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Round 2
Sampling and Analysis Plan
for
Mustard Gas Burial Ground

Naval Surface Warfare Center
Crane Division
Crane, Indiana

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888

Contract Task Order 0158

May 2002

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ROUND 2
SAMPLING AND ANALYSIS PLAN

FOR

MUSTARD GAS BURIAL GROUND

NAVAL SURFACE WARFARE CENTER
CRANE DIVISION
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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1.0 INTRODUCTION

This Sampling and Analyses Plan (SAP) has been prepared to support the field crew in describing the work scope and procedures for the conduct of the Round 2 sampling activities at the Mustard Gas Burial Ground (MGBG) at NSWC Crane.

The Field Activities will include:

- The installation of three monitoring wells.
- Sampling groundwater in the three new wells and seventeen existing wells (if all contain groundwater).
- The collection of up to 5 surface water and 2 seep samples and staff gage installations (if surface water exists)
- The collection of 6 sediment samples.
- The collection of a synoptic round of water level measurements in all wells and staff gages at the site.
- Surveying

This section is the Introduction to the SAP. Section 2 includes a description of the Scope of Work. Section 3 is a discussion of field support activities. Section 4 includes the site figure and associated tables. Standard Operating Procedures are contained in Appendix A. Appendix B contains hydrogeologic information including existing boring logs, well construction sheets, and associated cross sections. Reference material to support the field crew including Subcontracting Agreements are included in Appendix C.

2.0 SCOPE OF WORK

2.1 GENERAL APPROACH

Sampling and analyses will be performed in Round 2 to further determine the nature and extent of contamination in ground water and sediment. Round 1 data were collected in the fall of 2001 and are summarized a Technical Memorandum dated January 15, 2002. The Technical Memorandum outlined data gaps, which served as the basis for this Round 2 scope of work. This Round 2 data will be used to further estimate the level of human health and ecological risks associated with the MGBG. If project objectives are not attained after this field effort, TtNUS will notify the Navy to discuss with U.S. EPA Region 5 the need for additional sampling and analyses. All activities will be conducted in accordance with this document and the CTO 158 Quality Assurance Project Plan (QAPP) (TtNUS, 2001). Information contained in this document will supercede the QAPP in all cases. All samples collected during this round will be analyzed by Southwest Laboratory of Oklahoma.

2.2 MOBILIZATION/DEMOBILIZATION

The Field Crew will become familiarized with this document and the Health and Safety Plan (HASP) prior to initiating any field work activities. Initially, the Health and Safety Orientation meeting will be performed before any field activities begin. Second, the potential drilling locations will be identified, and the need for any road building or clearing will be brought to the attention of the Navy for approval.

Avoidance or clearance of unexploded ordnance (UXO), field screening for mustard gas and field screening for radiological contamination will not be required for this Round 2 field effort. The field crew, however, will retreat from the investigation area in the unlikely event of encountering UXO, and will notify the appropriate personnel in accordance with the HASP.

2.3 MONITORING WELL INSTALLATIONS

Three additional monitoring wells will be installed at the site at the locations shown on Figure 1. Two deep monitoring wells (01T03 and 01T04) will be installed adjacent to shallow wells 01-02 and 01-15, respectively; with the intention of bounding the vertical extent of ground water VOC contamination. Shallow well 01T05 will be located approximately 200 feet northwest of well 01-25 on the northwest side of a gully that drains to the northeast. This well is intended to define the northwest extent of shallow groundwater contamination. It is anticipated that all three of these wells will contain little or no groundwater contamination.

Deep wells 01T03 and 01T04 are intended to target groundwater in sandstone or limestone (preferably limestone) at an approximate elevation of 510 – 520 ft msl NGVD, which is the same monitored interval as well 01-06 (see Figure 4 in Appendix B). It is anticipated that groundwater in this unit is hydraulically separated from shallow groundwater, by the presence of a lower permeable shale (at an elevation of about 560 to 600 ft msl), which may act as a confining unit. In addition, the potentiometric surface elevation of this lower unit is expected to be significantly lower than the potentiometric surface elevation of shallow groundwater as shown in the cross sections, which were developed during the preparation of the Technical Memorandum and are contained in Appendix B.

The well borings will be drilled using hollow stem or rotary drilling techniques, depending on the subsurface materials encountered during drilling. Sampling of the overburden may be performed using split spoon sampling techniques, at depth intervals as determined by the field geologist. The bedrock will be cored the entire length of each boring. Each boring will be drilled and logged in accordance with SOP 1 and SOP 2.

The deep well borings 01T03 and 01T04 will be drilled through the overburden and into the bedrock as described above, however, a 6-inch diameter steel casing will be installed and pressure grouted in place to separate the shallow groundwater from deep groundwater. The casing will be installed in the shale confining unit and allowed to cure for a minimum of 24 hours prior to resuming drilling into the deep groundwater unit. The isolation casing length could be as great as 100 feet in each well boring.

The monitoring wells will be completed with 2-inch diameter PVC well screen (10-slot, 10 ft length) and riser pipe. A filter pack, bentonite pellet seal, and grout will be installed in the well annulus; with a concrete pad, locking protective casing and cap and barrier posts installed at the ground surface. A summary of proposed well construction details is included in Table 1 and monitoring well installation procedures are included in SOP 3. The newly installed wells will be developed in accordance with SOP 4.

2.4 GROUNDWATER SAMPLING

Groundwater samples will be collected from 17 existing and the 3 newly installed wells (identified in Table 2 and shown on Figure 1) and will be analyzed for the laboratory and field analytical parameters shown on Tables 2 and 3. The samples are being collected to confirm the lateral and vertical extent of VOC contamination in the groundwater. The wells will be purged and sampled in accordance with SOP 5 and

SOP 6. The groundwater samples will be collected starting with the least contaminated wells to the most contaminated wells at the discretion of the field crew and in the order listed in Table 2.

The total number of ground water samples to be analyzed for each analyte group are listed in Table 2. The numbers of field QA/QC samples to be collected and analyzed are also listed in Table 2. One duplicate sample will be collected for every 10 ground water samples. Note: The duplicate samples will be preferentially collected from monitoring wells that are known to be contaminated. One matrix spike and matrix spike duplicate will be collected and analyzed. One rinsate sample will be collected and analyzed each day of ground water sampling activities. A trip blank will be included with each cooler containing samples for VOC analysis. Two source water blanks (tap water and distilled water) will be analyzed during the Round 1 field effort to establish whether contaminants may be present in the water used for steam cleaning and decontamination of sampling equipment.

2.5 SURFACE WATER AND SEEP SAMPLING

Up to 5 surface water samples will be collected at the original Round 1 sample locations, contingent on the presence of water in the surface water bodies. In addition to these five samples, two seep samples may be collected if seeps or springs are found relatively close to the MGBG (e.g., within a 1200-foot radius) and the seeps are flowing to some extent (i.e., water is not stagnant). Sample locations are included on Figure 1. Samples were originally intended to be collected from these locations during Round 1, however no surface water was present during the sampling event. Rationale for these samples is included in the QAPP. The field crew will visually inspect the surface water bodies and report the findings to the TtNUS Task Order Manager. A decision will be made based on those findings regarding the need to collect the samples. The samples will be collected for the analytical parameters shown on Table 4. The samples will be collected in accordance with SOP 7. Surface water flow will also be measured at each of the surface water and seep sample locations in accordance with SOP 8.

One field duplicate, one trip blank, one matrix spike, and one matrix spike duplicate will be necessary for QA/QC purposes. No rinsate blanks will be collected because disposable sampling equipment will be used. The total number of analyses, including QA samples, are tabulated in Table 4.

Up to 5 Staff Gages will be installed in the vicinity of the surface water sample locations if flowing water is found in these areas. Existing permanent structures such as culverts and bridge abutments will be used as staff gages, if possible. A mark will be placed on these structures denoting the point where measurements will be taken and the staff gage number will be noted. If a permanent structure is not

available, the staff gage will consist of a metal pipe that will be pounded into the sediment with a sledge hammer.

2.6 SEDIMENT SAMPLING

A total of six sediment locations will be sampled to further delineate the extent of contamination as shown on Figure 1. Two of the locations are Round 1 sample locations that are being resampled in Round 2, and four of the locations are new. The two existing locations are being resampled to confirm Round 1 VOC results (01SD03) and to provide additional data to improve the performance of statistical testing (01SD01). The four new sample locations are intended to provide data on contamination extent to the south and northwest of the MGBG, where contaminated groundwater may be migrating. The sediment samples will be collected in accordance with SOP 9.

Each of the sediment samples will be analyzed for the analytes listed in Table 5. One field duplicate, one trip blank per VOC cooler, one rinsate blank, one matrix spike, and one matrix spike duplicate will be necessary for QA/QC purposes. The total number of analyses, including QA samples, are tabulated in Table 5.

2.7 WATER LEVEL MEASUREMENTS

A comprehensive round of water level measurements and total well depths will be obtained in all of the wells and staff gages at the MGBG. All water-level measurements will be taken within a 24-hour period of consistent weather conditions. All water-level measurements will be taken using an electronic water-level meter (per SOP 10).

2.8 SURVEYING

The horizontal and vertical locations of all monitoring wells and staff gages will be surveyed. In addition, the horizontal locations of the surface water, seep, and sediment samples will be surveyed. The horizontal location will be surveyed to the Indiana State Plane Coordinates within the nearest foot and referenced to the 1983 North American Datum (NAD83). The vertical elevations of the ground surface, top of riser, and top-of-casing will be measured to the nearest 0.1 foot.

Each sample location (with the exception of monitoring wells) will be identified by a 2-by-2-inch wooden stake with attached flagging material driven into the soil adjacent to the sampling location, and the sample location shall be marked on the stake with a black waterproof marker. This will be done to adequately identify each sample location for subsequent surveying or relocating in the field.

3.0 FIELD SUPPORT ACTIVITIES

3.1 SAMPLE IDENTIFICATION NOMENCLATURE

The field samples will be numbered in accordance with SOP 11 following the numbering system identified in Tables 2, 4, and 5 for groundwater, surface water, and sediment; respectively.

3.2 FIELD METERS AND INSTRUMENTATION

A list of field meters and instrumentation is included on Table 3. That list includes the Photovac Photoionization Detector, the YSI Environmental water quality meter, the LaMotte turbidity meter, CHEMetrics Titrets, the HACH Colorimeter, and the Heron Water Level Indicator. Those instruments will be operated in accordance with the manufacturers instructions and SOPs 10, 12, and 13. Each calibration of an instrument will be recorded on an equipment calibration log sheet.

3.3 QUALITY CONTROL SAMPLES

Quality control samples are listed for each media on Tables 2, 4, and 5 for groundwater, surface water, and sediment, respectively. A description of each type of sample is as follows:

Field Duplicates. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Duplicate samples will be collected at a rate of 1 for every 10 environmental samples of each type of environmental medium. All duplicate samples will be analyzed for the same parameters in the laboratory as their environmental sample counterparts. Duplicate samples will be preferentially collected where field evidence (i.e., PID reading or odor) indicates that contamination is likely to be present in the environmental sample.

Temperature Blanks. These blanks are vials of water inserted into each cooler. The temperature blank is measured upon receipt at the laboratory to verify that samples were properly cooled during transit.

Equipment Rinsate Blanks. Equipment rinsate blanks will be obtained under representative field conditions by running analyte-free water through sample collection equipment after decontamination and placing it in the appropriate sample containers for analysis. Equipment rinsate blanks will be collected for non-dedicated equipment for all sampling rounds. For sediment sampling activities, rinsate blanks will be collected by running analyte-free water over a decontaminated stainless steel bowl and mixing spoon; these items are used to mix sediment prior to being placed in sample jars. For ground water samples,

analyte-free water will be pumped through a decontaminated pump and tubing that will be used for ground water sampling. Surface water samples will be collected directly from the surface water body and will not require a equipment rinsate blank.

Source Water Blanks. Source water blanks will be obtained by sampling each water source (e.g., potable water and distilled water) used for decontamination activities during the field investigation. Source water blanks will be used to determine if the water or the laboratory bottles are contributing to sample contamination. Source water blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event. Source water blanks, as applicable, will be analyzed for the entire suite of parameters under investigation. It is anticipated that two source water blanks will be collected during Round 2 – one potable water sample and one sample of distilled water used for decontamination.

Trip Blanks. Trip blank samples are 40-mL glass vials that contain analyte-free water and are prepared by the analytical laboratory prior to the start of field activities. They should be stored in a sealed container until they are needed. During sampling activities, one trip blank, consisting of one vial, shall be placed in each cooler that contains environmental samples destined for VOC analysis. The trip blank shall be properly labeled, and added to the chain-of-custody form belonging to the cooler. Trip blanks are only analyzed for VOCs.

Matrix Spike/Matrix Spike Duplicates. Extra sample material will be collected to support the analysis of these samples. A detailed description of these samples is presented in Sections 8.2.5 and 8.2.6 of the QAPP.

3.4 DOCUMENTATION

Standard forms, field notebooks, and a field log book will be used to record and document all sample collection activities, field measurements, observations concerning site conditions, and other project-related information. This documentation includes:

- Site Logbook
- Field Logbook
- Sample label
- Sample tag
- Chain-of-Custody form
- Custody seals

- Equipment Calibration Log
- Water Level Measurement Form
- Low-Flow Purge Data Sheet
- Ground Water Sample Log Sheet
- Surface Water Sample Log Sheet
- Sediment Sample Log Sheet
- Boring Log
- Monitoring Well Construction Sheet
- Field Task Modification Request Form (if necessary)

Documentation will be performed in accordance with SOP 14. Applicable forms for specific field tasks are referenced in their respective SOPs.

At completion of the field activities, the FOL shall submit to the TOM all field records, data, field notebooks, logbooks, COC records, sample log sheets, daily activity logs, and other records concerning the project, including all of the forms and log sheets listed above. The FOL will check these records for legibility and completeness prior to submitting them to the TOM. These forms, data, and field notes will become part of the permanent project record.

3.5 SAMPLE HANDLING, PACKAGING, AND SHIPPING

3.5.1 Sample Preservation

Preservation requirements for each of the chemicals of interest are provided in Table 6. All samples will be preserved, packaged, and shipped according to SOP 15.

3.5.2 Sample Labeling

Before samples are packaged, the sample labels and tags should be checked to ensure that all information on the label and tag is complete and correct (SOP 11). This information should be checked to ensure that it matches the information placed on the sample collection log sheets and the chain-of-custody form.

3.5.3 Sample Packaging

Each sample container will be placed in a zip-lock bag to prevent cross-contamination or leakage. The zip-lock bag will be placed in a bubble-wrap sleeve to protect from breakage. Only shipping containers that meet all applicable state and federal standards for safe shipment will be used.

3.5.4 Sample Packaging

The sample coolers will be sealed with nylon strapping tape in at least two places, and custody seals will be signed, dated, and affixed in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory (SOPs 14 and 15).

Shipment will be made by a public courier at the next scheduled pickup following completion of sample collection. Copies of the Express Mail Air Bills should be retained by the FOL for tracking purposes, if needed, and for communications with the laboratory. Air Bills will be retained for the Permanent Record File.

3.5.5 Sample Custody

Custody of samples must be maintained and documented at all times as per SOP 14, beginning with the collection of samples in the field.

3.6 EQUIPMENT DECONTAMINATION

All equipment used to collect soil and ground water samples will be decontaminated in accordance with SOP 16. All decontamination fluids will be placed in the wastewater storage tank until it is discharged in accordance with the next section of this document.

3.7 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

It is anticipated that this investigation will generate the following types of potentially contaminated residues or investigation-derived waste (IDW):

- Personal protective equipment (PPE) and ground water sample tubing
- Well development and purge fluids
- Equipment decontamination fluids

PPE - All PPE will be double-bagged and placed in trash receptacles at the facility.

Well Development and Purge Fluids - All well development and purge fluids will be collected and stored on-site in a 300- or 500-gallon plastic holding tank. The development and purge fluids will be discharged to the NSWC Crane permitted sanitary sewer system. Discharge will occur at a manhole designated by NSWC Crane.

Equipment Decontamination Fluids - All decontamination fluids will be combined with well development and purge fluids and handled in the same manner.

Tubing Used for Development, Purging, or Sampling - All tubing used to develop, purge, or sample a well will be double-bagged and placed in a trash receptacle at the facility.

Drill Cuttings - Drill cuttings will be scanned for VOCs. Drill cuttings with readings at background levels will be spread out at the drill locations. Drill cuttings with readings above background will be placed in 55-gallon drums and the TtNUS Task Order Manager will be contacted to determine the appropriate means for offsite disposal.

4.0 TABLES AND FIGURES

TABLE 1

PHYSICAL CHARACTERISTICS OF POTENTIAL MONITORING WELLS
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Monitoring Well Location	Approximate Ground Surface Elevation (feet NGVD)	Approximate Total Depth (feet bgs)	Approximate Depth of 6"-diameter Steel Casing (feet)	Screen Length (feet)	Approximate Desired Well Screen Elevation[1]	
					Top (feet NGVD)	Bottom (feet NGVD)
01T03	665	155	60	10	520	510
01T04	665	155	60	10	520	510
01T05	650	30	NA	10	630	620

NGVD - National Geodetic Vertical Datum
Bgs - below ground surface
NA - Not applicable

TABLE 2

GROUND WATER LABORATORY AND FIELD ANALYSIS SCHEDULE, ROUND 2
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Monitoring Well Location	Sample Identification Number	Sample Order(1)	VOC(2)	Metals(3)	Gross Alpha	Gross Beta	Chloride	TOC(4)	Dissolved gases(5)	Field Parameters(6)
01-01	01GW0102	1	1	--	--	--	--	--	--	--
01-02	01GW0202(7)	17	1	1	--	--	1	1	1	1
01-03	01GW0302	2	1	--	--	--	--	--	--	--
01-04	01GW0402	3	1	--	--	--	--	--	--	--
01-05	01GW0502	16	1	--	--	--	--	--	--	--
01-06	01GW0602	4	1	--	--	--	--	--	--	--
01-08	01GW0802(7)	10	1	--	--	--	--	--	--	--
01-09	01GW0902	5	1	--	--	--	--	--	--	--
01-10	01GW1002	11	1	--	--	--	--	--	--	--
01-11	01GW1102	14	1	1	--	--	1	1	1	1
01-14	01GW1402	12	1	--	--	--	--	--	--	--
01-15	01GW1502	15	1	1	--	--	1	1	1	1
01-23	01GW2302	6	1	--	1	1	--	--	--	--
01-25	01GW2502	13	1	1	--	--	1	1	1	1
01-26	01GW2602	7	1	--	--	--	--	--	--	--
01C01	01GWC0102	8	1	--	--	--	--	--	--	--
01T02	01GWT0202	9	1	1	1	1	1	1	1	1
01T03	01GWT0302	TBD	1	1	1	1	1	1	1	1
01T04	01GWT0402	TBD	1	1	1	1	1	1	1	1
01T05	01GWT0502	TBD	1	1	1	1	1	1	1	1

TABLE 2

GROUND WATER LABORATORY AND FIELD ANALYSIS SCHEDULE, ROUND 2
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Monitoring Well Location	Sample Identification Number	Sample Order(1)	VOC(2)	Metals(3)	Gross Alpha	Gross Beta	Chloride	TOC(4)	Dissolved gases(5)	Field Parameters(6)
Field Quality Control Samples										
Trip Blanks	--	--	10	--	--	--	--	--	--	--
Rinsate Blanks	--	--	4	1	--	--	--	--	--	--
Source Water Blanks	--	--	2	2	--	--	--	--	--	--
Field Duplicates	--	--	2	1	--	--	--	--	--	--
MS/MSD	--	--	1	1	--	--	--	--	--	--
Totals	--	--	**39**	**13**	**5**	**5**	**8**	**8**	**8**	**8**

1 Well sample order is based on trichloroethene isoconcentration contours as of September 2001.
2 40 Code of Federal Regulations Part 264 Appendi1 I1.
3 Target Analyte List metals plus Sr and Sn. Unfiltered sample will be analyzed for total metals. If turbidity of water is greater than 5 NTUs, a filtered sample will also be collected and analyzed for dissolved metals.
4 Total organic carbon.
5 Dissolved Gases – Methane, ethane, and ethene.
6 Includes field measurements for monitored natural attenuation (MNA) parameters as follows:
Alkalinity, carbon dioxide, dissolved oxygen by test kit, iron(+2), manganese(+2), hydrogen sulfide, sulfide, sulfate, nitrate and nitrite.
All wells will have field measurements collected for well stabilization indicators as follows:
Dissolved oxygen, oxidation-reduction potential, pH, specific conductance, temperature, and turbidity.
7 Samples designated for duplicate anlayses.

Note: All wells will have field measurements collected for well stabilization indicators as follows:
-- Not applicable.
MS/MSDs – Matrix Spike/Matrix Spike Duplicates.
TBD – To be determined

TABLE 3

FIELD SCREENING AND MEASUREMENTS
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Parameter	Equipment	Method	Calibration
Volatile Organics	Perkin-Elmer Photovac 2020 Photoionization Detector	SOP 12	Per Manufacturer
pH, Temperature, oxidation-reduction potential, specific conductance, dissolved oxygen (water quality parameters)(1)	YSI 6-Series Environmental Monitoring System	SOP 13	Per Manufacturer
Turbidity (water quality parameter)	LaMotte Turbidity Meter	SOP 13	Per Manufacturer
Alkalinity, CO_2, dissolved oxygen	CHEMetrics Titrets	Test Kit Instructions(3)	Per Manufacturer
H_2S, Fe^{+2}, NO_3, NO_2, SO_4, S^{-2} (natural attenuation parameters)	HACH DR-800 Colorimeter (or equivalent)	Test Kit Instructions(3)	Per Manufacturer
Water-Level Measurements	Heron Dipper-T (or equivalent)(2)	SOP 10	Per Manufacturer

1 Field measurements used to establish well stabilization prior to collecting ground water samples.
2 Any electronic water-level indicator may be used with the capability of measuring to depths of 200 feet.
3 Test kit instructions will be used to ensure that the most current and applicable procedure is followed.

TABLE 4

SURFACE WATER AND SEEP SAMPLES AND ANALYSES, ROUND 2
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Location	Sample ID Number	VOC (1)	Field Parameters(2)
01SW01	01SW0102	1	1
01SW02	01SW0202	1	1
01SW03(4)	01SW0302	1	1
01SW04	01SW0402	1	1
01SW05	01SW0502	1	1
01SP01 (3)	01SP0102	1	1
01SP02 (3)	01SP0202	1	1
Field Quality Control Blanks			
Trip Blanks	--	1	--
Rinsate Blanks	--		--
Field Duplicates	--	1	--
MS/MSDs	--	1	--
Totals	--	**10**	**7**

1 Appendix IX.
2 Field parameters include pH, specific conductance, turbidity, temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP).
3 Discretionary samples to be collected if seeps are located near the MGBG.
4 Sample designated for duplicate analyses.

VOC = volatile organic compound
MS/MSDs – Matrix Spike/Matrix Spike Duplicate.
-- Not Applicable

TABLE 5

SEDIMENT LABORATORY ANALYSES, ROUND 2
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Sample Location	Sample Number	VOC(1)	Metals(2)	Thorium(3)
01SD01	01SD0102	1	1	1
01SD03(4)	01SD0302	1	--	--
01SD09	01SD0902	1	--	--
01SD10	01SD1002	1	--	--
01SD11	01SD1102	1	--	--
01SD12	01SD1202	1	--	--
Field Quality Control Blanks				
Trip Blanks	--	1	--	--
Rinsate Blanks	--	1	1	--
Field Duplicates	--	1	1	--
MS/MSDs	--	1	1	--
Totals	**--**	**10**	**4**	**1**

1 40 Code of Federal Regulations Part 264 Appendix IX.
2 Target Analyte List metals plus strontium and tin
3 Thorium-228, -230, -232 isotopes.
4 Sample designated for duplicate analyses.
MS/MSDs – Matrix Spike/Matrix Spike Duplicate.
--NotApplicable Applicabl

TABLE 6

SUMMARY OF ANALYTICAL METHODS, BOTTLEWARE, PRESERVATIONS, AND HOLDING TIME REQUIREMENTS
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Analytical Method	Parameter	Container Material	Container Volume(1)	Preservation(2)	Holding Time(3)
AQUEOUS SAMPLES					
SW-846 8260B	Appendix IX Volatile Organic Compounds	Glass vial, Teflon-lined septa	Two 40 mL	Cool to 4°C; HCl to pH < 2; Zero headspace	14 days to analysis
RSK SOPs 147 and 175	Dissolved gases (Methane, ethene, and ethane)	Glass vial, Teflon-lined septa	Two 60 mL	Cool to 4°C; HCl to pH < 2; Zero headspace	14 days to analysis
SW-846 9056	Chloride	Polyethylene bottle, plastic cap	250 mL	Cool to 4°C	48 hours to analysis (nitrate, nitrite, and ortho-phosphate); 28 days to analysis (chloride and sulfate)
SW-846 3010A followed by 6010B-trace or 6020, 7470A, and 7841	TAL Metals plus Strontium and Tin	Polyethylene bottle, plastic cap	1 L	Cool to 4°C; HNO_3 to pH < 2	6 months to analysis except mercury which is 28 days to analysis
EPA 900	Gross Beta	Polyethylene bottle, plastic cap	1 L	Cool to 4°C; HNO_3 to pH < 2	6 months to analysis
EPA 900	Gross alpha	Polyethylene bottle, plastic cap	1 L	Cool to 4°C; HNO_3 to pH < 2	6 months to analysis
SW-846 9060	Total Organic Carbon	Polyethylene bottle, plastic cap	250 mL	Cool to 4°C	28 days to analysis
SEDIMENT SAMPLES					
SW-846 8260B	Appendix IX Volatile Organic Compounds	If dry then use 4 EnCore Samplers. If wet then use Clear wide mouth glass jar	4 5-gram Encores (and 2 ounce for percent moisture) or 4 ounce	Cool to 4°C	14 days to analysis
SW-846 3050B (HCl option) followed by 6010B-trace or 6020, 7470A, and 7841	TAL Metals plus Strontium and Tin	Clear wide mouth glass jar	8 ounce	Cool to 4°C	6 months to analysis except mercury which is 28 days to analysis
EPA 907 EMSL-LV-0539 March 1979	Isotopic Thorium (228, 230, 232)	Clear wide mouth glass jar	8 ounce	Cool to 4°C	6 months to analysis

TABLE 6

SUMMARY OF ANALYTICAL METHODS, BOTTLEWARE, PRESERVATIONS, AND HOLDING TIME REQUIREMENTS
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

°C Degrees Centigrade
SM Standard Methods for the Examination of Water and Wastewater
EPA Chemical Methods for Analysis of Water and Waste
L liter
mL milliliter
SW Test methods for evaluating Solid Waste Physical/Chemical Methods
TAL Target Analyte List

1 Container volume may vary based on laboratory.
2 HCl = Hydrochloric acid; HNO_3 - Nitric acid
3 Measured from time of sample collection.

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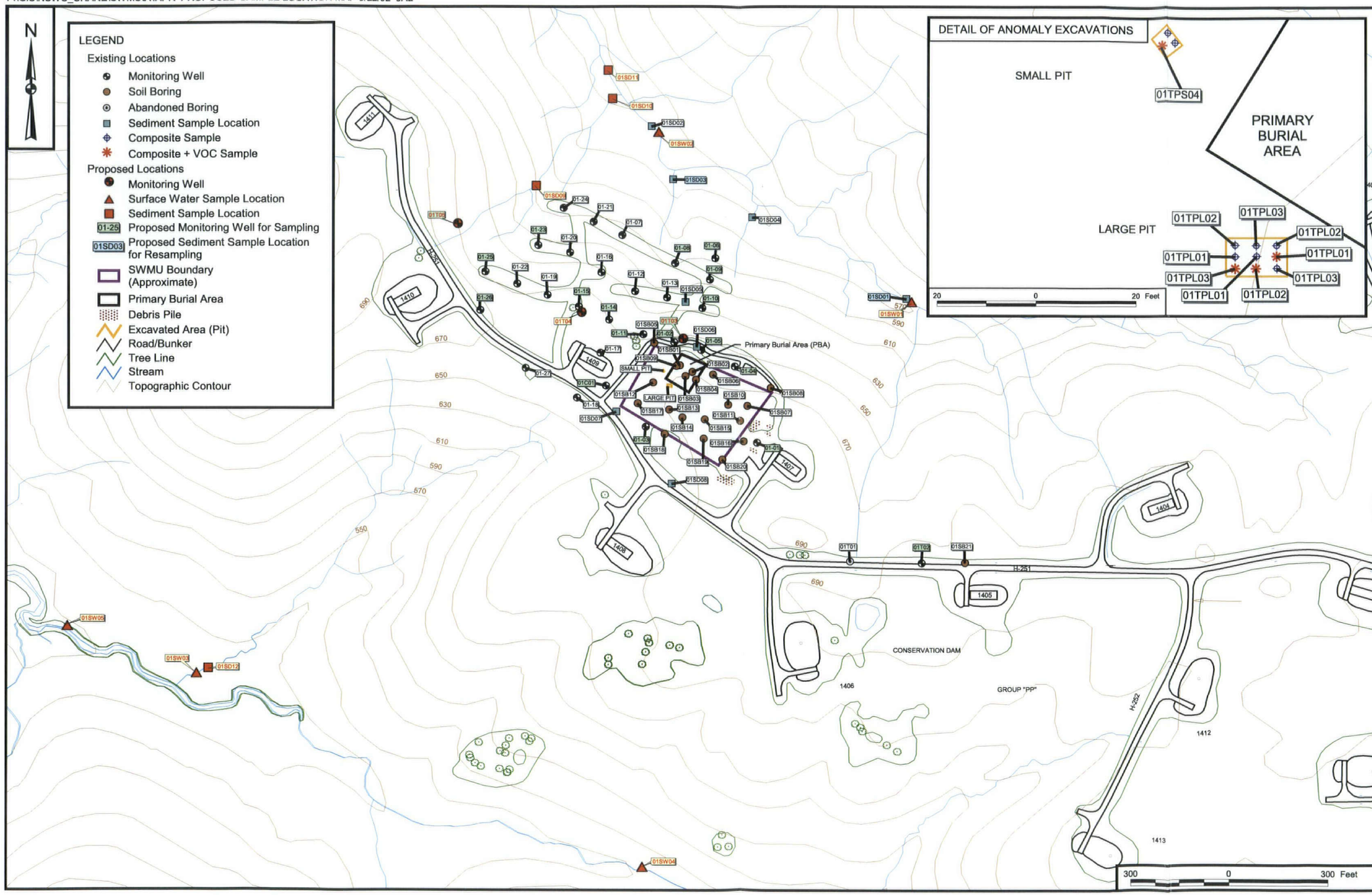
FIGURE 1 (11 X 17)

P:\GIS\NSWC_CRANE\SWMU01.APR PROPOSED SAMPLE LOCATION MAP 5/22/02 JAL



CONTRACT NO. 3959

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1

REV –

PROPOSED SAMPLE LOCATION MAP
SWMU 1 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

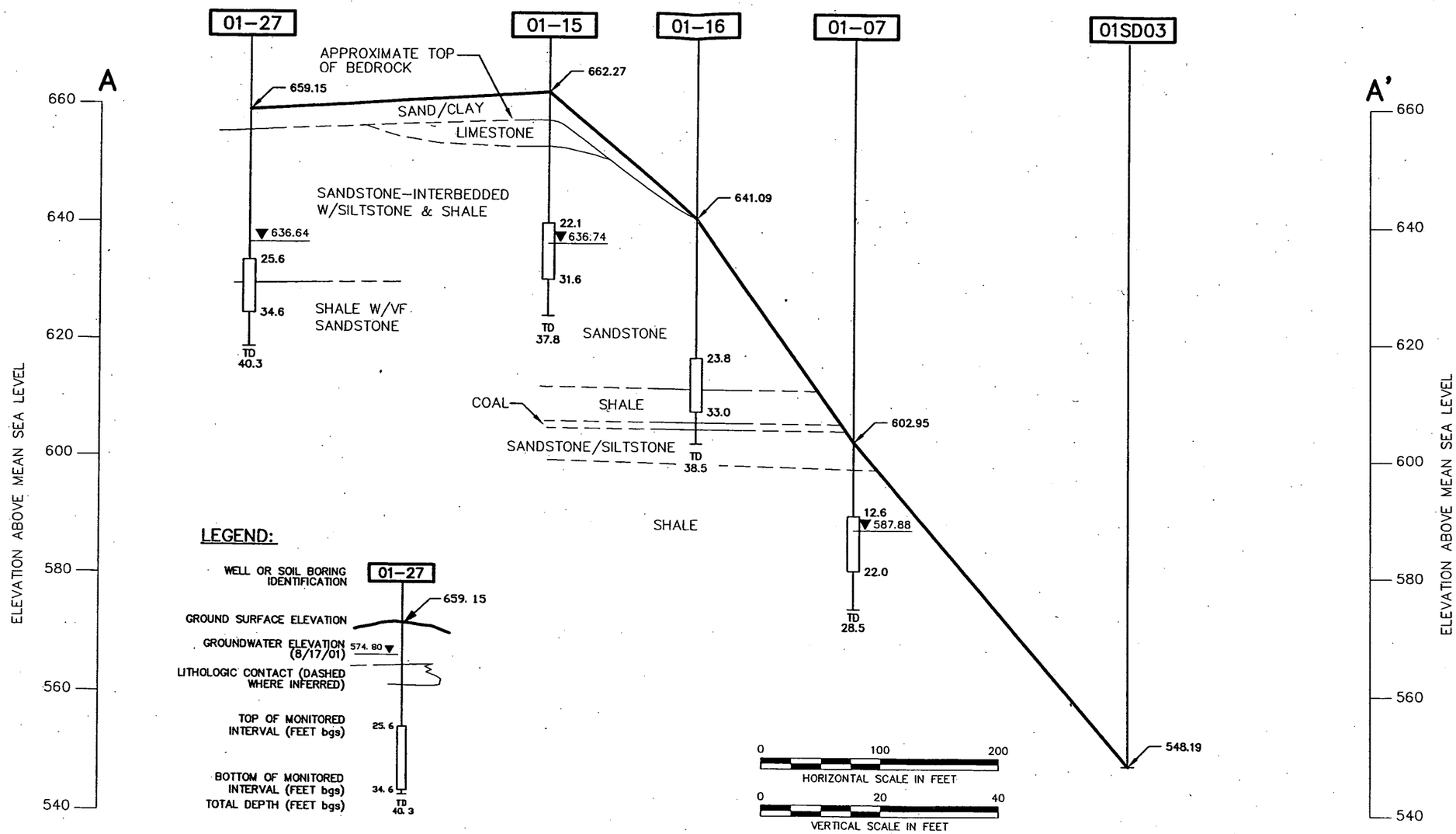
DRAWN BY J. LAMEY DATE 5/20/02

CHECKED BY DATE

COST/SCHED-AREA

SCALE AS NOTED

ACAD: 3959GX01.DWG 02/14/02 HJB



LEGEND:

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

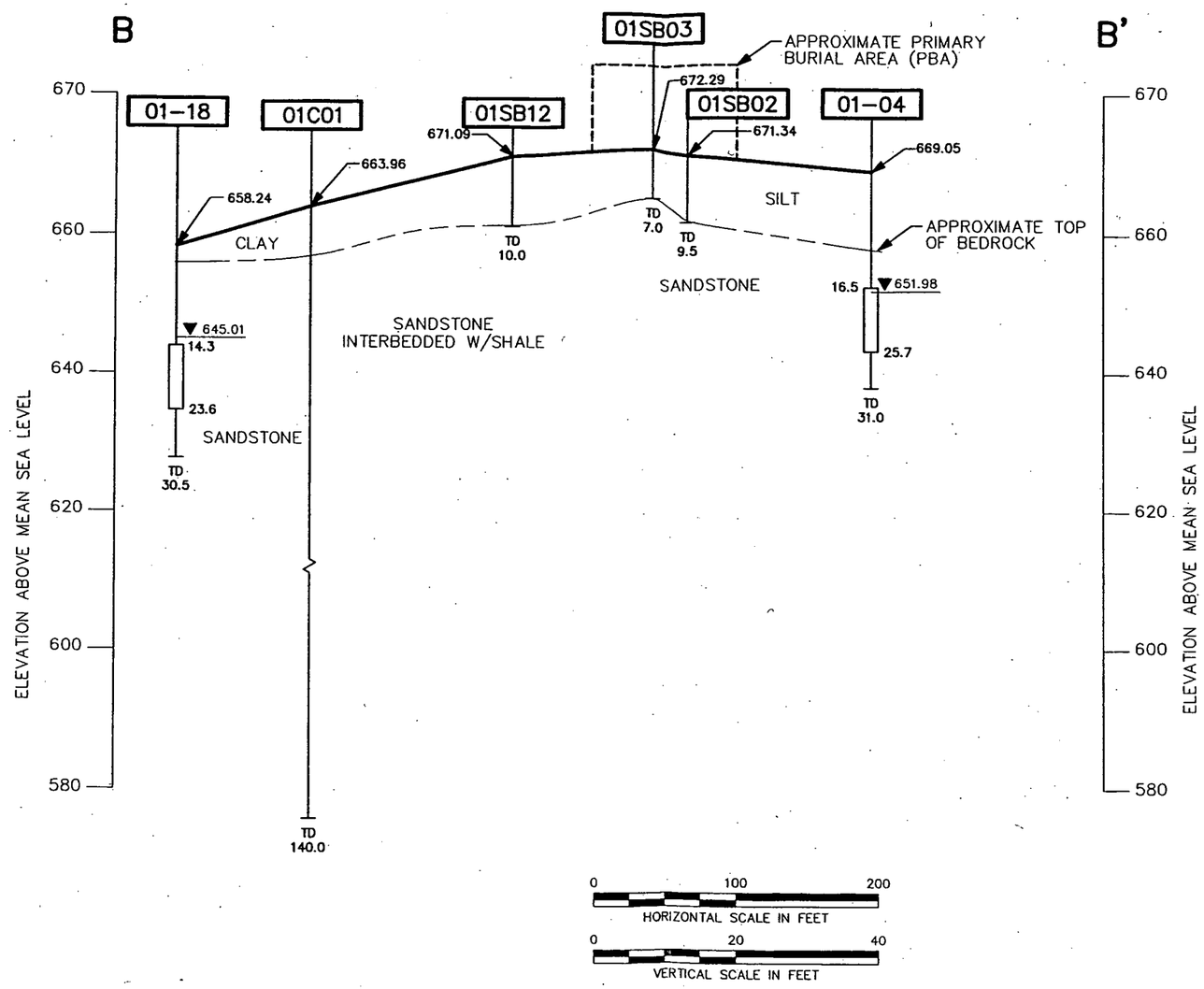
DRAWN BY DATE: DM 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE: AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS SECTION A-A'
SWMU1 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 3959GX02.dwg 02/14/02 HJB



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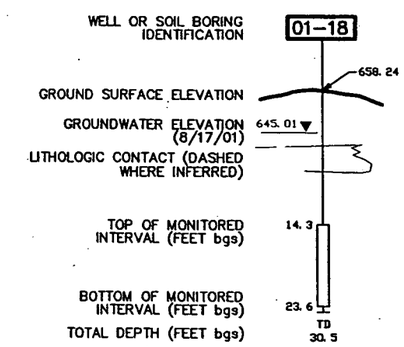


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

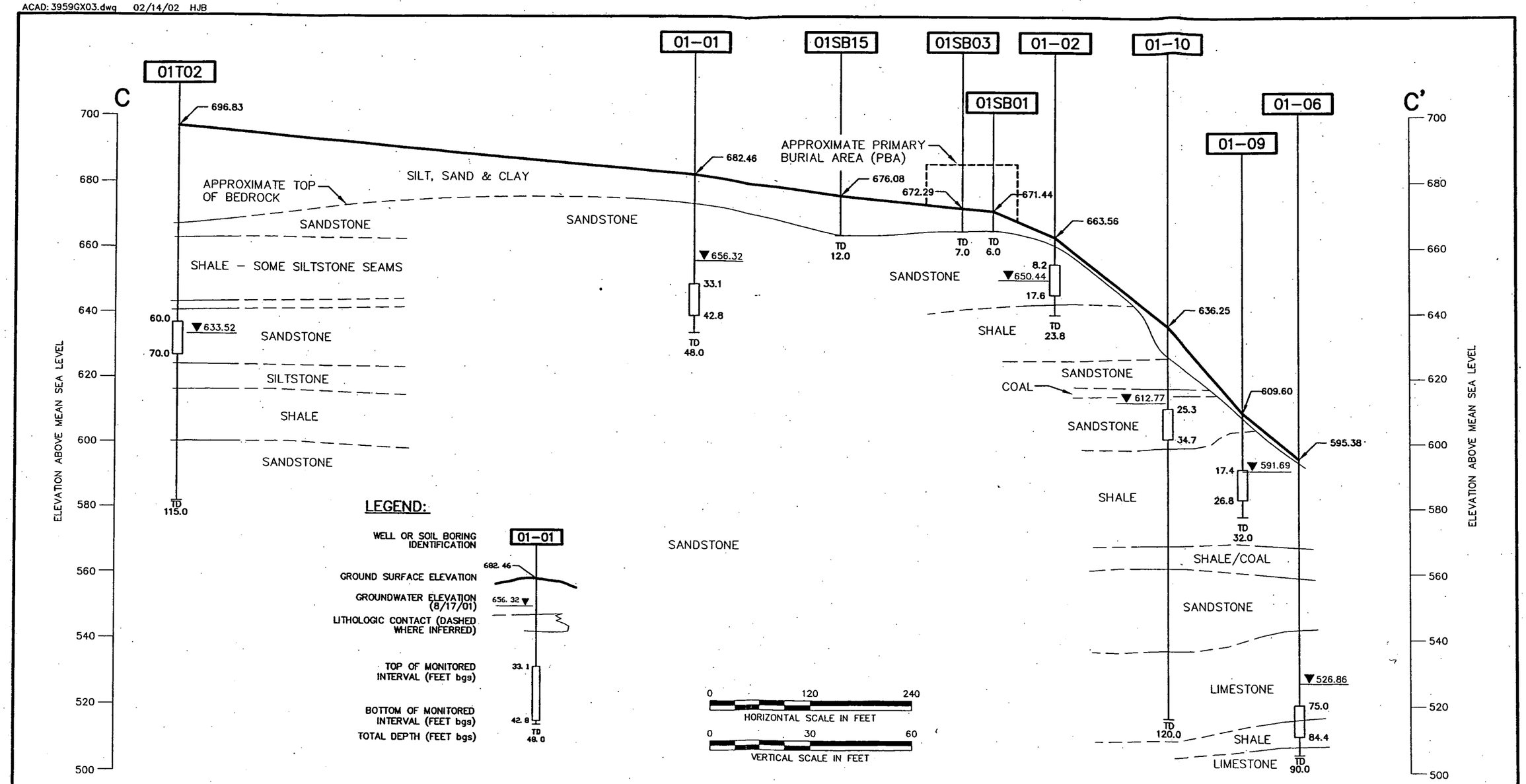
DEPARTMENT OF THE NAVY · SOUTHERN DIV FACILITIES ENGINEERING COMD

GENERALIZED HYDROGEOLOGIC CROSS-SECTION B-B'
SWMU1 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 3959GX03.dwg 02/14/02 HJB



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

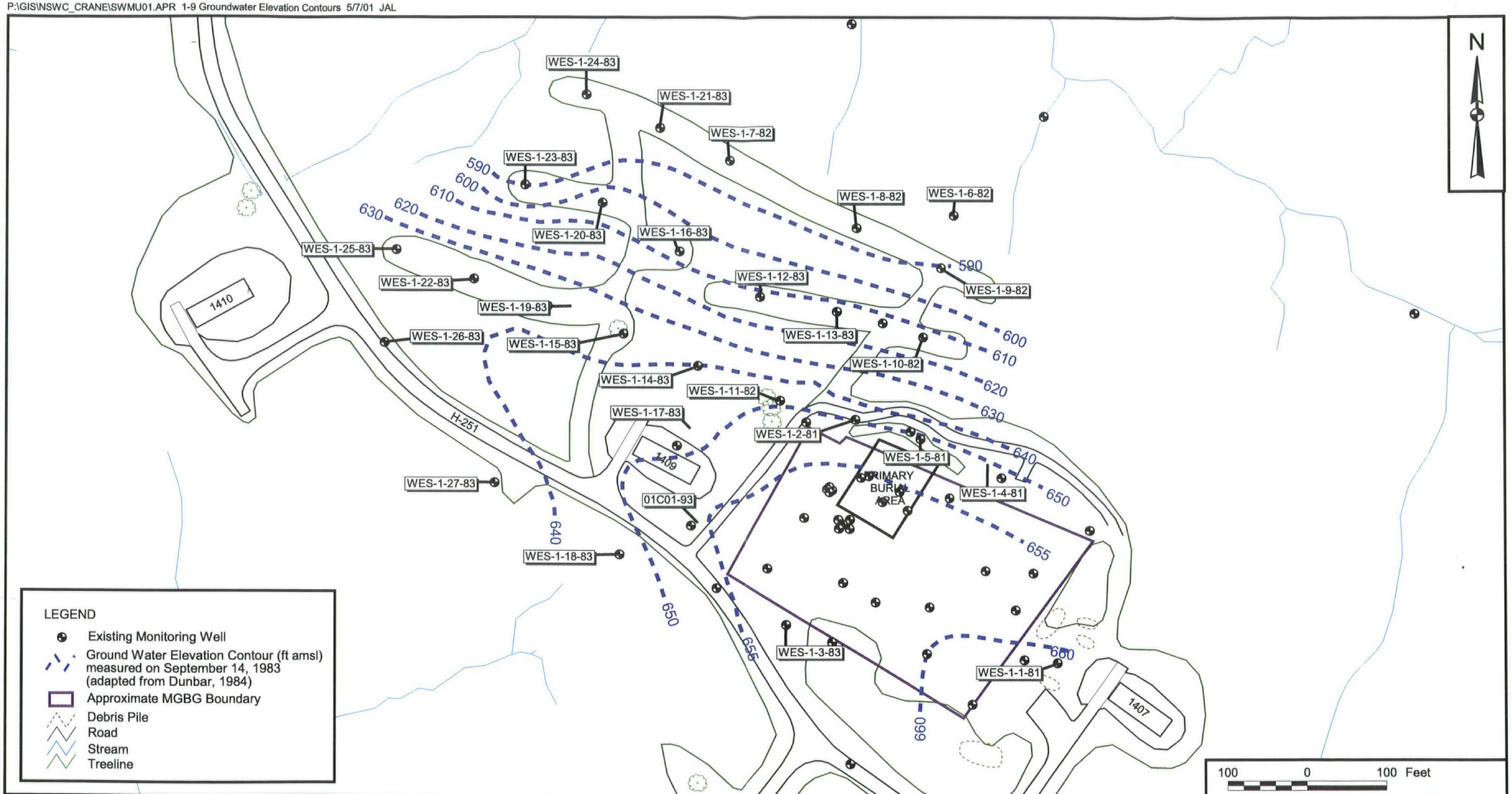
DRAWN BY DM DATE 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS SECTION C–C'
SWMU1 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

P:\GIS\NSWC_CRANE\SWMU01.APR 1-9 Groundwater Elevation Contours 5/7/01 JAL



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY J. LAMEY	DATE 4/3/00
CHECKED BY J. SCHUBERT	DATE 5/7/01
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

1983 POTENTIOMETRIC SURFACE CONTOUR MAP
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

CONTRACT NUMBER 0504	OWNER NUMBER 0131
APPROVED BY T. JOHNSTON	DATE 5/7/01
APPROVED BY —	DATE —
DRAWING NO. FIGURE 5	REV 0

REFERENCES

TtNUS, 2001. Quality Assurance Project Plan for Mustard Gas Burial Ground Resource Conservation and Recovery Act Phase III RCRA Facility Investigation, Naval Surface Warfare Center Crane, Crane, Indiana. Prepared by Tetra Tech NUS, Inc. for Southern Division Naval Facilities Engineering Command under Contract No. N62467-94-D, June, 2001.

TtNUS, 2002. Technical Memorandum concerning additional Ground Water Monitoring Well Installation and Sampling at Naval Surface Warfare Center, Crane Mustard Gas Burial Ground, SWMU 01. Issued to Mr. William Gates of Naval Facilities Engineering Command by Dr. Tom Johnston, Ph.D. of Tetra Tech NUS, Inc., dated February 15, 2002.

APPENDIX A

STANDARD OPERATING PROCEDURES

FIELD SOP TABLE OF CONTENTS

SOP 1	Borehole and Soil Sample Logging
SOP 2	Drilling and Geologic Logging of Boreholes in Rock
SOP 3	Monitoring Well Installation
SOP 4	Monitoring Well Development
SOP 5	Low-Flow Well Purging and Stabilization
SOP 6	Monitoring Well Sampling
SOP 7	Surface Water and Seep Sampling
SOP 8	Estimating Flow of Small Streams
SOP 9	Sediment Sampling
SOP 10	Measurement of Water Levels
SOP 11	Sample Identification Nomenclature
SOP 12	Calibration and Use of Photoionization Detector
SOP 13	Calibration and Care of Water Quality Meter
SOP 14	Sample Custody and Documentation of Field Activities
SOP 15	Sample Preservation, Packaging and Shipping
SOP 16	Decontamination of Field Sampling Equipment

STANDARD OPERATING PROCEDURE
NUMBER 01

BOREHOLE AND SOIL SAMPLE LOGGING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the standard procedures and technical guidance on the logging of soil cores collected at NSWC Crane.

2.0 FIELD FORMS AND EQUIPMENT

Knife
Ruler (marked in tenths and hundredths of feet)
Boring Log: An example of this form is attached.
Writing Utensil

3.0 RESPONSIBILITIES

A field geologist/engineer is responsible for supervising all boring activities and assuring that each borehole is properly and completely logged.

4.0 PROCEDURES FOR BOREHOLE AND SAMPLE LOGGING

To maintain a consistent classification of soil, it is imperative that the field geologist understands and accurately uses the field classification system described in this SOP. This identification is based on visual examination and manual tests.

4.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (attached to this SOP).

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 distinguishable 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 categories: 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.

4.2 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." Because 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.

4.3 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).

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 the following table.

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

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

The consistency of cohesive soils is determined by hand by determining the resistance to penetration by the thumb. The thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample. The sample shall be broken in half and the thumb 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. 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 the above-listed table.

4.4 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

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.

4.5 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 gloved 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 field activity.

4.6 Classification of Soil Grain Size for Chemical Analysis

It will be necessary to determine the gross grain size classification of samples collected for chemical analyses using the following table:

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Clay	CL	inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays,
	CH	inorganic clays of high plasticity, fat clays
	OH	organic clays of medium to high plasticity, organic silts
Silt	ML	inorganic silts and very fine sands, rock four, silty or clayey fine sands with slight plasticity
	OL	organic silts and organic silty clays of low plasticity
	MH	inorganic silts, micaceous or diatomaceous fine sand or silty soils

Gross Soil Grain Size Classification	USCS Abbreviation	Description
Sand	SW	well graded sands, gravelly sands, little or no fines
	SP	poorly graded sands, gravelly sands, little or no fines
	SM	silty sands, sand-silt mixtures
	SC	clayey sands, sand-clay mixtures

4.7 PID READINGS

PID readings will be taken from the sample, sampler breathing zone, borehole, and the driller's breathing zone and will be recorded on the boring log.

4.8 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
- Other distinguishing features
- Grain size
- Classification for chemical analyses
- PID readings

4.0 ATTACHMENTS

1. Figure 1 - Unified Soil Classification System
2. Boring Log

ATTACHMENT 1

FIGURE 1 - UNIFIED SOIL CLASSIFICATION SYSTEM

FIGURE 1

UNIFIED SOIL CLASSIFICATION (USCS)

FIELD IDENTIFICATIONPROCEDURES
(Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Sizes			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50%(+)>1/4"∅	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<1/4"∅	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see MCL)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights) Identification Procedures on Fraction Smaller than No. 40 Sieve Size				GROUP SYMBOL	TYPICAL NAMES
		DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Medium to High	None to Very Slow	Medium		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight		OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High		CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium		OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils

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

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

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

ATTACHMENT 2
BORING LOG

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	Color	Material Classification	USCS *	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. #: _____

STANDARD OPERATING PROCEDURE
NUMBER 02

DRILLING AND GEOLOGIC LOGGING OF BOREHOLES IN ROCK

1.0 PURPOSE

This procedure describes the methods and equipment necessary to drill rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain rock cores and prepare boring logs during drilling activities. Two types of drilling methods will be used to advance boreholes in rock:

- Diamond coring equipment might be used to core the entire depths of the boreholes. NX or similar size diamond core barrels will be used to collect 2 to 3 inch diameter continuous rock core. These cores will be used to describe the lithologic characteristics and fracture distributions in the Pennsylvanian-age bedrock.

- Air-rotary drilling will be used to ream out to a larger diameter borehole upon completion of coring. The holes need to be reamed to about 6 to 8 inches in diameter in order to install 6-inch diameter steel isolation casings and 2-inch diameter monitoring wells.

2.0 RESPONSIBILITIES

Field Operations Leader (FOL) - The FOL is responsible for coordinating all on-site personnel and for providing technical assistance, when required. The FOL, or designee, will coordinate and lead all activities and will ensure the availability and maintenance of all materials/equipment. The FOL is responsible for the completion of all field activities, field and chain-of-custody documentation; will assume custody of all samples; and will ensure the proper handling and shipping of samples. The FOL is a highly experienced environmental professional who will report directly to the TtNUS TOM. Specific FOL responsibilities include the following:

- Function as a communications link between field staff members, the Site QA/QC Advisor, Site Safety Officer, the Site Manager, and the TOM.

- Oversee the mobilization and demobilization of all field equipment and subcontractors.

- Coordinate and manage the Field Technical Staff.
- Adhere to the work schedules provided by the TOM.
- Bear responsibility for maintenance of the site logbook and field record keeping.
- Initiate field task modification requests, when necessary.
- Identify and resolve problems in the field, resolve difficulties in consultation with the NSWC Crane Site Manager, implement and document corrective action procedures, and provide communication between the field team and upper management.

Field Geologist - The field geologist is responsible for ensuring that standard and approved drilling procedures are followed. The field geologist will generate a detailed boring log for each borehole. This log shall include a description of geologic materials, samples (if any), method of sampling, and other pertinent information and observations that may be obtained during drilling.

Determination of the exact location for borings is the responsibility of the field geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan. Any deviation from this location will be discussed with the TOM prior to commencing drilling operations.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for supplying all services (including labor), equipment and material required to perform the drilling and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified for drilling and coring equipment specified in the project plan documents. The FOL will oversee the in-field equipment decontamination procedures to confirm compliance with the appropriate SOP and specific requirements of the NSWC Crane Environmental Department. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

3.0 PROCEDURES

3.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed.

3.2 Rock Coring

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required. When coring rock, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install monitoring wells in coreholes, the hole will be reamed out to the proper size after boring, using air rotary drilling methods. Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate.

Borehole diameter can be drilled to various sizes, depending on the information needed. NX, or a similar size (2 to 3 inch diameter core recovery), will be used for the MGBG investigation.

A temporary steel casing will be used to seal off the overburden prior to drilling the bedrock. Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately.

