis Time: ________

Program/Module: 91

Concentration: ________ mg/L Filtered: ☐

Standard Solution: ☐ Results: ________

Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Notes: ____________

Nitrite (NO_2^--N):

Analysis Time: ________

Equipment: DR-700 DR-8 __ Other: ________ Filtered: ☐

Program/Module: 60

Concentration: ________ mg/L Reagent Blank Correction: ☐

Standard Solution: ☐ Results: ☐

Notes: ____________

Nitrate (NO_3^--N):

Analysis Time: ________

Equipment: DR-700 DR-8 __ Other: ________ Filtered: ☐

Program/Module: 55

Concentration: ________ mg/L

Nitrite Interference Treatment: ☐

Standard Solution: ☐ Results: ________ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Notes: ____________

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ____________ Sample ID No.: ____________

Project No.: ____________ Sample Location: ____________

Sampled By: ____________ Duplicate: ☐

Field Analyst: ____________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 __ HACH MN-5 Other: ________ Analysis Time: ________

Program/Module: 525nm 41

Concentration: ________ mg/L Filtered: ☐

Digestion: ☐

Standard Solution: ☐ Results: ________ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:________ 0.2ml:________ 0.3ml:________

Notes: ____________

Ferrous Iron (Fe^{2+}):

Equipment: DR-700 DR-8 __ IR-18C Color Wheel Other: ________ Analysis Time: ________

Program/Module: 500nm 33

Concentration: ________ mg/L Filtered: ☐

Notes: ____________

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: ________ Analysis Time: ________

Concentration: ________ mg/L Exceeded 5.0 mg/L range on color chart: ☐

Notes: ____________

QA/QC Checklist:

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ______________________ **Project No.:** ______________________
Location: ______________________ **Personnel:** ______________________
Weather Conditions: ______________________ **Measuring Device:** ______________________
Tidally Influenced: Yes ___ No ___ **Remarks:** ______________________

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ___ of ___

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

Tetra Tech NUS, Inc.

PUMPING TEST DATA SHEET

PROJECT NAME: ____________ PUMPING WELL NUMBER: ____________
PROJECT NUMBER: ____________ MEASURED WELL NUMBER: ____________

[ ] PUMPING TEST [ ] STEP DRAW DOWN TEST

DATE(s): MONITORING POINT:
MEASUREMENT METHOD: DEPTH CORRECTION (ft):
TEST NUMBER: PUMP SETTING (Ft. below monitoring point):
STATIC WATER LEVEL (ft): DISTANCE FROM PUMPING WELL (ft):
PERSONNEL:
REMARKS:

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

NOTE: All measurements to nearest 0.01 foot measured from top of well riser pipe unless otherwise noted.

ATTACHMENT C-3

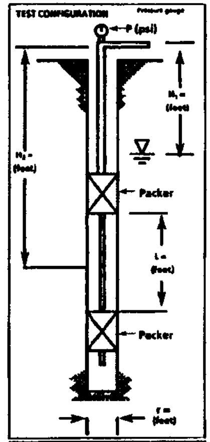
ATTACHMENT C-3
PACKER TEST REPORT FORM

PROJECT: ______ PROJECT NO.: ______ TEST NO: ______ PAGE ___ OF ___
BORING NO.: ______ CASING DEPTH: ______ CONTRACTOR: ______ STATIC WATER LEVEL ______
TEST INTERVAL: ______ BY: ______ CHECKED: ______ PACKER PRESSURE ______

Flow Test					Calculated Results							
Pressure, p (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(ft) = 2.31·(psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp·Q/H	K (cm/sec) = 9.67 x 10⁻⁷ · K (ft/yr)

CP = (1/(2 π L)) ln(L/r) (70,315 5)
7.48 Gallons = 1 Ft³
1 psi = 2.31 ft head
Remarks: ______

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



Length of Test Section in feet, l	Cp			
	Drilling Bit Size			
	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]

ATTACHMENT C-4

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: ____________ BORING No.: ____________
PROJECT NUMBER: ____________ DATE: ____________
DRILLING COMPANY: ____________ GEOLOGIST: ____________
DRILLING RIG: ____________ DRILLER: ____________

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

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ____

Remarks: ____

Converted to Well: Yes ______ No ______ Well I.D. #: ____________

ATTACHMENT C4 (Continued)

LEGEND

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

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

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

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights) — Identification Procedures on Fraction Smaller than No. 40 Sieve Size

	DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

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

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

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

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

S-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

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

Q-NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▽ 12.6' Initial Level w/Date & Depth

12/18

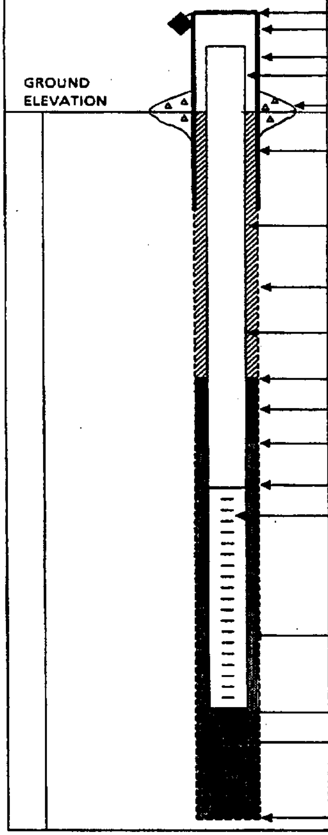
ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: ______

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER ______
DRILLING METHOD ______
DEVELOPMENT METHOD ______



ELEVATION OF TOP OF SURFACE CASING : ______
ELEVATION OF TOP OF RISER PIPE: ______
STICK - UP TOP OF SURFACE CASING: ______
STICK - UP RISER PIPE : ______
TYPE OF SURFACE SEAL: ______
I.D. OF SURFACE CASING: ______
TYPE OF SURFACE CASING: ______
RISER PIPE I.D. ______
TYPE OF RISER PIPE: ______
BOREHOLE DIAMETER: ______
TYPE OF BACKFILL: ______
ELEVATION / DEPTH TOP OF SEAL: ____/____
TYPE OF SEAL: ______
DEPTH TOP OF SAND PACK: ______
ELEVATION / DEPTH TOP OF SCREEN: ____/____
TYPE OF SCREEN: ______
SLOT SIZE x LENGTH: ______
I.D. OF SCREEN: ______
TYPE OF SAND PACK: ______
ELEVATION / DEPTH BOTTOM OF SCREEN: ____/____
ELEVATION / DEPTH BOTTOM OF SAND PACK: ____/____
TYPE OF BACKFILL BELOW OBSERVATION WELL: ______
ELEVATION / DEPTH OF HOLE: ____/____

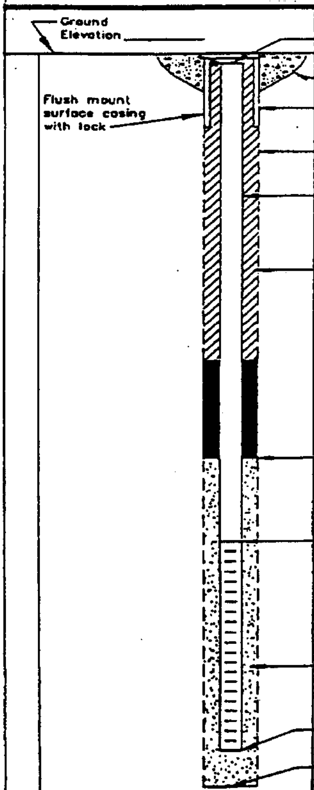
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: ______

MONITORING WELL SHEET

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

DRILLER ______
DRILLING METHOD ______
DEVELOPMENT METHOD ______



ELEVATION TOP OF RISER: ______
TYPE OF SURFACE SEAL: ______
TYPE OF PROTECTIVE CASING: ______
I.D. OF PROTECTIVE CASING: ______
DIAMETER OF HOLE: ______
TYPE OF RISER PIPE: ______
RISER PIPE I.D.: ______
TYPE OF BACKFILL/SEAL: ______

DEPTH/ELEVATION TOP OF SAND: ____/____
DEPTH/ELEVATION TOP OF SCREEN: ____/____
TYPE OF SCREEN: ______
SLOT SIZE x LENGTH: ______
TYPE OF SAND PACK: ______
DIAMETER OF HOLE IN BEDROCK: ______
DEPTH/ELEVATION BOTTOM OF SCREEN: ____/____
DEPTH/ELEVATION BOTTOM OF SAND: ____/____
DEPTH/ELEVATION BOTTOM OF HOLE: ____/____
BACKFILL MATERIAL BELOW SAND: ______