Since rock structures and the occurrence of bedding planes, porosity type/distribution, and fracture patterns are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of

the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

3.3 Rock Core Management and Labeling

Once the core barrel has been recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system.

Rock cores shall be placed in the sequence of recovery in well-constructed wooden or cardboard boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each. Wood partitions shall be placed at the end of each core run. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

Project name
Project number
Boring number
Run numbers
Footage (depths)
Recovery
RQD (%)
Box number and total number of boxes for that boring (Example: Box 5 of 7)

Contact person's name and telephone number.

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

3.4 Air Rotary Drilling

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole.

Advantages of this method include:

- The drilling rate is high (even in rock)
- The cost per foot of drilling is relatively low
- Air-rotary rigs are common in most areas
- No drilling fluid is required (except when water is injected to keep down dust)
- The borehole diameter is large, to allow room for proper well installation procedures

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow
- In-situ samples cannot be taken, unless the hole is cased
- Air-rotary drill rigs are large and heavy
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

4.0 GEOLOGIC DESCRIPTION OF BOREHOLES IN ROCK

These procedures provide descriptions of the standard techniques for borehole and sample logging. These logging techniques shall be used for each boring 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.

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.

4.1 Required Field Forms and Equipment

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

Rock hammer
Knife
Camera
10% Dilute hydrochloric acid (HCl)
Ruler (marked in tenths and hundredths of feet)
Hand Lens
Writing utensil with indelible ink
Field logbook
Soil/rock classification sheets

4.2 Classification of Rocks

Claystone - Very fine-grained rock made up of particle less than 1/256mm in diameter. Fractures irregularly.
Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

Shale - A fissile very fine-grained rock with particles less than 1/256mm in diameter. Fractures along bedding
planes.

Limestone - Rock made up predominantly of calcite ($CaCO_3$, which is mainly fossilized animal and plant debris). Effervesces strongly upon the application of dilute hydrochloric acid.

Coal – A very dark colored rock consisting mainly of organic (mainly fossilized plant debris) 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: 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 and are the only type present at NSWC Crane. 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 between 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.

Rock type
Color
Bedding thickness
Hardness
Fracturing
Weathering
Other characteristics

4.2.1 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, fossiliferous, etc.

Grain size is the basis for the classification of clastic (sandstones, siltstones, and shales) 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. Alternatively, the division between siltstone and shale may be measurable in the field by the 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 shale.

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	

4.2.2 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. 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.

4.2.3 Bedding Thickness

The bedding thickness designations listed below will also be used for rock classification.

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; Ingram, 1954)

4.2.4 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.

4.2.5 Fracturing

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

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.

4.2.6 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. Oxidation and weathering may be 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)

accentuated along fractures and should be noted.

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.

4.2.7 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.
- PID readings will be taken from the entire length of the core, the sampler breathing zone, borehole, and the driller's breathing zone and will be recorded on the boring log.

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.

4.2.8 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.

4.2.9 Abbreviations

Abbreviations may be used in the description of a rock. 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						

5.0 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 is attached at the end of this SOP.

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. All data shall be written directly on the boring log. Additional notes may be entered in a field notebook if more space is needed.

5.1 Remarks Column

The following information shall be entered under the "Remarks" column and shall include, but is not limited to, 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 radiation meter readings.

- 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.

5.2 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 above.

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.

5.3 Classification of Soil and Rock from Drill Cuttings

The previous section describe procedures for classifying 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.

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.

5.4 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.

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

6.0 REFERENCES

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7.0 ATTACHMENTS

1. Boring Log

ATTACHMENT 1
BORING LOG

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	Color	Material Classification	USCS *	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. #: _____

STANDARD OPERATING PROCEDURE
NUMBER 03

MONITORING WELL INSTALLATION

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper design and installation of ground water monitoring wells. The methods described herein are specific for monitoring well construction at the NSWC Crane. Guidelines by South Division, Naval Facilities Engineering Command, (South Div NavFac, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

2.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The drilling contractor personnel must have all of the health and safety training required to perform the work, as specified in the Health and Safety Plan.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that the screen interval for each monitoring well is properly placed to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

Health and safety equipment as required by the HASP and the Site Safety Officer.

Well drilling and installation equipment with associated materials (typically supplied by the driller).

Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineer's rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink

marker for marking monitoring wells, sample jars, well installation forms, boring logs, soil sample log forms, chain-of-custody records, sample coolers with ice, and a field notebook).

4.0 WELL DESIGN AND CONSTRUCTION

New wells will be installed only with Navy concurrence. Based on observations and information gathered during the drilling of each hole, the total depth of the hole and the placement of the well screen will be determined at the discretion of the field geologist or the FOL. The decision concerning the monitored interval and well depth will be based on the following (and possibly other) information collected while the well bore is being drilled and logged:

- The specific depths where poorly-cemented sandstone units, fractured rock, or other permeable rock zones are encountered,
- The specific depths where above-average rates of ground water were brought to the surface during drilling,
- The specific depth interval where contaminants (i.e., VOCs), if any, are encountered during drilling.

All of this information will be recorded on the borehole log as the hole is drilled.

Overburden drilling followed by diamond coring (if necessary) will be performed at borehole locations. For each well, the coring will proceed to the final depth of the borehole. Once the coring has been completed and the core has been logged, then the hole will be reamed out with a 6 to 8-inch diameter air rotary bit. The air rotary equipment must have a filter on the compressed air line going to the borehole to prevent oil and other organics from being introduced. Once the hole has been completed to depth, the boring shall be cleaned out using the compressed air of the rig. Note: all drilling equipment must be decontaminated before it is placed in a borehole.

A 6-inch diameter steel isolation casing will be installed and pressure grouted in the deep wells to seal the upper groundwater from deep groundwater. The grout will be allowed to cure for a minimum of 24 hours before resuming coring and reaming to the total depth of the borehole.

All monitoring wells will be constructed of schedule-40, flush-joint threaded, 2-inch ID PVC riser pipe and flush joint threaded, factory slotted well screen with a threaded end cap. The well screens will be factory slotted to 0.020-inch size. Each section of well casing and screen shall be National Sanitation

Foundation (NSF) approved. Well screens will be 10-feet long, but may be longer or shorter based on the subsurface conditions encountered. A PVC cap will be placed on the bottom and will also be flush-threaded. Thermoplastic pipe shall comply with ASTM F-480 (1981). Other means of joining casings using glue, gaskets, pop rivets or screws are not allowed. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material.

Monitoring wells will be installed immediately upon completion of drilling. A well screen section with bottom cap and the proper amount of riser pipe will be assembled and lowered down the borehole. Spacers may be used to ensure that the casing and screen are centered and are aligned straight. Clean silica sand pack will be installed through the borehole. The sand pack will be extended from 0.5 feet below the well screen to 2.0 feet above the top of the well screen. Clean silica sand of U.S. Standard Sieve Size No. 20 to 40 will be used.

A minimum 2-foot thick bentonite pellet seal will be installed above the filter pack and allowed to hydrate as determined by field geologist before grout is added above the seal. Only 100-percent, certified pure, sodium bentonite will be used for well construction. The depths of backfill materials will be constantly monitored during well installation using a weighted stainless steel or fiberglass tape measure.

The remaining annulus above the hydrated bentonite seal will be backfilled to the surface using a tremie pipe, with a 20:1 cement/bentonite grout. A maximum of 10 gallons of water per 94-pound bag of Type-1 cement will be used. The grout mixture should be blended in an above-ground rigid container or mixer to produce a thick lump-free mixture.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets extending to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging, and to provide a better seal. However, in shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

When the well is completed and grouted to the surface, a protective steel surface casing is placed over the top of the well. The finished well casing shall extend at least 2 ft above the ground level. This casing will have a cap that will be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective

casing has a larger diameter than the riser pipe and is set into the wet cement grout over the riser upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

Four barrier posts shall be placed at the corner of a 3 foot by 3 foot by 6 inch thick concrete pad located at the ground surface.

5.0 DOCUMENTATION OF FIELD ACTIVITIES

A critical part of monitoring well installation is recording of significant details and events in the site logbook, on field forms, and a field logbook.

All wells installed by the TtNUS must be registered with the TtMNUS WOUTHDIV Program Management Office (PMO) geologist. The PMO geologist will request that the Navy prepare well tags for the wells. The following information must be supplied to the PMO geologist for each well as soon as this information is known:

Tag number
Installation Name (i.e., NSWC Crane)
Contract Task Order number
TtNUS project number
Well identification number
Date installed
Installer (i.e., TtNUS)
Total well depth
Screened interval
Elevation (Top of casing)
Northing coordinate (ft)
Easting coordinate (ft)
Survey coordinate reference system
Information point of contact.

6.0 ATTACHMENTS

1. Bedrock Monitoring Well Sheet
2. Overburden Monitoring Well Sheet

ATTACHMENT 1
BEDROCK MONITORING WELL SHEET

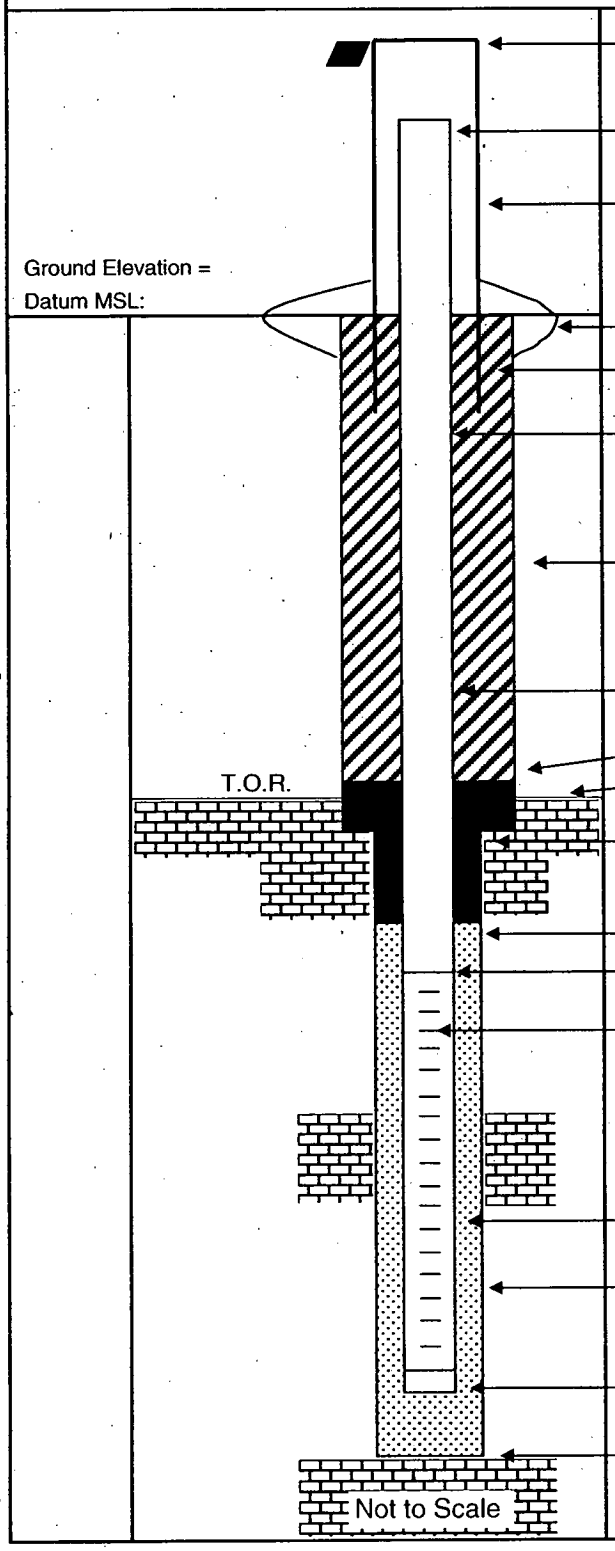
Tetra Tech NUS, Inc.

BEDROCK
MONITORING WELL SHEET

WELL No.: _____

PERMIT No: _____

PROJECT:		DRILLING Co.:		BORING No.:	
PROJECT No.:		DRILLER:		DATE COMPLETED:	
SITE:		DRILLING METHOD:		NORTHING:	
GEOLOGIST:		DEV. METHOD:		EASTING:	



Elevation of Top of Casing: _____

Stick Up of Casing Above Ground Surface: _____

Elevation of Top of Riser: _____

I.D. of Surface Casing: _____

Type of Surface Casing: _____

Type of Surface Seal: _____

I.D. of Permanent Casing: _____

I.D. of Riser: _____

Type of Riser: _____

Borehole Diameter: _____

Type of Backfill: _____

Elevation / Depth Top of Seal: _____ / _____

Elevation / Depth Top of Bedrock: _____ / _____

Type of Seal: _____

Elevation / Depth of Top of Fine Sand: _____ / _____

Elevation / Depth of Top of Filter Pack: _____ / _____

Elevation / Depth of Top of Screen: _____ / _____

Type of Screen: _____

Slot Size x Length: _____

I.D. of Screen: _____

Type of Filter Pack: _____

Diameter of Hole in Bedrock:
Core / Ream: _____

Elevation / Depth of Bottom of Screen: _____ / _____

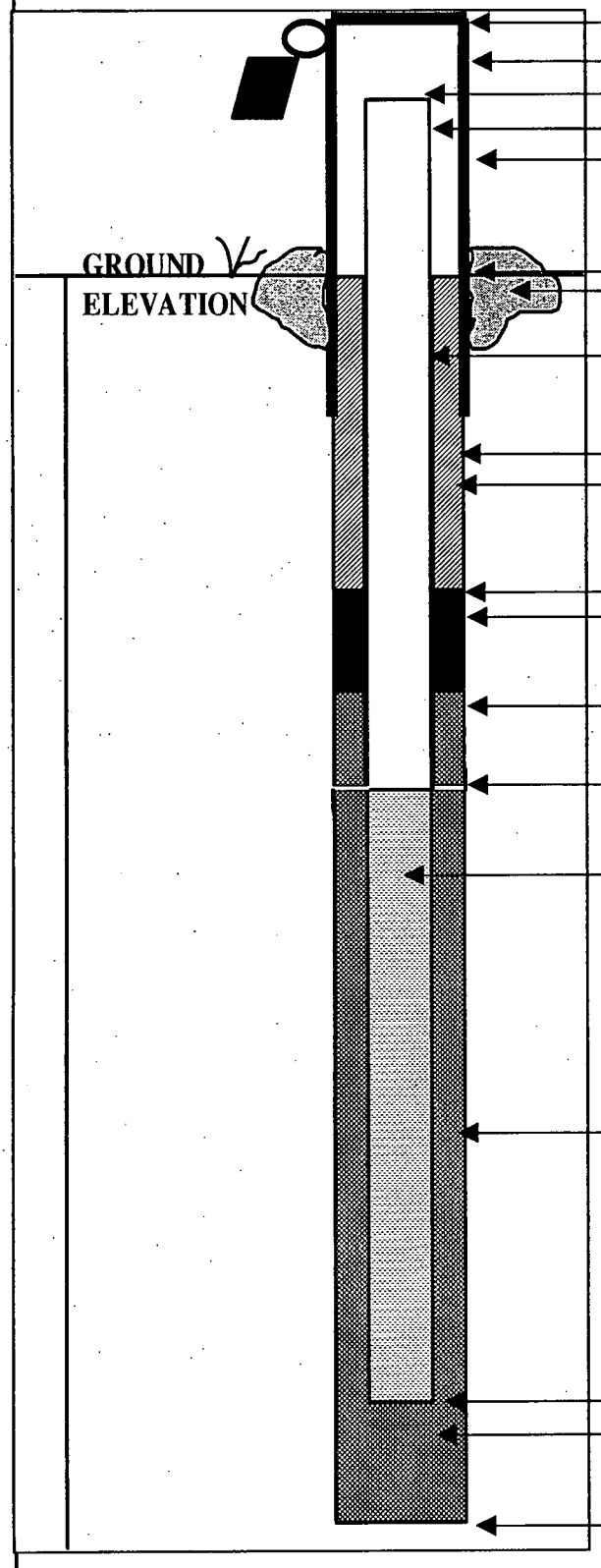
Elevation / Total Depth of Borehole: _____ / _____

ATTACHMENT 2
OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

Tetra Tech NUS, Inc. **OVERBURDEN MONITORING WELL SHEET**

PROJECT:		DRILLING Co.:		BORING No.:	
PROJECT No.:		DRILLER:		DATE COMPLETED:	
SITE:		DRILLING METHOD:		NORTHING:	
GEOLOGIST:		DEV. METHOD:		EASTING:	



ELEVATION OF TOP OF SURFACE CASING: _____

STICK -UP TOP OF SURFACE CASING: _____

ELEVATION OF TOP OF RISER PIPE: _____

RISER STICK-UP ABOVE GROUND SURFACE: _____

I.D. OF SURFACE CASING: _____

TYPE OF SURFACE CASING: _____

GROUND ELEVATION: _____

TYPE OF SURFACE SEAL: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF SEAL: _____

ELEVATION / DEPTH OF SEAL: _____ / _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF FILTER PACK: _____ / _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE X LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF FILTER PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF FILTER PACK: _____ / _____

TYPE OF BACKFILL BELOW WELL: _____

ELEVATION / DEPTH OF BOREHOLE: _____ / _____

STANDARD OPERATING PROCEDURE
NUMBER 04

MONITORING WELL DEVELOPMENT

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper development of new and existing monitoring wells. The methods described herein are specific for monitoring wells located at the NSWC Crane. Guidelines by South Division, Naval Facilities Engineering Command, (South Div NavFac, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

2.0 RESPONSIBILITIES

The drilling contractor will provide adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing the development of monitoring wells. The drilling contractor personnel must have all of the health and safety training required to perform the work, as specified in the Health and Safety Plan.

3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

Health and safety equipment as required by the HASP and the Site Safety Officer.

Well development equipment with associated materials (typically supplied by the driller).

Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).

4.0 WELL DEVELOPMENT METHODS

The development of new wells shall not occur until at least 24 hours after the well has been installed and grouted. This time is required so that the grout in the annulus can set and harden. The purpose of well development is to stabilize and increase the permeability of the sand pack and the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water, if any, is removed from the well.

Sequential measurements of pH, specific conductance, turbidity, and temperature will be taken during development. Development should proceed until criteria are met as stated in Navy Guidelines.

Vigorous on-and-off pumping or a surge block will be used for development.

A surge block that is approximately the same diameter as the well riser will be used to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. Site-specific conditions will dictate which type will be used. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Development should proceed until three consecutive pH, specific conductance, and temperature readings are within 10 percent of each other and three consecutive turbidity readings are within 5 nephelometric turbidity units (NTUs) of each other. If these criteria cannot be met after five volumes of water have been removed, then one additional well volume will be removed and well development will be considered complete.

If for any reason the above criteria cannot be met, the site geologist should document the event in writing and consult with the TOM regarding an alternate plan of action.

Well development must be completed at least 24 hours before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to sufficiently equilibrate to their new environment and for that new environment to re-stabilize after the disturbance of drilling.

5.0 ATTACHMENTS

1. Monitoring Well Development Record

ATTACHMENT 1

MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of _____

Well: _____ Depth to Bottom (ft.): _____ Responsible Personnel: _____
Site: _____ Static Water Level Before (ft.): _____ Drilling Co.: _____
Date Installed: _____ Static Water Level After (ft.): _____ Project Name: _____
Date Developed: _____ Screen Length (ft.): _____ Project Number: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in.): _____

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

STANDARD OPERATING PROCEDURE
NUMBER 05

LOW-FLOW WELL PURGING AND STABILIZATION

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for well purging and stabilization utilizing low-flow techniques.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow purging.

Low-Flow Purge Data Sheet: A copy of this form is attached at the end of this SOP.
Ground Water Sample Log Sheet: A copy of this form and instructions for its completion are included in SOP CTO131-6.
Bound Field Log Book
Well key
Electronic water level indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01-feet.
Electronic Programmable Controller, model 400: This controller regulates air flow in a bladder pump.
Cylinder of compressed nitrogen with regulator: Compressed gas serves as the power source for the bladder pump.
Multiple parameter water quality meter: This unit measures and displays field parameters measured in the field including pH, dissolved oxygen, oxidation-reduction potential (ORP), temperature, and specific conductance.
Flow-through cell adapter for water quality meter
LaMotte Turbidity Meter: Used to measure turbidity.
Purge water containers
Graduated cylinder and stopwatch: Used to calculate flow rate.

3.0 PROCEDURES FOR WELL PURGING

3.1 Prior to mobilizing to the site, clean, check for proper operation, and calibrate as per manufacturer requirements above equipment as necessary.

3.2 Obtain a static water level measurement of the well to be purged. Record the information on the Ground Water Sample Log Sheet and the Low-Flow Purge Data Sheet. Leave the water level meter suspended in the well casing.

3.3 Calculate one well casing volume as follows:

1. Obtain the total depth of the well.

2. Using the static water level determined in Step 3.2 of this SOP and the total depth of the well, calculate the well casing volume using the following formula:

$$V = (0.163)(T)(r^2)$$

where:

V	=	Static casing volume of well (in gallons).
T	=	Vertical height of water column (linear feet of water).
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.
r	=	Inside radius of the well casing (in inches).

Note: For wells of 1-inch radius (2-inch diameter) V = 0.163 gallons per foot of water column.

3.4 Connect the pump controller to the well pump air supply (at the well cap) by following the instructions in the pump control manual. The pump controller must be turned off when being connected.

3.5 Connect the nitrogen cylinder to the pump controller. The nitrogen cylinder valve must be closed and the regulator line pressure set at zero pounds per square inch (PSI) when being connected.

3.6 Following the instructions found in the water quality meter manual, connect the flow-through cell to the pump discharge line (at the well cap).

3.7 Place the discharge tubing from the flow-through cell to direct the purge water discharge into the graduated cylinder or purge-water container.

3.8 Following the instructions in the pump controller manual, start pumping water from the well.

3.9 Start with the initial pump rate set at approximately 0.1 liters/minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If ground water is drawn down below the top of the well screen, purging will cease and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same 8-hour workday and no later than 24 hours after the start of purging.

The time to sample any given well will vary greatly due to the many variables associated with low flow purging and sampling i.e.:

- Stabilization of parameters
- Possible draw down
- Analytical changes from quarter to quarter
- Varying QA sample requirements from quarter to quarter
- Variable pump rates

Normally, the time from the start of purging to the end of sampling will be between 1 to 4 hours.

3.10 Measure the well water level using the water level meter every five to ten minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP).

3.11 Record on the Low-Flow Purge Data Form every five to ten minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, and dissolved oxygen) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and

disconnect the cell. Rinse the cell with distilled water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

3.12 Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

3.13 During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

3.14 Stabilization is achieved and sampling can begin when a minimum of one casing volume has been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

pH ± 0.1 standard units
Specific conductance ± 3%
Temperature ± 3%
Turbidity less than 10 NTUs
Dissolved oxygen ± 10%
ORP ± 10%

If the above conditions have still not been met after the well has been purged for four hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data From onto the Ground Water Sample Log Form.

If there is a need to leave a well during purging, there are two options:

- One, if the sampler must move for 30 minutes or less but still has a clear line of sight to the well, the sampler may leave the pump running and watch the well until the sampler is able to return to the well.

- Two, if for whatever reason, the sampler must stop purging for an extended period of time or a clear line of sight cannot be maintained, the pump and cell will be shut-down. All equipment and supplies will be loaded into the sample vehicle, and the well will be secured before departing.

In both cases, the time purging was stopped and restarted will be noted on the Low-Flow Purge Data Form.

3.15 Once sampling activities have been completed, turn the pump off. Remove pump, hoses, cables, and other equipment from the well.

3.16 Decontaminate pumps, hoses, cables, flow-through cell, and other equipment.

4.0 ATTACHMENTS

1. Low-Flow Purge Data Sheet

ATTACHMENT 1

LOW-FLOW PURGE DATA SHEET

Tetra Tech NUS, Inc.

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ WELL ID.: _____

PROJECT NUMBER: _____ DATE: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celsius)	Salinity (%)	ORP (mV)	Comments (Volume & Color)

SIGNATURE(S): _____

PAGE___OF___

STANDARD OPERATING PROCEDURE
NUMBER 06

MONITORING WELL SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for monitoring well sampling. Low-flow sampling techniques will be used for ground water sampling at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow sampling of monitoring wells:
Ground Water Sample Log Form: A copy of this form is attached at the end of this SOP
BOUND FIELD LOG BOOK
Chain-of-Custody Form
Bladder Pump
Surgical Gloves
Labeled sample containers: Sample containers are certified clean by the laboratory supplying the sample containers.
Tag for each sample container
Plastic storage bags
Shipping containers with ice

3.0 MONITORING WELL SAMPLING PROCEDURES

3.1 Ground water sampling may be initiated when the monitoring well has been purged and stabilized.

3.2 Record the sample start time (using military time) on the Ground Water Sample Log Sheet. Record the field measurements for pH, ORP, specific conductance, temperature, dissolved oxygen, and turbidity.

3.3 With the pump continuing to run, disconnect the flow-through cell from the pump discharge tube and immediately start filling sample bottles directly from the pump discharge. All sample

containers will be supplied by the laboratory, and the laboratory will pre-preserve all sample containers, where appropriate.

3.4 Allow the pump discharge to flow gently down the inside of the container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled. Sample containers for volatile constituents (VOCs) must be completely filled so that no headspace exists in the container. The VOC vials shall be filled to the top so that a convex meniscus is formed. Gently secure the cap, turn the vial upside down, and check to see if any air has been trapped inside the vial. If so, open the cap, reform the meniscus, and attempt again to secure the lid without trapping air in the sample. All other sample containers can have air space included when the container lid is secured.

3.5 Cap each container immediately after filling.

3.6 Record the sample time on the Ground Water Sample Log Form, the sample tag, and on the sample label.

3.7 Secure the associated tag to each sample container.

3.8 Place the tagged sample container into a plastic storage bag and then into a cooler containing ice.

3.9 Enter the proper information on the Chain-of-Custody form for each sample container.

3.10 Repeat steps 3.3 through 3.9 for each sample container collected.

3.11 The pump rate should not be adjusted after sampling has commenced. If it becomes necessary to adjust the pump rate, document the change on the Ground Water Sample Log Form.

3.12 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. All samples will be collected in the following sequence (where applicable):

Volatile organic compounds (VOCs)
Other organics
Appendix IX Metals plus Sr and Sn (totals)
Thorium isotopes, gross alpha, gross beta

3.13 If the last turbidity measurement prior to the commencement of sampling showed turbidity to be greater than 5 Nephelometric Turbidity Units (NTUs), then filtered aliquots of ground water will be collected and analyzed for dissolved metals and dissolved thorium isotopes. Without turning off the pump, attach a disposable, inline, 0.45-um filter cartridge at the end of the discharge tube. Fill sample containers marked for "dissolved metals" and "dissolved thorium" so that the laboratory knows that these aliquots are distinct sample fractions and that the results should be reported as dissolved analytes.

3.14 Repeat steps 3.5 through 3.9 for the filtered sample containers.

3.15 After completion of sample collection, remove the bladder pump from well and decontaminate.

3.16 Replace the outer protective well cap and lock the well.

3.17 All equipment should be cleaned and packed into the sample vehicle, along with the sample cooler for transport. Disposable gloves and other equipment should be placed in a plastic trash bag and handled as investigation derived waste.

4.0 ATTACHMENTS

1. Ground Water Sample Log Sheet

ATTACHMENT 1

GROUND WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUND WATER 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	TBD	TBD
Time:	Visual	Standard	mS/cm	^{0}C	NTU	mg/l		
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	TBD	TBD
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):

TBD: To Be Determined

STANDARD OPERATING PROCEDURE
NUMBER 07

SURFACE WATER AND SEEP SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting surface water and seep samples at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Surface Water Sample Log Sheet: A copy of this form is attached at the end of this SOP.

Field Logbook

Multi-parameter water-quality meter: The water-quality meter is used for the measurement of dissolved oxygen, pH, specific conductance, temperature, oxidation-reduction potential, and turbidity.

LaMotte Turbidity Meter: Used to measure turbidity in the field.

Disposable sample containers: disposable sample containers are used to fill sample containers and transport sample(s) to a pump for filtering.

Labeled sample containers: Prelabeled, certified-clean sample containers will be provided by the laboratory that performs the analyses.

Sample Tags: One tag is to be completed and attached to each sample container.

0.45-micron filter assembly: These are single-use filter cartridges used to filter samples scheduled for dissolved metals or dissolved thorium isotope analyses. The filters become investigation-derived waste (IDW) after one use.

Peristaltic pump

Silicon tubing

Ziploc-type plastic storage bags

Shipping containers (coolers)

Trip Blank Sample **(if VOC samples are being collected)**

Temperature Blank

3.0 SURFACE WATER AND SEEP SAMPLING PROCEDURES

3.1 The same methods will be used to collect surface water and seep samples. Sampling will start at the downstream end of a stream and proceed to the farthest upstream location.

3.2 Gently remove any floating leaves or twigs, if present, that may be present in a sample pool area, in a manner that will not disturb the bottom sediment.

3.3 If the sample can be obtained from the shore, fill a decontaminated open-mouth drinking glass with sample water, move away from the sampling location, swish the water around all sides of the glass (inside and outside), and discard the water. Place the glass back in the water at the sampling location at a 45-degree angle and lower it to approximately half the sample pool depth. With the mouth of the glass facing upstream, fill the glass with water, being careful not to disturb the sediment.

3.4 If the sample cannot be obtained from the shore, carefully step into the water downstream of the sample location. Make certain that any disturbed sediment clears from the water before sampling. Begin sampling using a decontaminated glass. Obtain the sample upstream of your location. Hold the collection bottle at a 45-degree angle and lower it to approximately half the sample pool depth. With the mouth of the glass facing upstream, fill the glass with water, being careful not to disturb the bottom sediment.

3.5 Transfer the contents of the glass to the sample containers and cap the sample containers. All samples will be collected into certified-clean, pre-preserved bottles (if preservation is required for the analysis to be performed) supplied by the laboratory performing the analyses. Sample containers for volatile constituents (VOCs) must be completely filled, so that no headspace exists in the container. Other sample containers should <u>not</u> be filled completely; a small amount of air should be left at the top. Sample containers will be collected in the following sequence:

Volatile organic compounds (VOCs)
Other Organics
Total metals
Total thorium
Gross Alpha/Gross Beta
Total organic carbon (TOC)
Total suspended solids (TSS)

Dissolved metals

Dissolved thorium

3.9 Record the date and time that the sample containers are filled on the Surface Water Sample Log Sheet, the sample labels, the sample tags, and the Chain-of-Custody form.

3.10 After the sample label and sample tag are completed and checked, place the sample container into a ziploc-type plastic storage bag and then place the plastic storage bag holding the sample container into a cooler containing ice.

3.11 Repeat steps 3.3 through 3.10 until all the sample bottles containing unfiltered samples have been filled.

3.12 Fill two 1-liter unpreserved polyethylene bottles. Use these bottles to transfer the sample for field filtering. Set up a peristaltic pump for filtering of the dissolved metals and dissolved thorium samples. Using new, clean, disposable silicone tubing and a 0.45-micron filter, place the intake tubing from the pump into the transfer bottle with the filter attached to the discharge end and start the pump. Pre-rinse the filter with approximately 50-mL of sample water prior to filling the sample containers.

3.13 Using the discharge from the filter cartridge, fill two 1-liter polyethylene sample bottles, one for dissolved metals and one for dissolved thorium isotopes. Repeat steps 3.9 and 3.10 for these sample containers.

3.14 Obtain measurements of dissolved oxygen, pH, specific conductance, temperature, turbidity, and oxisdation-reduction potential using the multi-parameter water-quality meter and LaMotte Turbidity Meter. Record the readings in the appropriate fields on the Surface Water Sample Log Sheet.

3.15 Estimate the flow rate of the stream or spring. This is an estimate only. Round the flow rate to the nearest 5 gallons and record this number on the Surface Water Sample Log Sheet.

3.16 Decontaminate all equipment and load the equipment and the sample cooler in the sample vehicle for transport.

4.0 ATTACHMENTS

1. Surface Water Sample Log Sheet

ATTACHMENT 1

SURFACE WATER SAMPLE LOG SHEET

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:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER 08

ESTIMATING FLOW IN SMALL STREAMS

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides technical guidance on the measurement of stream channel cross-section and flow in a small stream. Stream flow measurements will be obtained to evaluate the migration potential of contaminants in a stream channel. This method is applicable for free flowing streams with uniform flow and widths greater than 3 feet and depths greater than about 6 inches. Flow in the unnamed tributaries at the NSWC Crane is expected to be low when surface water samples are collected. Stream flow rates will be measured at the same time when surface water samples are collected.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Measuring rod or yardstick
Measuring tape
Waders or rubber boots
Colored flagging tape
2x2 inch wooden stakes
Bound field logbook
Waterproof pen
Orange or apple
Surface water sample log sheet
Indelible marker
Stopwatch

3.0 PROCEDURES

3.1 Establish a transect across the stream, along a straight reach where the stream is relatively narrow and velocity across the stream is relatively uniform. Orient the transect perpendicular to the flow.

3.2 Mark both ends of the transect with colored plastic flagging tape. Tie the flagging to a tree branch or other elevated (about eye level) object. Pound wooden stakes into the ground at both ends of transect and tack a short piece of brightly colored flagging to the stakes. Use a black marker to identify the transect number, which will be the same as the surface water sample location.

3.3 Measure the total distance across the stream with a measuring tape and record the stream width (in feet) in the field logbook.

3.4 Measure the depth of water in the stream at three or four points across the stream. Record these measurements and calculate an average depth. Record the average depth (in feet) in the field logbook.

3.5 Measure a distance of 20 feet upstream of the transect. Tie a piece of flagging on a tree branch or other visable location above the stream.

3.6 Go another 20 feet upstream and place the orange or apple in the center of the stream or where the water current is fastest.

3.7 Using a watch with a timer or a stopwatch, measure the length of time it takes the orange (or apple) to travel from the first marker flag to the transect location (distance of 20 feet). Record the time.

3.8 Repeat step 3.7 two more times. Record the readings and calculate an average time.

3.9 Calculate approximate flow rate in the stream channel by multiplying the stream width (from step 3.3) times the average depth (from step 3.4) times the average velocity (from step 3.8). Record the estimated flow rate (in ft^3/s) in the field logbook and on the Surface Water Sample Collection Log Sheet.

STANDARD OPERATING PROCEDURE
NUMBER 09

SEDIMENT SAMPLING

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for sediment sampling in road ditches, surface water courses, and stream channels at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for sediment sampling.

Sediment Sample Log Forms: A copy of this form is attached at the end of this SOP.
Bound Field Log Book
Tags for each Sample Container
Disposable Plastic Trowels
Survey Stakes and Flagging: Used to mark sampling locations after completion of sampling.
Labeled Sample Containers: Sample containers are certified clean by the laboratory supplying the containers.
Plastic Storage Bags
Shipping Containers (containing ice)
Surgical Gloves
Indelible Marker
Chain-of-Custody Form

3.0 SEDIMENT SAMPLE LOCATION SELECTION

The sample locations include low spots in dirt roads, low spots in road ditches, low spots in erosion gullies, and low spots in ephemeral stream channels. At each of these locations, surface water is seldom flowing. Therefore, sediment samples will be collected from areas of sediment accumulation where the sediment is dry, nearly dry, or moist. If standing or flowing water is present at the general sampling location, then the sediment sample will be collected close to the edge of the water, but not from beneath the water.

In general, sediments composed of fine-grained materials with greater surface area available for adsorption, are more desirable for sample selection. The fined-grained materials may act as a sink or reservoir for adsorbing heavy metals and organic contaminants even if surface runoff concentrations are below detection limits. Therefore, it is important to locate the specific sampling points where the sediment has the greatest percentage of fine particles. The sampling personnel will determine specific sampling locations with these goals in mind.

3.0 SEDIMENT SAMPLING PROCEDURES

3.1 The sampler will wear clean, disposable, surgical gloves. Clear vegetative matter or debris, if present, from the sample location using a disposable sampling trowel or spoon. Use the trowel to dig up and homogenize the sediment in an 18-inch diameter circular area that is 6 inches deep. Stir the sediment within the circular area; do not move the sediment outside of the circle. Also, do not dig or stir sediment that is deeper than 6 inches below the ground surface.

3.2 Use the same trowel to scoop the homogenized sediment into the requisite labeled sample containers. All sample jars will be filled in the following sequence:

Volatile Organics
TAL metals plus Sr and Sn (total)
Thorium isotopes, gross alpha, gross beta

3.3 Record the sample time (using military time) on the Sediment Sample Log Form and sample container labels and tags. Record all other information required on the labels and tags.

3.4 Secure the tag to the neck of the sample container using a wire tie.

3.5 Place the tagged sample container into a plastic storage bag and then place the plastic storage bag holding the sample container into a cooler containing ice.

3.6 Record date, sampling site, site conditions, location map, and other information (e.g., presence and flow rate of water in channel) on the Sediment Collection Log Sheet. Enter the sample information onto the Chain-of-Custody.

3.7 Using an indelible marker, write the sample ID on a survey stake, drive the stake into the ground at the sample location. Tack on a piece of brightly colored flagging to the stake. In addition, tie a piece of flagging to an overhead tree branch or other eye-level object to improve the ability to relocate the sampling site in the future.

4.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

ATTACHMENT 1

SOIL AND SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

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

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

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

GRAB SAMPLE DATA:

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

COMPOSITE SAMPLE DATA:

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

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

STANDARD OPERATING PROCEDURE
NUMBER 10

MEASUREMENT OF WATER LEVELS

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for determining water levels in monitoring wells and staff gages.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for determining water levels in monitoring wells.

Ground Water Level Measurement Form: A copy of the Ground Water Level Measurement Form is attached.
Bound Field Log Book
Photoionization Detector (PID)
Well Key
Electronic Water-Level Indicator: The water level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01 feet.
Decontamination Supplies

3.0 WATER-LEVEL MEASUREMENT PROCEDURES

3.1 Check the operation of the electronic water level indicator or interface meter.

3.2 Record the well or staff gauge identification (ID), date, and time (using military time) on the Ground Water-Level Measurement Form.

3.3 Unlock the well and remove the well cap.

3.4 Place the well cap on a clean piece of plastic.

3.5 Check the well for the presence of organic vapors in the 2-inch PVC riser pipe as follows:

1. Calibration of the PID shall be done in accordance with appropriate calibration procedures.

2 Insert the PID sample inlet straw approximately three inches into the riser pipe.

3 Record the PID reading on the Ground Water Level Measurement Form. If the reading is less than concentrations specified in the site-specific HASP, proceed to step 3.6. If the reading is greater than the concentration specified in the HASP, measure the concentration in the breathing zone. If the concentration in the breathing zone is less than the concentration specified in the HASP, proceed to Step 3.6. If the reading is greater than the specified concentration, allow the riser pipe to ventilate for ten minutes and repeat the measurement of breathing zone concentrations until the concentrations fall below the level specified in the HASP before proceeding to step 3.6.

3.6 Ensure that the water level indicator probe has been decontaminated before use.

3.7 Slowly lower the probe into the well riser pipe (or into the surface water for staff gages) until an audible and/or visible signal is produced, indicating contact with the water surface.

3.8 Read the water level measurement from the top of the inner casing (or from the staff gage reference point) at the surveyed reference point to the nearest 0.01-foot.

3.9 Record the water level measurement on the Water Level Measurement Form.

3.10 Wind the meter cable measuring tape back onto the spool.

3.11 Replace the well cap and lock.

3.12 Decontaminate the meter's probe and cable.

4.0 ATTACHMENTS

1. Water Level Measurement Sheet

ATTACHMENT 1

WATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

WATER 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

STANDARD OPERATING PROCEDURE
NUMBER 11

SAMPLE IDENTIFICATION NOMENCLATURE

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes a consistent sample nomenclature system that will facilitate subsequent data management for NSWC Crane. The sample nomenclature system has been devised such that the following objectives can be attained:

Sorting of data by matrix
Maintenance of consistency (field, laboratory, and database sample numbers)
Accommodation of all project-specific requirements
Accommodation of laboratory sample number length constraints
Ease of identification and direct link to site, sample type, location, and depth.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Pen with Indelible Ink
Sample Tags:
Sample Container Labels:

3.0 SAMPLE IDENTIFICATION NOMENCLATURE

3.1 Monitoring Samples

All monitoring samples collected at NSWC Crane will be properly labeled with a sample label affixed to the sample container and a tag tied around the neck of the container. Each sample will be assigned a unique sample tracking number. The sample tracking number will consist of a four segment alphanumeric code that identifies the sample's associated solid waste management unit (SWMU) or associated site, sample type, location, and, for aqueous samples where applicable whether a sample is filtered and/or the sample round number.

The alphanumeric coding to be used in the NSWC Crane sample system is explained in the diagram and the subsequent definitions:

NN	AA	A or N 2 to 5 characters	NN and/or A Aqueous only	NNNN Soils and Sediment Only
SWMU or Site Number	Sample Type	Location	Round Identifier and/or filtered	Depth Interval

Character Type:

A = Alpha

N = Numeric

SWMU or Site Number:

01 = Mustard Gas Burial Ground (SWMU 1)

Sample Type:

GW = Ground water sample

SD = Sediment sample

SW = Surface water sample

SB = Soil boring sample

SS = Surface soil sample

SP = Seep or Spring

Location:

The sample location code is the well number, the soil sample location sediment sample location, or the stream sample location (i.e., surface water, springs, or seeps. Existing well numbers are used when unique. Existing well numbers have been abbreviated in the sample IDs. For example, the first sample obtained from well WES-1-9-82 is designated as 01-GW-09-01. "WES-1-9-82" is abbreviated as "09". New wells will be designated by a "T" for Tetra Tech NUS and, followed by a MW for permanent monitoring wells, TW for temporary wells, etc. and numbered sequentially, by SWMU, beginning with zero one (MWT01). Well clusters, two or more wells in close proximity, will be designated with the letter P followed by the number 2, 3, 4 etc. The number signifies the well's depth in relation to other wells in that cluster. This two-digit code will follow the well identification. Using well T02 as an example, of a three well cluster, the well identification will be as follows:

T02 = The deepest well in the cluster.

T02P2 = Intermediate well.

T02P3 = Shallowest well in the cluster.

Note: To keep the sample identification nomenclature to a minimum numbers of characters and to avoid redundancy, MW (monitoring well) is used for text, figures and tables and replaced with GW (groundwater) in the sample identification, example a sample from MWT01 would be GWT01.

Round Identifier:

A two digit round identifier will be used to tract the number of aqueous samples (GW, SW, etc.) taken from a particular aqueous sample location. The first sample collected from a location will be assigned round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Filtered:

Water samples that are field filtered (dissolved analysis) will be identified with an "F" in the last code section. No entry in this segment signifies an unfiltered (total) sample.

Depth Interval, Soil and Sediment only:

The depth code is used to note the depth, below ground surface (bgs), at which a soil or sediment sample is collected. The first two numbers of the four number code specify the top interval and the third and fourth specify the bottom, feet bgs (soil) inches bgs (sediment) of the sample. The depths will be noted in whole numbers only, further detail if needed, will be recorded on the sample log sheet, boring log, log book, etc.

Depth (for soils, in feet bgs):

0002 = soil collected from 0 to 2 foot bgs

0204 = soil collected from 2 to 4 feet bgs

0810 = soil collected from 8 to 10 feet bgs, etc.

Depth (for sediments, in inches bgs):

0006 = sediment collected from 0 to 6 inches bgs

0612 = sediment collected from 6 to 12 inches bgs

3.1.1 Examples of Sample Nomenclature

The first ground water sample collected from existing monitoring well WES-1-5-81 at the Mustard Gas Burial Ground for a filtered sample would be designated as 01GW0501 F.

The third ground water sample collected from existing monitoring well WES-1-19-83 for an unfiltered sample would be designated as 01GW1903.

The first unfiltered ground water samples collected from a new monitoring well 01T01 at the Mustard Gas Burial Ground would be designated as 01GWT0101.

A surface soil sample collected from location 21 in the Mustard Gas Burial Ground at the 0-2 foot interval would be designated 01SS210002.

A subsurface soil sample from boring 21 at an interval of 4-6 feet bgs would be designated as 01SB210406.

A sediment sample collected from drainage way location 01 at a depth of 0 – 6" would be designated as 01SD010006.

3.2 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC samples are described in the approved Field Sampling Plan and QAPP. They will be designated using a different coding system. The QC code will consist of a three- to four-segment alphanumeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	F or NNNN
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate

AB = Ambient Conditions Blank

SB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

3.2.2 Examples of Field QA/QC Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 1999, would be designated as FD06039901F.

The third duplicate taken of a subsurface soil sample collected on November 17, 2003, would be designated as FD11170303.

STANDARD OPERATING PROCEDURE
NUMBER 12

CALIBRATION AND USE OF PHOTOIONIZATION DETECTOR

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the maintenance, calibration, and use of a photoionization detector (PID). The procedures for its use are discussed in detail in the following sections.

2.0 GLOSSARY

Electron-volt (eV) - A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum.

Intrinsically Safe (I.S.) - Based on wiring, configuration, design, operation, gasketing, construction, this instrument may be employed within locations where flammable gases and/or vapors may exist.

Ionization Potential (I.P.) - The energy required to remove an electron from a molecule yielding a positively charged ion and a negatively charged free electron. The instrument measures this energy level.

Photoionization Detector (PID) - Photoionization detector employed as general reference to air monitors of this type. PID's detection method employs ultraviolet (UV) radiation as an energy source. As air and contaminants are drawn through the ionization chamber the UV light source causes the contaminant with ionization potentials equal to or less than the UV source to break into positive and negatively charge ions. The created ions are subjected to an electrostatic field. The voltage difference is measured in proportion to the calibration reference and the concentration of the contaminant.

Ultraviolet Radiation (UV) Lamp - Ultraviolet radiation is the energy source employed by the instrument to ionize collected sample gas streams. The UV lamp source is required to be equal to or greater than the ionization potential of the substance drawn through the instrument in order to create separate ionized species.

3.0 REQUIRED EQUIPMENT

Pen

Equipment Calibration Form

Photoionization Detector

Isobutylene Calibration Gas (i.e., span gas)

Regulator

4.0 PROCEDURES

4.1 Principle of Operation

The Photovac portable photoionizer detects many organic (and a few inorganic). The basis for detection of this instrument is the ionization of components gaseous streams. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many compounds associated with industrial activities. Molecules are transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively charged ion and a free electron. The instrument measures this energy level.

This instrument measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations. It does not distinguish between individual substances. Readings displayed represent the total concentration of all photoionizable chemicals present in the sample. This instrument is factory-set to display concentration in units of ppm or mg/m^3. The meter display updates itself once per second.

The 2020 also performs short-term exposure limit (STEL), time-weighted average (TWA) and PEAK calculations. You can view any of these results, but only one mode may be viewed at a time.

The 2020 has 6 keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate 2020. They allow you to manipulate the concentration data in various ways.

All information entered with the keys and stored in the 2020's memory is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be set each time the 2020 is turned on.

4.1.1 Displays

The 2020 has a meter display for reporting detected concentration and a display used for status/ information to guide you through configuration options. All functions of the 2020 will be controlled or reported using one of these displays.

4.1.1.1 Meter Display

The meter display is 4-digits. It will always be used for reporting detected concentration. When the detector and pump are off, the meter display will be blank.

In order to accommodate the range of concentrations the 2020 can detect, the meter reading will be reported using one of 2 resolutions. A resolution of 0.1 will be used for concentrations below 100 ppm, and a resolution of 1 will be used for concentrations above 100 ppm.

4.1.1.2 Status Display

The status display is a 2 line by 16-character display. The top line is used to display status/information and prompts you for your inputs. The bottom line is used for soft key names. Up to 3 names can be displayed for the 3 soft keys. If a name does not appear for a soft key, then the soft key has no associated function.

4.1.2 Keys

4.1.2.1 Fixed Keys

The three round keys below the soft keys each have a fixed function. The first key is the ON/OFF key, the middle key is the EXIT key, and the last key is the ENTER key.

The ON/OFF key is used to both turn power on and off. To turn on the 2020, press the ON/OFF key. To turn the power off, press the ON/OFF key and hold it down for 2 seconds, and then release it. This is done to prevent accidental power off.

The EXIT key provides a way of returning to the default display. In the functional map, the soft keys allow you to advance and the EXIT key provides a way to go back. If you are at the initial entry of the menu, EXIT will return you to the default display.

The ENTER key has a context sensitive function. When you are operating or navigating through the function map, the ENTER key is used to exit the functions and return you to the default display. When entering data such as a name, number, date, or time, ENTER is used to confirm the entry.

4.1.2.2 Soft Keys

The three soft keys on the 2020 are located directly below the status display. Each key has varying functions for configuring the 2020, editing the data logger, and controlling the display. Because only three soft keys are available, each function is broken down into a path.

4.1.2.3 Entering Text With the Soft Keys

For all information that you must enter, the left, center, and right soft keys correspond to the up, down, and right arrow.

The up and down arrows are used to change the character highlighted by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right most character, it wraps around to the first character again. To accept the changes, press the ENTER key. To ignore the change, press EXIT.

Formatting characters, such as the colon (:) in the time, the decimal (.) in a concentration, and the slash (/) in the date are skipped when advancing the cursor.

All inputs are an 8-character input, which is displayed on the right side of the top line of the status display. The prompt, describing the input, occupies the left half of the top line. The soft keys are defined on the bottom line of the status display.

4.2 Default Display

The meter display shows the detected concentration. The resolution of the display changes with the magnitude of the reading. A reading of 0 to 99.9 will be displayed with a resolution of 0.1 ppm. A reading greater than 99.9 will be shown with a resolution of 1 ppm or 1 mg/m^3. The meter will display concentrations up to 2000 ppm or 2(99) mg/m^3.

The status display is used to display the instrument status, date, time, units, and active soft keys.

The default display provides the following information: instrument status, current detected concentration, time, date, and measurement units. The status display toggles between showing time and units and then the date.

When the display mode is MAX, the date and time correspond to the date and time the MAX concentration was recorded. In TWA mode, the time represents the number of hours and minutes during which the TWA has been accumulating. For PEAK and STEL monitoring, the date and time correspond to the current date and time.

4.3 Monitoring

4.3.1 Instrument Status

The instrument status is shown on the left of the first line of the status display and on the Table and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

4.3.2 Alarms

While operating the instrument, any one of three alarm conditions can occur. To accurately identify the source of the alarm, each type of alarm has been given a unique status.

In addition to the status, the 2020 also has an audible alarm and a visual alarm LED. To conserve power, the 2020 alternates between these two alarm indicators, rather than operating both concurrently. Different alarms are identified by the frequency at which the 2020 alternates as follows: PEAK alarm-5 times per second; STEL alarm-2.5 times per second; and TWA alarm-1.25 times per second.

The left soft key is used for acknowledging alarms, and is labeled "Ack." If no alarm exists, then the "Ack" key is not shown. To clear the alarm, press the "Ack" key. Once acknowledged, the alarm indicators are cleared. The alarm status will remain until the alarm condition clears.

The 2020 updates the peak concentration once every second. Following every update, the peak concentration is compared to the peak alarm level, and if exceeded, an alarm is triggered.

If a 15-minute average concentration exceeds the selected STEL, a STEL alarm is generated.

The TWA alarm is generated when the current average concentration over an 8-hour period, since the TWA was last cleared, has exceeded the TWA exposure limit.

During calibration, all alarms are disabled. Once the calibration is complete the alarms are re-enabled.

4.4 STEL, TWA, MAX, and PEAK Operation

The 2020's meter display can be configured to show one of four values: STEL, TWA, PEAK, and MAX.

4.4.1 Short-term Exposure Limit Mode

The STEL mode displays the concentration as a 15-minute moving average. The 2020 maintains 15 samples, each representing a one-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new one-minute average. This moving average provides a 15-minute average of the last 15 minutes with a one-minute update rate. Because the average is calculated using 15 one-minute averages, the meter display will only update once every minute.

The STEL is set to zero each time the instrument is turned on. Because STEL is a 15-minute moving average, there is no need to clear, or reset the STEL.

STEL calculations are always being performed by the 2020. You can display the results of the calculations by selecting "STEL" as the Display mode.

4.4.2 Time-weighted Average (TWA) Mode

The TWA accumulator sums concentrations every second until 8 hours of data have been combined. If this value exceeds the TWA alarm setting, a TWA alarm is generated. The TWA is not calculated using a moving average. Once 8 hours of data have been summed, the accumulation stops. In order to reset the TWA accumulator, press the "Clr" key.

This sum will only be complete after 8 hours, so the meter displays the current sum divided by 8 hours. While you are in TWA mode, the time on the status display will show the number of minutes and hours of data that TWA has accumulated. When this reaches 8 hours, the 2020 stops accumulating data and the TWA is complete.

TWA calculations are always being performed by the 2020. You can display the results of the calculations by selecting TWA as the Display mode.

4.4.3 MAX Mode

The MAX mode displays the maximum signal, with the date and time that it was recorded. The 2020 continues to log data according to the selected averaging interval, but only the maximum detected concentration is displayed on the meter display.

The right soft key is used to clear the meter when displaying MAX. The "Clr" key only affects the reading that the meter is displaying. For example, if you display the MAX reading, and you press "Clr," only the MAX value is cleared. The TWA is still accumulating in the background.

4.4.4 PEAK Mode

The PEAK mode displays the current detected concentration. The reading is updated once a second. In the background, the 2020 data logger is sampling the concentration and measuring minimum, maximum, and average concentrations for the selected averaging interval. At the end of every interval, one entry is placed in the data logger until the data logger is full. For CTO 131, the instrument should be operated in this mode. Operation within the other specialized modes are the responsibility of the SSO.

4.5 Set Functions

Set functions are used to setup the 2020. There are three functions which can be set on the 2020: Pump, Clock, and Calibration.

4.5.1 Pump

The Pump function is used to control the pump. After selecting “Set Pump”, the 2020 responds by displaying the new pump status.

The detector is also turned off when you turn the pump off. This prevents the detector from being damaged when there is no sample flowing through the detector.

When the pump and the detector are off, the meter display will be blank. Turn the pump and detector off when concentration measurements are not necessary, and the 2020 will only be used for reviewing data

or generating reports. By operating the instrument with the pump and detector off when you do not need them, you will conserve the lives of the battery and ultraviolet (UV) lamp.

To set the pump:

1. Press the ENTER key. The top line of the status display changes to "Select?". The bottom line displays 3 soft key names: "Set," "Log," and "Disp."

2. Press the soft key below "Set."

3. The names of the soft keys change to reflect the Set options. The display now shows 3 devices which can be set: "Clock," "Pump," and "Cal." Press the "Pump" key.

4. The 2020 turns the pump off. If the pump was off, pressing "Pump" will turn the pump on.

5. A message will be displayed to show you the status of the pump. The 2020 reverts back to the previous menu after a few seconds.

6. To return to the default display, press the ENTER key.

4.5.2 Clock

The Clock function is used to set both the current date and time.

To set the clock:

1. Press the ENTER key.

2. Press the "Set" key.

3. When the names of the soft keys change, press the "Clock" key.

   The up and down arrows are used to change the character underlined by the cursor. The right arrow is used to advance the cursor to the next character on the right. When the cursor is advanced past the right-most character, it wraps around to the first character again.