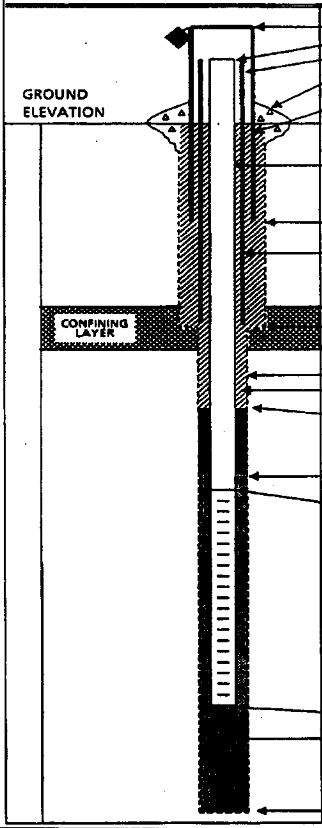
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: ____________

CONFINING LAYER
MONITORING WELL SHEET

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

DRILLER ____________
DRILLING METHOD ____________
DEVELOPMENT METHOD ____________



ELEVATION OF TOP OF SURFACE CASING : ____________
ELEVATION OF TOP OF RISER PIPE: ____________
ELEVATION TOP OF PERM. CASING: ____________
TYPE OF SURFACE SEAL: ____________
I.D. OF SURFACE CASING: ____________
TYPE OF SURFACE CASING: ____________
RISER PIPE I.D. ____________
TYPE OF RISER PIPE: ____________
BOREHOLE DIAMETER: ____________
PERM. CASING I.D. ____________
TYPE OF CASING & BACKFILL: ____________
ELEVATION / DEPTH TOP CONFINING LAYER: ____________
ELEVATION / DEPTH BOTTOM OF CASING: ____________
ELEVATION / DEPTH BOT. CONFINING LAYER: ____________
BOREHOLE DIA. BELOW CASING: ____________
TYPE OF BACKFILL: ____________
ELEVATION / DEPTH TOP OF SEAL: ____________
TYPE OF SEAL: ____________
DEPTH TOP OF SAND PACK: ____________
ELEVATION/DEPTH TOP OF SCREEN: ____________
TYPE OF SCREEN: ____________
TYPE OF SAND PACK: ____________
ELEVATION / DEPTH BOTTOM OF SCREEN: ____________
ELEVATION / DEPTH BOTTOM OF SAND PACK: ____________
TYPE OF BACKFILL BELOW OBSERVATION WELL: ____________
ELEVATION / DEPTH OF HOLE: ____________

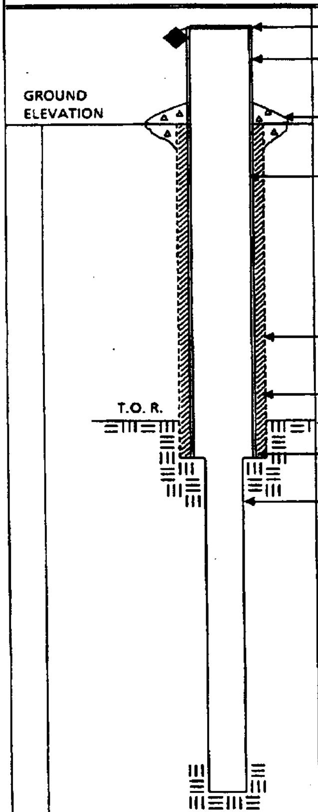
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO.: ____________

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER ____________
DRILLING METHOD ____________
DEVELOPMENT METHOD ____________



ELEVATION OF TOP OF CASING: ____________

STICK UP OF CASING ABOVE GROUND SURFACE: ____________

TYPE OF SURFACE SEAL: ____________

____

I.D. OF CASING: ____________
TYPE OF CASING: ____________

TEMP. / PERM.: ____________

DIAMETER OF HOLE: ____________

TYPE OF CASING SEAL: ____________

DEPTH TO TOP OF ROCK: ____________

DEPTH TO BOTTOM CASING: ____________

DIAMETER OF HOLE IN BEDROCK: ____________

DESCRIBE IF CORE / REAMED WITH BIT:

____

____

____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

____

____

____

ELEVATION / DEPTH OF HOLE: ______ / ______

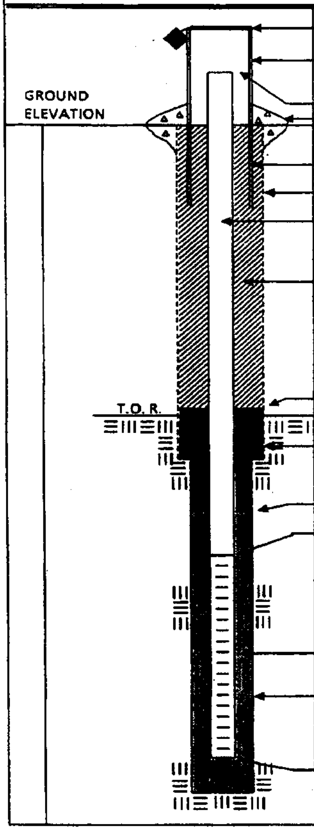
ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: ________

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER ________
DRILLING METHOD ________
DEVELOPMENT METHOD ________



ELEVATION OF TOP OF SURFACE CASING: ________

STICK UP OF CASING ABOVE GROUND SURFACE: ________

ELEVATION TOP OF RISER: ________

TYPE OF SURFACE SEAL: ________

I.D. OF SURFACE CASING: ________

DIAMETER OF HOLE: ________

RISER PIPE I.D.: ________

TYPE OF RISER PIPE: ________

TYPE OF BACKFILL: ________

ELEVATION / DEPTH TOP OF SEAL: ____/____

ELEVATION / DEPTH TOP OF BEDROCK: ____/____

TYPE OF SEAL: ________

ELEVATION / DEPTH TOP OF SAND: ____/____

ELEVATION / DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: ________

SLOT SIZE x LENGTH: ________

I.D. SCREEN: ________

TYPE OF SAND PACK: ________

DIAMETER OF HOLE IN BEDROCK: ________

CORE / REAM: ________

ELEVATION / DEPTH BOTTOM SCREEN: ____/____

ELEVATION / DEPTH BOTTOM OF HOLE: ____/____

ATTACHMENT C-9
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: ________

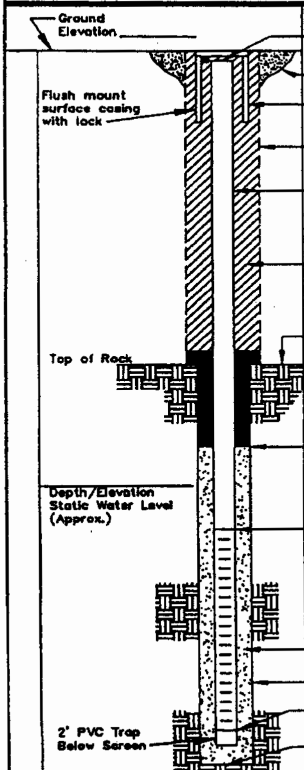
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: ________ LOCATION: ________ DRILLER: ________

PROJECT NO.: ________ BORING: ________ DRILLING METHOD: ________

ELEVATION: ________ DATE: ________ DEVELOPMENT METHOD: ________

FIELD GEOLOGIST: ________



ELEVATION TOP OF RISER: ________

TYPE OF SURFACE SEAL: ________

TYPE OF PROTECTIVE CASING: ________

I.D. OF PROTECTIVE CASING: ________

DIAMETER OF HOLE: ________

TYPE OF RISER PIPE: ________

RISER PIPE I.D.: ________

TYPE OF BACKFILL/SEAL: ________

____

DEPTH/ELEVATION TOP OF BEDROCK: ____/____

DEPTH/ELEVATION TOP OF SAND: ____/____

DEPTH/ELEVATION TOP OF SCREEN: ____/____

TYPE OF SCREEN: ________

SLOT SIZE x LENGTH: ________

TYPE OF SAND PACK: ________

DIAMETER OF HOLE IN BEDROCK: ________

DEPTH/ELEVATION BOTTOM OF SCREEN: ____/____

DEPTH/ELEVATION BOTTOM OF SAND: ____/____

DEPTH/ELEVATION BOTTOM OF HOLE: ____/____

BACKFILL MATERIAL BELOW SAND: ________

ATTACHMENT C-10
EXAMPLE TEST PIT LOG

TEST PIT LOG

Tetra Tech NUS, Inc.