Formatting characters, such as the colon (:) in the time and the slash (/) in the date are skipped when advancing the cursor.

4. Use the "arrow keys" to enter the correct time. The time is formatted as Hour:Minute:Second.

5. Press the ENTER key to confirm the time and move to the date option.

6. When setting the date, the 2020 prompts you for the current date formatted as Year/Month/Day. Use the "arrow keys" to enter the correct date.

7. Press the ENTER key to confirm the date and return to the Set options. You can wait for the display to timeout or press ENTER to return to the default display.

4.5.3 Calibration (Cal)

"Cal" allows you to setup and calibrate the 2020. There are three options under the Cal function: "Zero," "Span," and "Mem."

A calibration memory consists of a name, a response factor, and PEAK, TWA, and STEL alarm levels.

The "Zero" and "Span" keys are covered in detail in the manufacturer's operations manual for the instrument.

To edit the calibration memory, select "Mem" and then "Chng." The 2020 prompts you with two new soft keys: "User" and "Lib."

4.5.4 Library (Lib)

Library selections simplify Cal Memory programming, and provide standard response factors for approximately 70 applications. "Lib" allows you to select an entry from a pre-programmed library. The name, response factor, and three alarm levels are all set from the library. To select a library entry to program the selected Cal Memory:

1. Select "Set," "Cal," "Mem," "Chng," and "Lib."
2. Use the "Next" and "Prev" keys to scroll through the list. See the manufacturer's manual Appendix 8.7 for a list of the library entries.

4.6 Preparing for Field Operation of the Photovac 2020

Turning The 2020 On

1. Turn the 2020 on by pressing the ON/OFF key.

2. The 2020 will display the software version number. Wait for the 2020 to proceed to the default display.

3. Allow 10 minutes for the instrument to warm up and stabilize.

4. Press the Enter Key. The default display will provide 3 soft key selection "Set," "Log," and "Display."

5. Press "Set." From this option, 3 other soft key selections will be offered: "Pump," "Clock," and "Cal."

6. Press "Cal." This will begin the calibration sequence. The first selection is to Zero the instrument.

7. Press Enter, zeroing will begin. (Note: When employing zero gas attach and activate zero gas supply at this time.)

8. The next selection offered will be Span. Press Enter at which time the concentration will be requested. The isobutylene calibration gas employed under general service will be marked on the side of the container. Use the soft keys to toggle into position and to log the concentration. Once the concentration is logged press "Enter." The direction on the status display will indicate spanning. At this time hook up the span gas with a regulator to the Photovac 2020, and open it to supply enough flow to elevate the flow rate indicator to the green indicator line (1/8" from the rest position).

9. Once spanning is complete, the alarms, which have been disabled during calibration, will activate indicating that calibration is complete.

10. Document this calibration procedure using a Document of Calibration form (included in Appendix A).

This instrument is ready for general purpose application.

Calibration is to be performed daily or prior to each use in accordance with this section.

4.7 Maintenance and Calibration Schedule

Function	Frequency
Routine Calibration	Prior to each use
Factory Inspection and Calibration	Once a year, or when malfunctioning
Wipe Down the Outer Casing of the Unit	After each use
Clean UV Light Source	Every 24 hours of operation
Sample Inlet Filter	Change on a weekly basis or as required by level of use
Battery charging	After each use
Clean ionization chamber	Monthly

4.7.1 Cleaning the UV Light Source Window

1. Turn the FUNCTION switch to the OFF position. Use the 2020 multi-tool and remove the lamp housing cover. CAUTION: The UV lamp is delicate and expensive-handle carefully.

2. Tilt the lamp housing with one hand over the opening, slide the lamp out of the housing.

3. The lamp window may now be cleaned with any of the following compounds using lens paper:
   a. 11.7 eV Lamp - Dry Aluminum Oxide Powder (3.0 micron powder)
   b. All other lamps-HPLC Grade Methanol

4. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

5. Recalibrate the instrument as per Section 4.6.

4.7.2 Cleaning the Ionization Chamber

1. Turn the FUNCTION switch to the OFF position and remove the lamp housing cover and lamp as per Section 4.7.1.

2. Using a gentle jet of compressed air, gently blow out any dust or dirt.

3. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace the o-ring as necessary, reinstall the lamp housing cover, and tighten it using the 2020 multi-tool. (Do not over tighten).

4. Recalibrate the instrument as per Section 4.6.

4.8 Instrument Advantages

The Photovac 2020 is easy to use in comparison to many other types of monitoring instrumentation. Its detection limit range is in the low parts-per-million range. Response rapidly reaches 90 percent scale of the indicated concentration (less than 3 seconds for benzene). This instrument's automated performance covers multiple monitoring functions simultaneously, incorporating data logging capabilities.

4.9 Limitations of the Photovac 2020 Photoionization Monitor

- Because the 2020 is a nonspecific total gas/vapor detector, it cannot be used to identify unknown chemicals; it can only quantitate them in relationship to a calibration standard (relative response ratio).

- For appropriate application of the 2020, ionization potentials of suspected contaminants must be known.

- Because the types of compounds that the 2020 can potentially detect are only a fraction of the chemicals possibly present at a hazardous waste site or incident, a background or zero reading on this instrument does not necessarily signify the absence of air contaminants.

- The 2020 instrument can only monitor certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected.

- PID's are generally not specific. Their response to different compounds is relative to the calibration gas used. This is referred to as relative response ratio. Instrument readings may be higher or lower than the true concentration. This can be an especially serious problem when monitoring for total contaminant concentrations if several different compounds are being detected at once.

- The 2020 is a small, portable instrument which cannot be expected to yield results as accurately as laboratory instruments.

4.9.1 Variables Affecting Monitoring Data

Monitoring a hazardous waste site environment can pose a significant challenge in assessing airborne concentrations and the potential threats to site personnel. Several variables may influence both dispersion and the instrument's ability to detect actual concentrations. Some of the variables, which may impact these conditions, are as follows:

- Temperature - changes in temperature or pressure will influence volatization, and affect airborne concentrations. Additionally, an increase or decrease in temperature ranges may have an adverse effect on the instrument's ability to detect airborne concentrations.

- Humidity - excessive levels of humidity may interfere with the accuracy of monitoring results.

- Rainfall - through increased barometric pressure and water, may influence dispersion pathways affecting airborne emissions.

- Electromagnetic interference - high voltage sources, generators, other electrical equipment may interfere with the operation and accuracy of direct-reading monitoring instruments.

5.0 TROUBLESHOOTING

5.1 Fault Messages

When the "Fault" status is displayed, the 2020's operation is compromised.

Fault 1: Signal from zero gas is too high.

Cause: If another fault occurred while the 2020 was setting its zero point, then this fault is displayed.

Action: Ensure no faults are occurring and calibrate the 2020 again.

Cause: Contamination of sample line, sample probe, or fittings before the detector.

Action: Clean or replace the sample line, sample probe, or the inlet filter.

Cause: Span gas and zero air are switched.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of ambient air, use a supply of commercial zero grade air to zero the 2020.

Fault 2: Signal from span gas is too small.

Cause: Operator may have switched the span gas and zero air.

Action: Ensure clean air is used to zero the 2020. If you are using gas bags, mark the calibration and zero gas bags clearly.

Action: Ensure the span gas is of a reliable concentration.

Cause: UV lamp window is dirty.

Note: Do not remove the detector lamp in a hazardous location.

Action: Clean the UV lamp window.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Incompatible application.

Action: The concentration and sample gas are incompatible for use with the 2020.

Fault 3: UV lamp fault. UV lamp has not started.

Cause: The UV lamp has not started immediately.

Action: This fault may be seen momentarily when 2020 is first turned on. Allow 30 to 60 seconds for the UV lamp to start and the fault to clear.

Cause: The UV lamp serial number label is blocking the photocell.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the label is blocking the photocell. Rotate the lamp approximately 90 degrees and then try to start the 2020 again. If the fault persists, replace the lamp.

Cause: the UV lamp is not installed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a UV lamp.

Cause: The UV lamp has failed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Electronic problem.

Action: If a new UV lamp still generates this fault, then contact the Photovac Service Department.

Fault 4: Pump current too low or too high.

Cause: If the pump sounds labored, then the pump is operating beyond normal operating parameters.

Action: Check for an obstruction in the sample line. Make sure sample line, sample probe or inlet filter are not plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Action: Ensure the sample outlet, located on the underside of the 2020, is not obstructed.

Cause: The UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: The pump has failed.

Action: Contact the TtNUS Equipment Manager.

5.2 Specific Problems

Problem: Very low or no instrument response detected, yet compounds are known to be present.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6 of the User's Manual. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the TtNUS Equipment Manager.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Disconnect the battery charger before calibrating the 2020.

Cause: Calibration Memories have not been programmed correctly.

Action: Program all the calibration memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory.

Cause: The response factor has been set to zero.

Action: Enter the correct response factor. Refer to Appendix 8.6 for a list of response factors. If the compound is not listed in Appendix 8.6 or you are measuring gas mixtures, then enter a value of 1.0. See User's Manual.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector is leaking. A decrease in sensitivity may be due to a leak in the detector.

Note: Do not remove or replace the detection lamp in a hazardous location.

Action: Ensure the UV lamp has been installed correctly.

Action: Ensure the lamp cover has been tightened down. Do not overtighten the cover.

Action: Ensure the o-ring seal on the lamp cover is positioned correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The sampling environment is extremely humid.

Action: Water vapor is not ionized by the PID, but it does scatter and absorb the light and results in a lower reading. The 2020 detector has been designed to operate under high humidity conditions. Under extreme conditions you may notice decreased response due to humidity.

Cause: The UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: High concentration of non-ionizable compounds. Chemical compounds, such as methane, with IPs greater than the 10.6 eV scatter and absorb the UV light. Sensitivity may be decreased significantly. Application with high backgrounds of such materials, may be incompatible with the 2020. Contact the Photovac Applications Group for more information.

Problem: Erroneously high readings.

Cause: Sampling environment is extremely humid.

Action: Water vapor may contain mineral salts, which carry a charge. The water vapor becomes an electrolytic solution, which becomes ionized when it enters the detector. Atmospheric water in areas around the sea or stagnant water may produce a response in the absence of contaminants. The same effect may be seen when conducting ground water investigations in areas where the water is hard because it contains a significant concentration of minerals.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Section 4.6. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not contact the TtNUS Equipment Manager.

Cause: Cal Memories have not been programmed correctly.

Action: Program all the Cal Memories you require for your application. You must use the correct calibration gas and concentration for each Cal Memory. See Section 3.4, of the User's Manual.

Cause: You are not using the correct Cal Memory.

Action: Select the correct Cal Memory for your application. See Section 3.2.2 or 3.3.2, of the User's Manual.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: The Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Date and time settings are not retained.

Cause: The battery pack has been removed before the 2020 was turned off.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack and reset the time and date. Ensure that the 2020 has been turned off before removing the battery pack.

Cause: The 2020 has not been used for 3 months or more and the internal battery (not the external battery pack) has discharged.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Connect the 2020 to the AC adapter and turn the 2020 on. Turn the pump off. While the 2020 is running the internal battery is charging. Leave the instrument running for approximately 24 hours.

Problem: Instrument status shows "Over."

Cause: High concentrations of gases and vapors will cause a rapid change in signal level. The detector and associated electronics may become temporarily saturated.

Action: Wait a few seconds for the status to return to normal. PIDs are designed to detect relatively low concentrations of gases and vapors. Exposure to very high concentrations may result in a very high or maximum response.

Cause: The detector has become saturated.

Action: Move the 2020 to a location where it can sample clean air. Sample clean air until the reading stabilizes around 0.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust or dirt in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the TtNUS Equipment Manager.

Problem: Display is blank.

Cause: Battery pack is critically low.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack or connect the 2020 to the AC adapter.

Cause: The battery pack is not connected to the instrument correctly.

Action: Ensure the battery pack connector is securely attached to the connector on the 2020.

Cause: There is an undetermined problem.

Action: Reset the 2020. You must leave the instrument on while you disconnect the battery pack. This will reset the instrument. Reconnect the battery pack and close the battery hatch. Turn on the 2020, set the time and date and program all the calibration memories that you are using.

Action: Contact the TtNUS Equipment Manager.

Problem: Sample flow rate is less than 300 ml/min.

Cause: The inlet filter is plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Cause: The inlet filter has not been installed properly.

Action: Ensure that the inlet filter has been installed correctly.

Cause: The UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the TtNUS Equipment Manager.

Cause: The UV lamp is too wide, causing flow to be restricted.

Action: If you have a UV lamp with a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the TtNUS Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the TtNUS Equipment Manager.

Cause: Sample outlet is obstructed.

Action: Ensure the sample outlet is not obstructed in any way.

Cause: Pump has been damaged.

Action: Contact the TtNUS Equipment Manager.

Problem: Liquid has been aspirated.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter.

Action: Contact the TtNUS Equipment Manager.

Problem: Corrosive gases and vapors have been sampled.

Cause: The 2020 has been exposed to corrosive gases and vapors.

Action: Corrosive gases and vapors can affect the electrodes within the detector as well as the lamp window. Prolonged exposure to corrosive materials may result in permanent fogging or etching

of the window. If the 2020 is exposed to corrosive material, contact the TtNUS Equipment Manager.

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no calibration gas cylinder accompanying the kit. When shipping or transporting the calibration gas, a Hazardous Airbill must be completed.

7.0 REFERENCES

Photovac 2020 Photoionization Monitor User's Manual, 1995.

8.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME/MODEL: PID 2020

PROJECT NAME: NSWC CRANE

MANUFACTURER: Photovac

PROJECT NUMBER: CTO-038/7651

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

STANDARD OPERATING PROCEDURE
NUMBER 13

CALIBRATION AND CARE OF WATER QUALITY METER

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for the calibration and maintenance of field instruments used to measure water quality, and for the proper documentation of calibration and maintenance. The YSI 6-Series Environmental Monitoring System will be used to measure pH, temperature, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and turbidity in water. The YSI meter has a multiprobe sensor, which can be used in conjunction with a flow-through cell attached to a pump discharge tube to measure water quality parameters in a ground water discharge, or can be immersed in a surface water body such as a stream, pond, or drainage ditch.

2.0 FIELD FORMS AND EQUIPMENT LIST

The following log books, forms, equipment and supplies are required.

Site Log Book
Equipment Calibration Log Sheet
YSI Model 610-D and Sonde: multi-parameter water quality meter with flow through cell
Equipment Manual
Calibration Kit
Deionized water, paper towels, spray bottle etc.

3.0 PROCEDURES

This section describes the calibration procedure for the YSI Model 610-D. The meter is supplied with an instruction manual. Sections of this manual are reproduced in this SOP. The manual will be on-site and used as the calibration guidance document for the meter's calibration (page 29 section 2.6 of the manual starts the calibration procedure). This procedure will list requirements for frequency of calibration and checks to be performed on the meter.

The YSI Model 610-D and Sonde is a multi-parameter, water quality meter that may be used to measure open water bodies (streams, ponds, springs, etc.) with the probe guard installed. With the flow through cell attached, the meter has the ability to measure water quality parameters in ground water via a pump discharge line. By performing the measurements in the discharge line coming directly from the well, the parameters are measured prior to the ground water coming in contact with the atmosphere. The parameters measured by the YSI for this field effort are:

- Dissolved Oxygen (DO)
- Specific Conductance (SC)
- Temperature
- pH
- Oxidation-reduction Potential (ORP)
- Turbidity

3.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the Manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

3.2 Calibration

All of the parameters listed in Section 3.0 must be calibrated prior to the start of each field effort. After this initial calibration, the YSI will be checked each day that it is used. If the check shows any out-of-spec readings, the specific probe will be recalibrated. Meter specifications can be found in the equipment manual, starting on page 248. Calibration and calibration checks will be documented in the Field Logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration buffers and standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of rental company will also be recorded on the equipment calibration form.

3.3 Tips for Good Calibration

- The DO calibration is a water-saturated air calibration. Make certain to loosen the calibration cup seal to allow pressure to equilibrate before calibrating.

- Make certain that sensors are completely submersed in solution and readings are stable when calibration values are entered.

- Use a small amount of calibration solution (previously used solution may be used, then discarded for this purpose) to pre-rinse the sonde.

- Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.

- Make sure to rinse and dry the probe between calibration solutions. This will reduce carry-over contamination and increase the accuracy of the calibration.

4.0 MAINTENANCE

The YSI Meter will be rented for the duration of each brief field effort. Therefore, little field maintenance will be required. For any maintenance other than the routine cleaning, calibrating, or battery charging, the instrument should be returned to the vender and a replacement sent immediately to the job site.

4.1 Meter Storage

For this field effort, the meter storage will be short term, i.e. over-night or between work shifts (4-day break). During these breaks the meter shall be placed on charge. One-half inch of tap or distilled water shall be placed in the meter calibration cup and the cup threaded onto the sonde. The key for short-term storage of probes is to use a minimal amount of water so that the calibration cup will remain at 100% humidity. The water level must be low enough so that none of the probes are actually immersed. Proper storage of the sonde between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

Multi-parameter short term storage key points:

- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.

- Check periodically to make certain that water is still present.

4.2 Probe Cleaning

- Rinse the probe thoroughly with potable water.
- Wash the probe in a mild solution of Liquinox and water and wipe with paper towels and/or cotton swabs.
- Rinse and soak the probe in deionized water.
- If stronger cleaning is required, consult section 2.10 page 89 of the equipment manual.

Note: Reagents that are used to calibrate and check the YSI may be hazardous. Review Health and Safety Plan, Appendix A of the equipment manual, and MSDS's, all of which are on file in the field trailer.

5.0 ATTACHMENTS

1. Equipment Calibration Log

ATTACHMENT 1
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		

STANDARD OPERATING PROCEDURE
NUMBER 14

SAMPLE CUSTODY AND DOCUMENTATION OF FIELD ACTIVITIES

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for sample custody and documentation of field sampling and field analyses activities.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following logbooks, forms, and labels, are required.

Site Logbook
Field Logbook
Sample label and tag
Chain-of-Custody form
Custody seals
Equipment Calibration Log
Monitoring Well Inspection Form
Water Level Measurement Form
Low-Flow Purge Data Sheet
Ground Water Sample Log Sheet
Surface Water Sample Log Sheet

3.0 PROCEDURES

This section describes custody and documentation procedures. All entries made into the logbooks, custody documents, logs, and log sheets described in this SOP must be made in indelible ink (black is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, initialed, and dated.

3.1 Site Logbook

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

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of sampling activities
- Daily on-site activities performed each day
- Sample pickup information
- Health and safety issues
- Weather conditions

The site logbook is initiated at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that on-site activities take place.

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

- Project name
- Project number
- Book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). At the completion of each day's entries, the site logbook must be signed and dated by the Field Operations Leader (FOL).

3.2 Field Logbooks

The Field Logbook is a separate dedicated notebook used by field personnel to document his or her activities in the field. This notebook is hardbound and paginated.

3.3 Sample Labels and Tags

Adhesive sample container labels must be completed and applied to every sample container. Information on the label includes the project name, location, sample number, date, time, preservative, analysis, matrix, sampler's initials, and the name of the laboratory performing the analysis. A tag containing the same information shall also be completed and tied to each sample container.

3.4 Chain-of-Custody Form

The Chain-of-Custody form (COC) is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as it is transferred from person to person. Each COC is numbered. This form must accompany any samples collected for laboratory chemical analysis. A copy of a blank chain-of-custody form is attached at the end of this SOP.

The FOL must include the name of the laboratory in the "Remarks" section to ensure that the samples are forwarded to the correct location. If more than one COC is necessary for any cooler, the FOL will indicate "Page __ of __" on each COC. 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. Once the samples are received at the laboratory, the sample custodian checks the contents of the cooler(s) against the enclosed COC(s). Any problems are noted on the enclosed COC form (bottle breakage, discrepancies between the sample labels, COC form, etc.) and will be resolved through communication between the laboratory point-of-contact and the Task Order Manager (TOM). The COC form is signed and retained by the laboratory and becomes part of the sample's corresponding analytical data package.

3.5 Custody Seal

The Custody Seal is an adhesive-backed label with a number on each seal. It is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The Custody Seals are signed and dated by the samplers and affixed across the opening edges of each cooler (two seals per cooler) containing environmental samples. The laboratory sample custodian will examine the Custody Seal for evidence of tampering and will notify the TOM if evidence of tampering is observed.

3.6 Equipment Calibration Log

The Equipment Calibration Log is used to document calibration of measuring equipment (e.g., multi-parameter water-quality meter) used in the field. The Equipment Calibration Log 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 requiring calibration. Entries must be made for each day the equipment is used.

3.7 Water-Level Measurement Form

The Water Level Measurement Form is used to document the determination of water levels in monitoring wells.

3.8 Low-Flow Purge Data Sheet

The Low-Flow Purge Data Sheet is used to document field measurements made while purging wells to stabilization.

3.9 Ground Water Sample Log Sheet

The Ground Water Sample Log Sheet is used to document the samples taken from a monitoring well at the end of low-flow well purging.

3.10 Surface Water Sample Log Sheet

The Surface Water Sample Log Sheet is used to document the samples collected from surface waters.

3.11 Soil and Sediment Sample Log Sheet

The Soil and Sediment Sample Log Sheets are used to document the sampling of soils and sediments.

4.0 ATTACHMENTS

1. Chain-of-Custody Record

ATTACHMENT 1
CHAIN-OF-CUSTODY RECORD

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

DATE YEAR ____	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G)	PRESERVATIVE USED	TYPE OF ANALYSIS							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

STANDARD OPERATING PROCEDURE
NUMBER 15

SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for sample preservation, packaging, and shipping to be used in handling ground water, surface water (including seeps), soils, and sediments collected at the NSWC Crane.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Shipping labels
Custody seals
Chain-of-custody (COC) form(s)
Sample containers with preservatives: All sample containers for analysis by fixed-base laboratories will be supplied, with preservatives added (if required) and deemed certified clean by the laboratory.
Sample shipping containers (coolers): All sample shipping containers are supplied by the laboratory.
Packaging material: Bubble wrap, ZipLoc® bags, strapping tape, etc.

3.0 PROCEDURES FOR SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

3.1 The laboratory provides sample containers with preservative already included (as required) for the analytical parameter for which the sample is to be analyzed. All samples will be held, stored, and shipped at 4°C. This will be accomplished through refrigeration (used to hold samples prior to shipment) and/or ice.

3.2 The sampler shall maintain custody of the samples until the samples are relinquished to another custodian or to the common carrier.

3.3 Check that each sample container is properly labeled, the container lid is securely fastened, and the container is sealed in a ZipLoc® bag.

3.4 If the container is glass, place the sample container into a bubble-out shipping bag and seal the bag using the self-sealing, pressure sensitive tape supplied with the bag.

3.5 Inspect the insulated shipping cooler. Check for any cracks, holes, broken handles, etc. If the cooler has a drain plug, make certain it is sealed shut, both inside and outside of the cooler. If the cooler is questionable for shipping, the cooler must be discarded.

3.6 Put ice into ZipLoc® bags and place a layer of the sealed bags on the bottom of the cooler. Place the sample containers into the shipping cooler on top of the ice in an upright position (containers will be upright, with the exception of the 40-ml vials). Place ZipLoc® bags of ice flat against the sides of the cooler. Continue filling the cooler with samples until the cooler is nearly full and the movement of the sample containers is limited.

3.7 Place a temperature blank in the cooler. Make sure that all samples identified for VOC analysis and their associated trip blank are packed in the same cooler (i.e., VOC samples and trip blank that were stored together during sampling activities can not be separated into different coolers for shipping purposes).

3.8 Add a final layer of ice sealed in ZipLoc® bags to the top of the samples just before the cooler is closed and sealed.

3.9 Place the original (top) signed copy of the COC form inside a large ZipLoc® bag. Tape the bag to the inside of the lid of the shipping cooler that contains the samples for VOC analysis.

3.10 Close the cooler and seal the cooler with approximately four wraps of strapping tape at each end of the cooler. Prior to wrapping the last wrap of strapping tape, apply a signed, numbered, and dated custody seal to each side of the cooler (one per side). Cover the custody seal with the last wrap of tape. This will provide a tamper evident custody seal system for the sample shipment.

3.11 Affix a shipping label to the top of the cooler containing samples for VOC analysis, ensuring all of the shipping information is filled in properly. Overnight (e.g., FedEx Priority Overnight) courier services will be used for all sample shipments.

3.12 All samples will be shipped to the laboratory no more than 72 hours after collection. Under no circumstances will sample hold times be exceeded.

STANDARD OPERATING PROCEDURE
NUMBER 16

DECONTAMINATION OF FIELD SAMPLING EQUIPMENT

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures to be followed when decontaminating non-dedicated field sampling equipment during field investigations.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Waterproof pens
Non-latex Rubber or Plastic Gloves
Cotton Gloves
Field Log Book
Potable Water
Deionized Water
LiquiNox Detergent
Brushes, Spray Bottles, Paper Towels, etc.
55-Gallon Drum or Other Container to Collect and Transport Decontamination Fluids

3.0 DECONTAMINATION PROCEDURES FOR SAMPLING EQUIPMENT

3.1 Don non-latex and/or cotton gloves and decontaminate sampling equipment (in accordance with the following steps) prior to field sampling and between samples.

3.2 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.3 Wash the equipment with a solution of LiquiNox detergent. Prepare the LiquiNox wash solution in accordance with the instructions on the LiquiNox container. Collect the LiquiNox wash solution into a container. Use brushes or sprays as appropriate for the equipment.

3.4 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.5 Rinse the equipment with deionized water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the deionized water rinsate into a container.

3.6 Remove excess water by air drying, shaking, or by wiping with paper towels as necessary.

3.7 Document decontamination by recording it in the Field Logbook.

4.0 DECONTAMINATION PROCEDURES FOR PUMPING EQUIPMENT

This sequence of decontamination applies to the pump, hoses, cables, and other equipment placed in a monitoring well to obtain a groundwater sample.

4.1 Wash pump, hose, and cables in a tub containing potable water. Use brushes as appropriate.

4.2 Wash pump, hose, and cables in a tub containing LiquiNox wash solution. Use brushes as appropriate.

4.3 Rinse pump, hose, and cables in a tub containing clean potable water.

4.4 Pump clean potable water through pump and hoses for 15 minutes.

4.5 Drain and air dry all equipment.

4.6 Place decontaminated equipment into new plastic trash bags and store until next use.

APPENDIX B

REFERENCE MATERIAL

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE IDPT

BORING No.: 01 SB01
DATE: 8-26-01
GEOLOGIST: WILDKWYCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN	SILTY CLAY	CL	ROOTS				
S-1	2		2/2				GRAVEL		DAMP	0	0	0	0
									GRAVEL				
S-2	4		1/2						DAMP	0	0	0	0
						DRK	CLAY		DAMP				
S-3	6		2/2	5.5		GRY	SANDY SILT (WEATHERED BEDROCK)	SM	DRY	0	0	0	0
				TD 6'			REFUSAL @ 6'						

* When rock coring, enter rock brokeness.

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

Remarks: 2" x 4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes _____ No X Well I.D. #: _____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: 015B02
DATE: 8-26-01
GEOLOGIST: WUDKWYCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN ORG	CLAY S-SILT	CL	ROOTS				
S-1	2		2/2			GRY	MOTTLED		DRY	0	0	0	0
				2.5		BRN	SILT S-CLAY	ML					
S-2	4		2/2	4		ORG			DRY	0	0	0	0
							CLAY T-F SAND	CL					
S-3	6		2/2				MOTTLED		DRY	0	0	0	0
				6.5			SILT PIECES OF SANDSTONE	ML					
S-4	8		2/2						DRY CRUMBLY	0	0	0	0
						ORG							
S-5	10		1.5/2	9.5		GRY	SILTSTONE		DRY CRUMBLY	0	0	0	0
				TD 9.5			REFUSAL @ 9.5						

* 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): 0

Remarks: 2"x4' MACROCORE

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE

BORING No.: 01SB03
DATE: 8-26-01
GEOLOGIST: WV DKW YCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN	SILTY CLAY	CL					
S-1	2		2/2			ORG BRN	MOTTLED	CL	DRY	0	0	0	0
S-2	4		2/2			BRN ORG	SILT S-CLAY	ML	DAMP	0	0	0	0
				4.5		BRN ORG	CLAY S-SILT	CL					
S-3	6		2/2			"	"	"	DRY	0	0	0	0
S-4	7		1/2			BRN	SILT	ML	DRY				
				TD 7'			REFUSAL @ 7'						

* When rock coring, enter rock brokeness.

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

Remarks: 2" x 4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRCANE

BORING No.: 01SB04
DATE: 8-26-01
GEOLOGIST: WUDKWYCH
DRILLER: KEVIN RIFFE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN			ROOTS				
S1	2		2/2			ORG	CLAY S-SILT	CL	DAMP	0	0	0	0
				3			↓	L					
S2	4		2/2				SILT T-SAND	ML	DRY	0	0	0	0
				5			↓ PIECES OF SANDSTONE	↓					
S3	6		2/2			GRY ORG	CLAY MOTTLED	CL	DRY	0	0	0	0
				6.7			↓ U/SILT	↓					
S4	8		2/2				SILT T-F SAND	ML	DRY CRUMBLY	0	0	0	0
							↓ (WEATHERED)						
S5	10		2/2		DENSE	GRY BRN	SILT	↓	DRY CRUMBLY	0	0	0	0
				TD 10'									

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4" MACROCORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: 015B05
DATE: 8-26-01
GEOLOGIST: W. DRWYCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole*	Driller BZ**
						BRN	SILT S-CLAY	ML	ROOTS				
S-1	2		2/2			↓	↓	↓	DRY	0	0	0	0
						BRN ORG	SILT + FG SAND	SM					
S-2	4		1.5/2						DRY	0	0	0	0
S-3	6		2/2						DRY	0	0	0	
S-4	8		2/2						DRY	0	0	0	0
S-5			0.5/2	TD 8.5'			REFUSAL (BEDROCK) @ 8.5'						

* 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: 2" x 4' MACRO CORE

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE/DPT

BORING No.: 01SB06
DATE: 8-27-01
GEOLOGIST: WUDKWYCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						DRK		ML					
S-1	2		2/2			GRN	SILT		DRY	0	0	0	0
S-2	4		1.2/2	4		BRN			DRY	0	0	0	0
						ORG	CLAY S-SILT MOTTLED	CL					
S-3	6		2/2			GRY			DRY	0	0	0	0
						ORG	SILTY CLAY						
S-4	8		2/2	8		GRY	MOTTLED		DRY CRUMBLY	0	0	0	0
							SILT (WEATHERED BEDROCK)	ML					
S-5	10		2/2						DRY CRUMBLY	0	0	0	0
S-6			0.5/2	TD 10.5			SILTSTONE						
							REFUSAL @ 10.5'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE

BORING No.: 015B07
DATE: 8-27-01
GEOLOGIST: WOOKWYCH
DRILLER: RIFFE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole*	Driller BZ**
						BRN	CLAYEY SILT	ML					
S-1	2		2/2			ORG	↓	↓	DRY	0	0	0	0
						↓	SILT						
S-2	4		2/2				↓		DRY	0	0	0	0
							PIECES OF SANDSTONE (WEATHERED BEDROCK?)	↓	DRY	0	0	0	0
S-3	6		1/2	TD 5'									
							REFUSAL @ 5'						

* When rock coring, enter rock brokeness.

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

Remarks: 2" x 4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: 01SB08
DATE: 8-21-01
GEOLOGIST: WUDKNYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						LIGHT BRN	SILT	ML	ROOTS				
S1	2		1.5/2						DRY	0	0	0	0
							CALICHE NODULES						
S-2	4		2/2	4			T-CLAY		DRY	0	0	0	0
						ORG	SILT + FGR SAND	SM					
S-3	6		2/2			GRY	SANDSTONE FRAGS		DRY POWDERY	0	0	0	0
							WEATHERED SANDSTONE						
S-4	8		2/2			ORG RED			DRY	0	0	0	0
						GRY				13			
	10			10		ORG				0	0	0	0
					V. SOFT		SILT STONE		DRY				
OVER PACK S5	12		3/4				WEATHERED		CRUMBLY	0	0	0	0
				TD 12'			REFUSAL @ 12'	IRON STAINING IN SHOE					

* When rock coring, enter rock brokeness.

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

Remarks: (2" x 4') MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: OU5B09
DATE: 8-26-01
GEOLOGIST: WOOKWYCH
DRILLER: RIFFE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN ORG	SILTY CLAY	CL	ROOTS				
S-1	2		1.5/2						DAMP	0	0	0	0
S-2	4		2/2						DAMP	0	0	0	0
S-3	6		2/2						DRY	0	0	0	0
S-4			0.5/2	TD 6.5'			BEDROCK REFUSAL @ 6.5'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACROCORE

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE IDPT

BORING No.: 01SB10
DATE: 8-27-01
GEOLOGIST: WUDKWYCH
DRILLER: RIFFE

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN	SILT gravel	ML	ROOTS				
S-1	2		2/2			BRN DBR	S-CLAY		DRY	0	0	0	0
							SILT						
S-2	4		2/2	4			GRADING TO		DRY	0.1	0	0	0
							SILTY CLAY	CL					
S-3	6		2/2				S-SAND			0.1	0	0	0
S-4	7		1/2			ORG GRY	SILT/CLAY + SAND PIECES OF SANDSTONE		DRY				
				TD 7'			REFUSAL @ 7'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACROCORE

Drilling Area Background (ppm): 0

Converted to Well: Yes _____ No X Well I.D. #: _____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE 10PT

BORING No.: 015B11
DATE: 8-22-01
GEOLOGIST: WUDKWYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN	SILT	ML	ROOTS				
S-1	2		1.5/2			↓			DRY	3.4	0	0	0
						BRN GRY	S-CLAY		MOTTLED				
S-2	4		2/2			ORG	CALCHE		DRY	0	0	0	0
				4.5		ORG	SILT W/SAND	ML					
S-3	6		2/2			↓			DRY	0	0	0	0
						ORG							
S-4	8		2/2			GRY	(WEATHERED BEDROCK)		DRY	0	0	0	0
S-5	10		2/2			↓		↓	DRY	0	0	0	0
				TD 10'									

* 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): 0

Remarks: 2"x4' MACROCORE

Converted to Well: Yes _____ No X Well I.D. #: _____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE DPT

BORING No.: 01SB12
DATE: 8-25-01
GEOLOGIST: K. SIMPSON
DRILLER: EFS, KEVIN RIFFE

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole*	Driller BZ**
	0'						WEED AREA						
	1				SOFT	BRN	SILT TR FINE SAND	SM	MOIST, TR ROOTS	SEE			
	2			2/2						SCREENING			
	3					ORN BRN	CLAY SOME SILT TR F. SAND	CL	MOIST		LOG		
	4			3/2	MED. DENSE				TR RUST NODULES				
	5												
	6			2/2			MED SAND SOME CLAY	SC	WEATHERED SANDSTONE				
	7				STIFF		TR SANDSTONE FRAGS.		MOTTLED GRAY, BRIX				
	8			3/2		TAN GRAY	F TO MED SAND SOME CLAY TR ROCK FRAG.		(SOME CLAY)				
	9							SM					
	10			2/2	VERY STIFF	GRAY	WEATHERED SANDSTONE		MOIST				
				TD 10'									

* When rock coring, enter rock brokeness.

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

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: GEOPROBE

BORING No.: 01SB13
DATE: 8-24-01
GEOLOGIST: WUOKWYCH
DRILLER: STRATI

	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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
							BRN	SILT S-CLAY	ML	ROOTS				
140-220	S-1	2		2/2			↓	↓	↓	DAMP	0	0	0	0
							ORG GRY	SILTY CLAY	CL					
	S-2	4		2/2			↓	↓ MOTTLED	↓	DRY	0.3	0	0	0
					4.2			Clayey SILT	ML					
	S-3	6		2/2	6.5		↓							
							org	SAND+SILT	SM	DAMP	0	0	0	0
								clayey SILT T-SAND	ML					
	S-4	8		2/2			↓	↓ PIECES OF SANDSTONE		DRY	0	0	0	0
							ORG GRY	SILT T-CLAY						
	S-5	10		2/2			↓	↓	↓	DRY	0	0	0	0
					TD 10'									

* 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): 0

Remarks:

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: GEOPROBE

BORING No.: OLSB14
DATE: 8-24-01
GEOLOGIST: WUDKWYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						DRK BRN	SILT	ML	ROOTS	0			
S-1	2		2/2			BRN	SILT & CLAY	CL	DAMP	0	0	0	0
						BRN ORG							
S-2	4		2/2			↓	MOTTLED		DAMP	0.8	0	0	0
						ORG							
S-3	6		2/2			GRY	W/SAND		DRY	0.1	0	0	0
				6.4		ORG	Fine sand + silt	SM					
S-4	8		1.2/2	7.4		BRN ORG	clayey SILT + SAND	ML	DRY	0	0	0	0
				TD 9.5									
							CANNOT DRIVE SAMPLER TO 10'						
							PROBLEMS WITH DPT RIG						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACROCORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE DPT

BORING No.: 01SB15
DATE: 8-22-01
GEOLOGIST: WUDKNYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN	ROOTS	ML					
S-1	2		1.5/2	2.2			SILT		DRY	0.2	0	0	0
							SILTY CLAY	CL					
S-2	4		2/2	4					DAMP	0.1	0	0	0
							SILT S-CLAY	ML					
S-3	6		1.5/2	6					DAMP	0.1	0	0	0
						GRY ORG	SILTY CLAY mottled	CL					
S-4	8		2/2						DRY ORGANICS	0.1	0	0	0
				9									
S-5	10		2/2				SILT	ML	DRY	0	0	0	0
S-6	12												
				TD 12'			REFUSAL @ 12'						
							10' TO 12' SAMPLE STUCK IN BORING, REMOVED DPT TOOLS WITH BACKHOE INTERVAL WAS NOT LOGGED CUTTING SHOE BROKE-OFF AND REMAINS IN HOLE 12' ± DEEP						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE 10PT

BORING No.: 015B16
DATE: 8-21-01
GEOLOGIST: WUDKWICH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
				---		DRK	GRAVEL/ROOTS	ML					
S-1	2		2/2			BRN	CLAYEY SILT		DRY	0	0	0	0
						ORG	SILT T-CLAY						
S-2	4		2/2			GRY	MOTTLED		DRY	0	0	0	0
						BRN	CALICHE						
S-3	6		2/2	-6		ORG			DRY	0	0	0	0
						ORG	FINE SAND + SILT	SM	CRUMBLY				
S-4	8		2/2			GRY	T-CLAY THROUGHOUT		DRY	0	0	0	0
						GRY	FINE SAND						
S-5	10		2/2			ORG	(WEATHERED BEDROCK)		WEATHERED BEDROCK DRY	0	0	0	0
				TD 10'			TD 10'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x 4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: GEOPROBE

BORING No.: OLSB17
DATE: 8-24-01
GEOLOGIST: WUDKWYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						DRK		ML	ROOTS				
S-1	2		2/2	2		BRN	SILT T-CLAY	↓	DAMP	0	0	0	0
						BRN		CL					
S-2	4		2/2	4		GRY	SILT+CLAY MOTTLED	!	DAMPNESS	0	0	0	0
						BRN	SILT T-CLAY	ML					
S-3	6		2/2	6			↓	↓	DAMP	0	0	0	0
						GRY ORG	CLAY S-SILT	CL					
S-4	8		2/2				T-SAND MOTTLED @ BASE		DRY	0	0	0	0
S-5	10		2/2	9.7	½ HARD		SILT MOTTLED	ML	DRY CRUMBLY	0	0	0	0
				TD 10'			CANNOT PUSH SAMPLE PAST 10'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACRO CORE

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: GEOPROBE

BORING No.: 01SB18
DATE: 8-24-01
GEOLOGIST: WUOKWYCH
DRILLER: STRATI

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
						BRN.	SILT	ML	ROOTS				
S-1	2		2/2	1.5		ORG GRY	SILTY CLAY	CL	DAMP	0	0	0	0
						↓	MOTTLED T-SAND	↓					
S-2	4		1.5/2	4					DAMP	0	0	0	0
							SILT - T-CLAY	ML	CRUMBLY				
	6		2/2	6		↓	↓ MOTTLED	↓	DRY	0	0	0	0
S-3			1/1			BRN	SILT S-R.SAND		DRY	0	0	0	0
S-4	8		1/1			↓	↓	↓	CRUMBLY	0	0	0	0
				TD 8'			REFUSAL @ 8'						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACROCORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No x Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: GEOPROBE

BORING No.: 015B19
DATE: 8-24-01
GEOLOGIST: WUDKWYCH
DRILLER: STRATI

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
						ORG	SILTY CLAY	CL	ROOTS				
S-1	2		2/2	2		GREY	MOTTLED	↓	DRY	0	0	0	0
						BRN ORG	SILT T-CLAY	ML					
S-2	4		2/2	4		↓	↓	↓	DRY	0	0	0	0
						ORG	clay	CL					
S-3	6		2/2	5.8		↓	↓ SANDSTONE FRAGS	↓	DRY	0	0	0	0
							SILT+SAND						
							SAND+SILT+CLAY	SM					
S-4	8		2/2			↓	↓ (WEATHERED BEDROCK)	↓	DRY	0	0	0	0
				8'			TD 8'						
							REFUSAL						

* When rock coring, enter rock brokeness.

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

Remarks: 2"x4' MACRO CORE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: 015B20
DATE: 8-21-01
GEOLOGIST: WWORNYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						DK BRN	SILT	ML	ROOTS				
S-1	2		2/2			BRN	↓		damp	0.4	0	0	0
						BRN	Clayey SILT						
S-2	4		2/2			ORG	SOME MOTTLING		dry	0	0	0	0
						↓	SILT W/F Sand						
S-3	6		2/2			↓	↓		dry	0.5	0	0	0
						ORG	SILT + Fgr SAND	SM	crumbly				
S-4	8		2/2			↓	WEATHERED SANDSTONE	1	dry	0.8	0	0	0
				TD 8'			REFUSAL @ 8'						

* 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): 0

Remarks: 2"x4' MACRO CORE

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: CTO 158 #3959
DRILLING COMPANY: EFS
DRILLING RIG: HURRICANE / DPT

BORING No.: 01SB21
DATE: 8-21-01
GEOLOGIST: WUDKUYCH
DRILLER: STRATI

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
				---		BRN	clay S-SILT	CL	ORGANICS T-GRAVEL				
S-1	2		2/2			ORG GRY	MOTTLED	↓	damp	0	0	0	0
						GRY	SILTY clay GRADES	↓					
	4					↓	TO SILT	ML					
						ORG	↓	↓	MICACEOUS				
S-2	6		3/4	6		↓	↓ T-SAND	↓	dry	0	0	0	0
						BRN ORG	F.GR SAND + SILT	SM					
	8					↓	↓	↓					
							↓	↓	CEMENTED				
S-3	10		3/4		V. DENSE	↓ GRY	↓ T-CLAY	↓	DRY	0	0	0	0
				TO 10'									

* When rock coring, enter rock brokeness.

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

Remarks: MACRO-CORE (2")

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V1000X

BORING No.: 01T01
DATE: 9-7-01 / 9-8-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler B2	Borehole**	Driller B2**
						ORG	GRAVEL SILT	ML					
						TAN	SILT	ML	DRY			0	0
	10												
						BROWN	SILT	ML					
	20								DRY				
						BROWN	SILT	ML				0	0
						BRN ORG	SILT & CLAY	ML					
						BRN							
	30					GRY							
				32									
						ORG	SAND STONE					0	0
	40					ORG	SANDSTONE						
	50					DRK GRY	SHALE + SILTSTONE						

* When rock coring, enter rock brokeness.

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

Remarks: 6" AIR HAMMER 6" CASING SET TO 34'

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSADRILL V1000X

BORING No.: OIT01
DATE: 9-7-01 / 9-8-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

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

* When rock coring, enter rock brokeness.

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

Remarks: 6" AIR HAMMER

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V1000X

BORING No.: 01T01
DATE: 9-7-01 / 9-8-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	110					GRY	SANDSTONE						
	120					GRY	SANDSTONE						
				TD 120'									

* When rock coring, enter rock brokeness.

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

Remarks: 6" AIR HAMMER

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V-1000X

BORING No.: 01T02
DATE: 9-5-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
							GRAVEL		ROOTS				
						BRN	SILT	ML					
							S-CLAY						
	5												
						LGT							
						BRN	SILT S-FINE SAND	ML / SM					
						TAN							
	10								DRY				
	14			14									
	15										0	0	0
						BRN	SILT + CLAY	ML					
							(WEATHERED ROCK ?)						
	20												
						DRK	SILT + CLAY	ML					
						GRY							
	25								DRY				

* 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): 0

Remarks: 6" AIR HAMMER SET 6" CASING TO 32'
2" CORE BARREL SCREEN 60'-70'

Converted to Well: Yes X No _____ Well I.D. #: 01T02

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V-1000X

BORING No.: 01T02
DATE: 9-5-01 / 9-6-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						LGT							
						GRY	SILT	ML					
						ORG							
						ORG	SILT + SAND	SM					
	30			30									
					SOFT	ORG	SANDSTONE		DRY				
	32					ORG					0	0	0
						GRY			33.7 FRACTURE				
						↓							
	35												
						Yell	Shale + SANDSTONE		WET				
R-1						GRY							
			59%				DEDANG PLANE FRACTURED		IRON STAINING				
									37-39'				
	40					↓							
			8.4	40.2		DRK	SHALE		IRON STAINING BROKEN				
	42		9.5	41.5		GRY	SHALE + SILTSTONE		V.				
				43.	V. SOFT		COAL SEAMS THROUGHOUT		BROKEN				
	45						SHALE		DRY				
R-2							+ SILTSTONE						
			50%										
	50					↓							

* When rock coring, enter rock brokeness.

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

Remarks: 6" AIR HAMMER SET 6" SS CASING TO 32'
2" CORE BARREL SCREEN 60'-70'

Drilling Area Background (ppm): 0

Converted to Well: Yes X No _____ Well I.D. #: 01T02

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V-1000X

BORING No.: 01T02
DATE:
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
						GRY	SHALE						
	52		6.0/9.5	52									
						BLK	COAL		WET				
				52.5									
					HARD	GRY	SHALEY LIMESTONE		12"				
	55			54.5					WATER				
							V. FINE GR. SANDSTONE		52-62 INTERVAL				
R-3							ABUNDANCE OF QUARTZ						
			82%										
	60												
			9.8/9.5										
	62			62									
					DR	GRY	SHALE SEAMS		WET				
				62.5									
						GRY	V. FINE GR. SANDSTONE						
	65												
R-4							SHALE SEAM						
			53%	68									
						ORG	SANDSTONE, SHALE +						
	70					GRY	COAL INTERBEDDED		IRON STAINING				
			7.5/9.5										
	72			72									
					SOFT	GRY	SILTSTONE		V. BROKEN				
							IRON STAINING						
R-5	75												

* 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): 0

Remarks: 6" AIRHAMMER
2" CORE BARREL

Converted to Well: Yes X No _____ Well I.D. #: 01T02

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V1000X

BORING No.: 01T02
DATE: 9-6-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
R-5						GRY	SILTSTONE						
							GRADING TO						
			66%				SILTSTONE +						
							SHALE						
	80			80			GRADING TO						
			7.6		M HARD	DRK GRY	SHALE						
	82		9.5			BLK			SOFT ZONES				
	85												
R-6				87	M-HARD		SHALE						
			75%			DRK	SANDY SHALE						
				89		GRY	QUARTZ VEINS		V. BROKEN				
	90						SHALE						
	92		9.4/9.5		M. HARD								
						DRK GRY							
						BLK							
	95												
R-7													
				97.1									
						GRY	V. FINE GR. SANDSTONE						
	100								CLAY ZONE				

* 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): 0

Remarks: 6" AIR HAMMER
2" CORE BARREL

Converted to Well: Yes X No _____ Well I.D. #: 01T02

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE
PROJECT NUMBER: 3959
DRILLING COMPANY: BOWSER-MORNER
DRILLING RIG: VERSA-DRILL V-1000X

BORING No.: 01T02
DATE: 9-6-01
GEOLOGIST: WUDKWYCH
DRILLER: J. VANKIAK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
			8.7		M. HARD	GRY	V. FINE GR. SANDSTONE						
	102		9.5										
	105		85%										
R-8													
			9.5						T-CLAY LENSES THROUGHOUT				
	110		9.5		M. HARD								
						GRY							
R-9													
	115		5/5						V. BROKEN				
				TD 115'									

* 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): 0

Remarks: 6" AIR HAMMER
2" CORE BARREL

Converted to Well: Yes X No _____ Well I.D. #: 01T02

ATTACHMENT 1

BEDROCK MONITORING WELL SHEET

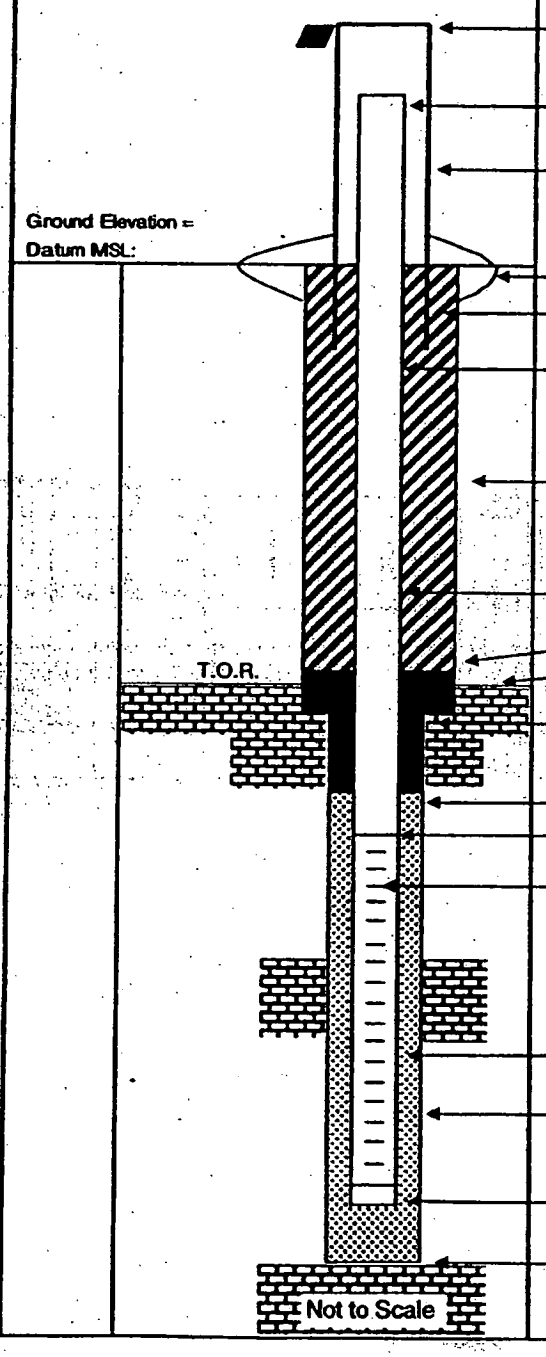
Tetra Tech NUS, Inc.

BEDROCK MONITORING WELL SHEET

WELL No.: 01T02

PERMIT No:

PROJECT:	NSWC CRANE	DRILLING Co.:	DUNCAN BROS.	BORING No.:	01T02
PROJECT No.:	3959	DRILLER:	VANKIAK	DATE COMPLETED:	9-8-01
SITE:	MCBG	DRILLING METHOD:	AIR ROTARY	NORTHING:	
GEOLOGIST:	WUOKWYCH	DEV. METHOD:		EASTING:	



Elevation of Top of Casing:

Stick Up of Casing Above Ground Surface:

Elevation of Top of Riser:

I.D. of Surface Casing: 4"

Type of Surface Casing: STEEL

Type of Surface Seal: CONCRETE PAD

I.D. of Permanent Casing: 6"

I.D. of Riser: 2"

Type of Riser: PVC

Borehole Diameter: 6"

Type of Backfill: GROUT

Elevation / Depth Top of Seal: 150

Elevation / Depth Top of Bedrock: 130

Type of Seal: BENTONITE PELLETS

~~Elevation / Depth of Top of Fine Sand:~~ — / —

Elevation / Depth of Top of Filter Pack: 154

Elevation / Depth of Top of Screen: 160

Type of Screen: SCH. 40 PVC

Slot Size x Length: 0.020" x 10'

I.D. of Screen: 2"

Type of Filter Pack: #5 SAND

Diameter of Hole in Bedrock: Core / Ream: 6"

Elevation / Depth of Bottom of Screen: 170

Elevation / Total Depth of Borehole: 115'

BORING LOG
FIELD DATA

Project N W S C Groundwater Study Site Crane, Indiana Date 20 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 683.14 ft Boring No. WES-1-1-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	Hyd. Press	Cont.	CLASSIFICATION AND REMARKS
1	20 Aug	0.0		0.0	0.5	0.0	1.85	3"ShelbyTube	0	S.T.	Clay(CL): light brown to grey in
1A				0.5	1.0	1.85	2.15		160	Jar	color, soft to slightly stiff, low
				1.0	1.5				280		plasticity.
				1.5	2.0				360		Sample length: 2.15'
				2.0	2.5				420		
				0.0	5.0			7"Folding Auger			Cleanout
2	20 Aug		5.0	5.0	5.5	5.0	6.37	*3"Fixed Piston Sampler	0	S.T.	Sand (SP): light brown to grey in
2A		5.0		5.5	6.0	6.37	6.67		20	Jar	color, v. fine-grained, uniform,
				6.0	6.5	6.37	6.67		300		with thin zones of moderately hard
			7.05	6.5	7.05				750		cemented sand.
											Sample length: 1.67'
	20 Aug	7.05		7.05	14.5			5-5/8" Rock	Bit		Cleanout
											Sandstone: brown to darkbrown in

Sheet 1 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.

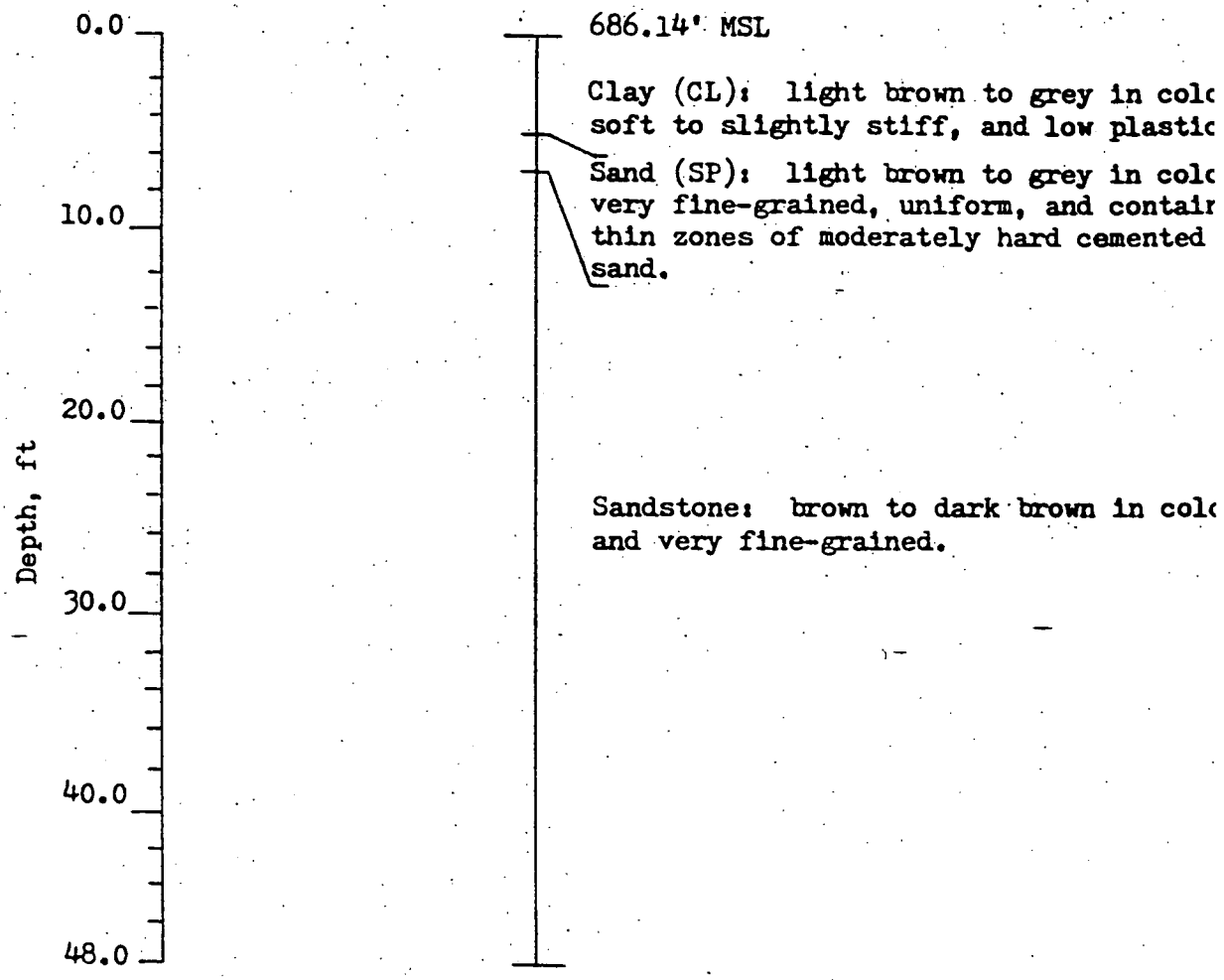
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES 1-1-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
											color and fine-grained.
3A	21 Aug			14.5	14.75	14.5	14.75	3"F.P.S.	750	Jar	Sandstone: same as above.
	21 Aug		48.0	14.5	48.0			5-5/8" Rock	Bit		Sandstone
											Water encountered at 38 ft.
											Blew hole of cuttings and fall-in
											with air. Installed well.

WES FORM 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

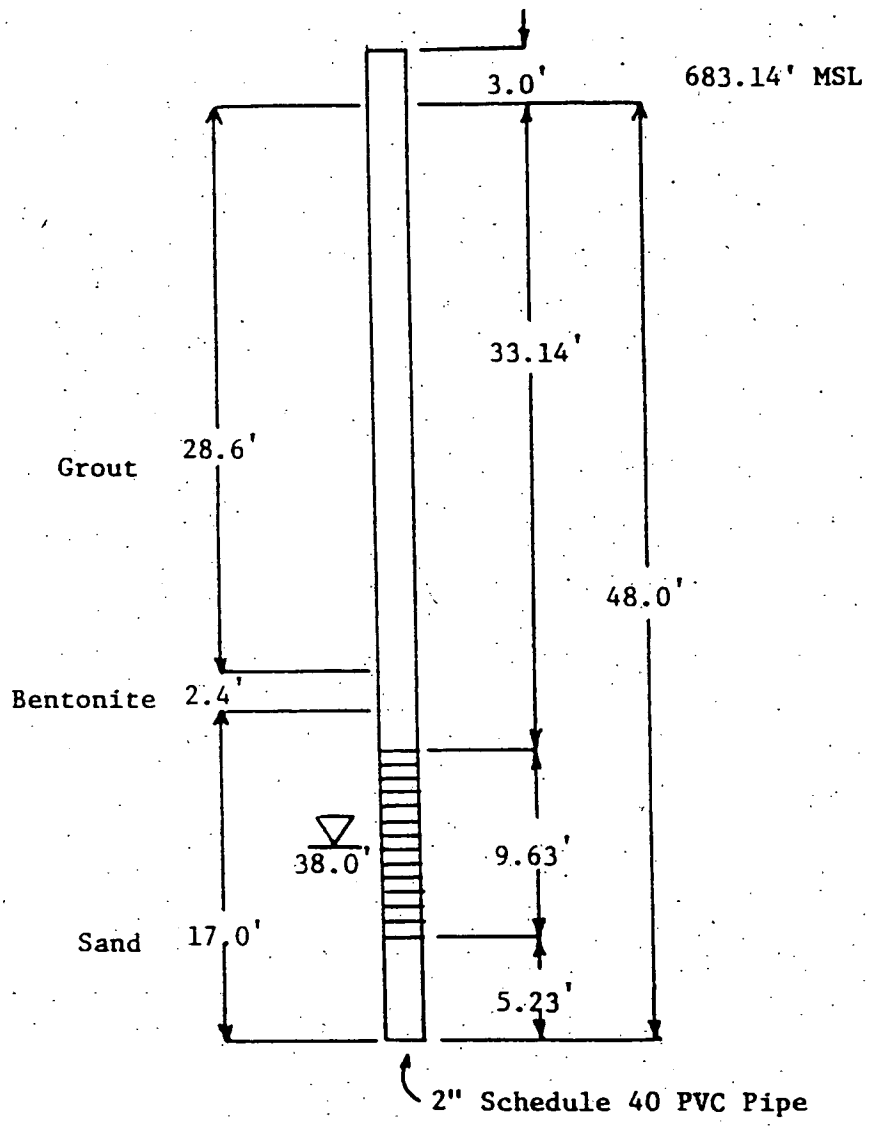


NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-1-81



Water depth at time of drilling

Well screen

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Well Completion

Boring Number: WES-1-1-81

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 20 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 664.04 ft Boring No. WES-1-2-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	Hyd. Press.	Cont.	CLASSIFICATION AND REMARKS
1A	22 Aug	0.0		0.0	0.5	0.0	0.65	3"ShelbyTube	180	Jar	Sandy silt(SM): lt. brown in color,
			1.2	0.5	0.65				700		dry, very fine-grained, with frag-
											ments of weathered sandstone.
				0.0	2.2	----------		5-5/8 " Rock Bit		----	Cleanout for core barrel.
											Continued on Eng Form 1836, page 2.

Sheet 1 of 4 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-1-2-81

DRILLING LOG	DIVISION U.S. Navy	INSTALLATION N.W.S.C., Crane, Indiana	SHEET 2 OF 4 SHEETS

1. PROJECT .N.W.S.C. Groundwater Study	10. SIZE AND TYPE OF BIT 4"x5-1/2"
2. LOCATION (Coordinates or Station) Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L.
3. DRILLING AGENCY C.E.W.E.S.	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-1-2-81	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED one
5. NAME OF DRILLER C. Drake	14. TOTAL NUMBER CORE BOXES zero
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 22 August 1981; COMPLETED 22 August 81
7. THICKNESS OF OVERBURDEN 1.2	17. ELEVATION TOP OF HOLE 664.04
8. DEPTH DRILLED INTO ROCK 21.6	18. TOTAL CORE RECOVERY FOR BORING 63%
9. TOTAL DEPTH OF HOLE 22.8	19. SIGNATURE OF INSPECTOR Joseph B. Dinkins

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
664.04	0.0		Overburden - See page one for soil information.			
663.04	1.0					
662.04	2.0					
			No recovery			
661.04	3.0		Sandstone: light brown, very fine-grained with 85% uniform quartz sand and 15% misc. materials. Sandstone is dry, weathered, very friable to moderately friable, and bedding is distinct with zones of oxidation.			#1 Run 1 Began 1:30 Rec 1.9' End 1:50 Loss 3.1' Time 20min. Gain__ Drl time 20min. Hyd press 200 psi Water press - RPM 100% Drl Action Smooth Water rot Brown
660.04	4.0					
			Fractured			
559.04	5.0					Used carbide bit.
558.04	6.0		No recovery			
557.04	7.0		Run 1	38%	-	
			No recovery			#1 - Run 2 Began 2:15 Rec 1.5' End 2:45 Loss 3.5' Time 30min Gain - Drl time 30min Hyd press 150-200psi Water press - RPM 100% Drl Action Smooth Water rot Brown Remarks
556.04	8.0					
			Sandstone: same - Core loss appears to occur in areas of unconsolidated sands or very weathered sandstone.			
555.04	9.0					
			Fractured			
554.04	10.0		No recovery			

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PROJECT | HOLE NO.

Hole No. HS-1-2-81

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
554.04	10.0					
553.04	11.0		No recovery			
552.04	12.0		Run 2	30%	-	
			No recovery Water at 12.8 ft.			
551.04	13.0					Run 3 Began 3:00 Rec 4.33' End 3:30 Loss 0.4' Time 30min Gain - Drl time 30min Hyd press 100psi Water press - RPM 75 1 Drl Action Smooth Water ret Brown
550.04	14.0		Sandstone: same			
549.04	15.0					Remarks Switched from carbide to to diamond bit.
			Water at 15.7 ft.			
548.04	16.0		Highly oxidized Run 3	91%	-	
547.04	17.0		Contact from brown to grey colored sandstone. Shale seam - 3/4"			Run 4 Began 4:00 Rec 3.37' End 4:30 Loss - Time 30min Gain - Drl time 30min Hyd press 100psi Water press - RPM 75 1 Drl Action Smooth Water ret Grey
546.04	18.0		Sandstone and interbedded shale: sandstone is grey, uniform, fine-grained quartz sands with numerous dark grey shale lamina interbedded.			
545.04	19.0		Shale ranges in thickness from 1/16" to 1/2" and controls rock breaks. Shale is fairly soft and sandstone is moderately friable.			Bit blocked off.
544.04	20.0		Shale seam - 1/2" Run 4	100%	-	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES-1-2-81

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
544.04	20.0		19.9' contact between sandstone and shale 0.2' black shale(pure) 0.05' black shale(pure)			
543.04	21.0		Sandy shale: recovered core indicates 60% soft, black sandy shale interbedded with a fine-grained, grey sandstone. Individual lamina range in thickness from 1/16" to 2".			Run. 5 Begun 4:30 End 4:50 Time 20min Drl time 20min Hyd press 100psi. Water press - RPM 75 Drl Action smooth Water ret -
542.04	22.0		No recovery - Left in hole			Rec 1.0 Loss 1.95 Gain
541.04	23.0					Remarks
			Run 5	34%	-	
			Went back in with 5-5/8" rock bit to remove fall-in and core left in hole. Slight "oily" oder was smelled when pulling core barrel on last run. Had test run for mustard gas and negative results on test.			

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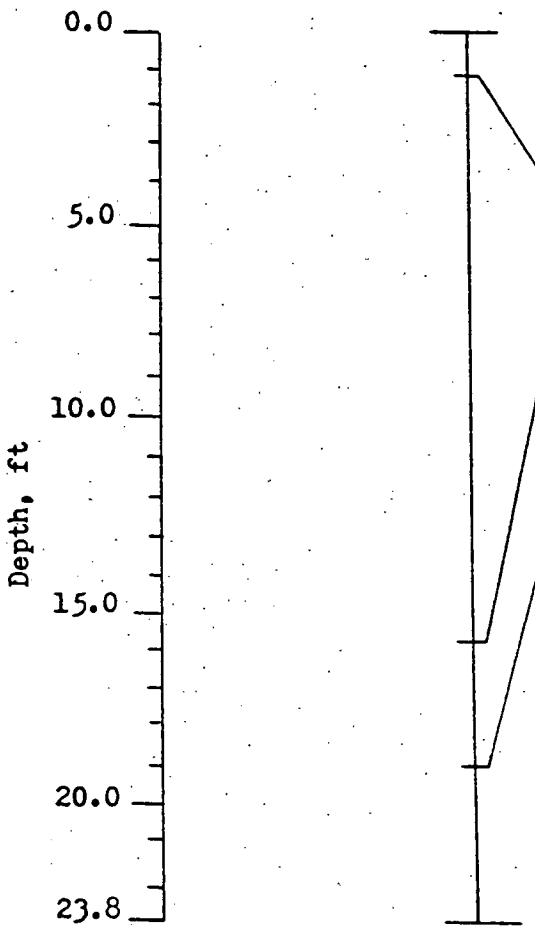
PROJECT | HOLE NO.



664.04' MSL

Silty sand (SM): light brown in color, dry, weathered, very fine-grained sand, and contains fragments of weathered san stone.

Sandstone: light brown in color, very friable to moderately friable, weathere uniform, and very fine to fine-grained quartz sand.

Sandstone and interbedded shale: sand-stone is grey in color, uniform, and ve fine-grained quartz sand. Shale is dar grey in color, soft, and ranges in thic ness from 1/16 to 1/2 in.

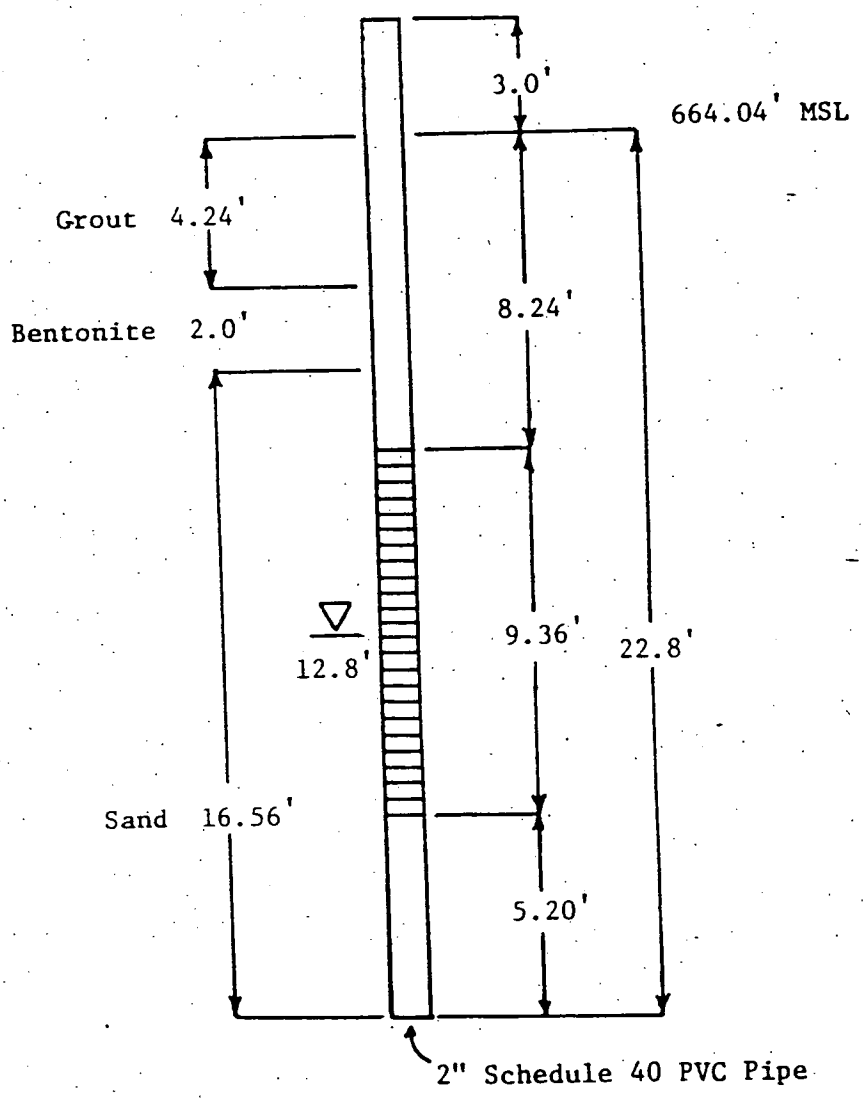
Sandy shale: black in color, soft, and interbedded with fine-grained, grey stone lenses which range in thickness 1/16 to 2 in.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-2-81



▽ -Water depth at time of drilling

▤ Well screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-2-81

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 25 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 667.43 ft Boring No. WES-1-3-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	Hyd. Press.	Cont.	CLASSIFICATION AND REMARKS
1	25 Aug	0.0		0.0	0.5	0.0	2.3	3"ShelbyTube	0	S.T.	Silt(ML): brown in color, soft
1A				0.5	1.0	2.3	2.5		20	Jar	organic matter, low plasticity.
				1.0	1.5				95		
				1.5	2.0				180		
			4.0	2.0	2.5				220		Sample length: 2.5 ft
				0.0	5.0	----------		7" Folding Auger		---	Cleanout: assumed change at 4.0 ft
2	25 Aug	4.0		5.0	5.5	5.0	6.02	3" FixedPis-	0	S.T.	Clayey sand(SC) with fragments of
2A				5.5	6.0	6.02	6.27	ton Sampler	40	Jar	weathered sandstone: reddish brown
			6.45	6.0	6.45				280		in color, dry, and uniform fine-
											grained sand.
											Sample length: 1.27 ft
	25 Aug			5.0	6.5	----------		7" Folding Auger		----	Cleanout

Sheet 1 of 2 Sheets

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1-3-81

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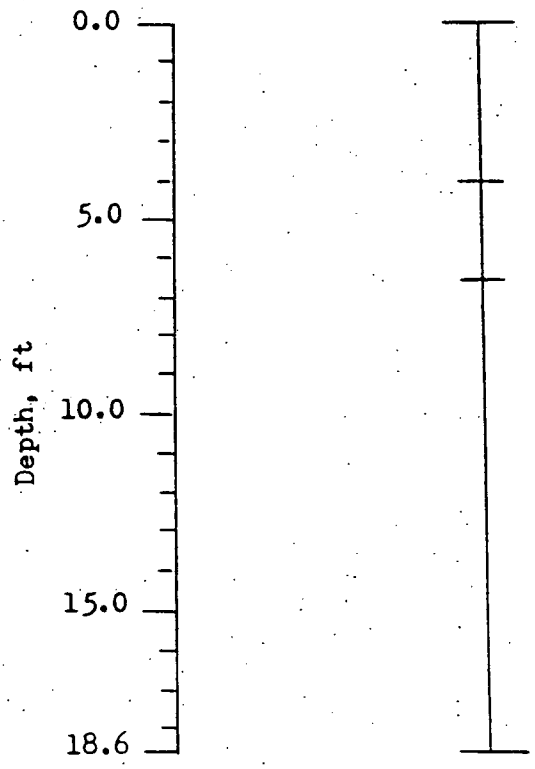


667.43' MSL

Silt(ML): brown in color, soft, organic matter, and low plasticity.

Clayey sand(SC): reddish brown in color, dry, uniform, and fine-grained sand and sandstone fragments.

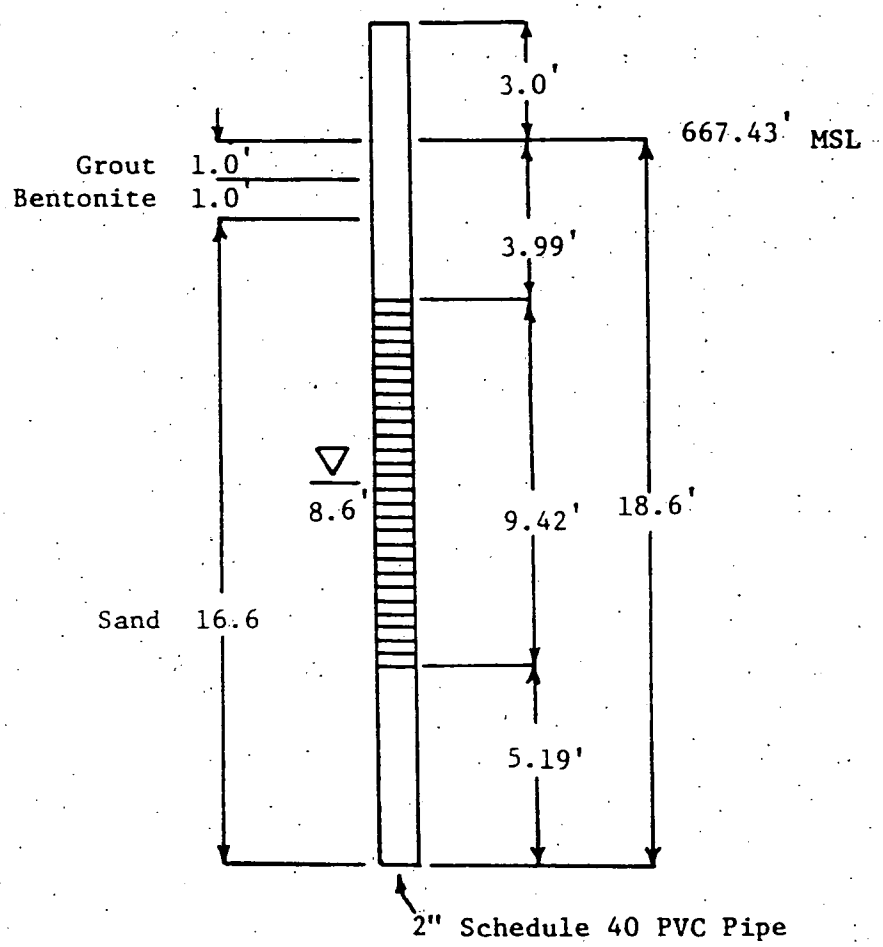
Sandstone: light brown to reddish brown and light grey in color, very friable to slightly friable, weathered, and very fin to fine-grained.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-3-81



Water depth at time of drilling

Well screen

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Well Completion

Boring Number: WES-1[redacted]1

1-4-81

PAGE 1 MISSING

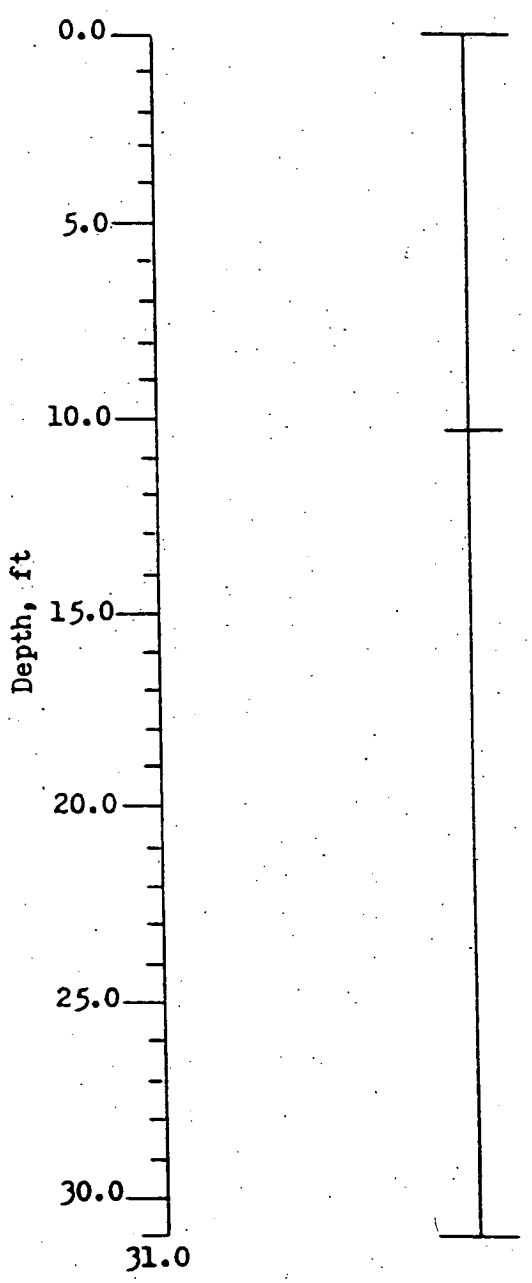
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-4-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	Hyd. Press.	Cont.	CLASSIFICATION AND REMARKS
3A	22 Sep		10.3	10.0	10.3	10.0	10.3	3" Fixed Piston Sampler	800	Jar	Sandy silt (SM) and weathered sandstone: grey to brown in color, dry, with sandstone reddish brown in color, fine-grained, and friable.
	22 Sep	10.3	31.0	10.0	31.0	----------	----------	5-5/8" Rock Bit	----------		Water at 21 ft. Drilled to 31.0 ft. Water on 23 Sep 81 at 21 ft. Blew hole and installed well.
											Sandstone: reddish brown in color, fine-grained and weathered.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED.

Sheet 2 of 2 Sheets



669.95' MSL

Sandy silt(ML): brown to grey in color, moderate cohesion, dry, stiff, and contains 20 to 30% fine-grained sand.

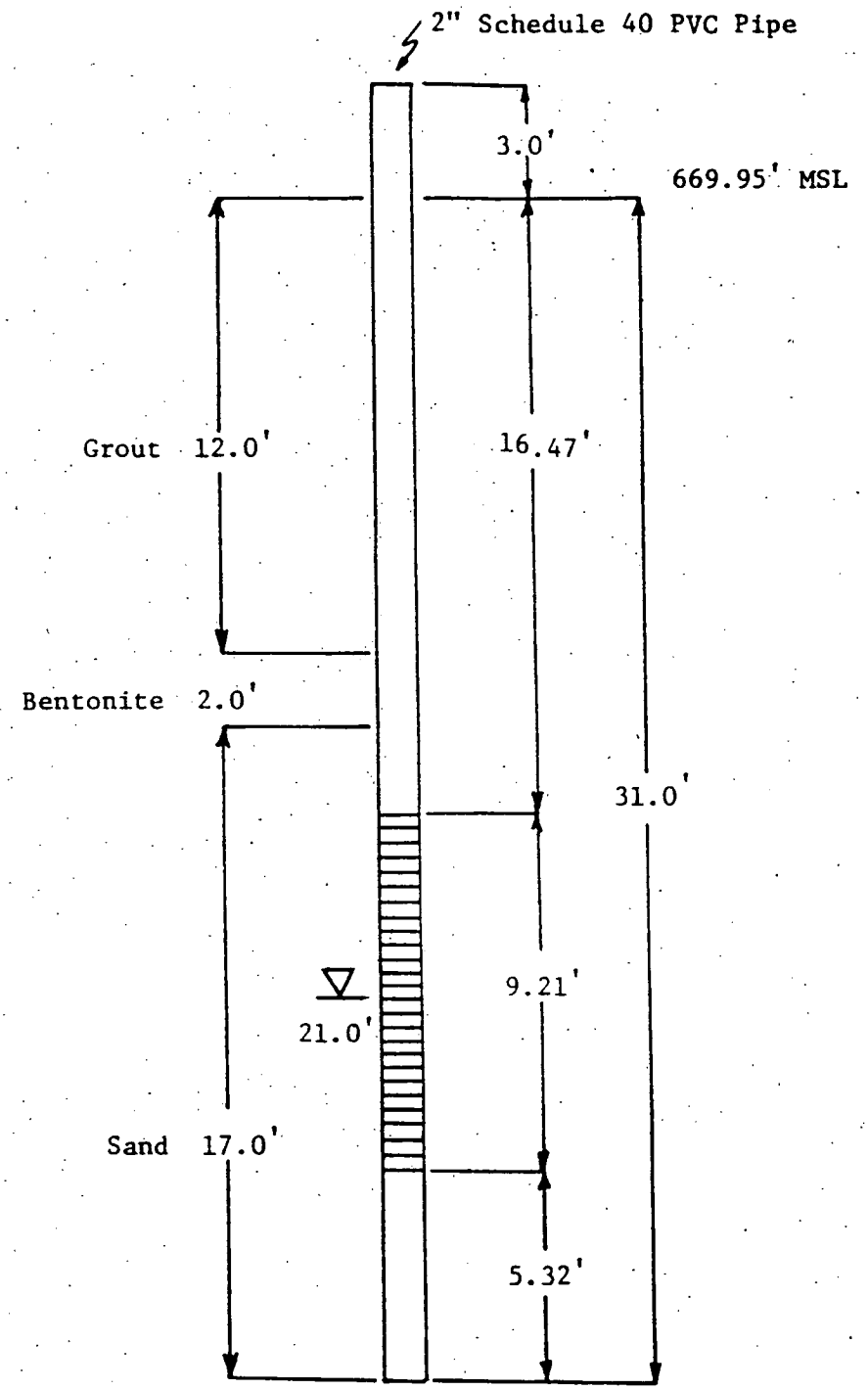
Sandstone: reddish brown in color, fine-grained, and weathered.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-4-81



▽ Water depth at time of drilling

Well screen

NWSC , Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-4-81

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 23 Sep 81
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 665.69 ft Boring No. WES-1-5-81

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER	Hyd. Press.	Cont.	CLASSIFICATION AND REMARKS
1	23 Sep	0.0		0.0	0.5	0.0	2.28	3" Shelby Tube	60	S.T.	Clay (CL): brown in color, dry,
1A				0.5	1.0	2.28	2.48		80	Jar	little cohesion, uniform. Approx-
				1.0	1.5				100		imately 5% sand and gravel.
				1.5	2.0				120		
				2.0	2.5				120		Sample length: 2.48 ft
				0.0	5.0	------	------	7" Solid Auger	------	------	Cleanout
2A	23 Sep		5.2	5.0	5.5	5.0	5.5	3" Fixed Piston Sampler	800	Jar	Sandstone: brown in color, layered,
											v. fine-grained, dry, weathered,
											friable.
	23 Sep	5.2	30.63	5.5	18.0	------	------	5-5/8" Rock Bit	------	------	At 18.0 ft, monitored hole for
				18.0	30.63	------	------	5-5/8" Rock Bit	------	------	water, negative results. Water at
											20.5 ft. Sandstone: brown in
											color with interbedded grey shale.
											Installed well on 24 Sep 81.

Sheet 1 of 1 Sheets

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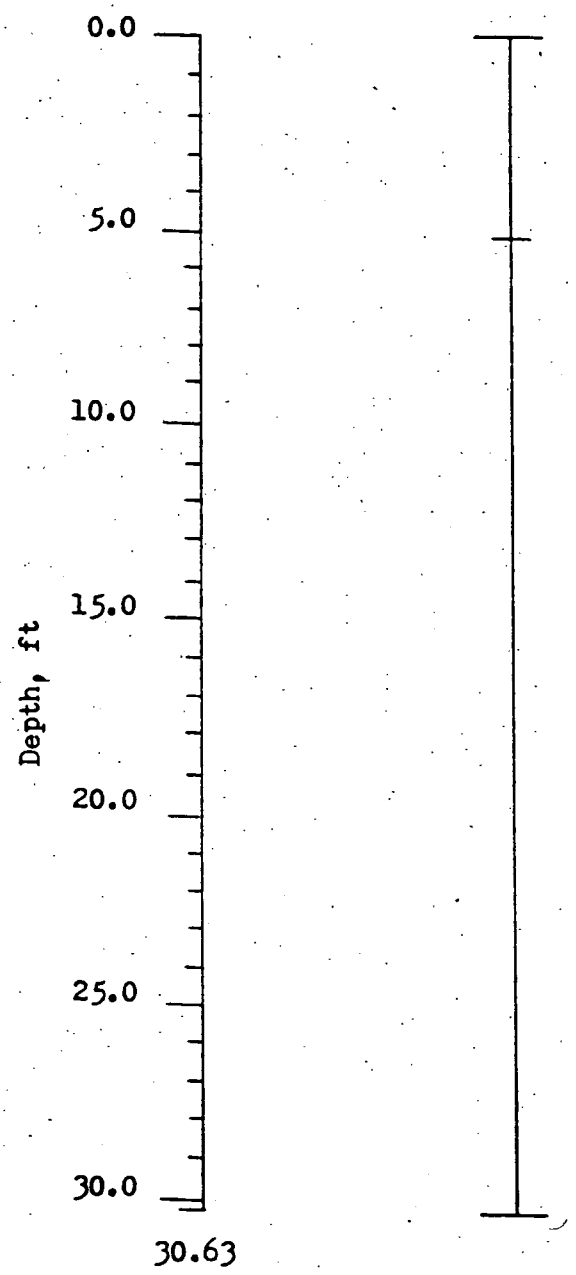


665.69' MSL

Clay (CL): brown in color, dry, little cohesion, uniform, and contains 5% sand and gravel.

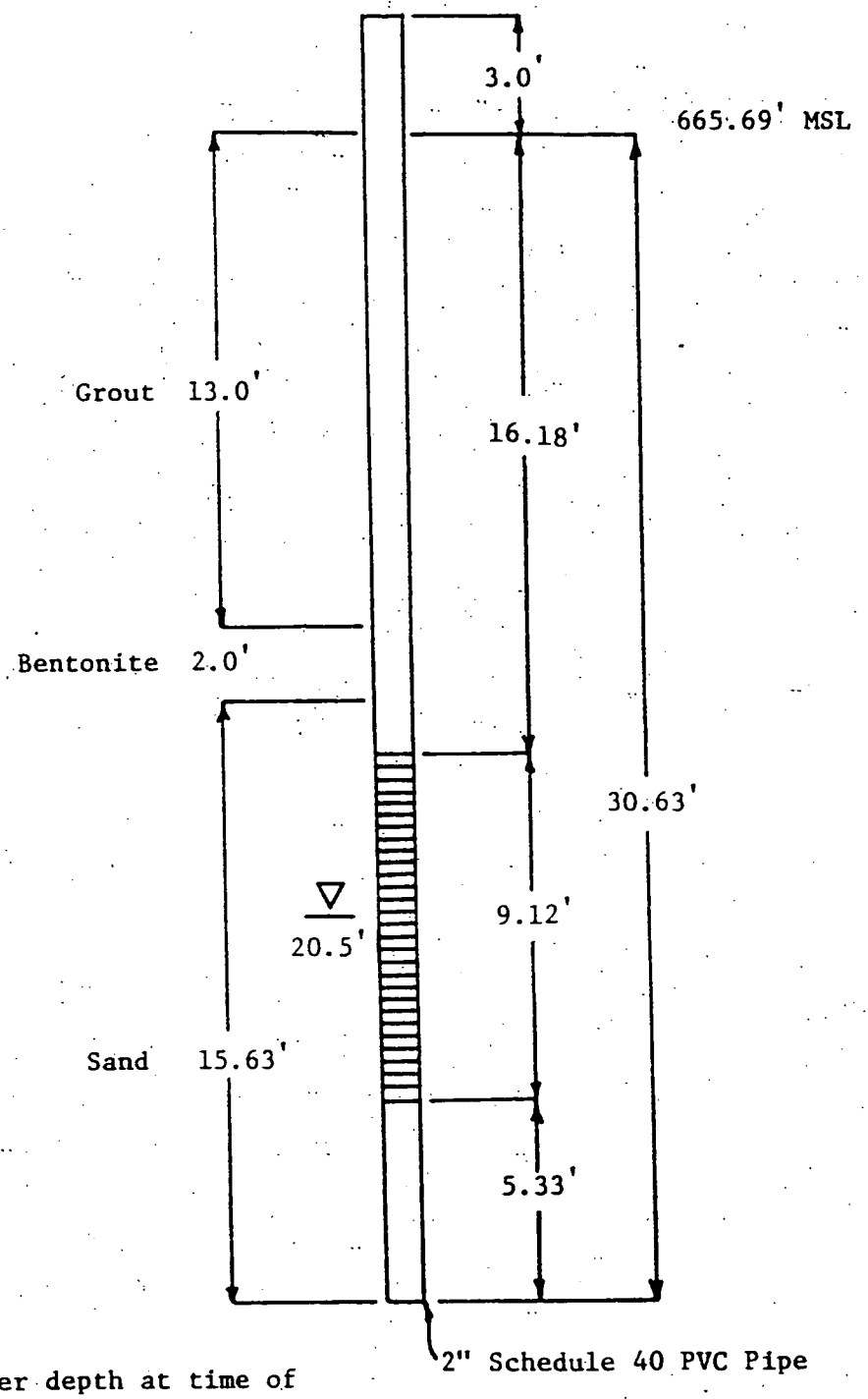
Brown sandstone and interbedded grey shale

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-5-81



Water depth at time of drilling

Well screen

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Well Completion

Boring Number: WES-1-5-81

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 November 82
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 596.02 Boring No. WES-1-6-82

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	10 Nov			0.0	1.5			6-3/4"Rock Bit			6" Casing-Stickup 0.5'
		0.0	11.7	0.0	26.0			5-5/8"Rock Bit			Siltstone: reddish brown, grey,
											soft, weathered, dry
		11.7	23.5								Shale: grey, soft-medium, dry
		23.5	26.0								Shale: dark grey, black, dry
	10 Nov			0.0	50.0			5-5/8"Rock Bit			Air compressor filter went out
											and pumped large quantity of oil
											into hole. Traded air compressors
											and moved drilling rig 10 ft west
											to drill another boring. Grouted
											up contaminated hole.
		26.0	27.2								Coal: black, soft
		27.2	35.2								Shale: grey, soft
		35.2	36.0								Coal: black, soft
	11 Nov	36.0	54.5	50.0	90.0			5-5/8"Rock Bit			Sandstone: brown, red, fine-
											grained, 75% quartz sand, hard

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

WORKING DRAFT

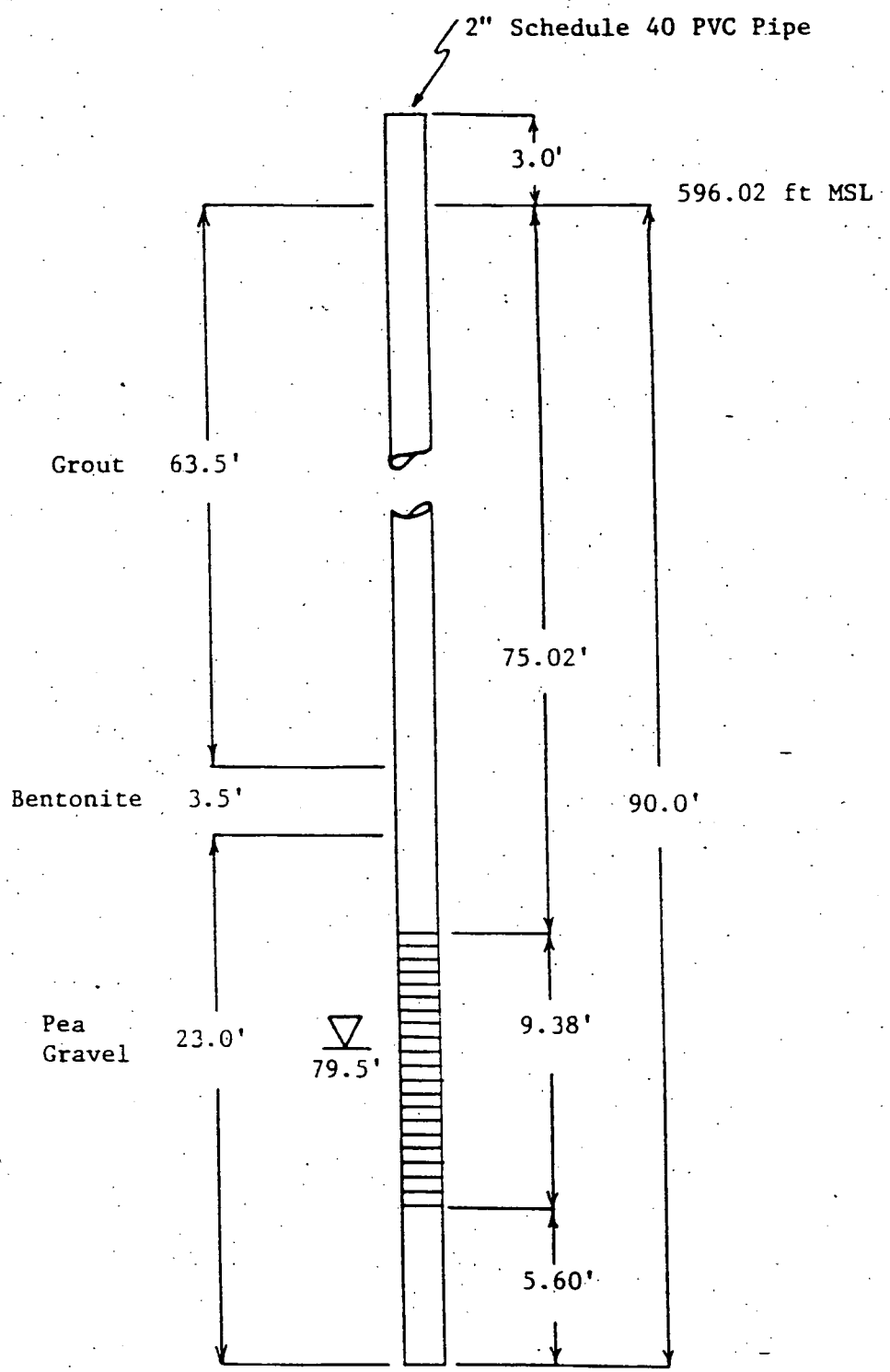
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-6-82

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
											Damp spot at 42 and 49 ft
											No water overnight
		54.5	82.5								Limestone: grey, white, hard
		82.5	88.5								Shale: grey, soft
		88.5	89.5								Limestone: grey, hard
		89.5	90.0								Shale: grey, soft
											Water at 79.5 ft - Blew water
											from hole several times and will
											monitor depth in morning before
											installing screen.
	12 Nov										Water level at 69.87 ft -
											installed well screen

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-6

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 14 November 82

Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22

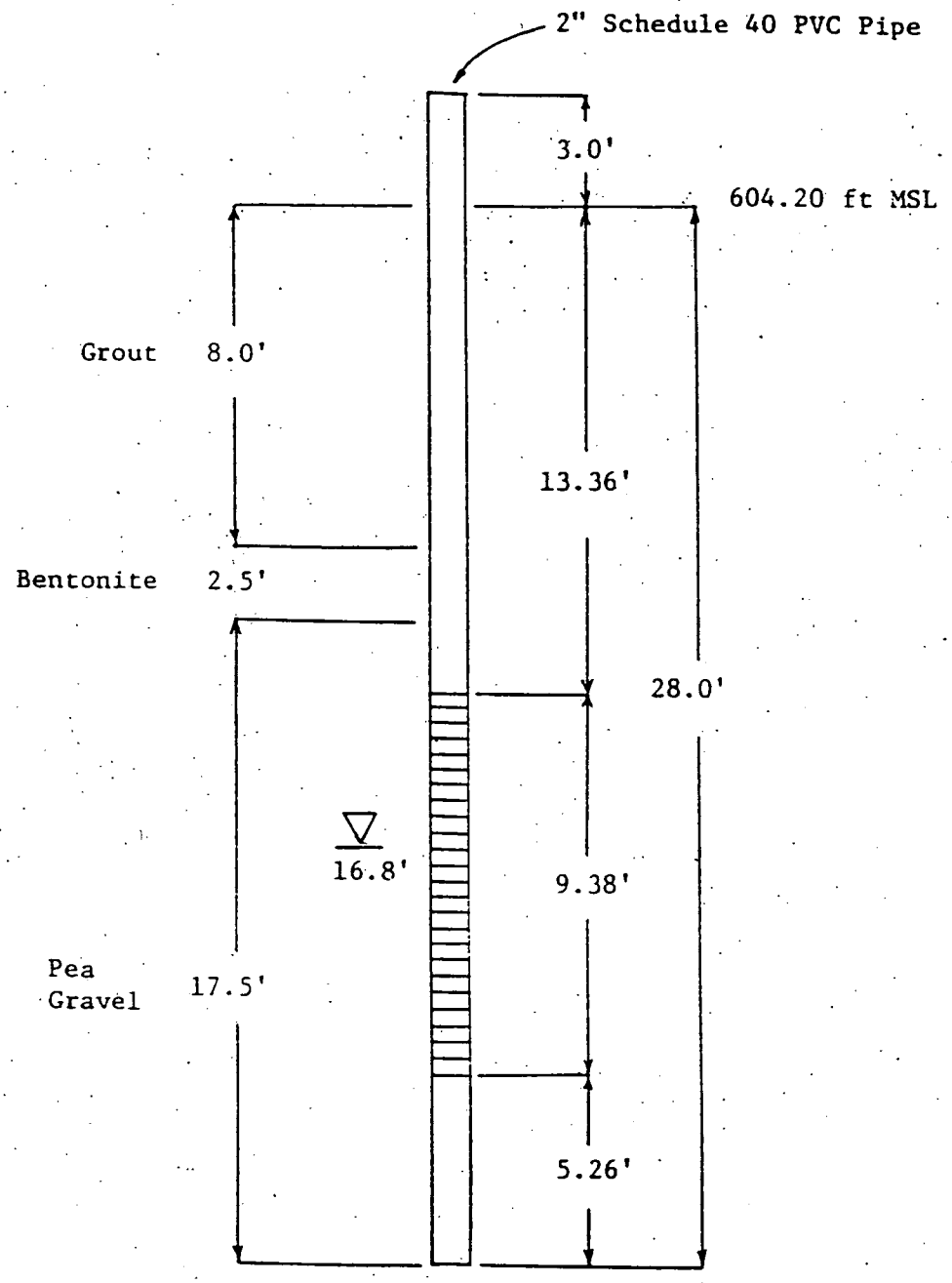
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 604.20 Boring No. WES-1-7-82

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	14 Nov			0.0	0.8			6-3/4"Rock Bit			6" Casing to 0.8-Stickup at 1.2 ft
		0.0	3.5	0.8	20.0			5-5/8"Rock Bit			Siltstone: brown, white, soft
				20.0	28.5			5-5/8"Rock Bit			weathered, dry
		3.5	28.5								Shale: grey, dark grey, soft
											Water between 15-20 ft -
											Water level at 16.8 ft after 60
											minutes. Installed well

Sheet 1 of 1 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT



Water level at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Ground
Well Completion
Boring Number WES-1-7-82

Project NWSC Groundwater Study Site Crane, IN Date 15 November 82

Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22

Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 601.99 Boring No. WES-1-8-82

SAMPLE NUMBER	DATE TAKEN 1982	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	15 Nov			0.0	0.8			6-3/4"Rock Bit			6"Casing to 0.8 ft-Stickup 1.2 ft
				0.0	4.0			5-5/8"Rock Bit			Cleanout for core barrel
				4.0	6.5			Pitcher Sampler			Run 1-Cleanout to 6.5 with rock bit
				6.5	11.3			4x5½"Core Barrel			Run 2
				11.3	16.4			" " "			Run 3
				16.4	21.1			" " "			Run 4-Water starts at 18.0 ft
				21.1	25.5			" " "			Run 5
				25.5	28.0			" " "			Run 6
				28.0	31.1			" " "			Run 7
		0.0	3.8								Siltstone
		3.8	12.0								Clay Shale
		12.0	28.8								Shale
		28.8	31.1								Limestone
											See boring log starting on
											page 2 for details

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 5 Sheets

Hole No. WES-1-8-82

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane, IN	SHEET 2 OF 5 SHEETS

1. PROJECT: NWSC Groundwater Study
2. LOCATION (Coordinates or Station): Mustard Gas Burial Grounds
3. DRILLING AGENCY: CEWES
4. HOLE NO. (As shown on drawing title and file number): WES-1-8-82
5. NAME OF DRILLER: D. Taylor
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 0.0
8. DEPTH DRILLED INTO ROCK: 31.1 ft
9. TOTAL DEPTH OF HOLE: 31.1 ft
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED Zero; UNDISTURBED Zero
14. TOTAL NUMBER CORE BOXES: Zero
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 15 Nov 82; COMPLETED 15 Nov 82
17. ELEVATION TOP OF HOLE: 601.99
18. TOTAL CORE RECOVERY FOR BORING: 91.5%
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
601.99	0.0					
600.99	1.0		Siltstone: brown, white, weathered, soft-brittle, dry			
599.99	2.0			0%		
598.99	3.0					
597.99	4.0					
596.99	5.0		Clay shale: brownish grey, grey, weathered, soft, oxidized in regions, recovered 1 ft with Pitcher Sampler	40%		
595.99	6.0		Run 1			
594.99	7.0		No recovery			2 11:45 3.7' 11.52 1.1' 7 Min 7 Min 200-300PSI
593.99	8.0		Clay shale: brownish grey, grey, dark grey, soft, dry oxidized in regions, weathered, thinly bedded to thickly bedded, attitude of bedding is horizontal, sandy	77.1%		70 ± Smooth Grey Carbaloid Drill Bit
592.99	9.0					
591.99	10.0					

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Hole No. WES-1-8-8

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane, IN	SHEET 3 OF 5 SHEETS

1. PROJECT: NWSC Groundwater Study
2. LOCATION (Coordinates or Station): Mustard Gas Burial Grounds
3. DRILLING AGENCY: CEWES
4. HOLE NO. (As shown on drawing title and file number): WES-1-8-82
5. NAME OF DRILLER: D. Taylor
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
591.99	10.0		Clay shale: same			
590.99	11.0		Run 2 RQD=64.7%			
589.99	12.0		No recovery			WL - Run 3 Began 12:45 Rec 3. End 1:05 Los 1. Time 20 Min - Drl time 20 Min Hyd press 200-300 PS Water press - RPM 70 + Drl Action Smoo Grey, darl
588.99	13.0		closed - limonitic			
				72.5%		
587.99	14.0		Shale: grey, dark grey, soft, thinly bedded, horizontal, dry, sandy, oxidized, contains 2-5% thinly bedded (1/8") limestone			
586.99	15.0					
585.99	16.0		Run 3 RQD=64.9%			
584.99	17.0					WL - Run Began 1:25 Rec End 1:40 Los Time 15 Min Gai Drl time 15 Min Hyd press 200-30 Water press - RPM 70+ Drl Action Smooth Grey
583.99	18.0		Shale: dark grey, black, soft, uniform, highly fractured, thinly bedded, horizontal. Water starts at 18 ft-	100%		Water st. at 18 ft - I quantity pr
582.99	19.0		20.15 ft - 1/2" grey sandstone, fine-grained, hard			
581.99	20.0					

PROJECT | HO

Hole No. WES-1-8-82

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane, IN	SHEET 4 OF 5 SHEETS

1. PROJECT: NWSC Groundwater Study	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: CEWES	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
4. HOLE NO. (As shown on drawing title and file number): WES -1-8-82	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: D. Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
581.99	20.0		Shale: same			
580.99	21.0		Run 4 RQD=46.8%			WL - Run 5 Began 2:00 Rec 4.4 End 2:15 Loss - Time 15 Min Gain - Drl time 15 Min Hyd press 200-300 PSI Water press - RPM 70± Drl Action ~~Water~~ ret Water-grey Remarks -
579.99	22.0					
578.99	23.0		Shale: same	100%		
577.99	24.0		fractured			
576.99	25.0		Run 5 RQD=54.5%			
575.99	26.0		fractured			WL - Run 6 Began 2:35 Rec 2.6' End 3:00 Loss - Time 25 Min Gain - Drl time 25 Min Hyd press 200 PSI Water press - RPM 70± Drl Action ~~Water~~ ret Water-dark grey Remarks
574.99	27.0		Shale: same	100%		
573.99	28.0		Run 6 RQD=0.0%			WL - Run 7 Began 3:50 Rec 3.0' End 4:15 Loss - Time 25 Min Gain - Drl time 25 Min Hyd press 200-300 PSI Water press - RPM 70± Drl Action ~~Water~~ ret Wet Brown Remarks Diamond Bit
			Shale: same			
572.99	29.0		Limestone: brown, grey, fossilized, cherty(2-3%),	100%		
571.99	30.0		fractured			

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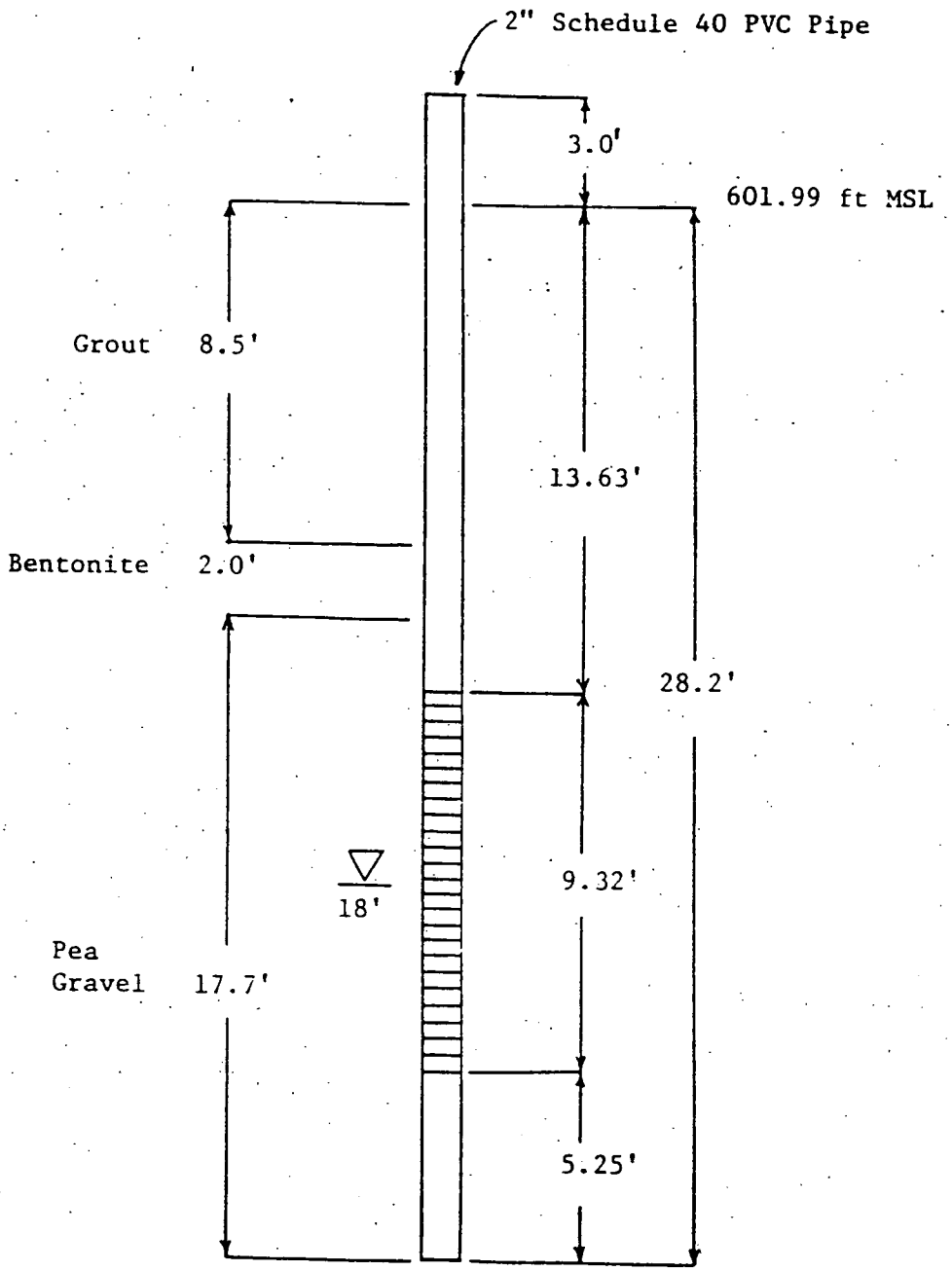
Hole No. WES-1-8-8

DRILLING LOG	DIVISION US Navy	INSTALLATION NWSC, Crane, IN	SHEET 3 OF 5

1. PROJECT NWSC Groundwater Study	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY CEWES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number) WES-1-8-82	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER D. Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
571.99	30.0					
			Limestone	100%		
570.99	31.0		Run 7 RQD=96.7%			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-8-82

WORKING DRAFT

BORING LOG
FIELD DATA

Project: NWSC Groundwater Study Site: Crane, IN Date: 16 November 82
Location: Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig: ____ Inspector: J. Dunbar Operator: D. Taylor Surface El: 610.18 Boring No. WES-1-9-82

SAMPLE NUMBER	DATE TAKEN 1982	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	16Nov			0.0	1.0			6-3/4"Rock Bit			6" Casing to 1 ft-Stickup 1 ft
		0.0	1.5	0.0	29.5			5-5/8"Rock Bit			Clay(CL): brown, soft, sandy
		1.5	2.3								Sandstone: brown, fine-grained, weathered
											Clay shale: brownish grey, soft
		2.3	5.3								Clay shale: grey, soft
		5.3	9.0								Clay shale: brownish grey, soft
		9.0	11.3								Shale: grey, soft-slightly damp
		11.3	14.2								Shale: grey, soft
		14.2	17.0								Shale: light grey-grey, soft, wet
		17.0	24.0								Shale: dark grey, hard
		24.0	32.0								Water overnight at 22.2 ft -
	17Nov			29.5	32.0			5-5/8"Rock Bit			drilled to 32 ft and installed well

Sheet 1 of 1 Sheets

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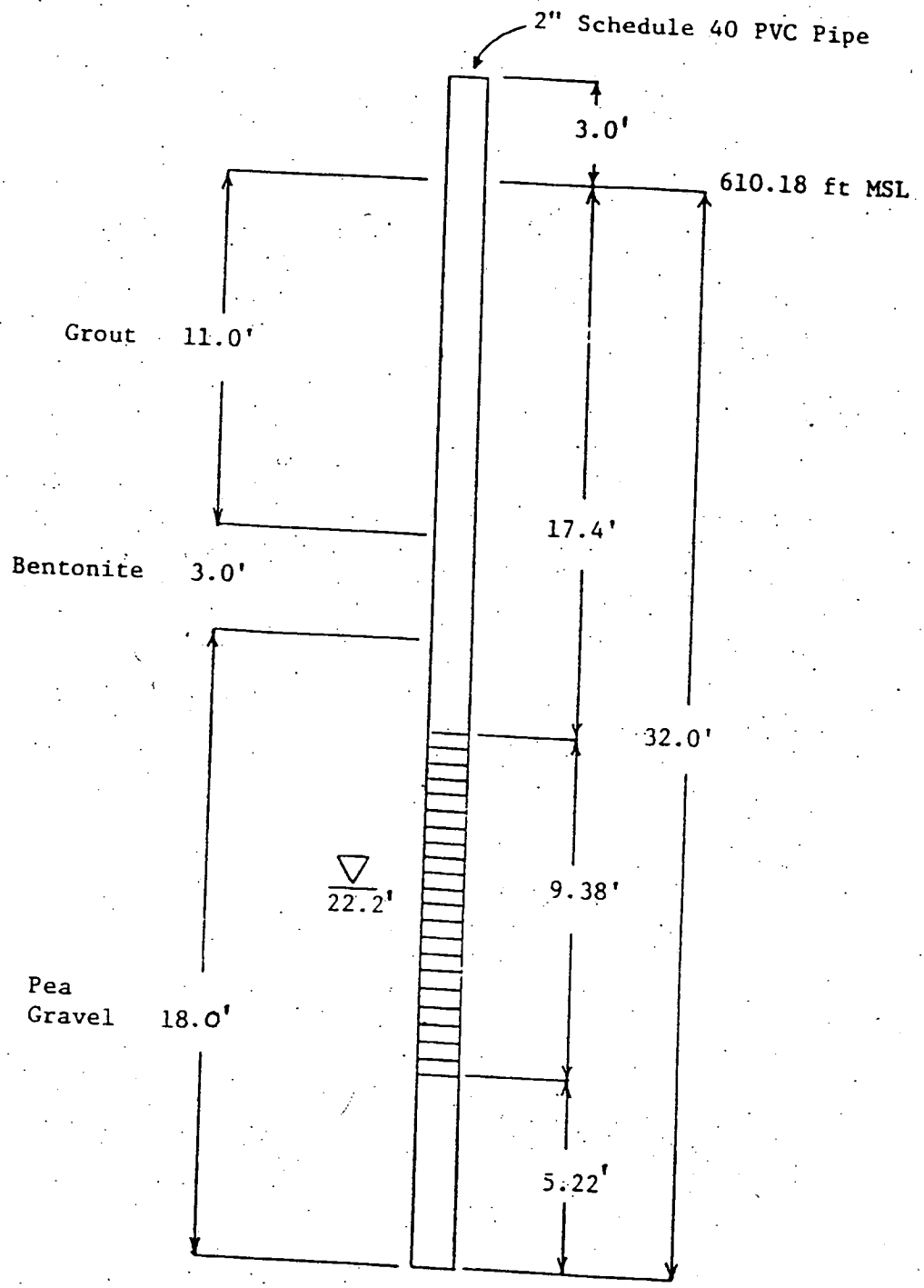

Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Ground
Well Completion
Boring Number: WES-1-9-8

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 30 November 82
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 636.77 Boring No. WES-1-10-83

SAMPLE NUMBER	DATE TAKEN 1982	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	30Nov			0.0	1.0			6 3/4"Rock Bit			6" Casing to 1 ft-Stickup 1 ft
		0.0	2.0	0.0	120.0			5 5/8"Rock Bit			Clay(CL): brown, soft, damp,
											sandy
		2.0	6.5								Clay shale: brown, grey, soft
		6.5	8.0								Clay shale and sandstone interbedded:
											brown, soft
		8.0	20.0								Sandstone with interbedded shale:
											sandstone is brown, grey, fine-
											grained and shale is dark grey, soft
		20.0	21.0								Coal: black, soft
											dry
		21.0	35.0								Sandstone: white, light grey, soft
											uniform
		35.0	65.3								Shale: dark grey, soft, damp at
											around 40 ft - very little water
											after 75 min.