PROJECT: ______________________ TEST PIT NO.:

PROJECT NO ______________ DATE: ______________

LOCATION: ______________________

FIELD GEOLOGIST: ______________________

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

Test Pit Cross Section and / or Plan View

REMARKS ______________________

PHOTO LOG ______________________ TEST PIT ______

PAGE ____ OF ____

ATTACHMENT C-11
EXAMPLE CERTIFICATE OF CONFORMANCE

MONITORING WELL MATERIALS CERTIFICATE OF CONFORMANCE

Well Designation: ____________ Site Geologist: ____________

Site Name: ____________ Drilling Company: ____________

Date Installed: ____________ Driller: ____________

Project Name: ____________ Project Number: ____________

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

Signature of Site Geologist: ____________

ATTACHMENT C-12
EXAMPLE MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ___

Site: ______
Well: ______
Date Installed: ______
Date Developed: ______
Dev. Method: ______
Pump Type: ______

Depth to Bottom (ft.): ______
Static Water Level Before (ft.): ______
Static Water Level After (ft.): ______
Screen Length (ft.): ______
Specific Capacity: ______
Casing ID (in.): ______

Project Name: ______
Project Number: ______
Site Geologist: ______
Drilling Co.: ______

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ___)	Turbidity (NTU)	Remarks (odor, color, etc.)

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ____________ INSTRUMENT NAME/MODEL: ____________

SITE NAME: ____________ MANUFACTURER: ____________

PROJECT No.: ____________ SERIAL NUMBER: ____________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT E

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: ______________________ PROJECT NUMBER: ____________

CLIENT: ______________________ LOCATION: ____________

DATE: ______________________ ARRIVAL TIME: ____________

Tt NUS PERSONNEL: ______________________ DEPARTURE TIME: ____________

CONTRACTOR: ______________________ DRILLER: ____________

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

COMMENTS: ____

APPROVED BY:

______________________ ______________________

Tt NUS REPRESENTATIVE DRILLER

DATE: ____________

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

MONDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

TUESDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

WEDNESDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

FRIDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

SATURDAY

Date: ______________________ Personnel: ______________

Weather: ______________________ Onsite: ______________

Site Activities: ____

____

____

____

APPENDIX B

TETRA TECH NUS, INC.
STANDARD FIELD FORMS

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: ____________________ BORING No.: ____________________

PROJECT NUMBER: ____________________ DATE: ____________________

DRILLING COMPANY: ____________________ GEOLOGIST: ____________________

DRILLING RIG: ____________________ DRILLER: ____________________

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

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): ______

Remarks: ____________________

Converted to Well: Yes ______ No ______ Well I.D. #: ____________________

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: ______________________ **PROJECT NUMBER:** ______________

CLIENT: ______________________ **LOCATION:** ______________

DATE: ______________________ **ARRIVAL TIME:** ______________

Tt NUS PERSONNEL: ______________________ **DEPARTURE TIME:** ______________

CONTRACTOR: ______________________ **DRILLER:** ______________

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

COMMENTS: ______________________

APPROVED BY:

______________________ ______________________

Tt NUS REPRESENTATIVE DRILLER

DATE: ______________

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ____________________ INSTRUMENT NAME/MODEL: ____________________

SITE NAME: ____________________ MANUFACTURER: ____________________

PROJECT No.: ____________________ SERIAL NUMBER: ____________________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Project Site Name: ______________________
Project No.: ______________________

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: ______________________
[] QA Sample Type: ______________________

Sample ID No.: ______________________
Sample Location: ______________________
Sampled By: ______________________
C.O.C. No.: ______________________

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings				
(Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: ____________________
Project No.: ____________________

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: ____________________
[] QA Sample Type: ____________________

Sample ID No.: ____________________
Sample Location: ____________________
Sampled By: ____________________
C.O.C. No.: ____________________
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:								
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

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