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BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-10-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		65.3	65.8								Coal/shale: black, soft
		65.8	73.2								Shale: light grey, dark grey, soft
		73.2	73.5								Shale/coal: black, soft
		73.5	83.0								Sandstone: grey, dark grey, very
											fine-grained, soft
		83.0	83.2								Limestone: grey, hard
		83.2	103.0								Sandstone: light brown, brown, grey
											very fine-grained, soft
		103.0	120.0								Limestone: grey, hard
	22Jan										Boring is to deep for any
											practical use. Filled boring with
											cement mix and grout. Moved
											approximately 10 ft from this
											location and drilled to 40 ft.
											Borings WES-1-12 and 13-83 on same

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Sheet 2 of 3 Sheets

WORKING DRAFT

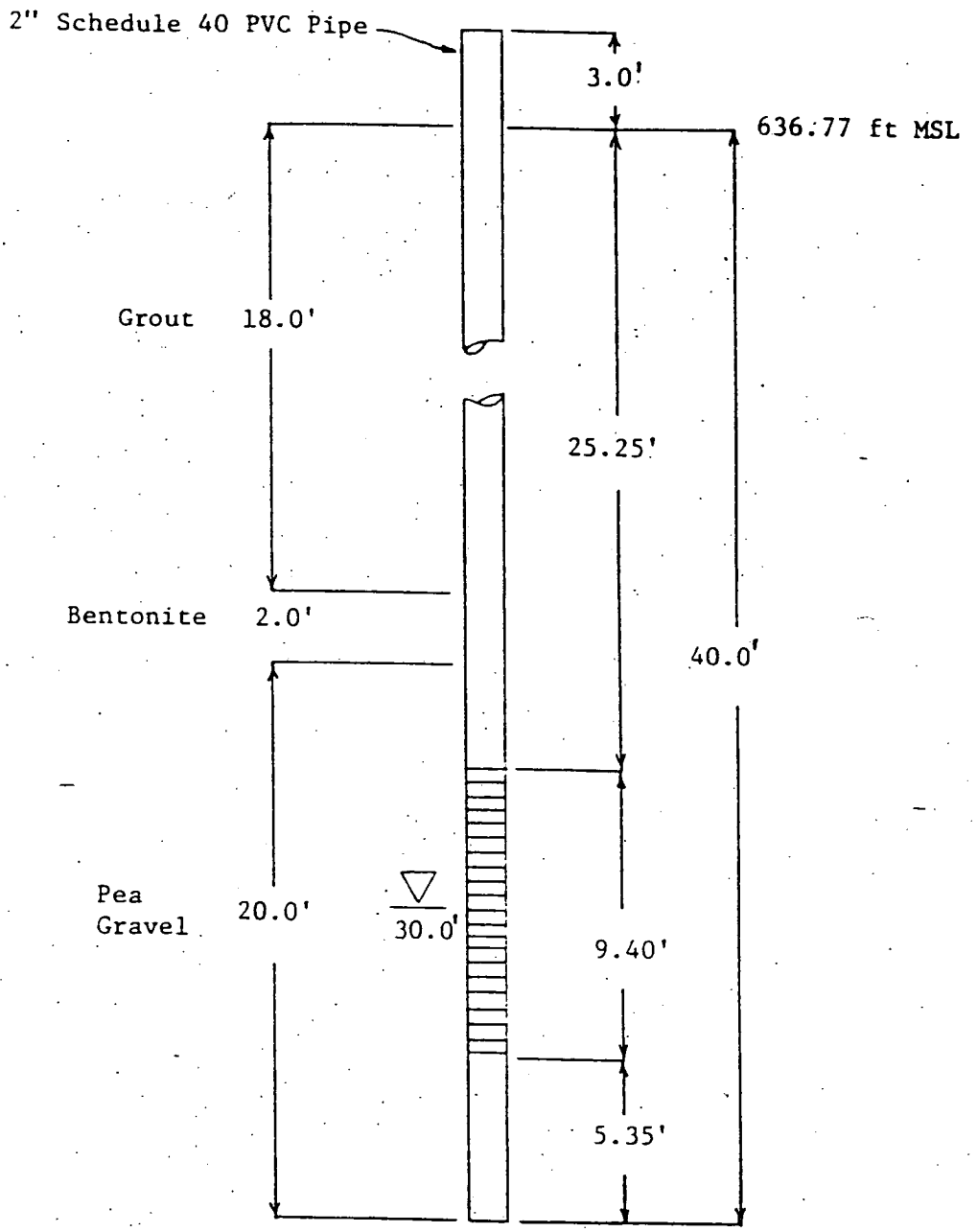
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-10-83

SAMPLE NUMBER	DATE TAKEN	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO				
											shelf, encountered water between
											20 to 30 ft. Fractures are not
											present or not as intense at this
											location as in WES-1-12 and
											1-13-83. Believe there is a damp
											spot at 30.0 ft. Will construct
											a longer gravel filter around
											well screen.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-10-83

WORKING DRAFT

BORING LOG
FIELD DATA

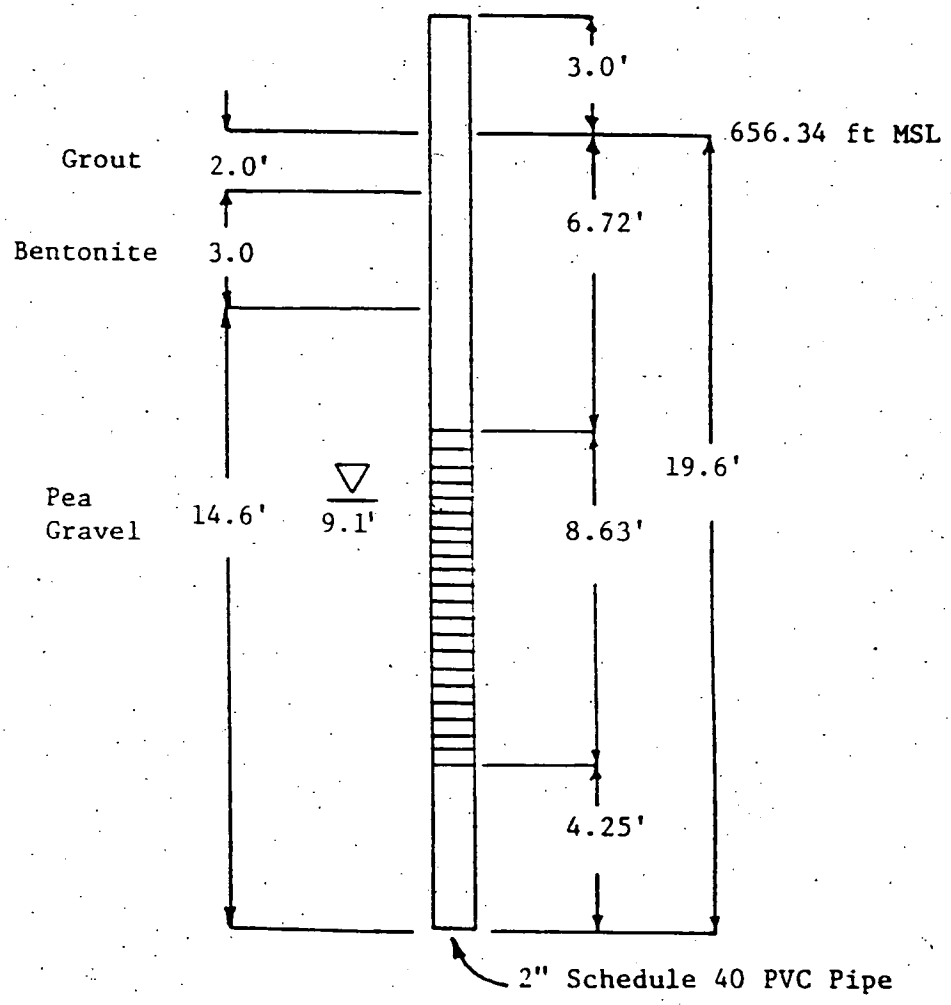
Project NWSC Groundwater Study Site Crane, IN Date 8 January 83
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 656.34 Boring No. WES-1-11-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	8 Jan			0.0	1.7			6" Casing			Stickup 0.3 ft
	8 Jan	0.0	4.6	0.0	19.6			5-5/8"Rock Bit			Clay(CL): brown, soft, moist, organic matter(roots)
		4.6	11.1								Sandstone: brown, very fine-grained, friable, water at 9.1 ft
		11.1	14.4								Sandstone: grey, very fine-grained, clayey
		14.4	18.8								Shale: dark grey, soft, interbedded with sandstone
		18.8	19.6								Limestone(?): very hard, no return
											Installed well

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

WORKING DRAFT



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grou
Well Completion
Boring Number: WES-1-1

BORING LOG
FIELD DATA

Project NWSC Groundwater Study
Location Mustard Gas Burial Grounds
Site Crane, IN
Date 19 January 83
Drill Rig Failing
Inspector J. Dunbar
Operator D. Taylor
Surface El 634.05
Job No. 441-G150.13GR21/22
Boring No. WES-1-12-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	19 Jan			0.0	1.0			6-3/4"Rock Bit			6" Casing - 1.0 ft stickup
		0.0	1.5	0.0	38.0			5-5/8"Rock Bit			Clay(CL): brown, soft, damp
		1.5	3.0								silty sand(SM): reddish brown, soft, damp, fine-grained
		3.0	7.5								Clay shale: brown, soft
		7.5	10.0								Shale: dark grey, soft
		10.0	13.5								Shale: dark grey, medium
		13.5	17.5								Shale: dark grey, medium, sandstone lenses-very fine-grained
		17.5	18.8								Shale: grey, soft
		18.8	19.5								Sandstone: grey, hard, fine-grained
		19.5	22.0								Coal: black, soft
		22.0	23.5								Shale: dark grey, soft
		23.5	28.0								Shale and sandstone: dark grey, soft, fine-grained sandstone, water at 27 ft
		28.0	38.0								Shale: light grey, soft, uniform

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

BORING LOG
FIELD DATA

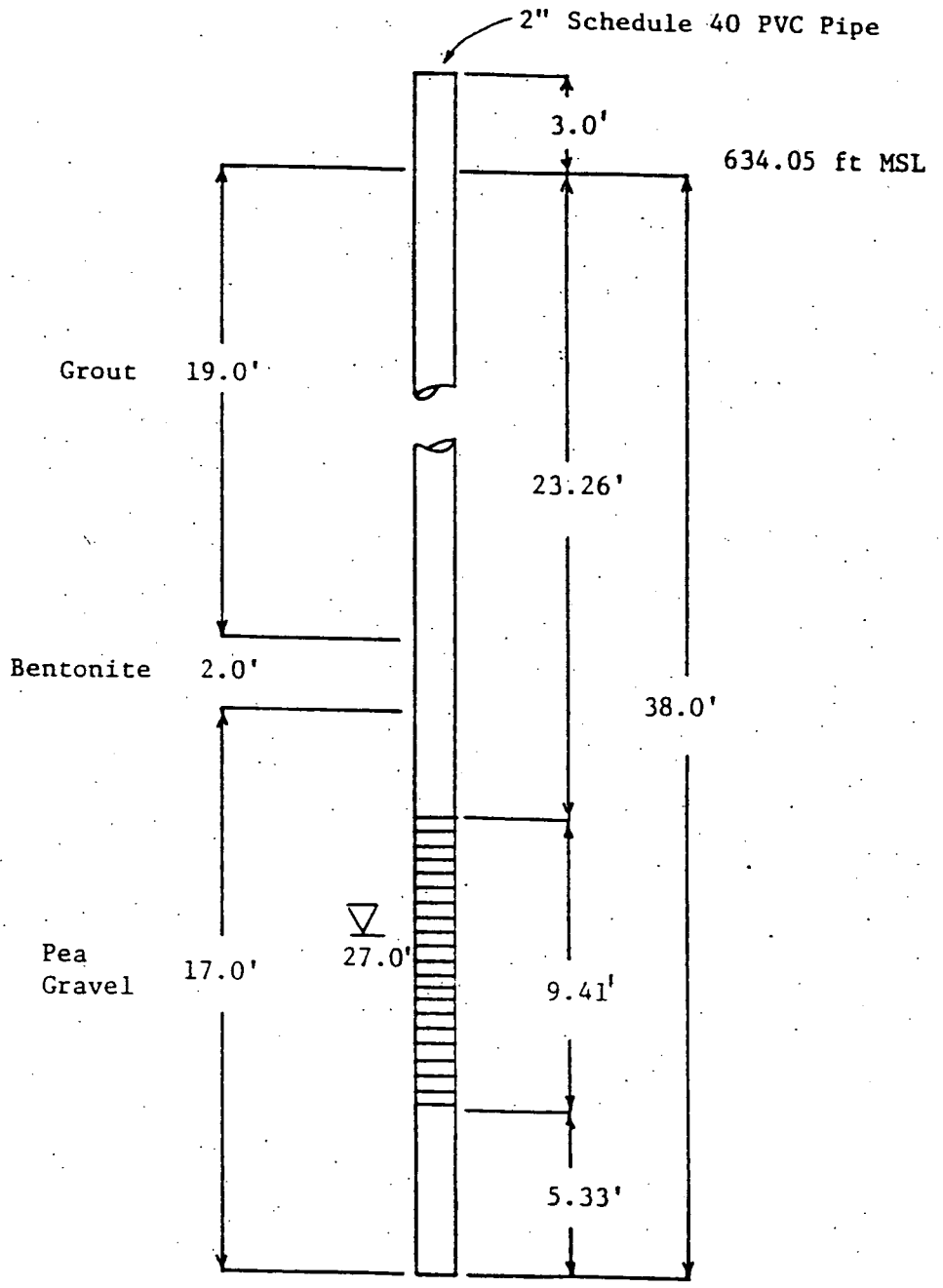
Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-12-83

SAMPLE NUMBER	DATE TAKEN	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO				
											Installed well

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

WORKING DRAFT



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-12-83

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Groundwater Study
Location Mustard Gas Burial Grounds
Site Crane, IN
Date 19 January 83
Drill Rig Failing
Inspector J. Dunbar
Operator D. Taylor
Surface El 634.98
Job No. 441-G150.13GR21/22
Boring No WES-1-13-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	19 Jan			0.0	1.0			6-3/4"Rock Bit			6"Casing - Stickup 1.0 ft
	21 Jan			0.0	4.0			5-5/8"Rock Bit			Cleanout for 4"x5½" Core Barrel
				4.0	7.2			4"x5½"Core Barrel			Run 1
				7.2	11.5			" "	"		Run 2
				11.5	12.6			" "	"		Run 3
				12.6	15.9			" "	"		Run 4
				15.9	20.3			" "	"		Run 5
				20.3	25.6			" "	"		Run 6
				25.6	30.35			" "	"		Run 7
				30.35	34.7			" "	"		Run 8
	22 Jan			0.0	35.0			5-5/8"Rock Bit			Cleanout
		0.0	10.5								
		10.5	18.6								Clay Shale
		18.6	21.4								Shale(60%) and Sandstone(40%)
		21.4	22.9								Shale
		22.9	30.35								Coal (Bituminous)
											Sandstone

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED.

Sheet 1 of 6 Sheets

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-13-83

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		30.35	35.0								Sandstone(80-90%) and Shale (10-20%)
											See boring log starting on page 3 for details. Installed monitoring well on 22 January 83. Flow is estimated to be approximately 10-20 GPM

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 6 Sheets

WORKING DRAFT

DRILLING LOG

DIVISION	US Navy
INSTALLATION	Crane, IN
1. PROJECT	NWSC Groundwater Study
2. LOCATION (Coordinates or Station)	Mustard Gas Burial Grounds
3. DRILLING AGENCY	CEWES
4. HOLE NO. (As shown on drawing title and file number)	WES-1-13-83
5. NAME OF DRILLER	D. Taylor
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	0.0
8. DEPTH DRILLED INTO ROCK	35.0
9. TOTAL DEPTH OF HOLE	35.0
10. SIZE AND TYPE OF BIT	4"x5½" Diamond
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MSL
12. MANUFACTURER'S DESIGNATION OF DRILL	Failing
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: Zero; UNDISTURBED: Zero
14. TOTAL NUMBER CORE BOXES	Zero
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED: 20 Jan 83; COMPLETED: 22
17. ELEVATION TOP OF HOLE	634.98
18. TOTAL CORE RECOVERY FOR BORING	92.6
19. SIGNATURE OF INSPECTOR	[signature]

Hole No. WES

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, weathering, etc., if significant) g
634.98	0.0					
633.98	1.0		Clay Shale: brown, dark grey, weathered, brittle, oxidized, limonitic, soft			
632.98	2.0					5-5/8" Rock Bit ft to make room 4"x5½" Core Barr
631.98	3.0					
630.98	4.0		MB = Machine break			21 January 83
629.98	5.0		MB; MB; MB — closed fracture			Began 9:50 End 10:10 Time 20 Min Drl time 20 Min Hyd press 200 PS Water press - RPM 70+ Drl Action Smooth ~~Water~~ ret brown,
			fractured-weathered			
628.98	6.0		Clay shale: brown, dark grey, weathered, brittle, oxidized, limonitic, soft.			Remarks Carbaloid bit
			fractured - v. brittle, broke on removal from barrel			
627.98	7.0		Run 1 RQD=15.6%	100%		
			fractured - partial recovery			Began 10:20 End 10:35 Time 15 Min Drl time 15 Min Hyd press 200 PSI Water press - RPM 70 + Drl Action Smooth ~~Water~~ ret brown, orange Remarks Carb bit
626.98	8.0		fractured - larger rock pieces (1" to 4" fragments)			
625.98	9.0		Clay shale: same	88.4%		
			closed			
624.98	10.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE

Hole No. WES-1-13-83

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane, IN	SHEET 4 OF 6 SHEETS

1. PROJECT NWSC Groundwater Study	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY CEWES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing
4. HOLE NO. (As shown on drawing title and file number) WES-1-13-83	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER D. Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
624.98	10.0		∠= 45° Clay shale: same			
			Shale(60%) and Sandstone(40%): ultra fine horizontal lamina and lenses of interbedded dark grey shale and light grey, very fine-grained sandstone, soft to medium			
623.98	11.0		Run 2 RQD=48.8%			
						HL- Run 3 Began 10:46 Rec 1.1' End 11:03 Loss - Time 17 Min Gain - Drl time 17 Min Hyd press 200 PSI Water press - RPM 70+ Drl Action Smooth ~~Water~~ ret lt to dark grey Remarks Carbaloid drill bit
622.98	12.0		MB Shale(60%) and Sandstone(40%) MB same as above	100%		
			Run 3 RQD=45.5%			
621.98	13.0		oxidized from 13.25 to 13.35 ft Spin			
620.98	14.0		Shale(60%) and Sandstone(40%) same as above	72.7%		
						HL - Run 4 Began 11:13 Rec 2.4' End 11:20 Loss 0.9' Time 7 Min Gain - Drl time 7 Min Hyd press 200 PSI Water press - RPM 70+ Drl Action Smooth ~~Water~~ ret light-dark grey Remarks Diamond drill bit
619.98	15.0		Run 4 RQD=72.7%			
618.98	16.0		Shale(50%) and Sandstone(50%) same as above			
617.98	17.0					HL - Run 5 Began 11:40 Rec 4.4' End 12:00 Loss - Time 20 Min Gain - Drl time 20 Min Hyd press 200 PSI Water press - RPM 70+ Drl Action Smooth ~~Water~~ ret light-dark grey Remarks same
616.98	18.0		MB	100%		
615.98	19.0		fractured Shale: dark grey, soft, uniform, possibly damp			
614.98	20.0					

WORKING DRAFT

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-1-1

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5
	US Navy	Crane IN	

1. PROJECT: NWSC Groundwater Study	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: CEWES	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing
4. HOLE NO. (As shown on drawing title and file number): WES-1-13-83	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: D. Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
614.98	20.0		Run 5 ROD=79.5%			
613.98	21.0		Shale: same - no recovery			WL - Run 6 Began 12:35 Rec 4. End 1:10 Loss 1. Time 35 Min Gain - Drl time 35 Min Hyd press 200 PSI Water press - RPM 70± Drl Action Smooth ~~Water~~ ret dark grey, black, white Remarks wet at coal seam
612.98	22.0		Coal (Bituminous): black, blocky, brittle, fractured, weathered-sulfides with gossan			
611.98	23.0		∠45°			
610.98	24.0		Sandstone: light grey, white, fine-grained, quartz sandstone, thinly bedded to massive with cross bedding visible, fractures are weathered, oxidized, with partial solution filling.	79.2%		WL - Run 7 Began 2:05 Rec 3. End 2:25 Loss - Time 20 Min Gain - Drl time 20 Min Hyd press 200 PSI Water press - RPM 70± Drl Action Smooth ~~Water~~ ret lt. grey, white Remarks Blocked off, More water
609.98	25.0		MB MB MB Run 6 ROD=40%			
608.98	26.0		orange brown from 26.7 ft to 27.1 ft			
607.98	27.0					
606.98	28.0		Sandstone: same as above	100%		
605.98	29.0		orange brown from 29.3 ft to 29.6 ft closed			
604.98	30.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

Hole No. WES-1-13-83

DRILLING LOG	DIVISION US Navy	INSTALLATION Crane, IN	SHEET 6 OF 6 SHEETS

1. PROJECT NWSC Groundwater Study	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) Mustard Gas Burial Grounds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY CEWES	12. MANUFACTURER'S DESIGNATION OF DRILL Failing
4. HOLE NO. (As shown on drawing title and file number) WES-1-13-83	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER D. Taylor	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
604.98	30.0		Run 7 RQD=100%			
			Sandstone: same			
603.98	31.0		fracture-weathered and oxidized			ML - Run 8 Began 3:00 Rec 4.35 End 3:35 Los - Time 35 Min Gain - Drl time 35 Min Hyd press 200 PSI Water press - RPM 70 ± Drl Action Smooth ~~Water~~ rat lt-dark grey
			Shale conrent in this interval at 5-10%			
602.98	32.0					
			Sandstone (see above) with 10-20% thinly bedded, soft, dark grey shale seams, coal lamina are also present			
601.98	33.0					Remarks Stuck core barrel and removed on 22 January 83 Estimate quantity of flow to be 10 to 20 GPM
600.98	34.0			100%		
			Run 8 RQD=54%			
599.98	35.0		Reamed hole with 5-5/8" Rock Bit and set well			

WORKING DRAFT

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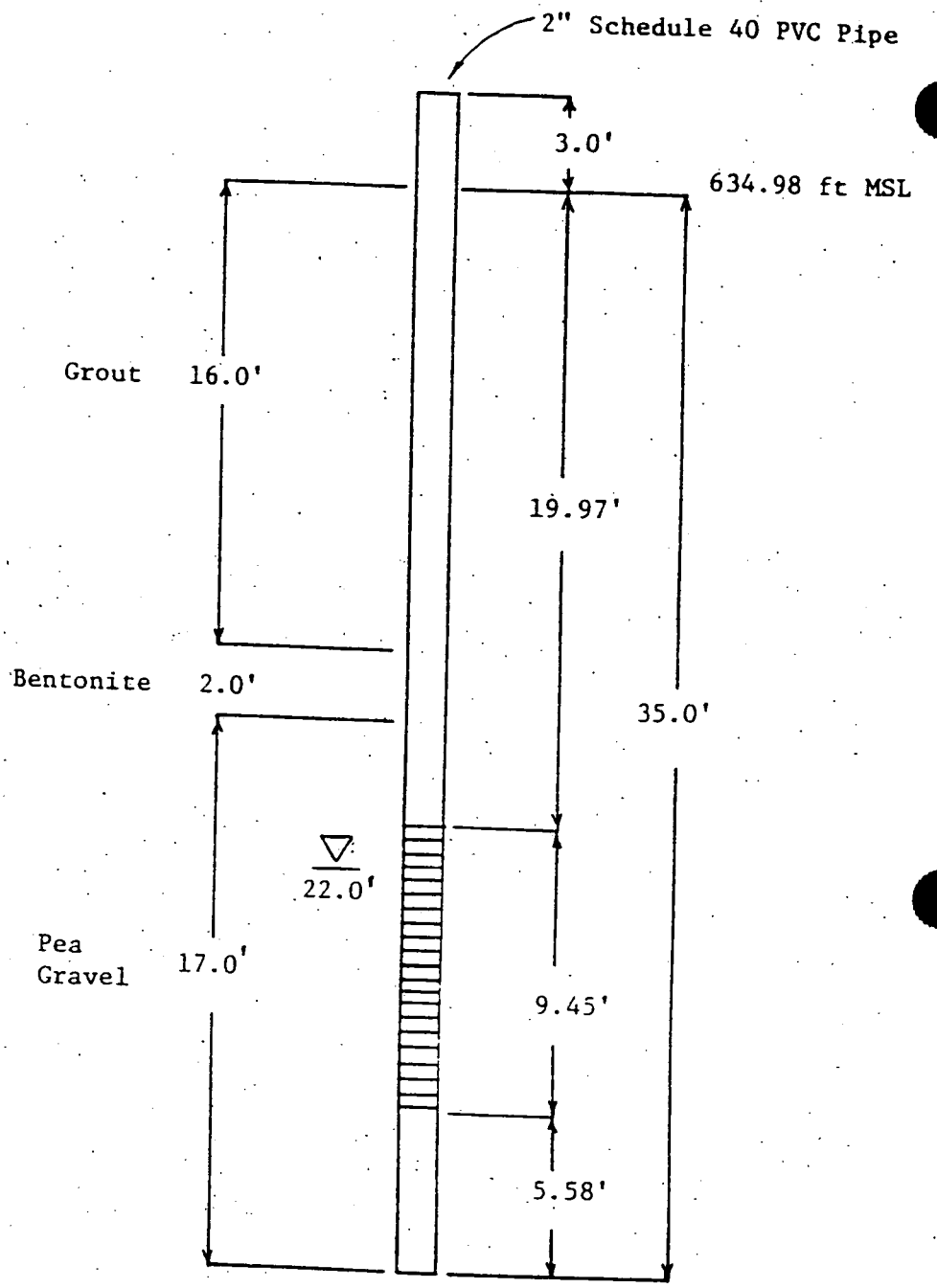


Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grou
Well Completion
Boring Number: WES-1-1

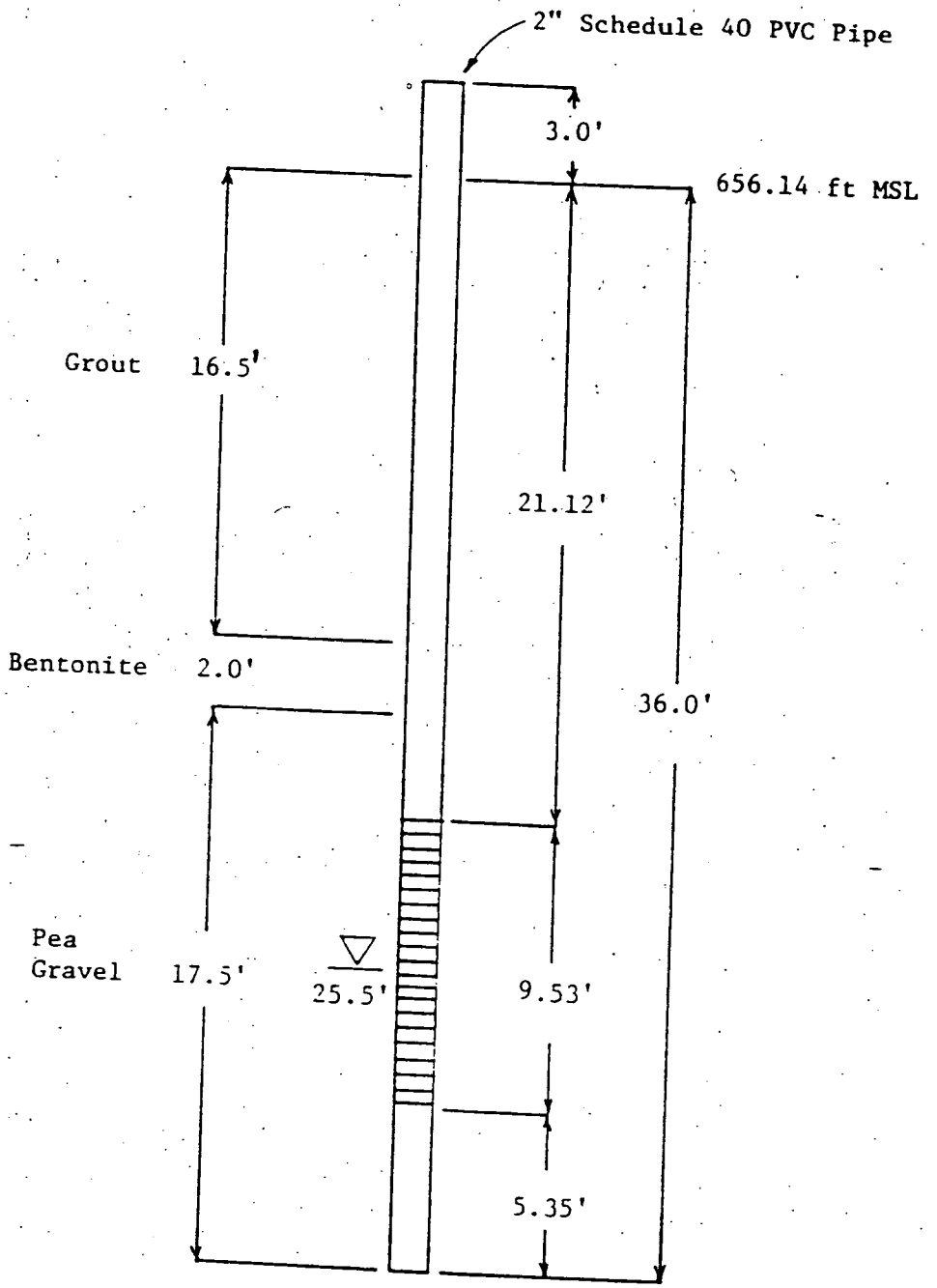
BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 25 January 83
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 656.14 Boring No. WES-1-14-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	26 Jan			0.0	1.0			6-3/4"Rock Bit			6" Casing - 1.0 ft stickup
		0.0	3.0					5-5/8"Rock Bit			Clay(CL): brown, soft, damp, sandy
		3.0	6.0								Gravelly clay(GC): same as above, gravel is fine to coarse at 30%
		6.0	7.5								Clay(CL): brown, soft, damp
		7.5	14.5								Sandstone: brown, fine-grained, soft, weathered
		14.5	15.5								Shale: brown, dark brown, soft
		15.5	20.0								Sandstone: brown, light grey, fine-grained, soft
		20.0	24.0								Shale(60%) and sandstone(40%): light grey, dark grey, medium fine-grained sandstone
		24.0	36.0								Shale: dark grey, uniform, water at 25.5 ft
											Installed well

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-14-83

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 February 83
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 663.01 Boring No. WES-1-15-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	10 Feb			0.0	1.0			6-3/4"Rock Bit			6" Casing - 1 ft stickup
		0.0	5.0	1.0	37.8			5-5/8"Rock Bit			Clay(CL): brown, soft, damp, sandy
		5.0	10.0								Limestone: grey, hard, fine-grained
		10.0	11.5								Clay: brown, soft
		11.5	13.2								Sandstone: reddish brown, fine-grained, soft
		13.2	15.8								Clay: brown, soft
		15.8	21.7								Sandstone: light brown, grey, fine-grained, soft
		21.7	32.0								Sandstone: grey, fine-grained, soft
											water between 25-26 ft
		32.0	33.0								Shale: grey, soft
		33.0	37.8								Sandstone: light grey, fine-grained, soft
											Installed well

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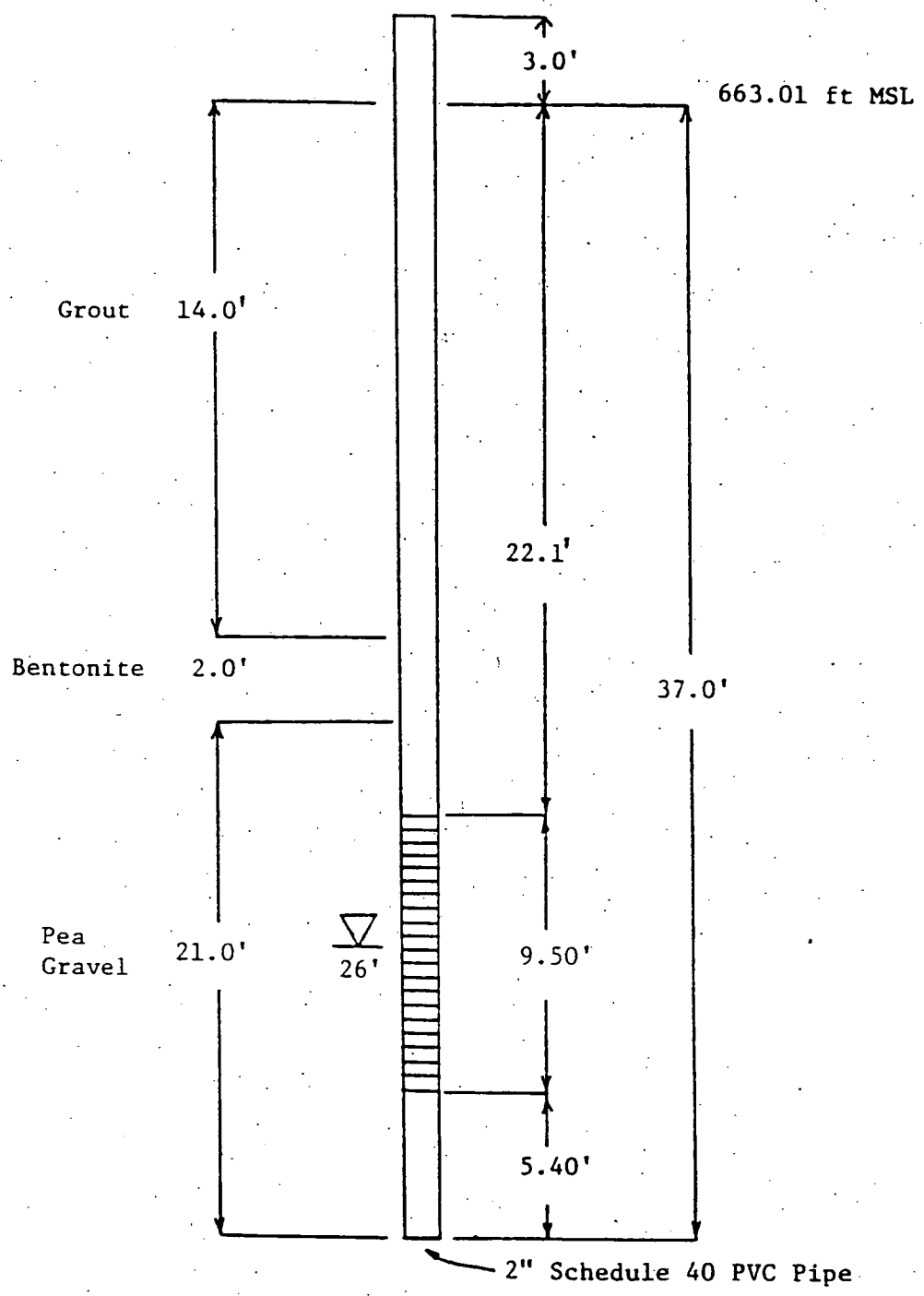
Sheet 1 of 1 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grour
Well Completion
Boring Number: WES-1-1:

BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 11 February 83
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 641.94 Boring No. WES-1-16-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	11 Feb			0.0	1.0			6-3/4"Rock Bit			6" Casing - 1 ft stickup
		0.0	9.5	1.0	38.5			5-5/8"Rock Bit			Sandstone: reddish brown, fine-
											grained, soft, weathered
		9.5	10.6								Clay: brown, soft
		10.6	16.5								Sandstone: brownish grey, soft,
											fine-grained
		16.5	26.0								Sandstone: grey, fine-grained, soft
		26.0	29.4								Sandstone: reddish brown, grey,
											soft, fine-grained, water at 27.5 ft
		29.4	35.2								Shale: blueish grey, soft, uniform
		35.2	36.0								Coal: black, soft
		36.0	38.5								Sandstone: grey, soft, fine-grained
											Installed well

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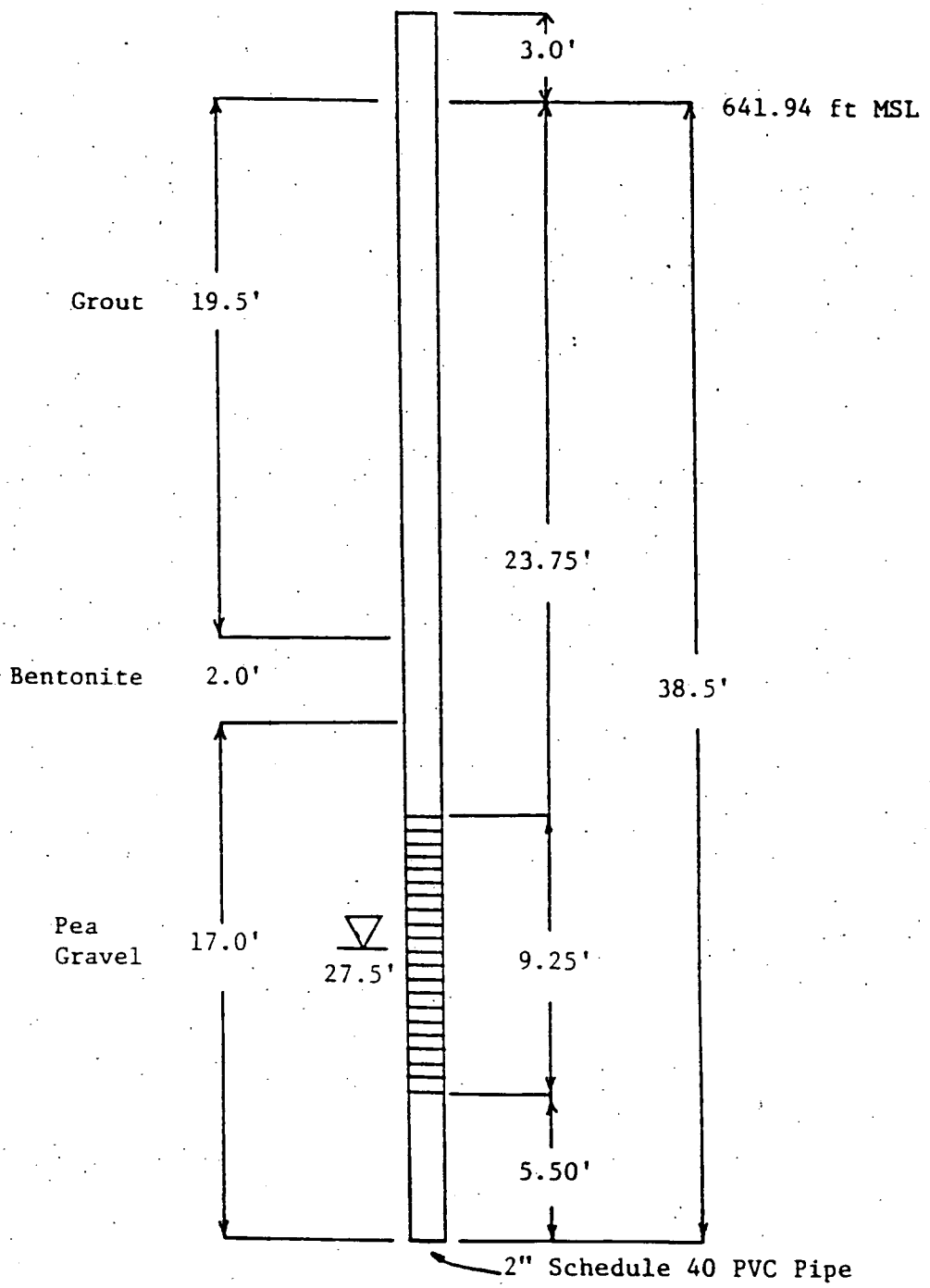
Sheet 1 of 1 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-16-83

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BORING LOG
FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 12 February 83
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 662.54 Boring No. WES-1-17-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	12 Feb			0.0	1.5			6-3/4"Rock Bit			6" Casing - 0.5 ft stickup
		0.0	2.8	1.5	39.0			5-5/8"Rock Bit			Clay(CL): brown, soft, damp, sandy
		2.8	10.0								Clay(CL) and sandstone gravel:
											brown, reddish brown, soft,damp, fin
											to coarse gravel, weathered
		10.0	18.0								Sandstone: tan, light brown, soft,
											fine-grained, uniform
		18.0	34.0								Sandstone: light brown, reddish
											brown, weathered, soft, water
											at 28 ft
		34.0	39.0								Shale: grey, soft, possibly oily
											Blew well several times. Appearance
											of oil film which did not come from
											compressor or rig. Installed well
											and gravel and rinsed with water to

WORKING DRAFT

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

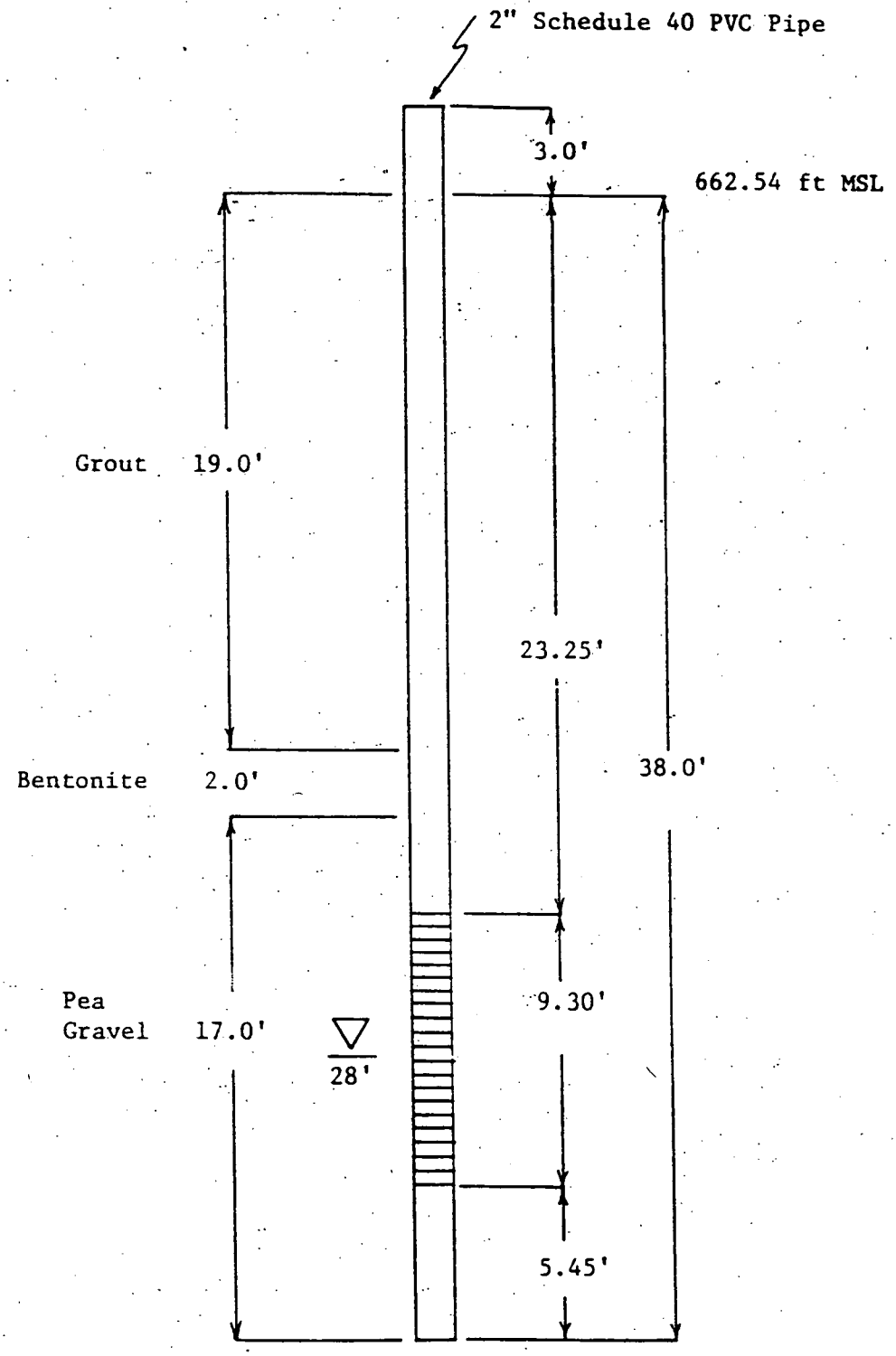
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-17-83

SAMPLE NUMBER	DATE TAKEN	STRATUM		DRIVE		SAMPLE		TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		FROM	TO	FROM	TO	FROM	TO				
											clear up. Poured bentonite pellets
											and grouted up.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-17-83

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 17 June 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 658.40 Boring No. WES-1-18-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	17 Jun	0.0	3.0	0.0	30.5			5-5/8" Rock	Bit		Clay (CL): brown, sandy, damp, slight to moderate cohesion, organic matter.
		3.0	11.0								Sandstone: light brown, soft weathered, very fine-grained, quartz sand.
		11.0	12.5								Sandstone: dark brown, weathered, soft, very fine-grained, quartz sand.
		12.5	13.5								Sandstone: light brown, weathered, soft, very fine-grained, quartz sand.
		13.5	13.7								Shale: light grey, soft.

Sheet 1 of 3 sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-18-83

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		13.7	14.0								Sandstone: light brown, soft, very fine-grained, quartz sand.
		14.0	16.5								Shale: light grey, soft.
		16.5	18.0								Sandstone: dark brown, very fine-grained, soft, wet at 18 ft.
		18.0	19.5								Sandstone and shale: brown, light grey, soft, thinly bedded.
		19.5	19.7								Sandstone: brown, weathered, very fine-grained.
		19.7	21.5								Sandy shale: dark grey, soft, sandy - very fine-grained.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 3 Sheets

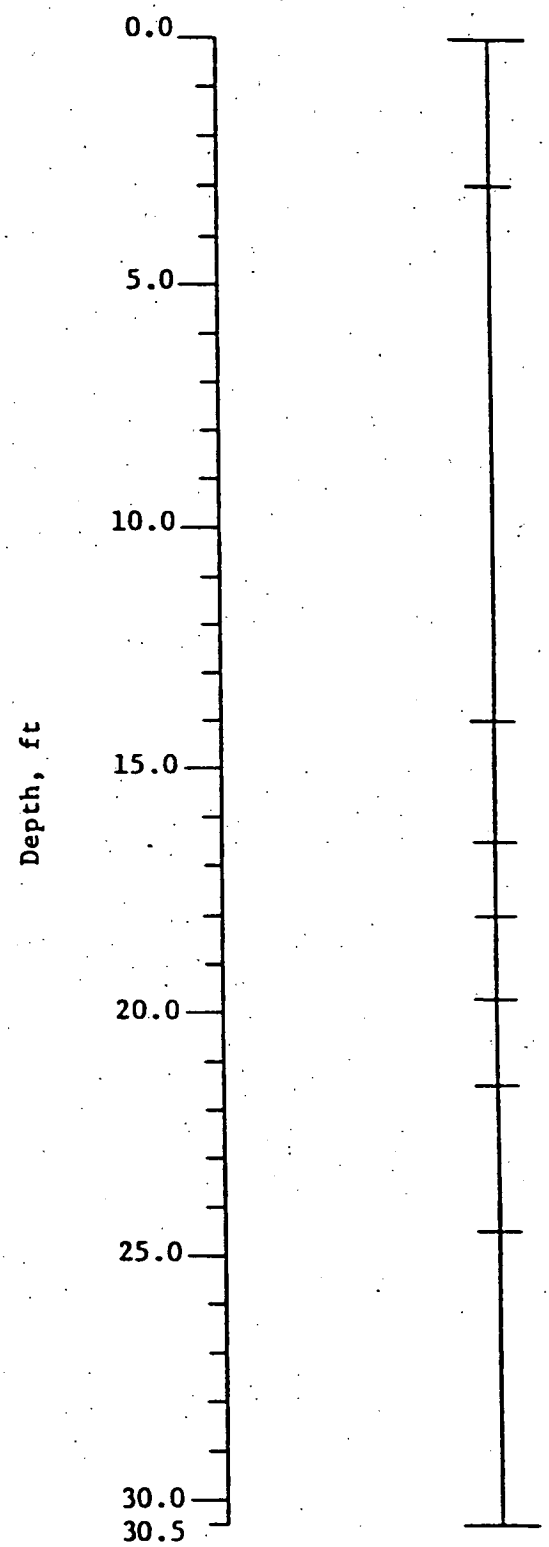
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-18-83

SAMPLE NUMBER	DATE TAKEN	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		21.5	24.0								Sandstone and shale: sandstone grades from dark brown to brown, shale ranges from light grey to dark grey, soft, thinly bedded.
		24.5	30.5								Sandstone: brown, tan, dark brown, soft, very fine-grained, quartz sand.
	18 Jun										Open hole overnight - water level at 14.04 ft. Installed monitoring well.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 sheets



658.40 ft MSL

Clay (CL): brown, sandy, damp, slight to moderate cohesion, organic matter.

Sandstone: light brown, dark brown, very fine-grained, quartz, weathered, soft. From 13.5 to 13.7 ft, grey shale.

Shale: light grey, soft.

Sandstone: dark brown, weathered, soft, very fine-grained, quartz sand.

Sandstone and shale: brown, light grey, soft, thinly bedded.

Sandy shale: dark grey, soft very fine-grained, white quartz sand.

Sandstone and shale: various shades of brown and grey, thinly bedded.

Sandstone: brown, tan, dark brown, soft very fine-grained, quartz sand.

NWSC, Crane, Indiana
Mustard Gas Burial Grunds
Lithology
Boring Number: WES-1-18-83

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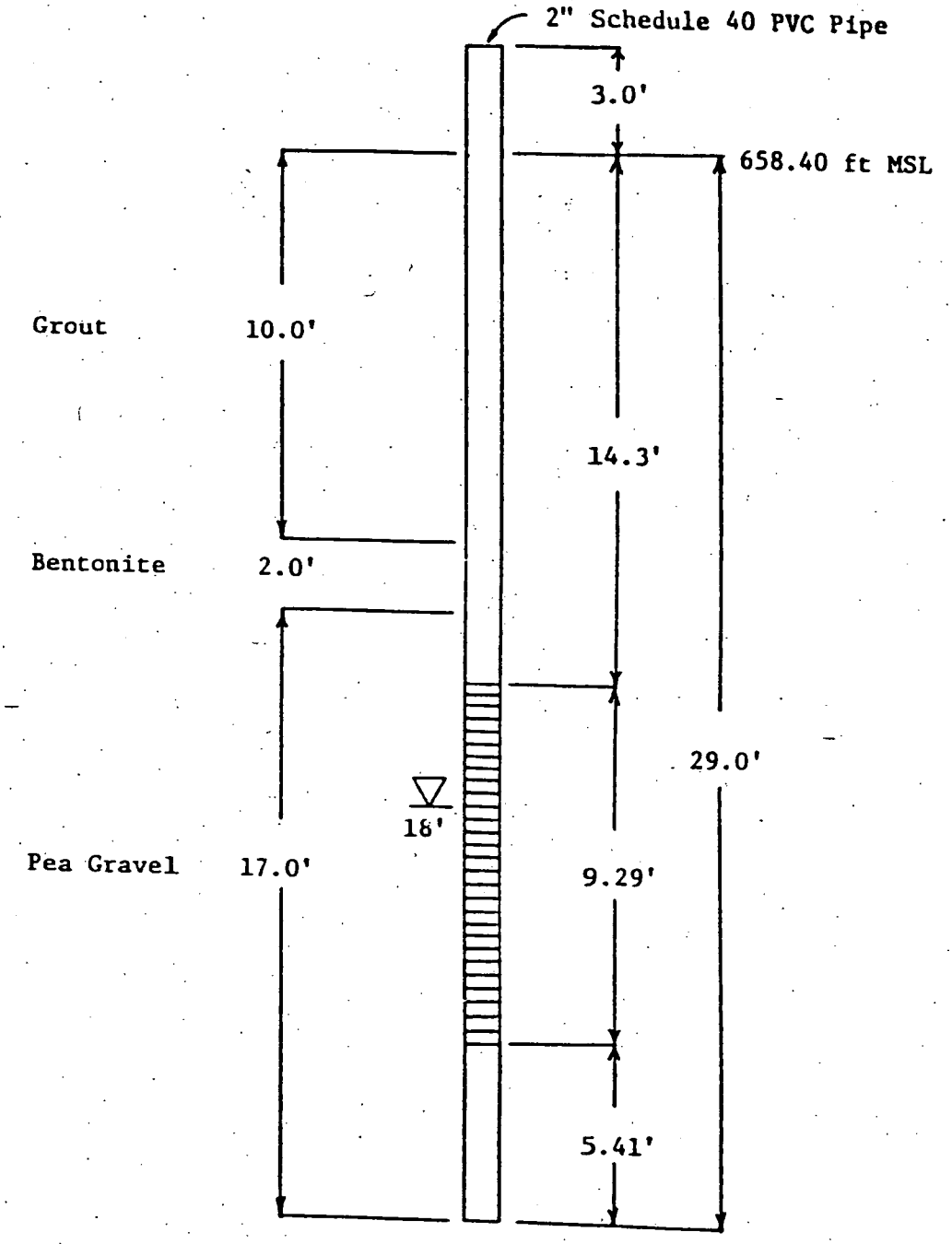

Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Gro
Well Completion
Boring Number: WE[redacted]1

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 17 June 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 656.79 Boring No. WES-1-19-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	17 Jun	0.0	6.5	0.0	30.2			5-5/8" Rock Bit			Clay (CL): brown, soft, sandy, organic matter, slight to moderate cohesion.
		6.5	11.5								Sandstone: brown, very fine-grained, soft.
		11.5	12.5								Shale: grey, very soft.
		12.5	15.0								Sandstone: light brown, very fine-grained, soft.
		15.0	16.0								Sandstone: light grey - same.
		16.0	16.5								Sandstone: brown - same.
		16.5	17.0								Clay/Shale: grey, very soft, damp.

Sheet 1 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No. _____

Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-19-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		17.0	30.2								Sandstone: brown, grey, dark brown, very fine-grained, quartz sand, soft, thinly bedded with trace of shale.
	18 Jun										Open hole overnight - water level at 19.2 ft. Installed monitoring well.

Sheet 2 of ___ Sheets

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1-19-83

WELL CONST ?

WORKING DRAFT

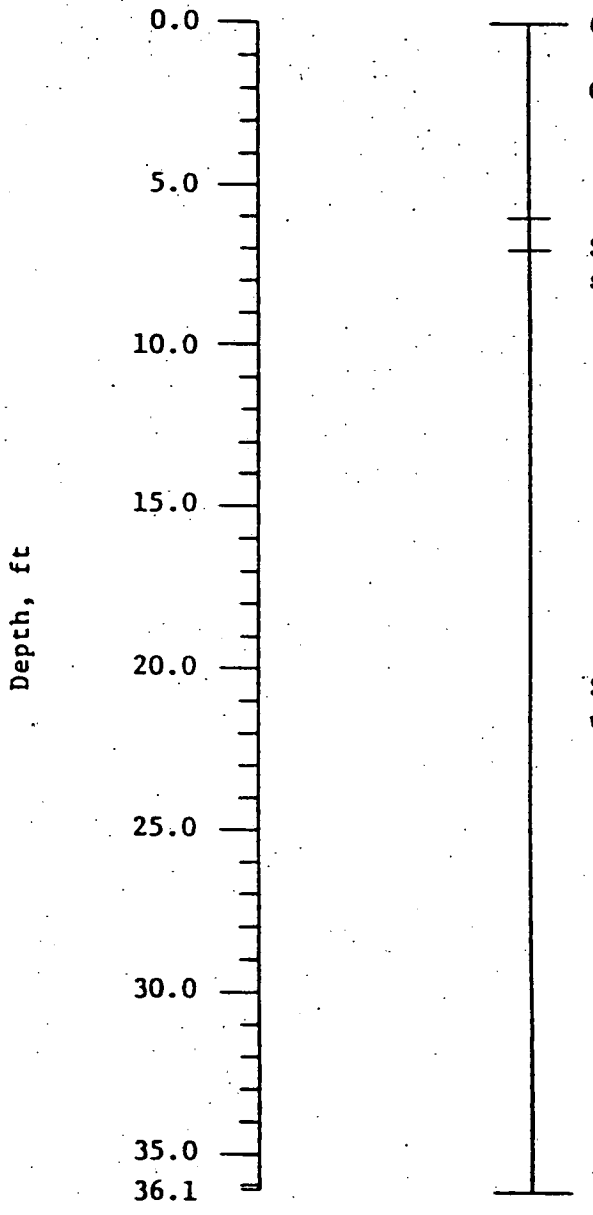
BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 20 June 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 631.35 Boring No. WES-1-20-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	20 Jun	0.0	6.0	0.0	36.1			5-5/8" Rock	Bit		Clay (CL): brown soft, gravelly, damp.
		6.0	7.0								Sandstone: brown, very fine-grained, soft, weathered.
		7.0	36.1								Shale: grey, light grey, dark grey, soft, uniform, water at 20 ft.
	21 Jun										Hole open overnight - water level at 24.55. Installed monitoring well.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets



631.35 ft MSL

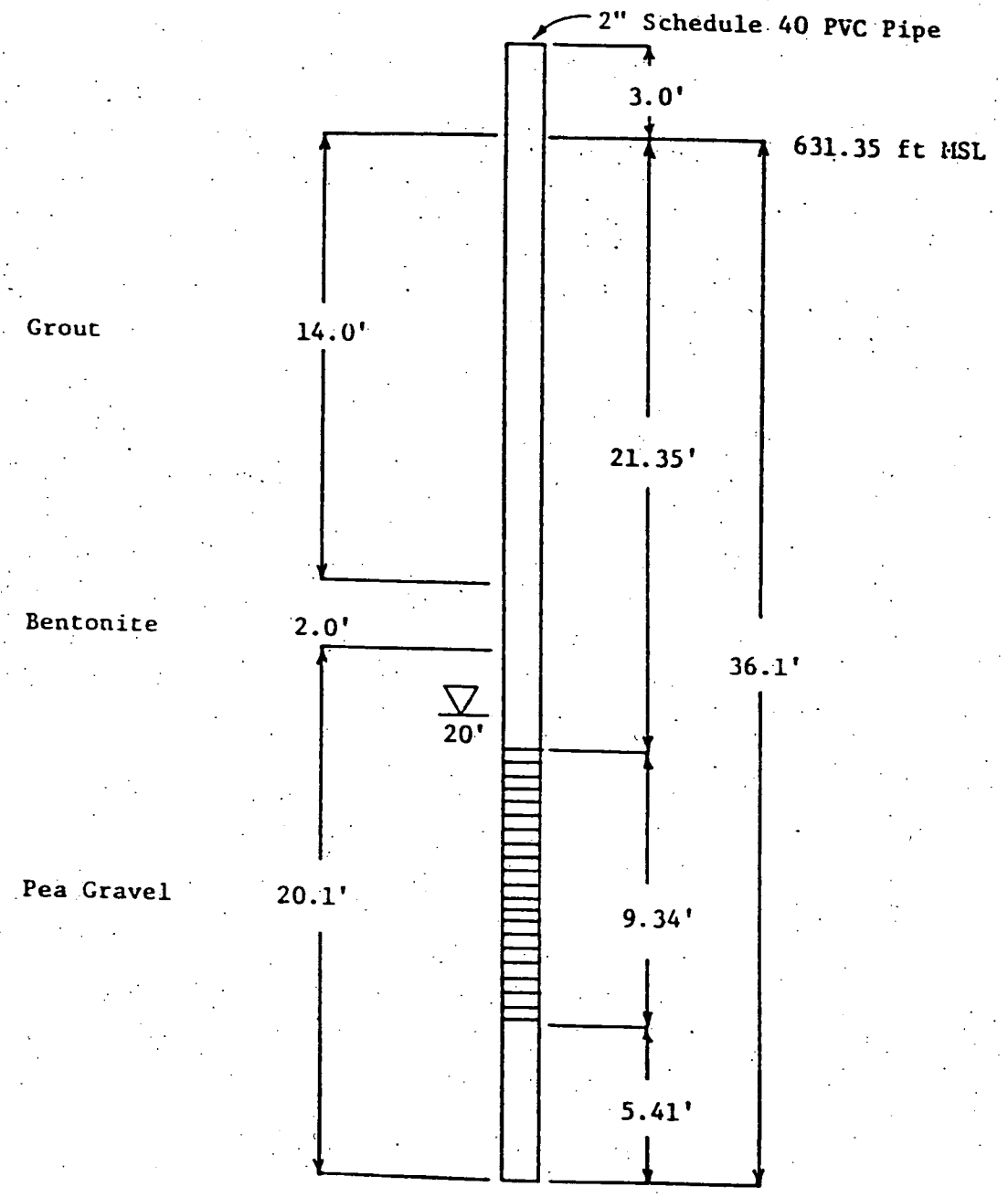
Clay (CL): brown, soft, gravelly, damp.

Sandstone: brown, very fine-grained, soft, weathered.

Shale: light grey to dark grey, soft, uniform.

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Lithology
Boring Number: WES-1-20-83

WORKING DRAFT



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-20[illegible]3

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 20 June 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 603.82 Boring No. WES-1-21-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	20 Jun	0.0	6.5	0.0	40.5			5-5/8" Rock	Bit		Clay (CL): brown, soft, gravelly, damp.
		6.5	9.5								Clay (CL): grey, soft, uniform.
		9.5	16.5								Clay (CL): brown, soft, uniform.
		16.5	24.5								Shale: grey, soft, uniform.
		24.5	40.5								Shale: light grey, grey, dark grey, soft, water at 28 ft.
	21 Jun										Installed monitoring well.

Sheet 1 of 1 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT

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MON. WELL CONST. SHEET!

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 8 July 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 653.55 Boring No. WES-1-22-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	8 Jul	0.0	13.0	0.0	35.0			6" Rock Bit			Clay (CL): brown and grey, sandy, soft to stiff.
		13.0	21.5								Sandstone: brown, weathered, very fine-grained, soft, damp at 17.5 (no water).
		21.5	22.0								Siltstone: brown, soft, weathered, damp at 22 ft.
		22.0	32.0								Sandstone: brown, light grey, soft, weathered, very fine-grained, water at 25 ft.
		32.0	35.0								Shaley Sandstone: brown, grey, dark grey, soft, weathered, very fine-grained.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No. _____

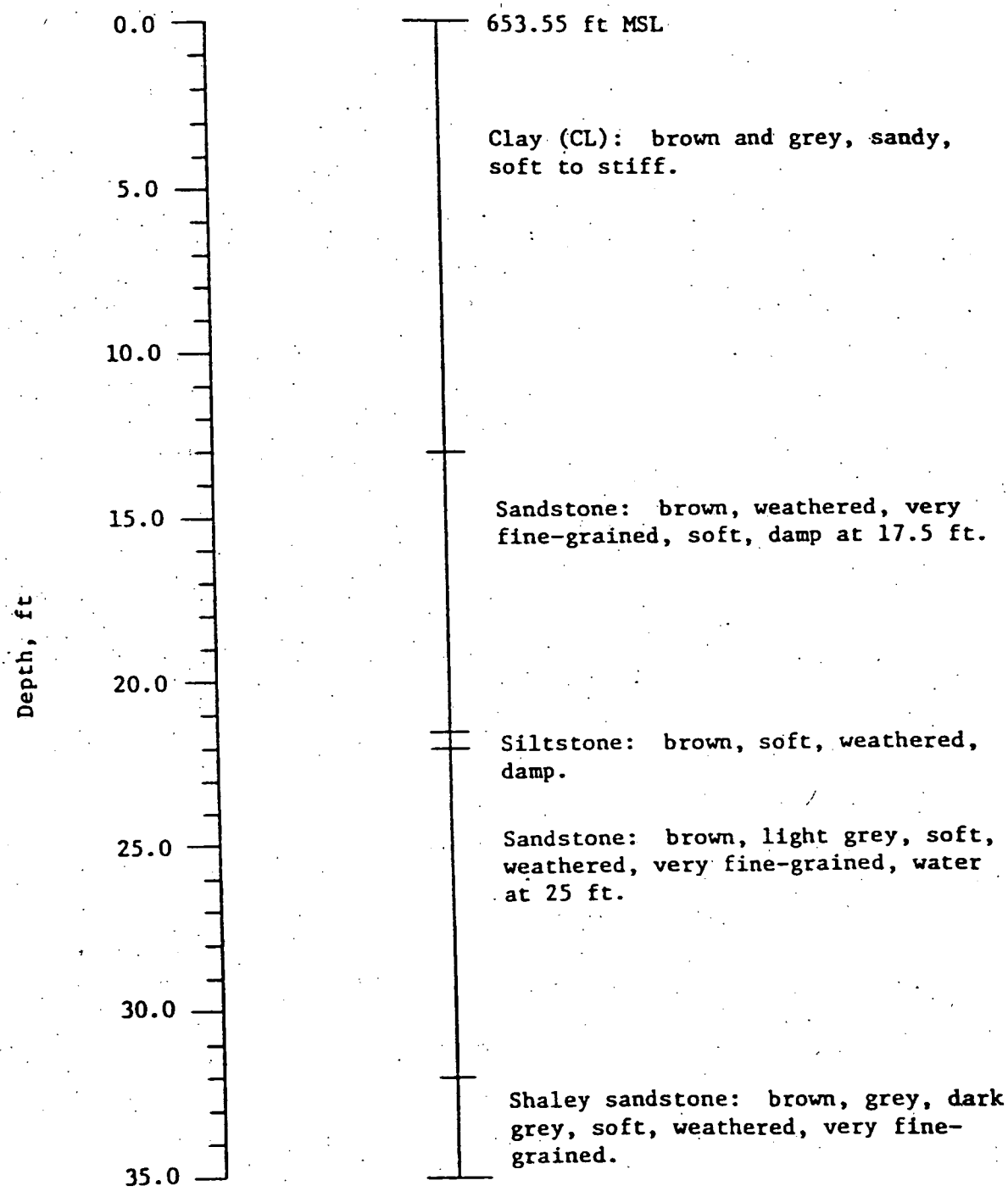
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-22-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	9 Jul										Installed monitoring well.

Sheet 2 of 2 sheets

WES FORM 819 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT



NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Lithology
Boring Number: WES-1-22-83

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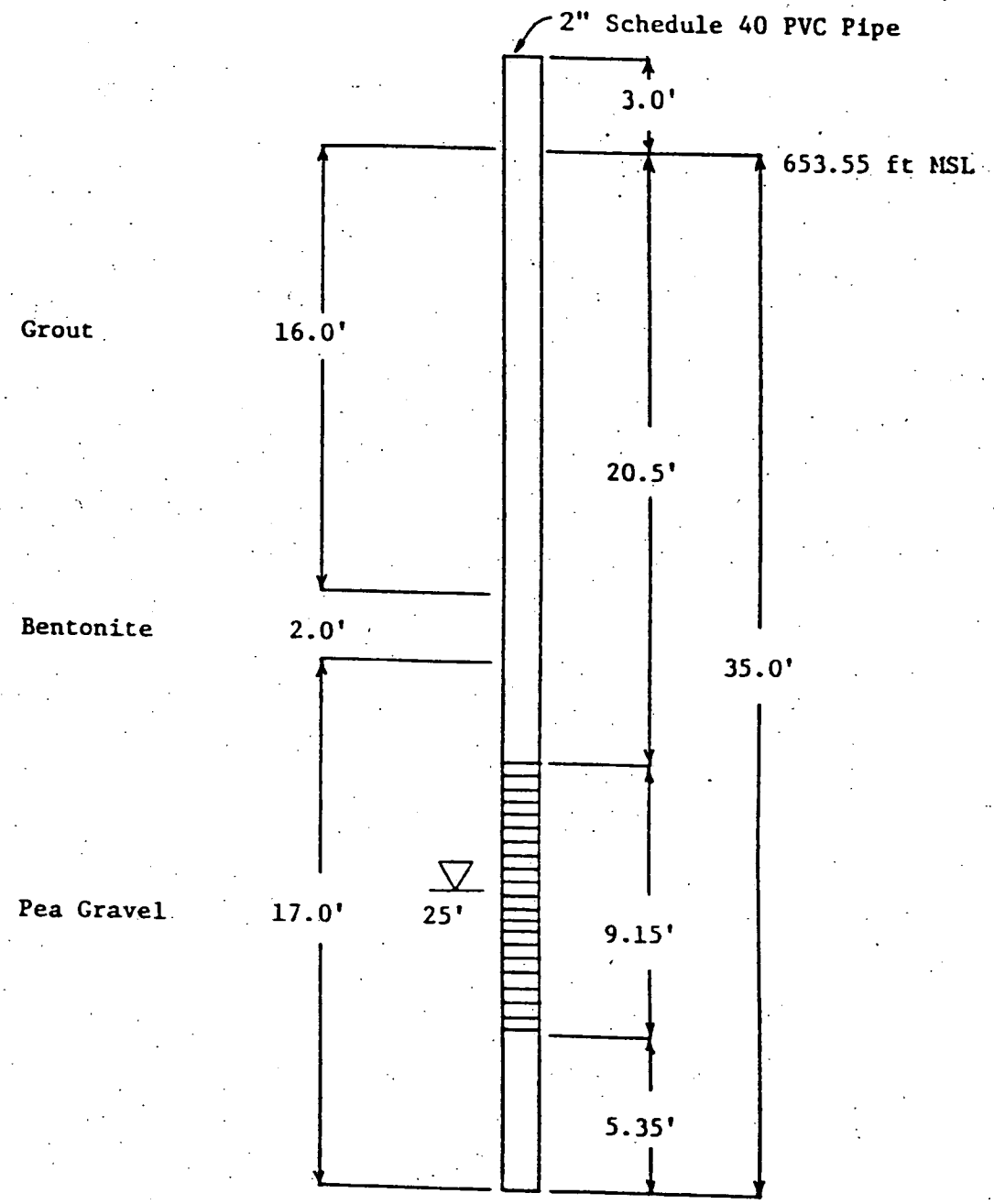

Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-22-83

WORKING DRAFT

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 9 July 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 625.81 Boring No. WES-1-23-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	9 Jul	0.0	3.0	0.0	40.4			6" Rock Bit			Clay (CL): brown, soft to stiff, sandy.
		3.0	6.5								Sandstone: brown very fine-grained, soft.
		6.5	9.0								Sandstone and clay: very fine-grained, brown sandstone and soft, brown clay, damp.
		9.0	17.5								Siltstone: grey, very soft.
		17.5	19.0								Sandstone: brown, very fine-grained, soft, weathered.
		19.0	38.5								Shale: grey, dark grey, soft, damp spot at 30 ft with slight water.

Sheet 1 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-23-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
		38.5	39.5								Coal: black, soft.
		39.5	45.0								Siltstone: light grey, soft.
											Water level overnight: 34 ft.
	11 Jul			40.4	45.0			6" Rock Bit			Drilled 10 ft below water depth.
											Rinsed mud from hole several times.
											Installed monitoring well.

WES FORM 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 sheets

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WELL CONST. SHEET

WORKING DRAFT

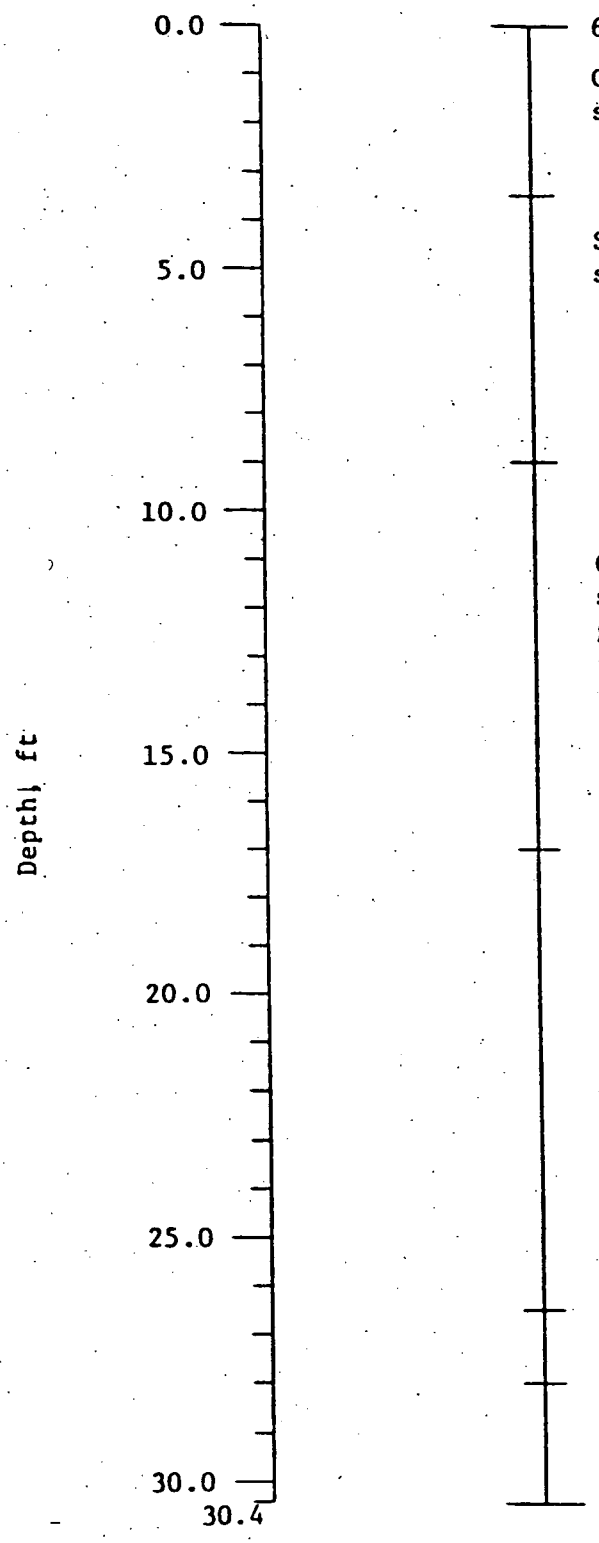
BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 9 July 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 600.57 Boring No. WES-1-24-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	9 Jul	0.0	3.5	0.0	30.4			6" Rock Bit			Clay (CL): brown, soft to stiff, sandy.
		3.5	9.0								Sandstone: brown, very fine-grained, soft.
		9.0	17.0								Clay and sandstone: brown, soft, sandy clay with interbedded very fine-grained, soft sandstone.
		17.0	26.5								Shale: grey, dark grey, soft, water at 20 ft.
		26.5	28.0								Siltstone: light grey, soft.
		28.0	30.4								Shale: dark grey, soft.

Sheet 1 of 1 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED



600.57 ft MSL

Clay (CL): brown, soft to stiff, sandy.

Sandstone: brown, very fine-grained, soft.

Clay and sandstone: brown, soft, sandy clay with interbedded, very fine-grained, soft sandstone.

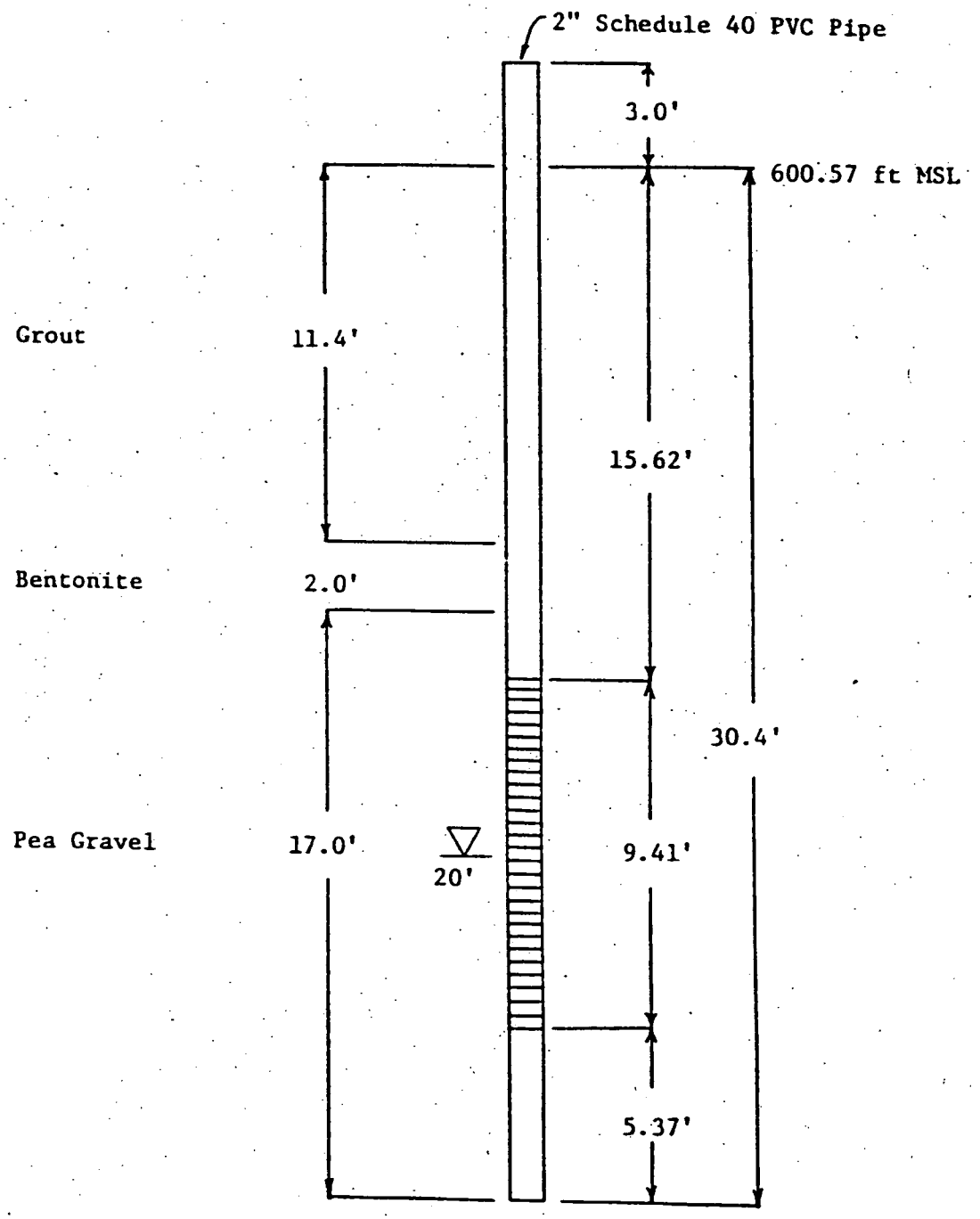
Shale: grey, dark grey, soft, water at 20 ft.

Siltstone: light grey, soft.

Shale: dark grey, soft.

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Lithology
Boring Number: WES-1-24-83

WORKING DRAFT



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-24-83

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 6 August 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 654.16 Boring No. WES-1-25-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	6 Aug	0.0	1.0	0.0	32.0			6" Rock Bit			Clay (CL): brown, soft, sandy, dry.
		1.0	7.0								Sandstone and clay: brown, grey, very weathered, thinly bedded, very fine-grained.
		7.0	16.5								Shale: brown, grey (15.5-16.5) soft, weathered, thinly bedded.
		16.5	19.0								Sandstone: brown, light grey, thinly bedded, soft, very fine-grained.
		19.0	21.8								Shale: brown and grey, soft.
		21.8	32.0								Sandstone and shale: brown, grey,

Sheet 1 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

INDIVIDUAL DRAFT

WORKING DRAFT

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No. _____

Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-25-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
											dark grey, thinly bedded, very fine-
											grained, soft, water at 22 ft.
	6 Aug										Installed monitoring well.

Sheet 2 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

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WELL CONST?

Unavailable

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BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 6 August 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 670.21 Boring No. WES-1-26-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	6 Aug	0.0	4.0	0.0	55.0			6" Rock Bit			Sandy clay (CL): brown, soft, dry.
		4.0	15.3								Sandstone: tan, brown, very fine-grained, weathered, thinly bedded with siltstone and clay shale.
		15.3	17.3								Clay shale: brown, soft.
		17.3	21.6								Sandstone and clay shale: brown, grey, thinly bedded, soft, very fine-grained.
		21.6	30.1								Shale: brown, grey, soft, thinly bedded.
		30.1	41.2								Sandstone and shale: light to dark grey, thinly bedded, very

Sheet 1 of 2 Sheets

WES FORM 810 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT

WORKING DRAFT

BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-26-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
											fine-grained.
		41.2	45.0								Sandstone: brown, reddish brown, soft, very fine-grained. Water at 45 ft.
		45.0	49.5								Sandstone and shale: brown, light to dark grey, thinly bedded, very fine-grained, soft.
		49.5	52.0								Shale: grey, dark grey, soft.
		52.0	55.0								Sandstone: dark brown, soft, very fine-grained.
	6 Aug										Installed well.

Sheet 2 of 2 Sheets

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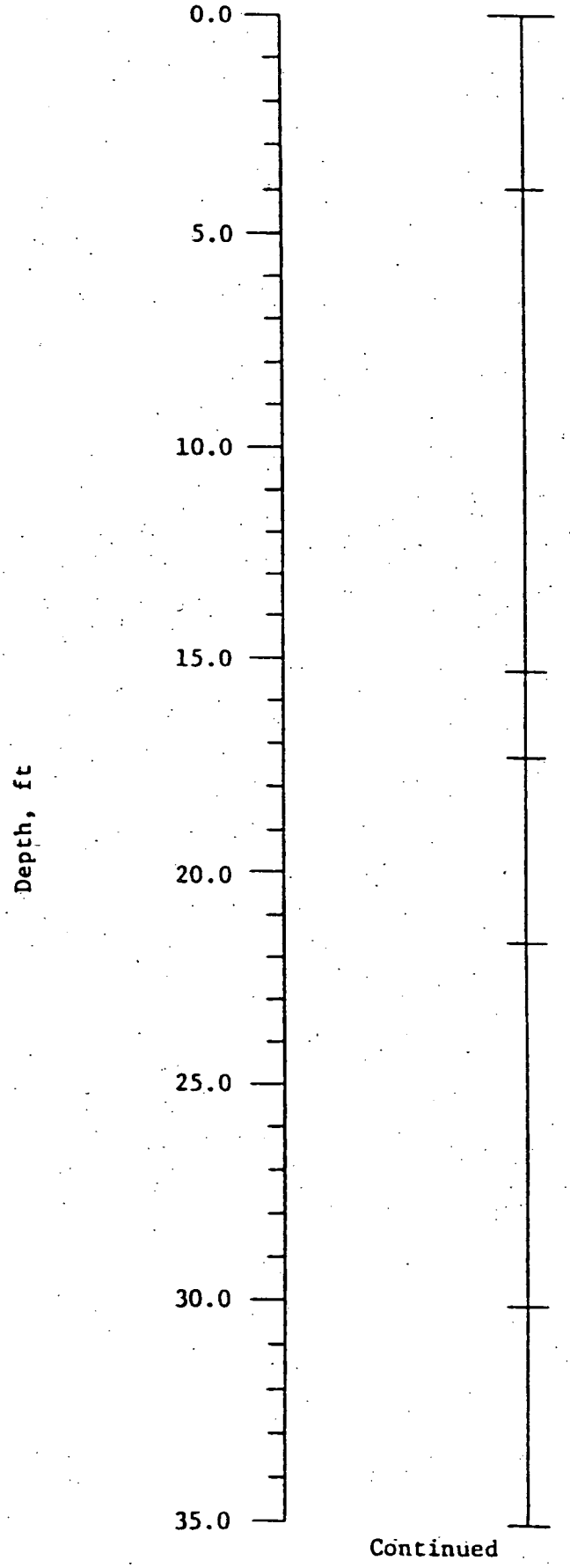


670.21 ft MSL

Sandy clay (CL): brown, soft, dry.

Sandstone: tan, brown, very fine-grained, weathered, thinly bedded with siltstone and clay shale.

Clay shale: brown, soft.

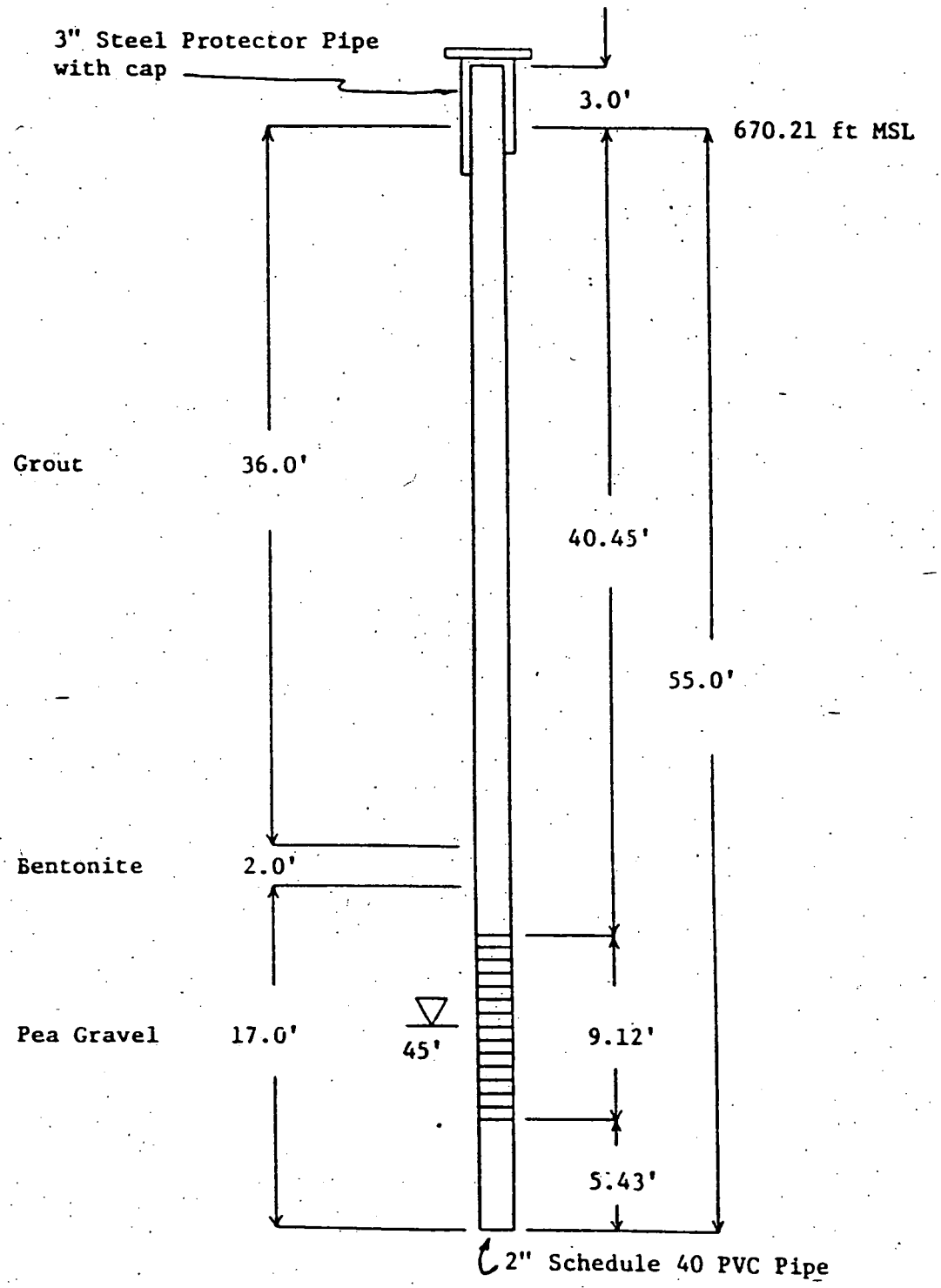
Sandstone and clay shale: brown, grey, thinly bedded, soft, very, fine-grained.

Shale: brown, grey, soft, thinly bedded.

Sandstone and shale: light to dark grey, thinly bedded, very fine-grained.

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Lithology
Boring Number: WES-1-26-83

WORKING DRAFT



Water depth at time of drilling

Well Screen

NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WLS-1-26-83

WORKING DRAFT

BORING LOG
FIELD DATA

Project NWSC Ground-Water Study Site Crane, IN Date 6 August 1983
Location Mustard Gas Burial Grounds Job No. 441-G150.13GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 659.75 Boring No. WES-1-27-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	6 Aug	0.0	2.3	0.0	25.0			6" Rock Bit			Clay (CL): brown, dark brown, dry, soft, sandy.
		2.3	29.3								Sandstone: brown, tan, very fine-grained, thinly bedded with siltstone and shale, weathered, soft, hard at 23 ft.
	6 Aug			--	30.0			6" Rock Bit			Crooked hole - used guide to straighten and sheared drill rod with bit - moved over 6 in. and drilled alongside existing hole to intersect drill tools.
	9 Aug										Recovered rod and bit except for approximately 2 ft section of rod. Unable to recover small piece.

Sheet 1 of 2 sheets

WES FORM 819 EDITION OF NOV 1971 MAY BE USED

WORKING DRAFT

WORKING DRAFT

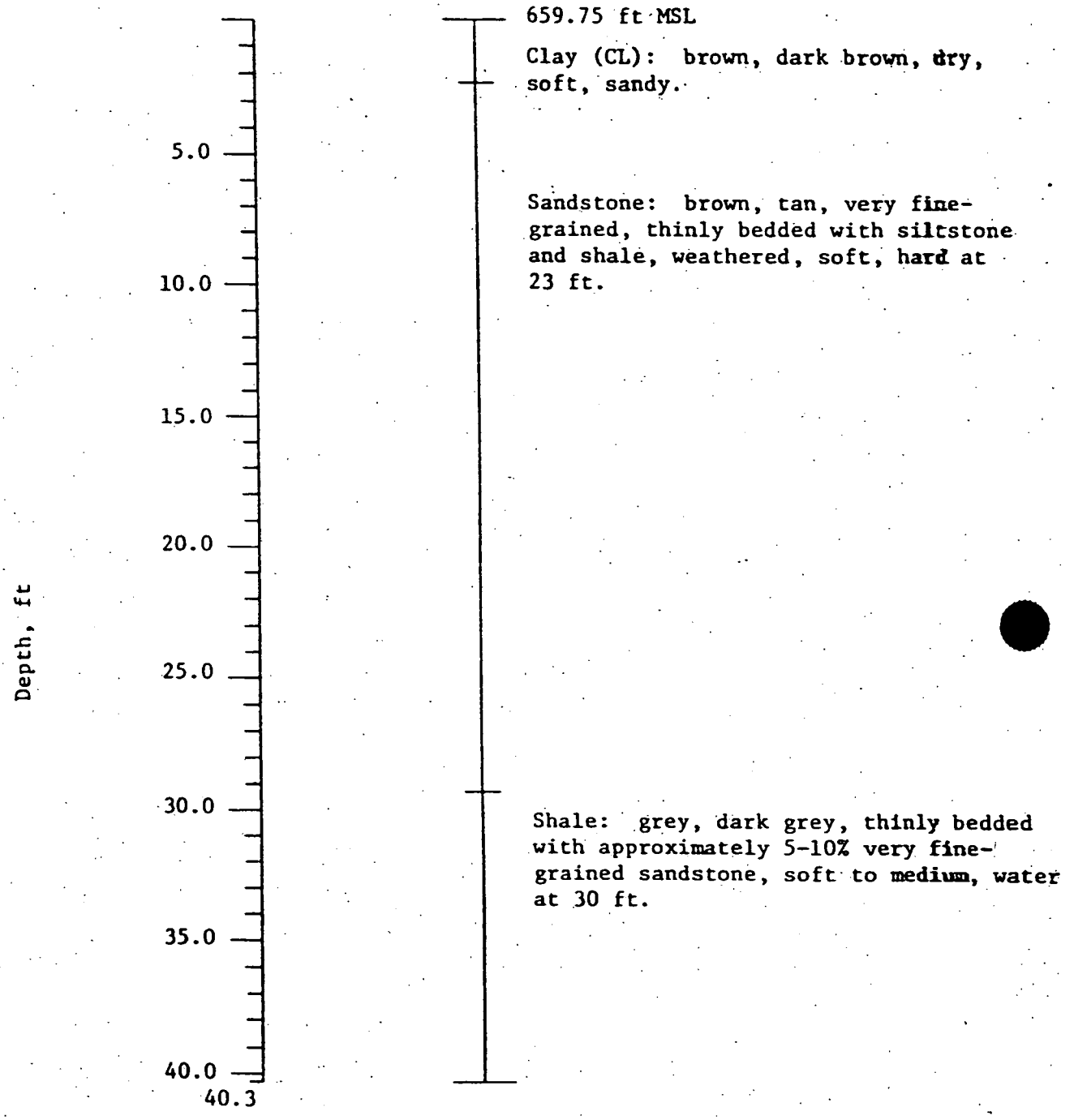
BORING LOG
FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-27-83

SAMPLE NUMBER	DATE TAKEN 1983	STRATUM FROM	STRATUM TO	DRIVE FROM	DRIVE TO	SAMPLE FROM	SAMPLE TO	TYPE OF SAMPLER			CLASSIFICATION AND REMARKS
	10 Aug			0.0	40.0			6" Rock Bit			Moved 10 ft east and drilled another boring. Grouted boring with rod.
		29.3	40.3								Shale: grey, dark grey, thinly bedded with approx 5-10% very fine-grained sandstone, soft to medium, water at 30 ft.
	10 Aug										Installed monitoring well.

Sheet 2 of 2 Sheets

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED



NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Lithology
Boring Number: WES-1-27-

WORKING DRAFT

1-27-83

WELL CONST. SHEET?

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5-23-02

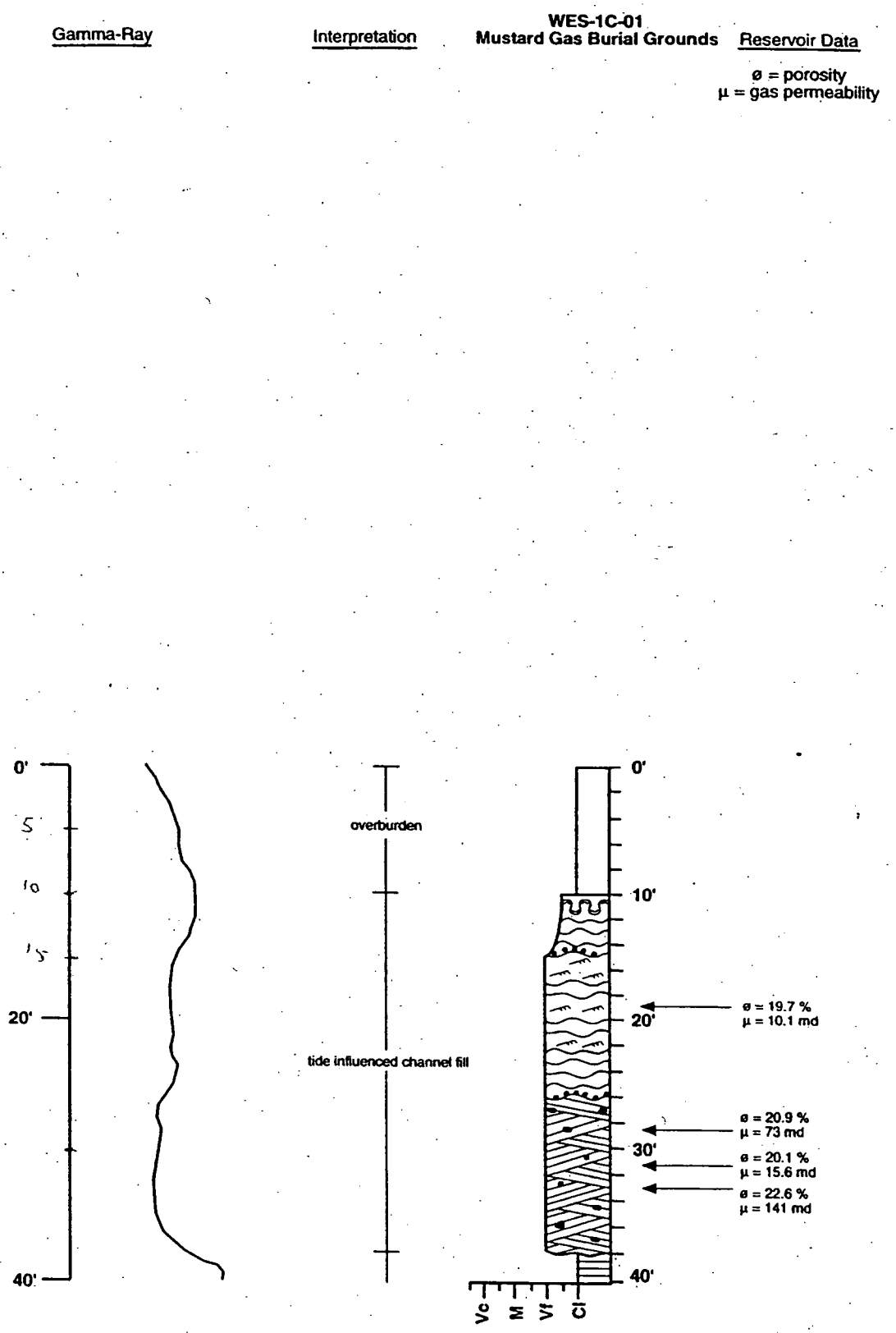

Figure 18b. Vertical columnar profile of corehole WES-1C-01

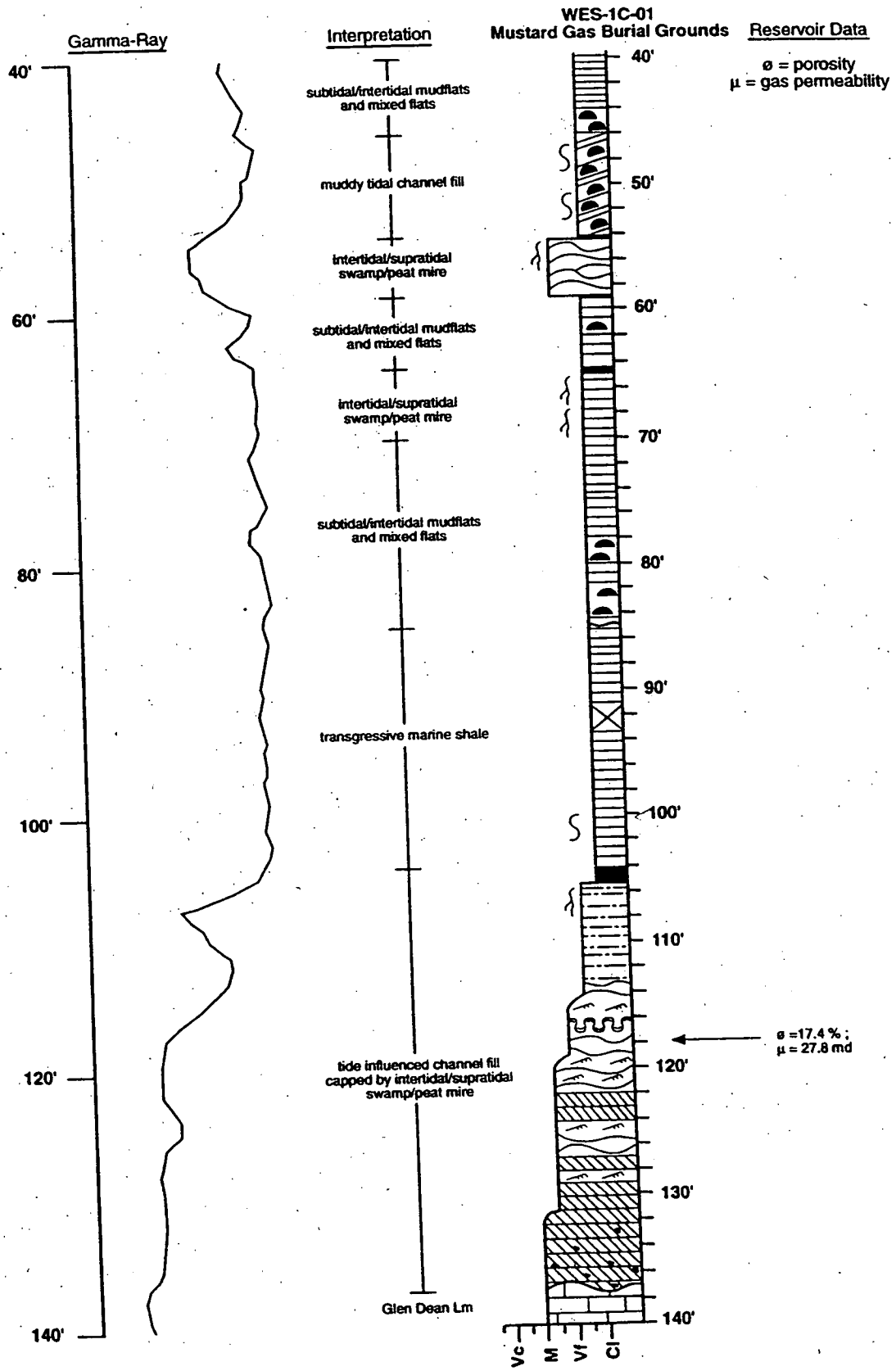

Figure 18a. Vertical columnar profile of corehole WES-1C-01

APPENDIX C

SUBCONTRACT AGREEMENTS

SHORT FORM SUBCONTRACT

GENERAL CONTRACTOR: TETRA TECH NUS, INC.
661 ANDERSEN DRIVE
PITTSBURGH, PA 15220

PAGE 1 OF 2 EFFECTIVE DATE 5/22/02	SUBCONTRACT NUMBER N3959-S2053(SS)
CONTRACTOR JOB NUMBER N3959, N3960	PROJECT NAME NSWC CRANE, IN CTO#'s 158, 159
PRIME CONTRACT N62467-94-D-0888	DPAS RATING N/A

SUBCONTRACTOR
BOWSER-MORNER, INC.
4518 TAYLORSVILLE ROAD
DAYTON, OH 45424
ATTENTION: JAMES NIDSGORSKI
(937) 2368805
Socioeconomic Status: LARGE BUSINESS

The Subcontract Terms appearing below together with the General Conditions and Attachments hereto form the provisions of this Subcontract.

SUBCONTRACT TERMS

SUBLET WORK: Provide all labor, materials, equipment and all other appurtenances necessary to perform the required Drilling services at the Naval Surface Warfare Center (NSWC) Crane, Indiana as directed by TtNUS and along with the Subcontract documents attached hereto.

SCOPE OF WORK: This Scope of Work for this subcontract shall be as defined in the attached Statement of Work.

TIME OF PERFORMANCE: Work shall begin on or about Tuesday, May 28, 2002 and shall continue until completed on or before Friday, June 21, 2002.

PRICE: **Contractor** agrees to pay **Subcontractor** for complete, satisfactory, and timely performance of the **sublet work** in strict accordance with the requirements set forth in this **Subcontract** the following Not to Exceed amount:

The total value of this subcontract shall not exceed $53,875.00 based on the Unit Costs and descriptions attached.

This price shall be inclusive of all applicable sales, use and all other taxes.

INVOICING INSTRUCTIONS:	**Subcontractor** shall provide 2 originals of each invoice. Invoices shall be sent to: **TETRA TECH NUS, INC.** **661 ANDERSEN DRIVE** **PITTSBURGH, PA 15220** **ATTENTION: ACCOUNTS PAYABLE** **NOTE: Final invoice submitted for sublet work under this Subcontract, Subcontractor shall submit an "Affidavit for Subcontractor".**
ACKNOWLEDGEMENT:	Subcontractor shall sign all originals of this subcontract and mail directly to the Subcontract Administrator at the following address: **TETRA TECH NUS, INC.** **661 ANDERSEN DRIVE** **PITTSBURGH, PA 15220** **ATTENTION: SHAWN SCAFF**
MATERIAL SAFETY DATA SHEETS:	[X] REQUIRED AND WILL BE PROVIDED (as necessary) [ ] NOT REQUIRED

Prior to commencement of any work under this Subcontract, Subcontractor must furnish General Contractor with insurance evidencing coverage outlined in the Subcontract General Conditions Section 7.

ATTACHMENTS (AS CHECKED):

[X] STATEMENT OF WORK

[X] SUBCONTRACT GENERAL CONDITIONS

[X] AFFIDAVIT FOR SUBCONTRACTOR

[X] SPECIAL SUBCONTRACT CONDITIONS

[X] SPECIAL SUBCONTRACT REQUIREMENTS

SUBCONTRACTOR	GENERAL CONTRACTOR
SIGNATURE	SIGNATURE
BOWSER-MORNER, INC.	TETRA TECH NUS, INC.

SCOPE OF WORK
DRILLING SERVICES
NSWC CRANE

1.0 GENERAL OVERVIEW / PROJECT DESCRIPTION

1.1 Introduction

Tetra Tech NUS, (TtNUS) requires drilling services to support environmental investigations being performed at the Jeep Trail and Mustard Gas Burial Ground (MGBG) sites located in Crane, Indiana. A summary of monitoring wells is included in Table 1.

The Jeep Trail Site consists of a burn area and burn pit that were used to burn out bombs and flash powder from the mid seventies through 1983. The burn area and burn pit have since been backfilled and the area have been regraded. Chlorinated solvents, explosives, and metals have been detected in groundwater and soil samples collected at the Jeep Trail Site. The scope of work at the Jeep Trail Site will consist of the drilling and installation of 2 wells.

The MGBG was used as a burial ground for mustard gas bombs and radioactive thorium or thorium – containing chemicals and equipment. The mustard gas bombs were demilitarized prior to disposal. The presence of unexploded ordnance or explosives has never been documented at this site but some bombs were found to contain mustard gas during past exhumations. Past radiological investigations of the Mustard Gas Burial Ground culminated in a declaration that the site had been cleared of radiological hazards. Groundwater samples from the site have revealed the presence of organic contaminants. The scope of work at the MGBG will consist of drilling and installing 3 deep wells with steel isolation casings.

2.0 TECHNICAL SPECIFICATIONS

This section details the technical specifications for performing the required work stated in Section 1.0. Refer to the attached Price Proposal Form for the estimated quantities of each corresponding line item.

2.1 TASK 1: MOBILIZATION / DEMOBILIZATION

The Subcontractor will furnish one all terrain vehicle (ATV) rig, support crew, all necessary tools, personal protective equipment (PPE) for the drill crew, water hauling containers, and any miscellaneous equipment and materials required to complete the described activities. The subcontractor will provide his or her own electricity and water. Mobilization/demobilization costs will include setting up equipment storage areas and removal of all equipment, supplies, and waste materials upon project completion.

A bulldozer will also be provided in mobilization / demobilization for building roads and transporting equipment during the field activity.

The subcontractor will be responsible for obtaining all required local, State, and Federal permits necessary for performing the activities. TtNUS will be responsible for locating utilities for this project. An Indiana registered/licensed well driller must perform all drilling activities.
All down-hole drilling equipment, sampling tools, and the rear of the drill rig must be steam cleaned prior to arrival onsite. All safety shut-off equipment must be in full working condition and will be tested by TtNUS prior to initiating drilling activities. Other equipment checked prior to mobilization onto the site includes, back-up warning beeper, cables, clamps, winches, hydraulic leaks, electrical contacts, fire extinguisher, etc. All drilling equipment must be in good condition with no oil or other fluid leaks. Any drill rig that does not pass the initial safety and cleanliness inspection will not be allowed to enter the site, and will not be chargeable for the mobilization cost.

A two-hour health and safety meeting will be performed prior to the initiation of onsite activities. All subcontractor personnel (including substitutes) must attend the meeting, which will be held only once.

All subcontractor personnel will provide and use safety glasses, steel-toe work boots, hearing protection, and hard hats during work activities.

The subcontractor will keep the work site and adjacent areas as free of material, debris, and rubbish as is practicable and shall remove from any portion of the site such materials, which in the opinion of TtNUS, may interfere with the work or constitute a nuisance to onsite personnel. All efforts will be made to minimize dispersal of drill cuttings and water produced during drilling operations. All rubbish or debris will be removed from each drilling location at the completion of each boring.

All drill cuttings accumulated during drilling activities will be spread out at the drill locations, unless otherwise directed by TtNUS. Compensation for spreading out drill cuttings will be included in the unit rates for drilling activities.

All waters will containerized and transferred to containers provided by TtNUS, or dumped as directed by TtNUS. The Subcontractor will be required to transport waters to a centralized area designated by TtNUS. Compensation for water management will be included in the unit rates for drilling activities. The subcontractor shall have 5 drums with lids available for miscellaneous purposes during the work activity.

All downhole drilling equipment will be steam cleaned between sampling locations, and at the conclusion of the drilling program. All decontamination activities will take place at a temporary decontamination pad to be constructed by the subcontractor. The decontamination pad will be constructed of a heavy plastic-lined bermed area capable of collecting decontamination water during steam cleaning operations. The subcontractor will remove the decontamination pad at the conclusion of the drilling program. Compensation for construction of the pad is included in mobilization / demobilization, whereas compensation for decontamination activities and water management is included in the unit rates for drilling and sampling activities.

All activities will be conducted in an efficient and professional manner, with the minimum practical damage to the site environment. The subcontractor will be responsible for the security of their equipment and materials throughout the duration of the project, although a fenced area will be provided.

Upon award, the subcontractor will provide to TtNUS the names, social security numbers, birthdates and place of birth of all personnel expected to perform the field survey. All subcontractor employees that will be onsite must have photo identification, such as a driver's license. Vehicles used by the subcontractor should be clearly labeled with the company name and must have proof of current registration and insurance. This information is necessary for site access.

At the end of each day, the subcontractor's representative and the TtNUS representative will complete a Daily Activity Form (provided by TtNUS) detailing the day's activities, including drilled footage, hourly charges, etc. Both parties will sign the sheet and the quantities on the sheet will be the basis for invoicing. Any unresolved issues related to pay items between the TtNUS representative and the subcontractor's representative will be brought to the attention of the TtNUS Project Manager. The driller will prepare a separate written boring log for each boring to be submitted to the site geologist prior to the completion of field activities. The invoice for payment will be in same format as the Price Form.

Travel time to and from the site as well as travel time between drilling locations will be included in the unit rates for drilling activities.

This item includes all labor, equipment, and materials for performing mobilization/demobilization. Per diem for the drill crew during mobilization / demobilization is included in this pay item. The measurement for payment will be by lump sum.

2.2 TASK 2: OVERBURDEN AND WEATHERED BEDROCK DRILLING

Borings may be drilled for well installation using any drilling technique except mud rotary. Mud rotary however, may be used for drilling borings to accomodate the installation of the isolation casings in the MGBG wells. The borings will be of sufficient diameter to accomodate 2 - inch diameter monitoring wells and associated backfill materials. It may be necessary to drill into weathered bedrock at several locations to ensure adequate well depth, therefore, a rig with capable torque will be required for this activity.

This item includes all labor, equipment, and materials for drilling. Per Diem for the drill crew, decontamination of downhole drilling equipment, management of water, and spreading drill cuttings is included in this pay item. The measurement for payment will be in feet measured from the ground surface to the depth of the bottom of boring.

2.3 TASK 3: SPLIT-SPOON SAMPLING

Split-spoon samples will be collected in accordance with ASTM specification D1586-84. Split-spoon samplers will be of 2-inch diameter and 2-foot minimum length. Samples will be collected at intervals as directed by TtNUS. The subcontractor shall bring an adequate number of split-spoon samplers (five) to minimize interruption of the drilling progress for decontamination of sampling equipment. The subcontractor will also supply 8-ounce jars for the collection of lithologic samples, if required, from each split spoon. Every effort shall be made to achieve maximum recovery of sample material during split-spoon sampling, including use of traps as needed. After each sample is collected, the subcontractor shall disassemble and deliver the split-spoon sampler to the TtNUS representative. The subcontractor shall perform decontamination, which will include washing with Alconox and rinsing with deionized water. TtNUS will provide the Alconox and deionized water.

This item includes all labor, equipment, and materials for performing split spoon sampling. Per Diem for the drill crew, decontamination of downhole drilling and sampling equipment, management of water, and spreading drill cuttings. The measurement for payment will be by the sample.

2.4 TASK 4: BEDROCK CORING AND REAMING

The bedrock will be cored at a depth where encountered using rotary drilling techniques. Wooden core boxes will be provided to store the core. Each boring will be reamed using rotary techniques to the necessary diameter to accomodate either well installation or a permanent isolation casing depending on the location. The subcontractor shall be prepared to have the appropriate equipment (including a downhole air hammer and high volume compressor to perform this task).

This item includes all labor, equipment, and materials for bedrock coring and reaming. Setting up equipment to perform coring, including the installation of any temporary casing through the drilled overburden; is included in the unit coring price for this pay item. Per diem for the drill crew, decontamination of downhole drilling equipment, management of water, and spreading drill cuttings is also included in this pay item. The measurement for payment will be in feet measured the entire length that is cored and reamed.

2.5 TASK 5: PERMANENT ISOLATION CASING INSTALLATION

Permanent steel isolation casings will be installed in the deep wells drilled at the MGBG. In order to protect the deep groundwater from infiltration of shallow contaminants, each well will require the installation of a steel casing grouted to a depth as determined by the field geologist (approximately 100 feet of bedrock drilling in each deep boring).

A 6-inch diameter black steel casing will be pressure grouted in place with a cement-bentonite slurry (10 to 1 ratio) seal and allowed to set for a minimum of 24 hours. The steel casing will be set such that a 6- to 12-inch stick-up exists above the ground surface. Drilling shall resume into the bedrock after the grout has cured.

This item includes all labor, equipment, and materials for casing installation. Per diem for the drill crew, decontamination of downhole drilling equipment, management of water, and spreading drill cuttings at drill locations is included in this pay item. The measurement for payment will be in feet measured the total length of installed casing.

2.6 TASK 6: MONITORING WELL INSTALLATION

Monitoring wells will be constructed of schedule-40, flush-joint threaded, 2-inch I.D. PVC riser pipe and flush-joint threaded, factory slotted well screen with a threaded end cap. The well screens will be factory slotted to 0.020-inch size. Each section of riser pipe and screen shall be National Sanitation Foundation (NSF) approved. Well screens will be 10-feet long, but may be longer or shorter based on subsurface conditions encountered. Bottom plugs will be flush threaded. Select deep wells may be completed as open boring monitoring wells, in the event of no collapse in the bedrock below the isolation casing.

Monitoring wells and associated backfill materials will be installed immediately upon completion of each well boring. A Clean silica sand of U.S. Standard Sieve Size No. 20 to 40 will be used. The sand pack will be extended from 0.5 feet below the well screen to 2.0 feet above the top of the well screen. A minimum 2-foot thick bentonite pellet seal will be installed above the sand pack and allowed to hydrate as per the manufacturer's recommendations. Only 100-percent, certified pure, sodium bentonite will be used for well construction. The depths of backfill materials will be constantly monitored during well installation using a weighted stainless-steel or fiberglass tape measure. The remaining annulus above the hydrated bentonite seal will be backfilled to the surface, with a 20:1 cement/bentonite grout. A maximum of 10 gallons of water per 94-pound bag of Type-I cement will be used.

This item includes all labor, equipment, and materials for 2-inch well installation. Per diem for the drill crew is included in this pay item. The measurement for payment will be in feet measured from the ground surface to the depth of the bottom of the well.

2.7 TASK 7: PROTECTIVE CASINGS WITH BARRIER POSTS

A protective steel casing equipped with a locking steel cap will be installed around each well. Home made protective casings with welded hinged lids that are prone to rusting will not be allowed. Protective casings will be grouted at least 3 feet into the ground and will have at least one drain hole approximately 0.5 feet above the ground. The protective casing will be installed either over the PVC riser pipe or inside the steel casing in the case of wells with isolation casings. A 3-feet by 3-feet by 6-inch thick concrete apron with a 1-inch per foot slope from the center will be constructed around each well. Pad edges should be squared to surrounding structures, other concrete pads in the area, and/or property lines. Four barrier posts (4-inch nominal diameter, 5-feet long steel pipe filled with cement) will be cemented approximately 2-feet into the ground around the outside of the concrete apron. All locks on all wells will be keyed alike with heavy-duty, brass, weather resistant locks. All casings and barrier posts will be painted with safety yellow enamel paint.

This item includes all labor, equipment, and materials for protective casing installations. Per diem for the drill crew, and spreading excess surface cuttings is included in this pay item. The measurement for payment will be by the protective casing.

2.8 TASK 8: WELL DEVELOPMENT

Monitoring wells will be developed no sooner than 24 hours after well installation. Wells will be developed by bailing and surging, and/or by pumping, as determined by the field geologist. The wells will be developed until the discharge water is visibly clear or as determined by the field geologist (approximately 1-hour per well). Particular attention should be given to the development of mud rotary drilled wells (if applicable), potentially including pre-development during well installation.

This item includes all labor, equipment, and materials for well development. Per diem for the drill crew, decontamination of downhole development equipment, and containerization and staging of development water is included in this pay item. The measurement for payment will be by the hour and shall begin when the development water begins discharging from the well and shall end after the development water is completely discharged to containers.

2.9 TASK 9: BACKHOE MOBILIZATION / DEMOBILIZATION

It may be necessary to utilize a backhoe for miscellaneous excavation / clearing / road building as directed by TtNUS. The subcontractor will furnish a rubber tired backhoe with a front end loader and capability to excavate to 15 feet, an operator, all necessary tools, personal protective equipment (PPE) for the operator, and any miscellaneous materials and supplies required to complete the described activities.

The backhoe must be clean prior to arrival onsite. All safety shut-off equipment must be in full working condition and will be tested by TtNUS prior to initiating drilling activities. Other equipment checked prior to mobilization onto the site includes, back-up warning beeper, cables, clamps, winches, hydraulic leaks, electrical contacts, fire extinguisher, etc. The backhoe must be in good condition with no oil or other fluid leaks. Any backhoe that does not pass the initial safety and cleanliness inspection will not be allowed to enter the site, and will not be chargeable for the backhoe mobilization cost.

This item includes all labor, equipment, and materials for performing mobilization/demobilization of the backhoe. The measurement for payment will be by lump sum.

2.10 TASK 10: BACKHOE FIELD ACTIVITIES

The Subcontractor will provide all labor, equipment and materials necessary to perform miscellaneous excavation / clearing / and road building as directed by TtNUS.

This item includes all labor, equipment, and materials for performing the backhoe activities. The measurement for payment will be by the hour.

2.11 TASK 11: CONTAINERIZATION OF DRILL CUTTINGS

There is a remote possibility that selected drill cuttings may be collected in DOT approved 55 gallon drums. The drums will be covered with lids and transported to a centralized location identified by TTNUS, and shall be placed on pallets.

This item includes all labor, equipment, and materials containerizing drill cuttings in drums, and transporting the drums to a designated area. The measurement for payment will be by the drum.

2.12 TASK 12: STANDBY

Standby includes reasonable delays (>15 minutes) in drilling activities called for by the TtNUS field geologist. Standby will be considered only when an actual delay of progress occurs as the result of TtNUS and will not cover periods when subcontractor personnel are off-site, working on equipment, eating, or otherwise performing or preparing to perform project related work. Delays caused by weather, equipment breakdown or immobilization of equipment and including, but not limited to acts of government authority, acts of God, strikes, or other concerted acts of workmen, inability to procure materials or labor, fire, floods, explosions, riot, war, rebellion, and sabotage are not chargeable to TtNUS. Minor delays due to water level measurements, site preparation/clean-up, and other delays of less than 15 minutes are also not chargeable. Minor delays at access gates or fenced in areas of less than 15 minutes shall not be charged as standby. The TtNUS representative and the subcontractor shall agree on a daily basis as to the extent of any potential standby time.

This item includes all downtime costs for labor, equipment, and materials during standby. Per Diem for the drill crew is included in this pay item. The measurement for payment will be by the hour and starts when standby is directed by the geologist and ends when the geologist directs the drill crew to resume work.

2.13 IDLE TIME

The Subcontractor will compensate TtNUS for idle time greater than 1 hour in duration when caused by the Subcontractor's error (e.g., lack of materials, broken equipment, or insufficient manpower for the job). The Subcontractor will be notified in writing at the end of each day if idle time has occurred.

The Subcontractor will pay TtNUS the rate of $60.00 per hour for accruing idle time. No more than 8 hours per day will be charged as idle time. The Subcontractor's inability to arrive at the work site at the scheduled time for the initiation of each days' drilling activities may be considered idle time; additionally the repeated break-down or equipment failure of the Subcontractor's equipment may be considered idle time. In addition, the Subcontractor will not be paid for idle time.

3.0 SCHEDULE

It is assumed that work activities will be conducted during 10-hour workdays in 10-day shifts (including weekends). The first work shift will be started on tuesday May 28, 2002 at 1:00 P.M. and will continue until 1:00 P.M. on Thursday June 6, 2002. The second work shift (if necessary) will start on Monday June 10, 2002 at 1:00 P.M. and willl continue until the work is completed.

TABLE 1

PHYSICAL CHARACTERISTICS OF POTENTIAL MONITORING WELLS
NSWC CRANE, CRANE, INDIANA

Monitoring Well Number	Approximate Ground Surface Elevation (feet NGVD)	Approximate Total Depth (feet bgs)	Screen Length (feet)	Approximate Desired Well Screen Elevation[1]	
				Top (feet NGVD)	Bottom (feet NGVD)
JEEP TRAIL WELLS					
03MWT01 (E of 03-24)	590	55	10	545	535
03MWT02 (N of 03-24)	590	55	10	545	535
MGBG					
01T03 (near 01-02)	665	155	10	520	510
01T04 (near 01-15)	665	155	10	520	510
01T05 (NNW of 01-25)	650	30	10	630	620

NGVD - National Geodetic Vertical Datum
Bgs - below ground surface

1 Elevations will vary depending on the soil and rock types and fracture distributions encountered in each boring, with the intent of monitoring similar hydrogeologic zones at each site.

PRICE PROPOSAL FORM
DRILLING SERVICES
NSWC Crane, IN

Task Item	Est. Quantity	Unit	Unit Cost
1. Mobilization/Demobilization (ATV)	1	Lump Sum	$10,000.00
2. Overburden / weathered bedrock drilling	50	Feet	$30.00
3. Split-Spoon Sampling	25	Samples	$25.00
4. Bedrock Coring and Reaming	400	Feet	$50.00
5. Permanent Casing Installation	230	Feet	$30.00
6. Monitoring Well Installation	450	Feet	$18.00
7. Protective Casings With Barrier Posts	5	Casings	$500.00
8. Well Development	5	Hours	$150.00
9. Backhoe, Mobilization/Demobilization	1	Lump Sum	$100.00
10. Backhoe	30	Hour	$100.00
11. Containerization of Drill Cuttings	0	Drum	$100.00
12. Standby	0	Hour	$200.00

Quantities shown on this Price Form are estimates only. TtNUS does not guarantee that any or all task items listed will be required and reserves the right to vary quantities or delete items. All Unit Costs are fixed and are not subject to escalation of any kind. Unit Costs include all sales, use, and other taxes.

Revision 2
May 2002

Health and Safety Plan
for
RFI Phase III Investigation – Round 2
at
Mustard Gas Burial Ground
(SWMU 01/12)

Naval Surface Warfare Center
Crane Division
Crane, Indiana

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Orders 0158

May 2002

Revision 2
May 2002

HEALTH AND SAFETY PLAN
FOR
RFI PHASE III INVESTIGATION – ROUND 2
AT
MUSTARD GAS BURIAL GROUND (SWMU 01/12)

NAVAL SURFACE WARFARE CENTER (NSWC)
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS
Foster Plaza 7 661 Andersen Drive
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0158

May 2002

PREPARED UNDER THE SUPERVISION OF:

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TETRA TECH NUS
PITTSBURGH, PENNSYLVANIA

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1.0 INTRODUCTION

Authorization: This Health and Safety Plan (HASP) and the work described within are completed under the authorization of:

Contract: Comprehensive Long-Term Environmental Action Navy (CLEAN III)

Contract Number: N62467-94-D-0888

Contract Task Order: 0158

Statement of Work: The development of planning documentation for the investigation of the Mustard Gas Burial Ground (MGBG). This HASP consists of one element of the planning documentation.

Application: This Health and Safety Plan (HASP) has been written to encompass site activities that are to be conducted at the Naval Surface Warfare Center Crane (NSWC Crane), located in Crane, Indiana. Specifically this HASP addresses RCRA Facility Investigation (RFI) Phase III activities to be conducted at the MGBG or Solid Waste Management Unit (SWMU 01/12).

Site activities to be conducted at NSWC Crane include the following (see Section 3.1 for a detailed description):

- Multi-media sampling:
  - Groundwater
  - Sediment
  - Surface Water
- Monitoring well installation.
- Developing/Redeveloping monitoring wells and associated activities in preparation for sampling.
- Geographical surveying.

Compliance: The elements of this HASP are intended to be in compliance with the requirements established by:

- OSHA 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" (HAZWOPER)
- Applicable sections of 29 CFR 1926 "Safety and Health Regulations for Construction."
- Tetra Tech NUS Health and Safety Program

Modifications/Changes: The following conditions are considered sufficient basis for change and will serve as triggers to institute review and possible changes to this document

- The addition of activities outside of those specified in Section 3.0, Scope of Work.
- Task Modifications to those activities specified within Section 3.0, Scope of Work.
- New information becomes available through the course of the investigation or from outside sources.

All changes to this HASP will be requested through the Task Order Manager (TOM) to the Tetra Tech NUS Health and Safety Manager (HSM). It is the responsibility of the TOM to notify all affected personnel of all changes to this HASP. Changes to the HASP will be documented using a Document Review Record.

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

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

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

- The Project Health and Safety Officer (PHSO) is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  i. Providing information regarding site contaminants and physical hazards associated with the site.
  ii. Establishing air monitoring and decontamination procedures.
  iii. Assigning personal protective equipment based on task and potential hazards.
  iv. Determining emergency response procedures and emergency contacts.
  v. Stipulating training requirements and reviewing appropriate training and medical surveillance certificates.
  vi. Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work.
  vii. Modifying this HASP, as it becomes necessary.

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

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

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

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

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

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: NSWC Crane

Address: Code 095 B-3260
300 Highway 361
Crane, Indiana 47522-5009

Client Contact: Mr. Thomas Brent
Environmental Site Manager
NSWC Crane

Phone Number: (812) 854-6160
Fax Number: (812) 854-3981
E-mail:

Alternate Contact: Ms. Chris Freeman

Phone Number: (812) 854-4423
Fax Number: (812) 854-3981
E-mail:

Remediation Program Manager(RPM):

Mr. William Gates
U.S. Navy
SOUTHNAVFACENGCOM

Phone Number: (843) 820-7360
Fax Number: (843) 820-7465
E-mail: gateswh@efdsouth.navfac.navy.mil

Purpose of Site Visit: This activity is divided into a multi-task operation (see Section 4.0), including surveying, monitoring well installations, groundwater and sediment sampling, and other related activities.

Project Team:

Tetra Tech NUS Personnel:	Discipline/Tasks Assigned:	Phone No.
Thomas Johnston, Ph.D.	Task Order Manager	(412) 921-8615
Mark Francis CIH, CSP, CHMM	Deputy Task Order Manager	(412) 921-8544
Matthew M. Soltis, CIH, CSP	CLEAN Health and Safety Manager	(412) 921-8912
Thomas M. Dickson, CSP	Project Health and Safety Officer	(412) 921-8457
Jeff Schubert	Project Geologist	(412) 921-8794
Terry Rojahn	Field Operations Leader (FOL)	(412) 921-8857
TBD	SSO/RSO	
TBD	Field Technician	
Tom Patton	Equipment Manager	(412) 262-4583

NOTE: Other Project Team members are identified in Table 2-1

Non-Tetra Tech NUS Personnel	Affiliation/Discipline/Tasks Assigned	
Sandy Grovenstein	Southwest Laboratory of Oklahoma	(918) 251-2858
TBD	Surveyor (Geographical)	
TBD	Drilling Subcontractor	
FedEx	Sample/Parcel Delivery	1(800)463-3339

Partnering Team:

PERSON / TITLE / ORGANIZATION	ADDRESS	TELEPHONE
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NSWC Crane
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1.3 FACILITY HISTORY

The NSWC Crane is located in Crane, Indiana, approximately 75 miles southwest of Indianapolis and 71 miles northwest of Louisville, Kentucky. The facility encompasses approximately 98.2 square miles (62,832 acres). NSWC Crane provides material, technical, and logistical support to the Navy for equipment, weapons systems, and expendable and non-expendable ordnance items. The facility was opened in 1941 as the Naval Ammunition Depot (NAD), Burns City, to serve as an inland munitions production and storage center. In 1943, the name was changed to NAD Crane in honor of Commodore William Montgomery Crane, the first chief of the Navy's Bureau of Ordnance. The name changed again in 1975 to Naval Weapons Support Center to reflect the facility's growing involvement in high-technology weapons system.

In 1977, the Secretary of Defense combined all conventional ammunition acquisition under the responsibility of a single service. The ammunition production and storage function was assigned to the Army, and the Crane Army Ammunition Activity was established as a Crane tenant to accomplish this task for Naval ammunition. In 1992, based on changing missions and alignment, the name was changed to the Naval Surface Warfare Center Crane. The Army has assumed ordnance production, storage, and related responsibilities under the single-service management directive. All environmental activities on the installation, including permitting activities, remain the responsibility of the Navy. Although ordnance production and storage is still in existence, Crane now supplies highly technical product lines, such as microwave devices, acoustic sensors, small arms, and microelectronic technology. The Army activity is currently considered a tenant activity on the base.

1.4 SITE TO BE INVESTIGATED

The MGBG (SWMU 01/12) is located in the southeast corner of NSWC Crane adjacent to Road 251, which is accessible from Highway 161. The MGBG is located between storage bunkers 1409 and 1407 (see Figure 1-1). The site is located atop a broad ridge with gently rolling topography and approximately 5 to 10 feet of relief from the southeastern to northwestern boundary of the site. The MGBG was used between the end of WWII and 1956 for disposal of mustard munitions and other items. Several burial sites were marked or remarked in 1955 and 1956 with signs detailing the contents, or in some cases, the authority under which burial was performed. However, the signs gave little indication of the number of items actually buried. Historical documentation relative to the total amount and types of material disposed at the site is inconclusive. However, it is known that the site was used in the disposal of some chemical weapons and chemical waste.

Documentation has shown that efforts to exhume the weapons were conducted in 1974 and 1980. During these two separate excavation procedures, sixteen aerial bomb casings and a quantity of Thorium Nitrate were unearthed. Fourteen of the sixteen items (bomb cases) were empty except for mud. In addition, no trace of Mustard Gas was found in the soil surrounding the bomb cases. However, one bomb casing contained approximately ½ gallon and one bomb contained approximately 3 gallons of the mustard material. Various non-intrusive magnetometer studies have been conducted at the site to locate burial sites. In addition, three groundwater investigative projects were conducted in 1981, 1982, and 1983. The results show that the groundwater contaminants are comprised mainly of chlorinated solvents. The most recent groundwater sampling conducted in 2001 by TtNUS confirmed this. Field screening and laboratory analysis for radiation and mustard gas yeilded radiation levels comparable to background levels and no detectable concentrations of mustard gas based on data collect from samples in 2001. Additionally, no UXO was encountered during implementation of UXO avoidance measures in 2001.

Figure 1-1 Site Location Map

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a planning effort to direct and guide field personnel in the event of an incidental or emergency release or occurrence. Tetra Tech NUS will, through necessary services, include incidental response measures for incidents such as:

- Initial stage fire fighting support and prevention
- Initial spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provide initial medical support for injuries or illnesses requiring only first-aid level support
- Provide site control and security measures as necessary

Incidental response measures will only be provided to the capabilities of on-site personnel and available resources. Incidental response measures are not considered an emergency response as per 29 CFR 1910.120 (b). Incidents and situations, that are deemed to be an emergency/emergency response as defined by 29 CFR 1910.120 (b) will be handled by outside resources. From this point on in this document "Outside Emergency Response Support" is referring to NSWC Crane Emergency Response support. This emergency action plan has been structured in accordance with 29 CFR 1910.120 (l)(ii) complying with 29 CFR 1910.38 (a)

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, injuries or illnesses resulting from exposure to chemical or physical hazards or fire are the most probable emergencies that could be encountered during site activities.

To minimize and eliminate these potential emergency situations, emergency planning activities associated with this project include the following.

The SSO and/or the FOL are responsible for:

- Coordinating with NSWC Crane Emergency Services to ensure that Tetra Tech NUS emergency action activities are compatible with existing facility emergency response procedures.

- Establishing and maintaining information at the project staging area (support zone) or Field Office for easy access in the event of an emergency. This information will include the following:
  - Chemical Inventory (used on-site), with Material Safety Data Sheets.
  - On-site personnel medical records (medical data sheets).
  - A logbook identifying personnel on site each day.

- Identifying a chain of command for emergency action. Due to the nature of the work to be performed a Site Safety Officer (SSO) will be present during field operations. This person will serve as the emergency coordinator should an incident or emergency arise.

- Educating site workers to the hazards and control measures associated with planned activities at the site, and to provide early recognition and prevention where possible.

- Drilling and practicing incidental response measures periodically. The SSO will guide and direct all drills and will be responsible for logging, review and analysis of the drill by Tetra Tech NUS and subcontractor personnel.

The use of two-way communication devices (cellular phones and radios) must be approved by the NSWC Crane Safety Office and such equipment will not be used until official permission is obtained.

2.3 EMERGENCY RECOGNITION AND PREVENTION

The primary focus of this section is the ability to recognize and control factors, which could contribute to an emergency situation/condition. The FOL, and/or the SSO will preview all site work location prior to committing personnel or resources. Their actions will be as follows:

- Identify, remove, and/or barricade and physical hazards within the estimated work area.

- Identify prevalent emergency conditions and their control measures and ensure they are stated on the Safe Work Permits.

- Provide the necessary equipment to control potential emergencies (i.e., safety cans for flammable liquid storage, spill containment equipment, PPE, and emergency equipment such as fire extinguishers).

- Evaluate operations to ensure that necessary measures are taken to control and/or minimize the impact of emergency situations/conditions.

- Field Crew shall:

  - Identify, remove, or barricade physical hazards within the estimated work area.
  - Follow the guidelines for control of emergency conditions
  - Report any potential emergency situation to the FOL and/or the SSO.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

Upon activation of the on-site emergency alarm system the following actions will occur:

- All operations will cease. There are no critical operations, that would require personnel to remain during an emergency.
- Field personnel will note the direction of the wind.
- Based on the wind direction, personnel will move cross and up wind to either the primary or secondary safe place of refuge as determined in the field by the FOL and/or the SSO as part of daily safety meetings.
- All personnel will remain at this location until directed otherwise by the FOL and/or the SSO.

2.4.1 Safe Place of Refuge Selection

The FOL and/or the SSO shall identify a safe place of refuge (in the event of an emergency) and communicate to all field personnel as part of the daily safety meeting. Selection will be based on the following considerations:

- A location providing telephone communications and or shelter.
- A location from which the field crews can provide site security restricting access to the emergency area, however, a point from which the field crew may direct emergency crews (i.e., intersection or gate, etc.).

This location should be positioned a safe distance from the operation so not to be impacted by the emergency. This distance is impacted by a number of conditions (i.e., tasks being conducted; chemical, physical, and toxicological properties; potential for fire and explosion; meteorological conditions; terrain).

2.5 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

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

2.5.1 Life threatening

- Engage emergency response protocol, notify outside support services.
- Remove outer PPE. Outer protective garments should be removed by assisting personnel. Removal may require the use of bandage scissors to remove the outer garments.
- Begin life saving techniques as appropriate (CPR, cooling or warming regimens, etc.).
- Wrap the injured in a blanket for transport to the hospital.

Note: One person from the field team will accompany the injured to the hospital with medical data sheets, MSDSs, a copy of this HASP, and the incident forms. This person will collect as much information as possible and transfer that information to the HSM and Work Care as per the Emergency Response Protocol provided in Figure 2-4. All other personnel will engage site control/site security measures.

2.5.2 Emergency Medical Treatment

Tetra Tech NUS and subcontractor personnel are only permitted to provide treatment to the level of First-Aid Training.

To support medical treatment until outside services arrive, two members of the field crew will be current Cardio Pulmonary Resuscitation (CPR) / First-Aid trained. The necessity to have first-aid trained personnel on-site is based on the remote location of the site and the impact this has on the response time of outside emergency services. The estimated response time to the site is a minimum of 15 minutes.

Emergency medical treatment will be initiated under the following guarded restrictions:

- Notify the FOL and/or the SSO of the incident.

- Take the necessary precautions to prevent direct contamination with the injured person's body fluids.

- Use surgeons gloves when handling cuts, abrasions, bites, punctures, etc. or any part of the injured person. The use of safety glasses and surgeons masks maybe necessary if there is the potential for uncontrolled spread of body fluids.

- Should Cardio-Pulmonary Resuscitation (CPR) be required, use a CPR Micro-Shield mouthpiece when administering CPR.

2.6 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

There are several aspects associated with emergency alerting procedures that must be taken into account at NSWC Crane. These are as follows:

- Due to the physical setting (size and remoteness) of the sites where field activities will be conducted, readily available means of communication are not always available.

- In addition, again based on the size of the facility and location, there are limited cellular communication points on Base where a signal may be obtained. This also limits communication capabilities.

- Lastly, due to the schedule that Tetra Tech NUS, Inc. will work (10 days on; 4 days off) the potential exists for field personnel to be present during holidays, off days, and after hours. Primary safe places of refuge that would normally be accessed in the event of an emergency during normal working hours will be closed during these periods.

In order to overcome these restrictions, the Base Environmental Office may allocate a Public Works/Fire/Security Radio to be used in support of this field effort. This radio will be available throughout the entire project so that filed personnel can establish a direct link to security and emergency services.

If an emergency occurs at NSWC CRANE within the Tetra Tech NUS operations, the following procedures are to be initiated:

- Initiate an emergency notification by hand signals, voice commands, air horn, or two-way radios to the FOL/SSO. Describe to the FOL (who will serve as the Incident Coordinator) what has occurred and as many details as possible.

- Have your partner evacuate non-essential persons from the incident scene, engage initial response measures given the emergency type (i.e., spill response, fire extinguisher, first-aid) .

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

Primary Means of Notification

- If provided, use the emergency notification radio which will establish a direct link to security and emergency services. If not, use an on-base phone and call 1333 or 3300 (Table 2-1) and report the emergency. Give the emergency operator the location of the emergency, the type of emergency, the number of injured, and a brief description of what occurred. Stay on the phone and follow the instructions given by the operator. The operator will then notify and dispatch the proper emergency response agencies. The Fire Dept. coordinates ambulatory service. They will provide emergency medical, ambulatory, hazardous materials response, and rescue.

  Note: On-base extensions 1333 and 3300 are the primary emergency phone numbers. From an NSWC Crane phone base extensions must be proceeded with "854". Off base numbers from a base phone can only be reached by dialing "990" or " 991" first. Furthermore, all emergencies should be subsequently reported to the Environmental office (x6160).

- Evacuate all TtNUS and subcontractor personnel to the identified safe place of refuge. Conduct a head count of site personnel using the site logbook.

2.7 PPE AND EMERGENCY EQUIPMENT

A first aid kit, eye wash units, stretcher, and fire extinguishers will be maintained on-site at the central decontamination unit and shall be immediately available for use in the event of an emergency. Based on the hazards anticipated, these incident response abatement items may be maintained at the exclusion zone of on-going operations as determine and communicated to the field crew through the Safe Work Permit. This will be and is at the discretion of the SSO.

2.8 EMERGENCY CONTACTS

Prior to performing work, all personnel will be thoroughly briefed on the emergency procedures. A mobile phone may be available on site. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted on site where it is readily available to all site personnel. Telephone numbers for the Base Safety Office, the Base Emergency Preparedness Coordinator, and the Base Environmental Office are listed in Table 2-1.

All persons approved for participation in this field effort will be issued a card with medical data information and the emergency contact numbers on the reverse.

In addition, TtNUS personnel who are injured or become ill on the job must notify appropriate company representatives. Figure 2-4 presents the procedure for reporting an injury/illness, and the form to use for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps in Figure 2-4.**

TABLE 2-1
EMERGENCY REFERENCE
NSWC CRANE, INDIANA

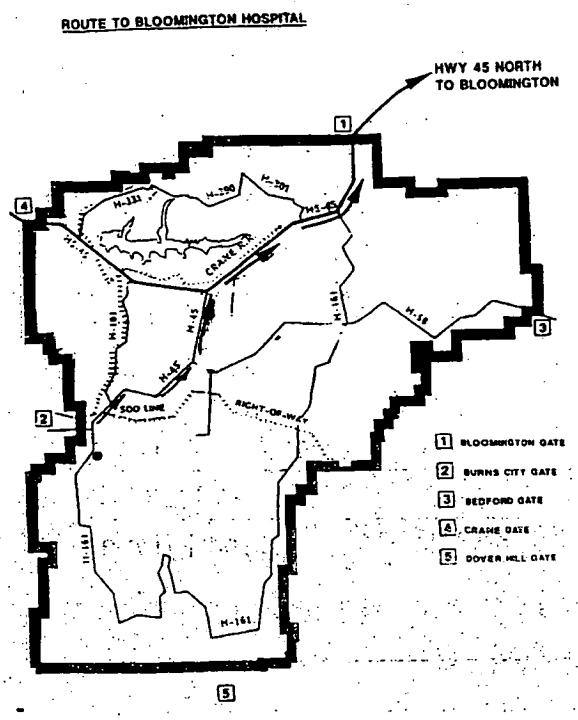
AGENCY	TELEPHONE
Base Emergency Number (Fire Department, Base Security, Ambulance)	854-3300 or 854-1333
Base Environmental Office	(812) 854-3114
Bedford Ambulance	(812) 279-6545
Bloomington Hospital (Bloomington, IN)	(812) 336-9515
Hospital, Bedford Medical Center (Bedford, IN)	(812) 275-1200
Poison Control Center	1-800-222-1222
National Response Center	1-800-424-8802
Base Contact, Thomas Brent	(812) 854-6160
Contract Task Order Manager, Ralph Basinski	(412) 921-8308
TtNUS Crane Field Office Building 3245	(812) 854-0280
Field Operations Leader, Terry Rojahn On-Site Off-Site (Pittsburgh)	 (812) 854-0280 (412) 921-8131
TtNUS Office, Pittsburgh	(412) 921-7090
CLEAN Health and Safety Manager, Matthew M. Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer, Thomas Dickson, CSP	(412) 921-8457

Note: Most phones require the number to be preceded by 991 (i.e., 991-812-854-0280) or by "99" (if 812 is left off) (i.e., 99-854-0280)

Figure 2-1

Hospital Route Map (Bloomington Gate)

**Note: The Bloomington Gate is open 24 hours.



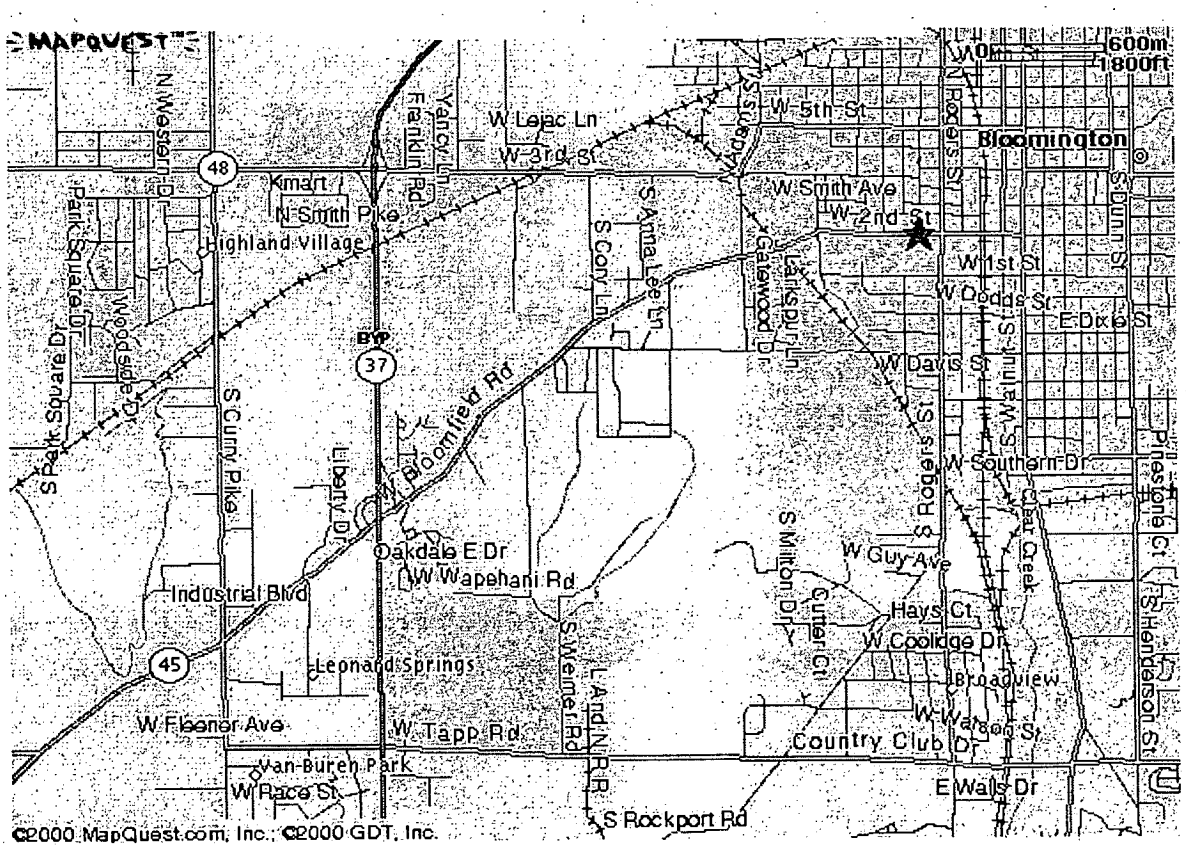
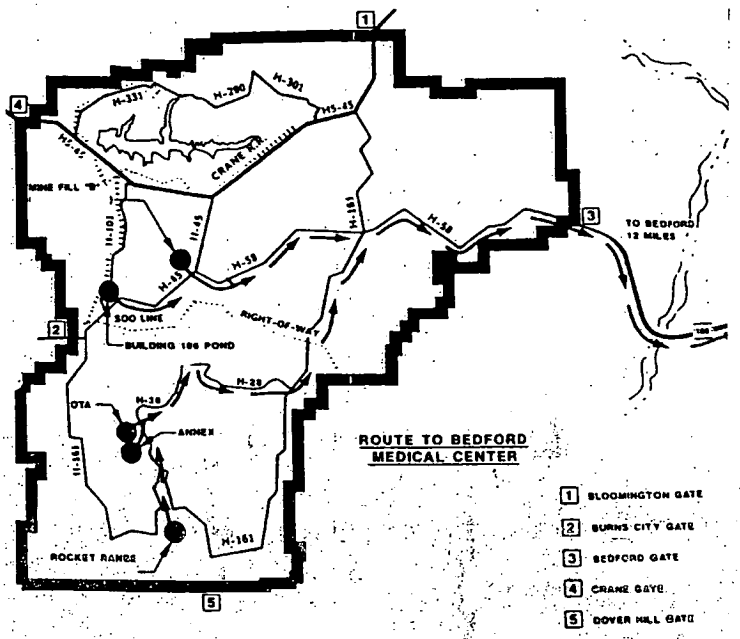


Figure 2-2

Hospital Route Map (Bedford Gate)

*Note: The Bedford Gate is open only from 0600 - 0830 and 1500 - 1800 hours; Monday through Friday.



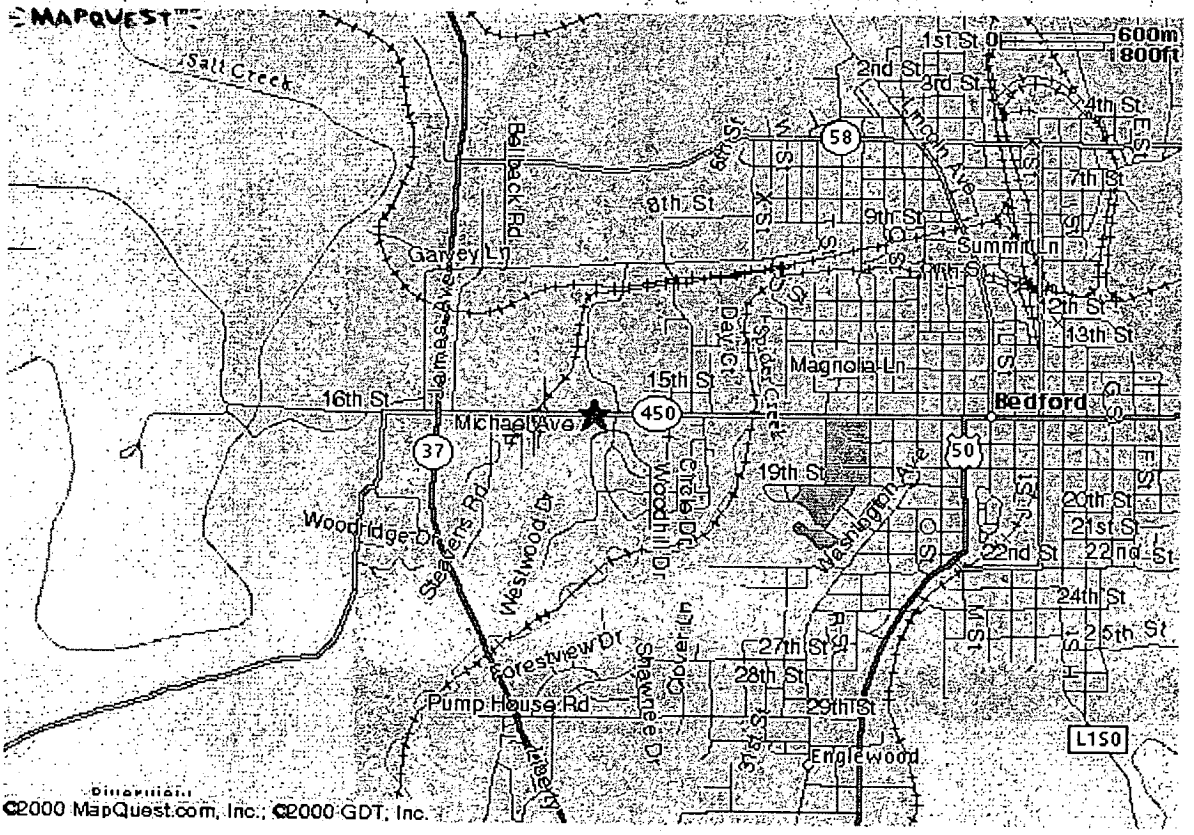


FIGURE 2-3
EMERGENCY RESPONSE PROTOCOL

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

In the event of a personnel injury or accident:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the injured person is a Tetra Tech NUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. WorkCare physicians will monitor the care of the victim. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at 1-800-455-6155 and enter Extension 109, or follow the voice prompt for after hours and weekend notification and be prepared to provide:
  - Any known information about the nature of the injury.
  - As much of the exposure history as was feasible to determine in the time allowed.
  - Name and phone number of the medical facility to which the victim(s) has/have been taken.
  - Name(s) of the involved Tetra Tech NUS, Inc. employee(s).
  - Name and phone number of an informed site officer who will be responsible for further investigations.
  - Fax appropriate information to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) at 1-800-245-2730, 8:00a.m. to 5:00p.m., Monday through Friday.
- As data is gathered and the scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of all data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

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

FIGURE 2-4 (continued)
WORKCARE
POTENTIAL EXPOSURE REPORT

Name: _____ Date of Exposure: _____

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

Client Contact: _____ Phone No.: _____

Company Name: _____

I. **Exposing Agent**
Name of Product or Chemicals (if known): _____
_____
Characteristics (if the name is not known)
Solid Liquid Gas Fume Mist Vapor

II. **Dose Determinants**
What was individual doing? _____
How long did individual work in area before signs/symptoms developed? _____
Was protective gear being used? If yes, what was the PPE? _____
Was their skin contact? _____
Was the exposing agent inhaled? _____
Were other persons exposed? If yes, did they experience symptoms? _____

III. **Signs and Symptoms** (check off appropriate symptoms)

Immediately With Exposure:

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

Delayed Symptoms:

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

IV. **Present Status of Symptoms** (check off appropriate symptoms)
Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)
Improved: _____ Worsened: _____ Remained Unchanged: _____

V. **Treatment of Symptoms** (check off appropriate response)
None: _____ Self-Medicated: _____ Physician Treated: _____

3.0 SCOPE OF WORK

The following subsections discuss the specific tasks that are to be conducted as part of this scope of work. These tasks are the only ones addressed by this HASP. Any tasks to be conducted outside of the elements listed here will be considered a change in scope requiring modification of this document. The TOM or a designated representative will submit all requested modifications to this document to the HSM.

The following activities will be completed in the execution of this scope of work. These are as follows:

- Mobilization and Demobilization
- Monitoring well installation – 3 additional monitoring wells will be installed (two are in an area that have existing wells, one will be installed in the west-northwest area where no wells have been previously drilled).
- Developing/Redeveloping monitoring wells in preparation for sampling.
- Multi-media sampling:
  - Groundwater – Monitoring wells will be sampled to determine level of contamination, which exists over the area represented as the MGBG. Groundwater sampling may be conducted to include sampling for and the measurement of Natural Attenuation parameters.
  - Surface water – Surface water may be sampled at a limited number of stream location in the vicinity of sediment sampling locations.
  - Sediment – Sediment samples will be collected from stream beds in a wooded area to the west-northwest, and north of the MGBG. Other sediment samples will be collected on the south side of the top of the MGBG ridge.
- Decontamination of Equipment (Sampling and Heavy Equipment)
- Geographical surveying.

These tasks are discussed in detail below.

3.1 MONITORING WELL INSTALLATION

Monitoring wells will be installed using Hollow Stem Augering Techniques. At this time it is anticipated that two will be installed in an area that have existing wells and one will be installed in the west-northwest area where no wells have been previously drilled.

3.1.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. Advantages of this type of drilling include:

- Samples can be obtained while augers remain in the ground. Sampling requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and back-filled as the augers are withdrawn.

3.2 MONITORING WELL DEVELOPMENT/REDEVELOPMENT

The steps to develop or redevelop the new and existing monitoring wells are as follows:

- The depth to water and total depth of the well is measured using an M-scope or other electronic water level indicator.
- A surge block or submersible pump is lowered into the screened section of the well. The surge block or submersible pump is rapidly lowered and raised in the well causing groundwater to flow in and out of the well screen thus flushing fine sediment and debris out of the sandpack.
- A submersible pump or airlift hose is lowered into the well. The monitoring wells are pumped using a submersible pump, or by airlift. The pumping will continue until well stabilization parameters (pH, temperature, specific conductance, etc.) have stabilized or the amount of water extracted from the well has reached a predetermined volume.

3.3 MONITORING WELL SAMPLING

The monitoring wells will be sampled using low-flow purging and sampling techniques. Peristaltic pumps will be used to purge and to collect the samples. Field measurements of pH, temperature, specific conductance, and turbidity will be made during purging. These measurements will be taken at the start of purging and every 3 to 5 minutes until the parameters have stabilized. The wells will be purged until a sufficient predetermined amount of water has been removed and the water quality measurements are acceptable. All tubing used for sampling will be dedicated and disposed of after the sample has been collected.

In addition to the contaminant analysis for groundwater samples, aliquots may be removed for Natural Attenuation sampling purposes.

3.3.1 Natural Attenuation Sampling

Natural Attenuation Sampling uses a variety of testing mechanisms and reagents to measure the efficiency of degradation of contaminants within the hydrologic systems. This is accomplished through biodegradation, dispersion, dilution, sorption, volatilization and abiotic degradation mechanisms. This process utilizes chemical reagents to determine the geochemical properties of the sample substrate.

3.3.2 Water Level Measurements

Water level measurements will be taken at the existing and newly installed monitoring wells during this field investigation. The water levels will be taken with an electric water level indicator using the top of the well casing as the reference point for determining water depths.

3.4 SEDIMENT/SURFACE WATER SAMPLING

The collection of sediment samples will proceed as follows:

- Selection of location
- Direct-Reading monitoring instrument sweep.
- Transfer the selected environmental media into the containers to be sent to the analytical laboratory using stainless steel or disposable trowels

Surface water samples may be collected from streams in the vicinity of the sediment samples.

3.5 GEOGRAPHICAL SURVEYING

This activity is generally non-intrusive in nature, however limited brush removal may be required using chain saws, machetes, and brush hooks. The brush removal will facilitate lines of sight and passage routes for the equipment during the survey.

3.6 DECONTAMINATION

The equipment involved in the field activities for this investigation will be decontaminated prior to, during and after the sampling activities.

3.6.1 Sampling Equipment

All non-dedicated sampling equipment (i.e. stainless-steel hand augers, trowels, bowls) will be decontaminated prior to the initiation of field sampling, between sample locations, and at the completion of the field activities. The following decontamination steps will be taken.

- Potable water rinse
- Alconox or Liquinox detergent wash
- Deionized (DI) water rinse
- Solvent rinse (Isopropanol)
- DI water rinse
- Air dry

3.6.2 Heavy Equipment

All non-dedicated heavy equipment (i.e. auger flights, split spoons, drive rods, etc.) will be decontaminated prior to use, between sample locations, and at the completion of the field activities. The following decontamination steps will be taken.

- Potable water rinse
- Alconox or Liquinox detergent wash
- Pressure Washer
- Deionized (DI) water rinse
- Solvent rinse (Isopropanol)
- DI water rinse
- Air dry

- Instrument scan – This will be performed after air drying to ensure all chemical solvents have been effectively removed. Positive results require re-rinsing and re-scan to ensure removal of the applicable chemical solvents.

4.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

4.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section specifies health and safety training and medical surveillance requirements for both Tetra Tech NUS and subcontractor personnel participating in on site activities.

4.1.1 Requirements For All Field Personnel

Tetra Tech NUS and subcontractor personnel who will engage in field associated activities as described in this HASP will have:

- Completed 40 hours of introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e).
- Completed 8-Hour Refresher Training, if the identified persons had introductory training more than 12 months prior to site work.
- Completed 8-hour Supervisory training in accordance with 29 CFR 1910.120(e)(4), if their assigned function will involve the supervision of subordinate personnel.

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

4.2 SITE-SPECIFIC TRAINING

Tetra Tech NUS will provide site-specific training to all Tetra Tech NUS employees and subcontractor personnel who will perform work on this project.

Figure 4-1 will be used to document the provision and content of the project-specific and associated training. All site personnel will be required to sign this form prior to commencement of site activities.

Due to the complex nature of the work to be performed at NSWC Crane MGBG, the personnel selected will require cross training in various support functions and specialties. Figure 4-2 Training and Medical Surveillance Tracking form has been compiled to assist the FOL and/or the SSO in tracking the status of these persons over the course of the project. This form will assist in determining who has clearance and who may perform certain tasks or support functions based on their training and/or medical qualifications.

FIGURE 4-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing investigatory activities at the NSWC Crane Mustard Gas Burial Grounds located in Crane, Indiana, and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health (Section 1.2)
- Safety, health, and other hazards present on site (Table 5-1, 6-1; Section 2.0)
- Use of personal protective equipment (Table 5-1)
- Safe use of engineering controls and equipment (Table 5-1 and HSGM)
- Safe work practices to minimize risks from hazards (Sections 5.1 and 5.2)
- Medical surveillance requirements (Section 8.3)
- Signs and symptoms of overexposure (Table 6-1)
- Decontamination procedures (Section 3.6.1, 3.6.2, and Table 5-1)
- Contents of the Health and Safety Plan
- Emergency action procedures (evacuation and assembly points, Section 2.0)
- Incipient response procedures (Section 10.0)
- Review of the contents of relevant Material Safety Data Sheets (Section 5.0 of the HSGM)
- Use and application of the Safe Work Permits (Section 9.4)
- Spill containment program (Section 10.0)

I further state that I have been given the opportunity to ask questions, that all of my questions have been answered to my satisfaction, and that I agree to abide by the procedures and policies addresses in this plan.

I further state, by the presence of my signature below, that the date of my training (introductory, refresher, and supervisory, as applicable) and my medical surveillance requirements are accurate and correct to the best of my knowledge.

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

4.3 MEDICAL SURVEILLANCE

4.3.1 Medical Surveillance Requirements for Tetra Tech NUS and Subcontractor Personnel

All Tetra Tech NUS and subcontractor personnel participating in project field activities will have had a physical examination. All physical examinations shall meet the minimum requirements of paragraph (f) of OSHA 29 CFR 1910.120. The physical examinations will be performed to ensure all personnel are medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained at the job site and made available, as necessary. Subcontractor personnel may use an alternative documentation for this purpose. The "Subcontractor Medical Approval Form" can be used to satisfy this requirement, or a letter from an officer of the company. The letter should state that the persons listed in the letter participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response." The letter should further state the following:

- The persons listed have had physical examinations under this program within the frequency as determined sufficient by their occupational health care provider
- Date of the exam
- The persons identified have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive- and negative- pressure respiratory protection.

A sample Subcontractor Medical Approval Form and form letter have been provided to all eligible subcontractors in the Bid Specification package.

4.3.2 Requirements for All Field Personnel

Each field team member, including subcontractors and visitors, entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet also supplied to eligible subcontractors as part of the Bid Specifications Package and also available in Attachment III. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

4.4 SUBCONTRACTOR EXCEPTION

If through the execution of their contract elements the subcontractor will not enter the exclusion zone and there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from the

training and medical surveillance requirements with the exception of Section 8.2. Examples of subcontractors who may qualify as exempt from training and medical surveillance requirements may include surveyors who perform surveying activities in site perimeter areas or areas were there is no potential for exposure to site contaminants and support or restoration services. **Use of this Subcontractor Exception is strictly limited to the authority of the CLEAN Health and Safety Manager.**

5.0 TASK HAZARDS ASSESSMENTS AND CONTROL MEASURES

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

The FOL/SSO will utilize this table as the primary reference for completion of the task-specific Safe Work Permits. The Safe Work Permit is the primary tool for accomplishing safety and health reviews with field personnel prior to the initiation of any tasks. These permits are to be completed by the FOL/SSO and reviewed with all field personnel at the beginning of each day's activities.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific work practices identified on Table 5-1, the following general safe work practices are to be followed when conducting work involving known and unknown site hazards. These safe work practices establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations. This list is not inclusive and may be amended as necessary.

- Do not eat, drink, chew gum or tobacco, take medication, or smoke in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. A thorough shower and washing must be conducted as soon as possible if excessive skin contamination occurs.
- Avoid contact with potentially contaminated substances. Do not walk through puddles, pools, mud, or other such areas. Avoid, whenever possible, kneeling on the ground or leaning or sitting on equipment. Do not place monitoring equipment on potentially contaminated surfaces.
- Be familiar with, knowledgeable of, and adhere to all instructions in the site-specific HASP.
- Be aware of the location of the nearest telephone and all emergency telephone numbers. See Section 2.0, Table 2-1.

- Attend briefings on anticipated hazards, equipment requirements, SWPs, emergency procedures, and communication methods before going on site.
- Plan and delineate entrance, exit, and emergency escape routes. See Section 2.0.
- Rehearse unfamiliar operations prior to implementation.
- Establish appropriate Safety Zones including Support, Contamination Reduction, and Exclusion Zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the Exclusion Zone). Non-essential vehicles and equipment should remain within the Support Zone.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report all injuries, illnesses, and unsafe conditions, practices, and equipment to the Site Safety Officer (SSO).
- Matches and lighters are restricted from entering in the Exclusion Zone or Contamination Reduction Zone.
- Observe coworkers for signs of toxic exposure and heat or cold stress.
- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 DRILLING SAFE WORK PRACTICES

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

5.2.1 Before Drilling

- Identify all underground utilities and buried structures before drilling. Use the Utility Locating and Excavation Clearance Standard Operating Procedure.
- All drill rigs will be inspected by a Competent Person (the SSO or designee), prior to the acceptance of the equipment at the site and prior to the use of the equipment. All repairs or deficiencies identified will be corrected prior to use. The inspection will be accomplished using the Equipment Inspection Checklist. Inspection frequencies will be once every 10 day shift or following repairs.

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

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

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

5.2.2 During Drilling

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

- Minimize contact to the extent possible with contaminated tooling and environmental media.

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

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

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

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

5.2.3 After Drilling

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

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

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

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

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
NAVAL SURFACE WARFARE CENTER CRANE DIVISION, CRANE, INDIANA

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions or the FOL or SSO dictate.)	Decontamination Procedures
Mobilization/ Demobilization	***Chemical hazards:*** 1) The on-site Hazard Communication Program will be followed. All chemicals brought onto the site by Tetra Tech NUS and subcontractor personnel will be inventoried and have an MSDS on site. This effort shall include - Accurate Chemical Inventory List (Entries will match chemicals brought on-site, as the names appear on the MSDS) This list, which also includes quantities and storage locations will be provided to NSWC Crane Emergency Response Units. - MSDS's will be maintained in a central location, accessible to all personnel. All containers will have labels specifying the following information: - Chemical Identity (As it appears on the label, MSDS, and Chemical Inventory List) - Appropriate Warning (i.e., Eye and skin irritation, flammable, etc.) - Manufacturer's Name Address and Phone Number ***Physical hazards:*** 2) Lifting (strain/muscle pulls) 3) Pinches and compressions/Struck by 4) Slips, trips, and falls 5) Heavy equipment hazards (rotating equipment, hydraulic lines, etc.) 6) Vehicular and foot traffic 7) Ambient temperature extremes (heat/cold stress) ***Natural hazards:*** 8) Insect/animal bites and stings, poisonous plants, etc. 9) Inclement weather	1) All personnel will be required to review the appropriate MSDS's, prior to the use of a specified chemical substance. This direction should also be communicated on the Safe Work Permit completed for this task. 2) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques - Lift with your legs, not your back, bend your knees move as close to the load as possible, and ensure good hand holds are available. - Minimize the horizontal distance to the center of the lift to your center of gravity. Minimize turning and twisting when lifting as the lower back is especially vulnerable at this time. Break lifts into steps if the vertical distance (from the start point to the placement of the lift) is excessive. Plan your lifts – Place heavy items on shelves between the waist and chest; lighter items on higher shelves. Periods of high frequency lifts or extended duration lifts should provide sufficient breaks to guard against fatigue and injury. In determining whether you can lift an item several factors must be considered, these are as follows: - Maximum weight lifted by a single person should not exceed 70 pounds. Items over 70 pounds or the amount you feel you can confidently lift up to 70 pounds should define a point where assistance in the lift is sought. - Level of demand – Weight + frequency & duration. - Area available to maneuver the lift. - Area of the lift – Work place clutter, slippery surfaces - Overall physical condition 3) Keep any machine guarding in place. Do not modify tooling without manufacturer's expressed permission. - Avoid moving parts. - Use tools or equipment where necessary to avoid contacting pinch points. - Adjust machine guarding as necessary to minimize distance between guards and point of operation. - When staging equipment, insure all stacked loads, shelving, are adequately secure to avoid creating a hazard from falling objects. 4) Preview work locations for unstable/uneven terrain. - Cover, guard and barricade all open pits, ditches, and floor opening as necessary. The FOL and the SSO during site surveys and site preparation should identify these potential hazards. 5) All equipment will be - Inspected in accordance with OSHA and manufacturer's design. - Operated by knowledgeable operators and ground crew. 6) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom or mast + 5 feet). - Foot and vehicular traffic routes shall be well defined - Secure all loose articles. - All self-propelled equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the site requirements. 7) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat and cold stress is provided in HSGM. 8) Avoid nesting areas, use repellents. Report potential hazards to the SSO. 9) Suspend or terminate operations until directed otherwise by SSO.	Visual observation of work practices by the SSO to minimize potential physical hazards (i.e., improper lifting, unsecured loads, etc.).	Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - *Safety glasses* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.*	Not required.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions for the FOL or SSO dictate)	Decontamination Procedures
Decontamination of Sampling and Heavy Equipment	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern in the groundwater: Chlorinated Solvents - 79-34-5 1,1,2,2-Tetrachloroethane 79-01-6 Trichloroethene (TCE) Other contaminants have been identified within the groundwater, however, the concentrations identified were not sufficient enough to present an occupational exposure threat. Table 6-1 provides additional information about each of the identified contaminants of concern. 2) Decontamination fluids - Liquinox (detergent); isopropanol (decontamination solvent) ***Physical hazards:*** 3) Lifting (strain/muscle pulls) 4) Noise in excess of 85 dBA 5) Flying projectiles 6) Struck by 7) Slips, trips, and falls ***Natural hazards:*** 8) Inclement weather	1) and 2) Employ protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. Obtain manufacturer's MSDS for any decontamination fluids used on-site. Solvents may only be used in well-ventilated areas, such as outdoors. Use appropriate PPE as identified on MSDS or within this HASP. All chemicals used must be listed on the Chemical Inventory for the site, and site activities must be consistent with the Hazard Communication Program. 3) Use multiple persons where necessary for lifting and handling heavy equipment, such as auger flights for decontamination purposes. - Employ proper lifting techniques as described in Table 5-1, Mobilization/Demobilization. 4) Wear hearing protection when operating the Steam Cleaner. Sound pressure levels measured during the operation of similar pieces of equipment indicate a range of 87 to 93 dBA. 5) Use eye and face protective equipment when operating the steam cleaner. All other personnel must be restricted from the area. In addition to minimize hazards (flying projectiles, water lacerations and burns) associated with this operation, the following controls will be implemented - A 25° Fan Tip will be used on pressurized systems over 3,000 psi. This will reduce the possibility of lacerations. - Thermostat control to regulate the temperature levels. - Visual evaluations of hoses and fittings for structural defects - Construct deflection screens as necessary to control overspray and to guard against dispersion of contaminants driven off by the spray. 6) Struck by – Ensure wash and drying racks are suitable construction to support heavier items such as auger flights and will secure them against falling during this process. 7) The decontamination pad should be constructed to contain wash waters generated during decontamination procedures. Temporary decontamination pads are usually 10-30 mil polyethylene or polyvinyl chloride tarp construction. Although these items when used as a liner offer containment, they also present a slipping hazard. When these temporary liners are employed, it is recommended that a light coating of sand be spread over the walking surface to provide traction. - In addition, adequate slope should be provided to the pad to permit drainage away from the object being cleaned. The collection point for wash waters should be of adequate distance that the decon workers do not have to walk through the wash waters while completing their tasks. - Hoses should be gathered when not in use to eliminate potential tripping hazards. 8) Suspend or terminate operations until directed otherwise by SSO.	Use visual observation and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried. Instrumentation will not be used to determine airborne concentrations during this activity. Levels of protection will be initiated based on positive detections during field operational activities. After decontamination is completed and parts are visually clean. VOCs using PID/FID Screen dried equipment with a PID/FID. If any elevated readings (i.e., above background) are observed, perform rinse process again and re-screen. Repeat until no elevated PID/FID readings are noted. The intent is two-fold. First to ensure the removal of all site contaminants. Secondly, to ensure the removal of decontamination solvents to prevent cross contamination.	**For Heavy Equipment** This applies to steam cleaning operations and soap/water wash and rinse procedures. Level D Minimum requirements: - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Chemical resistant boot covers - Nitrile outer gloves Safety glasses underneath a splash shield - Hearing protection (plugs or muffs) - Hooded PVC Rainsuits or PE or PVC coated Tyvek **For sampling equipment** (trowels, bailers, etc.), the following PPE is required Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Nitrile inner gloves (surgical gloves) - Safety glasses In the event of overspray of chemical decontamination fluids, employ PVC Rainsuits or PE or PVC coated Tyvek as necessary. **Note:** The Safe Work Permit(s) for this task will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of removing outer layers of disposable PPE and washing the hands and face prior to performing hand to mouth activities such as eating, smoking, etc. Any reusable PPE will be go be cleaning with soap and water and allowed to dry completely. **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing a steam cleaner. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will have restricted access to exclusion zones, and have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. **Sampling Equipment Decontamination** Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving on-site, leaving the site, and between locations. No equipment will be authorized access, exit, or movement to another location without this evaluation.

Tasks/ Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions or the FOL or SSO dictate.)	Decontamination Procedures
Multi-media sampling, including soils (surface and subsurface); surface water, ground water, and seeps; sediments. This task also includes well development of existing and newly installed ground water monitoring wells.	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern in the groundwater: Chlorinated Solvents - 1,1,2,2-Tetrachloroethane 79-01-6 Trichloroethene (TCE) Other contaminants of concern that may be encountered based on past practices of disposal include Table 6-1 provides additional information about each of the identified contaminants of concern. 2) Transfer of contamination into clean areas ***Physical hazards:*** 3) Noise in excess of 85 dBA 4) Lifting (strain/muscle pulls) 5) Pinches and compressions 6) Slips, trips, and falls 7) Ambient temperature extremes (heat/cold stress) 8) Vehicular and foot traffic 9) Contact with UXO ***Natural hazards:*** 10) Insect/animal bites and stings, poisonous plants, etc. 11) Inclement weather	1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized. If airborne dusts are observed, area wetting methods may be used. If area wetting methods are not feasible, activities must be suspended until dust levels subside, or until an acceptable alternative control method can be selected. 2) Decontaminate all equipment and supplies between sampling locations and prior to leaving the site. See decontamination of heavy and sampling equipment for direction in this task. 3) When sampling at an operating Hollow Stem Auger or other type of drill rig use hearing protection. The use of hearing protection outside of 25 feet from the rig should be incorporated under the following condition: If you have to raise your voice to talk to someone who is within 2 feet of your location, you may be approaching excessive noise levels (80-85dBA) and hearing protection should be worn until the noise source may be positively quantified. 4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques (See Lifting Mobilization/Demobilization, Table 5-1). 5) Avoid moving parts, do not remove any machine guarding. - Use tools or equipment where necessary to avoid contacting pinch points. - A remote sampling device must be used to sample drill cuttings near rotating tools. The equipment operator shall shutdown machinery if the sampler is near moving machinery parts. - Remove any snag points - Follow Safe Work Practices and permits for drilling procedures when working in and around the drill rigs. 6) Preview work locations for unstable/uneven terrain. - Ruts, roots, and other tripping hazards should be eliminated from around the rotating apparatus to minimize trips and falls when approaching the rotating tooling. - Use multiple persons and small loads to pack sampling resources to remote locations. - Construct rope ladders and other engineered assistance for traversing hills and inclines > 45°. 7) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. 8) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Mast or Boom + 5 feet). See Section 9 of the HASP for specific safety zones and established clearance recommendations. - All self-propelled equipment shall be equipped with movement warning systems. - When sampling along roadways, use signs to indicate men working as well flag persons, as necessary. Personnel working in and around any established traffic patterns should wear high visibility vests to increase visual recognition. 9) Work areas are outside of the MGBG where mustard gas bombs were once buried. Therefore, UXO hazards are not anticipated to be encountered. However, verification through the Base Contact will be necessary. If any suspicious items are uncovered or encountered, the area will be marked, personnel will leave the area, and appropriate site contacts will be notified. 10) Avoid nesting areas, use repellents approved by the FOL. Report potential hazards to the SSO. 11) Suspend or terminate operations until directed otherwise by the SSO.	Samples will be screened for VOCs using direct read instrumentation. **VOCs Screening** A direct reading Photoionization Detector (PID) equipped with a 10.6 eV lamp (Primary), or a Flameionization Detector (FID) (Secondary/Back-up), will be used to screen samples and to detect the presence of any potential volatile organics. Source monitoring of the sample collection area will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above 5 ppm in the breathing zone of the at-risk employees requires site activities to be suspended and site personnel to retreat to an unaffected area, notify PHSO. - Work may only resume if airborne readings in worker breathing zone return to below 5 ppm or based on the use of identified respiratory protection. Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be minimized to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be performed by observing work conditions for visible dust clouds. Potential exposure to contaminated dust will be controlled using water suppression, by avoiding dust plumes, or evacuating the operation area until dust subsides.	Level D protection will be utilized for the following sampling activities. Surface soils, surface water, groundwater, sediments, and seeps Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Safety shoes (steel toe/shank) - Safety glasses - Surgical style gloves *(double-layered if necessary)* - *Reflective vest for high traffic areas* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential for soiling work attire exists.* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.* **Note:** The Safe Work Permit(s) for this task will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** Personal decontamination will vary based on the type of sampling conducted. These are as follows: Supporting subsurface investigations at the drill rig. - Decontamination will be the same as prescribed for the drilling activity Sampling surface water, groundwater, and sediments, the following provisions will apply - Upon completion of the sampling dedicated trowels, tubing, etc. will be bagged for transport back to the central decontamination area. - PPE (gloves) will be removed and also bagged for disposal. - Handi-Wipes or similar product will be used to clean hands prior to moving to the next location. **Equipment Decontamination** All equipment used in remote sampling locations will be brought back to the central decontamination area for decontamination and re-use or decontamination and gross removal of contamination prior to disposal. **Note:** Field screening instruments will be wrapped to minimize the necessary decontamination except for wiping down parts which are necessary to expose to the external environment. The equipment reference above is largely directed at hand tools. Decontamination of equipment (sampling and hand tools) will proceed as indicated in the Sampling and Analysis Plan and/or Work Plan.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions of the FOL or SSO dictate.)	Decontamination Procedures
Natural Attenuation Groundwater sampling. This sampling will employ geochemical analysis of the groundwater samples obtained to determine natural attenuation propensity.	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern in the groundwater: Chlorinated Solvents 79-34-5 1,1,2,2-Tetrachloroethane 79-01-6 Trichloroethene (TCE) **Note:** Other contaminants have been identified within the groundwater, however, the concentrations identified were not sufficient enough to present an occupational exposure threat. During Natural Attenuation sampling various reagents including, but not limited to the following, will be used: - Manganous sulfate - Alkaline iodide azide - Sulfamic acid - 0.02 N Sodium thiosulfate - Starch Indicator Solution - 1,10-phenanthroline indicator solution - Ferrous Iron Reagent - Sodium/potassium bicarbonate - Sodium Hydroxide - Phenolphthalein solution Refer to the manufacturer MSDS for specific chemicals and the associated hazards and required protective measures. 2) Transfer of contamination into clean areas ***Physical hazards:*** 3) Lifting 4) Slips, trips, and falls 5) Sharps ***Natural hazards:*** 6) Insect/animal bites and stings, poisonous plants, etc. 7) Inclement weather	1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.) and reagents used in the natural attenuation sampling process. Generation of dusts should be minimized. If airborne dusts are observed, area wetting methods may be used. If area wetting methods are not feasible, activities must be suspended until dust levels subside, or until an acceptable alternative control method can be selected. The MSDSs for the Natural Attenuation Sampling Reagents will be maintained at the site. All personnel identified as participating in the Natural Attenuation sampling must review the MSDSs prior to the commencement of that sampling. Establish a secondary containment (small mortar type tub) to conduct natural attenuation field screening parameter measurements. Portable Eyewash - As some of the reagent components are irritating and under extreme conditions corrosive a portable eyewash will be maintained to flush skin and/or eyes should incidental contact occur. 2) Decontaminate all equipment and supplies between sampling locations and prior to leaving the site. See Decontamination of heavy and sampling equipment for direction in this task. ***Physical hazards:*** 3) Lifting Hazards - As some of the locations may require carrying sampling equipment and supplies the following precautions should be employed: - Use machinery or multiple personnel for heavy lifts. - Use proper lifting techniques (See Lifting Mobilization/Demobilization, Table 5-1). - Break loads to be transported into smaller lighter increments. 4) Slip, trip, and Fall - Preview work locations for unstable/uneven terrain. - Ruts, roots, and other tripping hazards should be eliminated from access paths to the extent possible. - Use multiple persons and small loads to pack sampling resources to remote locations. The consequences of a slip or fall while carrying a load could potentially magnify the severity of the outcome. - Construct rope ladders and other engineered assistance for traversing hills and inclines > 45°. 5) Sharps – Many of the reagents to be used for natural attenuation sampling are provided in glass ampules which require snapping the tip off and invert the ampule multiple times to mix the sample media with the reagent. To minimize hazards associated with this task, the following safe work practices will be used: - Invert the glass ampule and place within the sampling stream inside the collection funnel. Apply pressure to the side when snapping the ampule head, NOT downward. - The ampule will fill with sample media, leaving a bubble to facilitate mixing. Place a gloved finger over the opening, invert the ample to mix the sample and reagent. This procedure may require repeating several times. Care should be exercised as not to apply too much pressure which may result in damage to your glove. - Upon completion, broken ampule shall be rinsed and placed in a hard sided container for disposal. - If you must go into the disposable items in the trash, make sure you dump it out onto a table to retrieve the item you require. Do NOT reach into the trash. This will prevent sharp sticks in the event someone has mistakenly thrown a broken ampule away. ***Natural hazards:*** 6) Avoid nesting areas, use repellents approved by the FOL. Report potential hazards to the SSO. 7) Suspend or terminate operations until directed otherwise by the SSO.	**VOCs Screening** A direct reading Photoionization Detector (PID) equipped with a 10.6 eV lamp (Primary), or a Flameionization Detector (FID) (Secondary/Back-up), will be used to screen samples and to detect the presence of any potential volatile organics. Source monitoring of the sample collection area will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above 5 ppm in the breathing zone of the at-risk employees requires site activities to be suspended and site personnel to retreat to an unaffected area, notify PHSO. - Work may only resume if airborne readings in worker breathing zone return to below 5 ppm or based on the use of identified respiratory protection. Frequency : Monitoring will be performed at periodic intervals initially, quarter of the extraction volume is pumped; half the extraction volume is pumped. **Note:** For all newly constructed monitoring wells, the frequency of radiation and CWM monitoring may be extended, if no contaminants were encountered during the soil boring phase.	Level D protection will be utilized for the following sampling activities. Groundwater samples Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Safety shoes (steel toe/shank) - Safety glasses - Surgical style gloves *(double-layered or a heavy neoprene or nitrile glove for protection against the sharpedge ampoules)* - *Reflective vest for high traffic areas* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential for soiling work attire exists.* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.*	**Personnel Decontamination** Personal decontamination will vary based on the type of sampling conducted. These are as follows: Sampling surface water, groundwater, sediments, and seeps the following provisions will apply - Upon completion of the sampling dedicated tubing, etc. will be bagged for transport back to the central decontamination area. - PPE (gloves) will be washed, removed and also bagged for disposal. - Handi-Wipes or similar product will be used to clean hands prior to moving to the next location, when access to soap and water is not feasible due to the location. - In all instances hands and face washing will be conducted upon arrival back at the central decontamination unit prior to scheduled breaks and when leaving the site. **Equipment Decontamination** All equipment used in remote sampling locations will be brought back to the central decontamination area for decontamination and re-use or decontamination and gross removal of contamination prior to disposal. **Note:** Field screening instruments will be wrapped to minimize the necessary decontamination except for wiping down parts which are necessary to expose to the external environment. The equipment reference above is largely directed at hand tools. Decontamination of equipment (sampling and hand tools) will proceed as indicated in the Sampling and Analysis Plan and/or Work Plan.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
NAVAL SURFACE WARFARE CENTER CRANE DIVISION, CRANE, INDIANA

Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment *(Items in italics are deemed optional as conditions or the FOL or SSO dictate.)*	Decontamination Procedures
Monitoring Well Installation These tasks will be accomplished using the following methods: **Monitoring Well Installation** - Drill Rig (Hollow Stem Auger)	***Chemical hazards:*** 1) Previous analytical data identified the following compounds as contaminants of concern in the groundwater: Chlorinated Solvents - 79-34-5 1,1,2,2-Tetrachloroethane 79-01-6 Trichloroethene (TCE) Table 6-1 provides additional information about each of the identified contaminants of concern. Well Construction Materials - Bentonite - Grout - Filter Sand 2) Transfer of contamination into clean areas or onto persons ***Physical hazards:*** 3) Heavy equipment hazards (pinch/compressions points, rotating equipment, hydraulic lines, etc.) 4) Noise in excess of 85 dBA 5) Energized systems (contact with underground or overhead utilities) 6) Lifting (strain/muscle pulls) 7) Slips, trips, and falls 8) Vehicular and foot traffic 9) Ambient temperature extremes (heat/cold stress) 10) Flying projectiles 11) Contact with UXO ***Natural hazards:*** 10) Insect/animal bites and stings, poisonous plants, etc. 11) Inclement weather	1) Use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized. If airborne dusts are observed, area wetting methods may be used. If area wetting methods are not feasible, activities must be suspended until dust levels subside, or until an acceptable alternative control method can be selected. -Verify monitoring well construction materials (grout, bentonite, sand, and decontamination solutions) MSDS are included in Hazard Communication Program. Ensure personnel constructing wells have reviewed the MSDS and understand potential health effects. 2) Decontaminate all equipment and supplies between boreholes and prior to leaving the site. Wrap all portable equipment to be transported across clean areas of the site to the central decontamination pad. 3) All equipment will be: - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600.601.602), and manufacturer's design. All inspections will be documented using the Equipment Inspection Checklist. - Operated and supported by knowledgeable operators, and ground crew. - Used within safe work zones, with routes of approach clearly demarcated. All personnel not directly supporting this operation will remain at least 25 feet from the point of operation. See Section 9.0 of this HASP. This will be the area identified as the exclusion zone. In addition to equipment considerations, the following safe operating procedures will be incorporated: - Hydraulic masts or other projecting devices shall be at least 20 feet from overhead power sources and a minimum of 3 feet from underground utilities. - Hand signals will be established prior to the commencement of the operation. - A remote sampling device must be used to sample drill cuttings near rotating tools - Only manufacturer-approved equipment may be used in conjunction with equipment repair procedures (e.g., flight connectors). - Work areas will be kept clear of clutter. - Secure all loose articles to avoid possible entanglement during coring activities. - All self-propelled equipment shall be equipped with movement warning systems. - All personnel will be instructed in the location and operations of the emergency shut-off device(s). This device will be tested initially (and then periodically) to ensure its operational status. - Areas will be inspected prior to the movement of the drill rig and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. - The drill rig and support vehicles will be moved no closer than 3 feet to unsupported side-walls of excavations and embankments. Available outriggers or other supports will used on steep terrain. 4) Hearing protection will be used during all subsurface activities using drill rig when noise levels are between 87 and 92 dBA. (during operation). Boundaries will be established to limit noise hazard. Height of the mast + 5 feet or a minimum of 25 feet is normal. Excessive noise levels are being approach when you have to raise your voice to talk to someone within 2 feet of your location . 5) All drilling activities will proceed in accordance with the Utility Locating and Excavation Clearance SOP. All utility clearances will be obtained, in writing, and locations identified and marked prior to activities. Overhead utilities will also be identified. 6) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 7) Preview work locations for unstable/uneven terrain. Some locations are on steep terrain that pose fall hazards and instability of equipment. 8) Use traffic-warning signs, flag persons, and high visibility vests as determined by the SSO when working in or along traffic thoroughfares. 9) Wear appropriate clothing for weather conditions. Acceptable shelter and liquids for field crews. 10) Wear eye protection and hard hat when the drill rig is operating. Restrict all others from the area. 11) Work areas are outside of the MGBG where mustard gas bombs were once buried. Therefore, UXO hazards are not anticipated to be encountered. However, verification through the Base Contact will be necessary. If any suspicious items are uncovered or encountered, the area will be marked, personnel will leave the area, and appropriate site contacts will be notified. leave the area and notify appropriate site contacts. 12) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Relative to the time of the year this operation is conducted, certain natural hazards may have little bearing. 13) Suspend or terminate operations until directed otherwise by SSO.	**VOCs Screening** A direct reading Photoionization Detector (PID) equipped with a 10.6 eV lamp (Primary), or a Flameionization Detector (FID) (Secondary/Back-up), will be used to screen samples and to detect the presence of any potential volatile organics. Source monitoring of the sample collection area will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source or downwind location(s) which may impact operations crew will require the following actions: - Monitor the breathing zone of at-risk and downwind employees. Any sustained readings (greater than 1 minute in duration) above 5 ppm in the breathing zone of the at-risk employees requires site activities to be suspended and site personnel to retreat to an unaffected area, notify PHSO. - Work may only resume if airborne readings in worker breathing zone return to below 5 ppm or based on the use of identified respiratory protection. Site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be minimized to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be performed by observing work conditions for visible dust clouds. Potential exposure to contaminated dust will be controlled using water suppression, by avoiding dust plumes, or evacuating the operation area until dust subsides.	Level C - (Minimum Requirements) Initiated **Subsurface Soils - Borings and well advancement** **Screening and Sampling Staff** - Standard field attire including sleeved shirt and long pants - Safety shoes (Steel toe/shank) - Safety glasses - Surgical style gloves *(double-layered if necessary)* - Hard hat (when overhead hazard exists) - Tyvek® coveralls; Impermeable garments if the potential exists for soiling or saturating. - Hearing protection for high noise areas - *Reflective vest for traffic areas* **Driller and Driller Helper** - Standard field attire including sleeved shirt and long pants - Safety shoes (Steel toe/shank) - Safety glasses - Nitrile gloves - Hard hat (when overhead hazard exists) - Impermeable outer garments such as PVC Rain-suit or Saranex®, PE coated Tyvek® due to contact with contaminated tooling. Tyvek® coveralls with Butyl sleeves and apron is acceptable due to heat stress. - Hearing protection for high noise areas - *Reflective vest for traffic areas* Note: The Safe Work Permit(s) for this task will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task. Protective levels may require modification should this activity be required to be conducted within a controlled zone due to an on-going operation.	**Personnel Decontamination** Personal decontamination will vary based on the type of sampling conducted. These are as follows: Sampling surface water, groundwater, sediments, and seeps the following provisions will apply - Upon completion of the sampling dedicated tubing, etc. will be bagged for transport back to the central decontamination area. - PPE (gloves) will be washed, removed and also bagged for disposal. - Handi-Wipes or similar product will be used to clean hands prior to moving to the next location, when access to soap and water is not feasible due to the location. - In all instances hands and face washing will be conducted upon arrival back at the central decontamination unit prior to scheduled breaks and when leaving the site. **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing a steam cleaner. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will have restricted access to exclusion zones, and have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. **Sampling Equipment Decontamination** Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving on-site, leaving the site, and between locations. No equipment will be authorized access, exit, or movement to another location without this evaluation.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
NAVAL SURFACE WARFARE CENTER CRANE DIVISION, CRANE, INDIANA

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions or the FOL or SSO dictates)	Decontamination Procedures
Surveying – Geographical	***Chemical hazards:*** Significant exposure to site contaminants is anticipated to be unlikely given the nature of this task. ***Physical hazards:*** 1) Slips, trips, and falls 2) Ambient temperature extremes (cold stress ***Natural hazards:*** 3) Inclement weather 4) Insect/animal bites or stings, poisonous plants, etc.	1) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation, establish temporary means for traversing hazardous terrain (i.e., rope ladders, etc.) 2) Wear appropriate clothing for weather conditions. Acceptable shelter and liquids for field crews. 3) Suspend or terminate operations until directed otherwise by SSO 4) Avoid nesting areas, use repellents. Report potential hazards to the SSO. Relative to the time of the year this operation is conducted; certain natural hazards may have little bearing.	No air monitoring is needed given the unlikelihood that airborne contaminants will be present. The potential for exposure to site contaminants during this activity is considered minimal. As most of this activity is conducted either before or after the intrusive aspect of this operation, therefore, minimizing potential exposure.	Surveying activities shall be performed in Level D protection Level D Protection consists of the following: - Standard field dress including sleeved shirt and long pants - Safety shoes (Steel toe/shank) - *Safety glasses, hard hats (if working near machinery or within brushy areas)* - *Snake chaps for heavily wooded area where encounters are likely.* - *Tyvek coveralls may be worn to provide additional protection against poisonous plants and insects, particularly ticks. Work gloves may be worn if desired.* **Note:** The Safe Work Permit(s) for this task will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task. Protective levels may require modification should this activity be required to be conducted within a controlled zone due to an on-going operation.	**Personnel Decontamination** - A structured decontamination is not required as the likelihood of encountering contaminated media is considered remote. However, survey parties should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be employed to stop the transfer of these insects into vehicles, homes, and offices.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring - Type and Action Levels	Personal Protective Equipment (Items in italics are deemed optional as conditions of the FOL or SSO dictate:)	Decontamination Procedures
Removal of Vegetation	***Chemical hazards:*** Significant exposure to site contaminants is not anticipated given the nature of this task. ***Physical hazards:*** 1) Power equipment hazards - Struck by flying debris - Caught by rotating mechanisms - Entangled in the vegetation introduced into the feeder - Loose clothing entangled in the feeder 2) Cuts (or other injuries associated with hand and power tool use) 3) Slips, trips, and falls 4) Ambient temperature extremes (heat/cold stress) 5) Noise ***Natural hazards:*** 6) Inclement weather 7) Insect/animal bites or stings, poisonous plants, etc.	1) There are inherent hazards associated when working with chainsaws and chipper in the removal and sizing of wood and vegetation. **Chipper Safe Work Practices:** To protect workers from being caught by the chipper feed mechanism, employers should ensure the following: - All safety devices and controls, such as emergency shut-off devices, are tested and verified to be functioning properly before the chipper is used. - Workers are trained in safe work procedures, including operating wood chipper safety devices and safety controls. These procedures should be based on the manufacturer's recommendations for each machine. - At least two workers are in close contact with each other when operating the chipper. - Workers wear close-fitting clothing, gloves without cuffs, trousers without cuffs and skid-resistant foot wear. Clothing should be kept tucked in. - Worker's hands and feet remain outside the infeed hopper. - Workers feed brush and limbs into the infeed hopper butt end first. - Workers feeding material are positioned at the side of the machine to allow quick operation of the emergency shut-off device and minimize risk of entanglement in branches. Because of differences among machines, the manufacturer's operating manual should be consulted for guidance. Safe feeding of some disc-type chippers requires the worker to be on the right side. - Workers walk away once the feed mechanism has grabbed the material. - Workers lay short material on top of longer material that is feeding or use a longer branch to push it through the infeed hopper. - Workers load small raked-up material such as twigs and leaves directly into the chip truck or in trash cans or bags instead of feeding it into the chipper. - Workers keep the area around the wood chipper free of tripping hazards. - Workers wear hard hats, eye protection, and hearing protection. To protect workers against being struck by flying hoods covering chipper discs or drums, employers should ensure the following: - Wood chippers are inspected each working day before startup for defects such as broken or missing hood latches and pins or cracked and worn hinges. Broken, damaged, or missing machine components should be repaired or replaced before the machine is placed in service. - The hood covering the chipper knives is completely closed and latched according to manufacturer's recommendations before starting the machine. - Before processing material and unless the manufacturer recommends otherwise, the machine is run at the lowest possible speed while workers listen for noise that might indicate broken or loose machine parts. If unusual noise is detected, the machine should be shut down immediately and evaluated by a competent person. If necessary, the machine should be repaired before being placed in service. - All internal machine parts have come to a complete stop before the hood covering the chipper disc or drum is opened. Chainsaw operations - Ensure all machine guarding is in place and functional - Ensure all protective gear is properly employed (i.e., chainsaw chaps, helmet, visor, hearing protection, etc.) - Ensure the chain is properly adjusted and sharp - Ensure operators are knowledgeable in the operation of the chainsaw and the procedures for falling large trees - Place the saw on the ground, foot on pad, hand on control bar, brake is in place to start - Ensure ample clearance when falling trees over 10 feet in height - Provide a clear escape route when falling trees of substantial height 2) All tools will be inspected prior to use for broken components, insure guarding is in place and functional, and suitability for use. - All personnel not directly supporting this clearance activity will remain at least 25 feet from the point of this operation. - Work areas will be kept clear of clutter. - Brush should be cut for lines of sight as close to the ground as possible to eliminate puncture and trip hazards. All brush should be cleared from sight path where persons will have to travel. - Brush hooks, machetes, chain saws, and other tools should be kept sharp to provide ease of cutting. Broken or loose handles should be repaired prior to use. - Falling larger trees (>4 inch girth) requires a two man operation. All chipping operations require two men working closely with one another. 3) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation, establish temporary means for traversing hazardous terrain (i.e., rope ladders, etc.) 4) Wear appropriate clothing for weather conditions. Provide acceptable shelter and liquids for field crews. Additional information regarding heat/cold stress and other assorted natural and physical hazards are provided in the HSGM. 5) The various motorized equipment including chainsaws and chippers are extremely noisy. Levels anticipated range between 97 and 108 dBA, therefore, will require the use of hearing protection. 6) Suspend or terminate operations until directed otherwise by SSO 7) Avoid nesting areas, use repellents. Report potential hazards to the SSO.	Based on historical information and the type of activities and the contaminants of concern, it is not anticipated that field crews associated with this task will be overexposed to any of the site contaminants. Chainsaw and chipper operations exceed 85dBA, therefore no additional noise dosimetry will be conducted to further quantify noise sources.	The removal of vegetation is anticipated to be initiated in a modified Level D protection. Level D - (Minimum Requirements) For vegetation clearance activities: Hand tools (Brush hook, machete, etc.) - *Tyvek coveralls (Based on site conditions, time of the year, etc.)* - Field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Work gloves - Safety glasses (with face shield for highly overgrown areas or where hazards to the face are present/created) - *Hardhat (when overhead hazards exists, or identified as an operation requirement)* - *Snake chaps for heavily wooded area where encounters are likely.* **Chainsaw/Chipper Operation** - Same as above - Chain saw chaps - Screen visor - Hearing Protection Note: The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** It is not anticipated that site personnel engaged in this task will encounter any of the associated site contaminants. Therefore, personnel decontamination will consist of - Equipment drop - Remove disposable outer protective garments as applicable - Wash hands, face, and exposed skin areas, leave contamination reduction zone Note: A variety of plant species (i.e., poison ivy, poison oak, etc.) will cause allergic dermatitis in some persons. Care should be taken to apply barrier guards/creams to exposed skin, and wash with cool water to remove associated oils derived from contact with these plants. This precaution is recommended when these plant species are identified within the area of operation. As this activity may have personnel entering and working in high brush, field personnel should perform a visual inspection of themselves and partners of their outer garments for ticks. A closer self inspection should be performed when showering for any insects which may have gotten under your clothing and attached to your body. Areas to check closely are those which are more moisture laden, inside socks, groin area, arm-pits, etc.

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical, physical, and natural hazards associated with the sites to be investigated and the activities that are to be conducted as part of the scope of work. Table 6-1, which is included as part of this HASP, provides information on potential chemical contaminants, including exposure limits, symptoms of exposure, physical properties, and air monitoring and sampling data.

6.1 CHEMICAL HAZARDS

The potential health hazards associated with work to be conducted at NSWC Crane include inhalation, ingestion, and dermal contact with contaminants that may be present in ground water and shallow soils. Based on the site history and prior sampling efforts, the following have been identified as the primary classes of site contaminants, including the specific compound(s) of interest:

- Volatile Organic Compounds (VOCs), primarily chlorinated solvents include the following substances

CAS No.	Substance
79-34-5	1,1,2,2-Tetrachloroethane
79-01-6	Trichloroethene (TCE)

Table 6-1 provides information on these compounds and individual substances likely to be present at the sites to be investigated. Included is information on the toxicological, chemical, and physical properties of these substances. It is anticipated that the greatest potential for exposure to site contaminants is during intrusive activities (soil borings, sampling, etc.). Exposure to these compounds is most likely to occur through inhalation or dermal contact of contaminated soil or water, or through ingestion via hand-to-mouth contact during soil disturbance activities. For this reason, PPE and basic hygiene practices (e.g., washing face and hands before leaving site) will be extremely important. Inhalation exposure will be avoided by using appropriate PPE and engineering controls where necessary.

Other sources of potential chemical exposure are decontamination fluids (e.g., Liquinox, isopropanol), and analytical preservatives. For any substances brought onto the site, the SSO is responsible for instituting a site-specific Hazard Communication Program and for collecting the appropriate Material Safety Data Sheets (MSDS) from the chemical manufacturers/suppliers. The SSO is also responsible for completing the Safe Work Permit for the decontamination task using the appropriate MSDS and for reviewing the contents of the MSDSs and Safe Work Permit with anyone who will use these substances.

6.2 PHYSICAL HAZARDS

In addition to the chemical hazards discussed above, the following physical hazards may be present during the performance of the site activities.

- Slips, trips, and falls
- Cuts (or other injuries associated with hand tool use)
- Lifting (strain/muscle pulls)
- Ambient temperature extremes (cold and heat stress)
- Pinches and compressions
- Heavy equipment hazards (rotating equipment, hydraulic lines, etc.)
- Energized systems (contact with underground or overhead utilities)
- Vehicular and foot traffic
- Contact with Unexploded Ordnance (UXO)
- Noise in excess of 85 dBA
- Flying projectiles

Information on the associated control measures for these hazards are discussed in Table 5-1 of this HASP. Some of these hazards and the associated control measures are discussed below.

6.2.1 Slips, Trips, and Falls

Conditions such as steep terrain and/or heavy vegetation may create an increased potential for slip, trip, and fall hazards.

- The safest approach to sample points will be identified and cleared to permit field crew access to sample locations.
- Establish anchor points and rope handrails for traversing/ascending/descending angles and slopes greater than 45% grade.
- Footwear with an adequate traction.
- Prepare work areas by removing tripping hazards (ruts, roots, debris). This is especially critical around rotating equipment, where a fall into the rotating apparatus could be life threatening.

6.2.2 Cuts or Other Injuries Associated with Hand Tool Use

The clearing of brush and vegetation will be performed using hand tools that may include machetes, brush axes, chainsaws and chippers. Chainsaws and chipper operations are discussed in detail in Table 5-1.

However, the use of hand tools has only briefly discussed. The control measures presented below will help minimize the potential for physical and cutting hazards.

- Wear leather or heavy cotton work gloves when using tools to protect against blisters, cuts, or other hand injuries.
- Wear eye protection (safety glasses with side shields) to protect the eyes from twigs, sticks, or flying debris.
- Clear the immediate cutting area of all personnel (radius of the tool swing area).
- Wear long pants and long-sleeved shirts to protect against abrasions.
- Wear hard hats if work will involve areas with overhead hazards (e.g., overhanging branches).
- Wear sturdy work boots.
- Inspect all hand tools [i.e., shovel handles (cracks, splinters, etc.), brush hook handles and blade attachment points, etc.)
- Ensure all hand tools are sharp to facilitate cutting action. This will avoid persons forcing the tool to cut and increasing potential hazards.
- Use the proper tool for the intended purpose. This to will avoid potential injury possibly created through improper use.

6.2.3 Contact with UXO

UXO hazards are unlikely to be encountered at the proposed areas where site investigations for this scope of work are to be conducted. However given the prior uses of the site and areas nearby the proposed investigation areas, there is a possibility that UXO may be encountered during operations. All activities will be conducted consistent with the UXO procedures and SOP.

- In general, field personnel will practice UXO avoidance techniques.
  - Do not pick-up or kick any unknown materials.
  - Notify the EOD Specialist if you encounter unknown materials.
  - Where the potential exists for UXO materials the EOD Specialist will clear all access routes and work areas.

- To minimize the risk of a UXO encounter, areas to be investigated will be cleared by the Base contact to verify that no UXO hazards exist.

- Although unlikely, if UXO hazards are determined to be a concern, the borehole will be cleared down to a depth of two (2) feet and a magnetic gradiometer (down-hole instrument) or similar instrument will be lowered into the hole to clear the borehole. This clearance procedure will continue until the

borehole has been cleared to a depth of ten (10) feet. This will be accomplished by hand. Advancement through mechanical means may proceed within a two foot radius of the clearance boring.

The site-specific training in avoidance techniques and safe work practices will be discussed in detail during site-specific training.

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, and inclement weather are natural hazards that may be present given the location of activities to be conducted. As previously discussed, some portions of the site include vegetated areas which increases the potential for field crews to encounter ticks, bees, mosquitoes/insects, snakes, and poisonous vegetation.

6.3.1 Insect Bites and Stings

Insect/animal bites and stings are difficult to control given the climate and environmental setting of NSWC Crane. However, in an effort to minimize this hazard the following control measures will be implemented where possible.

- Commercially available bug sprays and repellents will be used whenever possible – Pesticides analytical screening includes chlordane, endrin, lindane, methoxychlor, toxaphene and heptachlor. Commercially available repellants may be used providing they don't contain substances which appear on the analytical list for pesticide analysis. Products such as DEET should not be applied directly to the skin due to potential irritation. This product, when permitted for use, should be applied over clothing articles.

- Where possible, loose-fitting and light-colored clothing with long sleeves should be worn. This will also aid in insect control by providing a barrier between the field person and the insects and to provide easy recognition of crawling insects against the lighter background. Pant legs should be secured to the work-boots using duct tape to prevent access by ticks. Mosquito nets are also recommended for use when commercially available repellents are not permitted.

- Clothing/limited body checks for ticks and other crawling insects should be conducted upon exiting heavily vegetated areas. Workers should perform a more detailed check of themselves when showering in the evening. Ticks prefer moist areas of the body (arm-pits, genitals, etc.) and will migrate to those locations.

- The FOL/SSO will preview all access routes and work areas in an effort to identify physical hazards including nesting areas in and around the work sites. These areas will be flagged and communicated to all site personnel.

- The FOL/SSO must determine if site personnel (through completion of Medical Data Sheets), suffer allergic reactions to bee and other insect stings and bites. Field crew members who are allergic to bites should have their emergency kit containing antihistamine and a preloaded syringe of epinephrine readily available.

Any allergies (insect bites, bee stings, etc.) must be reported on the Medical Data Sheet and to the SSO.

Tick and Mosquito Transmitted Illnesses And Diseases

Ticks and mosquitoes have been identified in the transmission of diseases including Lyme's disease and malaria. Warm months (Spring through early Fall) are the most predominant time for this hazard. Information concerning Lyme's Disease including recognition, evaluation, tick removal, and control is provided in the HSGM.

Malaria may occur when a mosquito or other infected insect sucks blood from an infected person, and the insect becomes the carrier to infect other hosts. The parasite reproduces within the mosquito, and is then passed on to another person through the biting action. Acute symptoms include chills accompanied by fever and general flu like symptoms. This generally terminates in a sweating stage. These symptoms may recur every 48 to 72 hours.

6.3.2 Snakes and Other Wild Animals

Indigenous animals including snakes (poisonous and non-poisonous varieties), raccoons, and other animals native to the region may be present at the site. These animals may be encountered if work locations encroach on nesting or territories claimed by these animals.

To avoid the obvious hazards conveyed as part of a direct encounter, the following actions will be taken to minimize impact on the field crews and/or operations. The FOL/SSO will preview access routes and work locations for nesting areas or signs of animal activities (tracks, foraging areas, etc.). All identified suspect areas will be communicated to the field crews. Snake chaps will be required as a precaution.

Snake Bites

All initial efforts will be directed to avoid, where possible, nesting and territorial areas. However, should field personnel come in contact with these animals and receive a bite, the following actions are necessary.

- Obtain a detailed description of the snake. This and the bite mark will enable medical personnel administering medical aid to provide prompt and correct antidotes, as necessary.

- Immobilize the bite victim to the extent possible. Physical exertion will mobilize the toxins (if poisonous varieties) from the bite point systemically through the body.

- Apply a pressure wrap (for extremities), just above and over the bite area. With a couple wraps of the pressure wrap in place over the bite area, apply a splint, and continue the application of the pressure wrap. The purpose for the splint is to restrict the movement of the extremity, this along with the pressure wrap will aid in restricting the toxins from leaving the site of the bite.

- Seek medical attention immediately.

6.3.3 Poisonous Plants

Various plants which can cause allergic reactions may be encountered during field work. These include, poison ivy, poison oak, and poison sumac. Contact with these plants may occur when clearing vegetation for access to work areas, or as a result of movement through these plants. An irritating, allergic reaction can occur after direct contact with the plant or indirect contact through some piece of equipment or clothing article. Oils are transferred from the plant to exposed skin, clothing, or piece of equipment. The degree of the irritating, allergic reaction can vary significantly from one person to the next.

Protective measures to control and minimize the effects of this hazard may include, but not be limited to, the following:

- Identify plants for field personnel.

  - Poison Ivy - Characterized by climbing vines, three leaf configuration ovate to elliptical in shape, deep green leaves with a reddish tint, greenish flowers, and white berries.

  - Poison Sumac - Characterized as a tall bush of the sumac family bearing compound leaves (7-13 entire leaflets), branched from a central axis, drooping, with axillary clusters of white fruit: However, these white fruits and berries may exist only during pubescent stages.

- Poison oak - Characterized as similar to poison ivy consisting of a shrub, stems erect, 0.3 to 2.0 meters tall, leaflets consist of broad thick lobes coarsely serrated configuration, denser at the base, less so than the top.

- Protective measures may include wearing disposable garments such as Tyvek when clearing brush. These may be carefully removed and disposed of along with any oils accumulated from the plants.

- Personal Hygiene - The oils obtained from the plants will only elicit an allergic response when the person's bare skin layer is contacted. This can be aggravated when skin pores are open (perspiring), or through breaks in the skin such as cuts, nicks, scratches, etc. This can also be accomplished when using excessively hot water for cleaning the skin, which also causes pores to open. Prior to break time, lunchtime, etc. personnel should wash with cool water and soap to remove as much of the oils as possible. In heavily vegetated areas of these plants, additional measures including barrier creams and blocks may be used to prevent the oils from accessing and penetrating the skin.

All of these plants present an airborne sensitization hazard when burned. This is not to occur as part of this scope of work and therefore will not be addressed.

6.3.4 Inclement Weather

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

TABLE 6-1

CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NSWC CRANE, CRANE, INDIANA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
1,1,2,2-Tetrachloroethane	79-34-5	PID: I.P. 11.1 eV, relative response ratio unknown. FID: 100% response with FID.	Air sample using charcoal tube; carbon disulfide desorption, GC/FID detection. Sampling and analytical protocol in accordance with OSHA Method #07, or NIOSH Method #1003.	OSHA: 5 ppm (skin) ACGIH; NIOSH: 1 ppm (skin) IDLH: 100 ppm	Odor threshold for this substance is 7.3 ppm. This level in comparison to the TLV is considered poor. Air purifying elements (organic vapor/acid gas) are recommended for escape purposes only. Combination units (APR/airline respirator) are recommended for working in concentrations in excess of the TLV. **Recommended glove:** Butyl rubber 4.6 hrs; solvent dipped, unsupported. PV alcohol >8.00 hrs; Teflon >15.20 hrs; Viton >8.00 hrs	**Boiling Pt:** 296°F; 147°C **Melting Pt:** -33 to -47°F; -36 to -43.8°C **Solubility:** 0.3% **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 9 mmHg @ 86°F; 30°C **Specific Gravity:** 1.59 @ 77°F; 25°C **Incompatibilities:** Strong oxidizers, alkalis, fuming sulfuric acid, and chemically active metals. When heated to decomposition temperatures will emit toxic fumes of chlorine. **Appearance and Odor:** Colorless to pale yellow liquid with a pungent chloroform like odor.	Overexposure may result in CNS effects including depression, sleepiness, hallucinations, distorted perceptions, tremors(fingers), and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, abdominal pains, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, enlarged tender liver, jaundice, hepatitis, kidney, and lung damage.
Trichloroethylene	79-01-6	PID: I.P. 9.45 eV, High response with PID and 10.2 eV lamp. FID: 70% Response with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol shall proceed in accordance with OSHA Method #07, or NIOSH Method #1022 or #1003.	OSHA: 50 ppm 200 ppm (Ceiling) ACGIH: 50 ppm 100 ppm STEL NIOSH: 25 ppm IDLH: 1000 ppm	Inadequate - Odor threshold 82 ppm. APRs with organic vapor/acid gas cartridges may be used for escape purposes. Exceedances over the exposure limits require the use of positive pressure-demand supplied air respirator. **Recommended gloves:** PV Alcohol unsupported >16.00 hrs; Silver shield >6.00 hrs; Teflon >24.00 hrs; or Viton >24.00 hrs; Nitrile (Useable time limit 0.5 hr, complete submersion for the nitrile selection)	**Boiling Pt:** 188°F; 86.7°C **Melting Pt:** -99°F; -73°C **Solubility:** 0.1% @ 77°F; 25°C **Flash Pt:** 90°F; 32°C **LEL/LFL:** 8% @ 77°F; 25°C **UEL/UFL:** 10.5 @ 77°F; 25°C **Vapor Density:** 4.53 **Vapor Pressure:** 100 mmHg @ 90°F; 32 °C **Specific Gravity:** 1.46 **Incompatibilities:** Strong caustics and alkalis, chemically active metals (barium, lithium, sodium, magnesium, titanium, and beryllium) **Appearance and Odor:** Colorless liquid with a chloroform type odor. Combustible liquid, however, burns with difficulty.	Central nervous system effects including euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence. Damage to the liver, kidneys, heart, lungs, and skin have also been reported. Contact may result in irritation to the eyes, skin, and mucous membranes. Ingestion may result in GI disturbances including nausea, and vomiting NIOSH lists this substance a potential human carcinogen.

7.0 HAZARD MONITORING – TYPES AND ACTION LEVELS

This section provides direction and protocol for the real time monitoring and laboratory assisted personal sampling. The monitoring of hazardous conditions has two primary objectives.

- Qualify and quantify potential hazards (chemical, physical, and biological) which, may impact the work force or sensitive receptors in the immediate area.

- Evaluate environmental sampling media, which will be sent off-site. The purpose of this evaluation will be to qualify potential hazards to provide sufficient warning to down stream parties, which may potentially encounter these hazards. This would include hazard qualification for transportation purposes as well as notification to the analytical laboratory of potentially high hazard samples.

7.1 TASKS TO BE CONDUCTED

The following tasks are to be conducted as part of the scope of work at NSWC Crane, MGBG. It is hazards associated with these tasks, which may be monitored for the purpose of quantification/ qualification of those hazards.

- Hollow Stem Auger (HSA) Drilling
- Monitoring Well Development/Monitoring Well Sampling/Hydraulic Conductivity Testing
- Multi-media Sampling – Sediment; Surface waters
- Decontamination activities
- Geographical surveying

7.2 ASSOCIATED HAZARDS

Hazards associated with these tasks for which monitoring may be used to qualify/quantify, include, but not limited to:

- Noise – Information obtained from previous monitoring efforts indicate noise levels associated with this type of activity, dependent on the type of rig,

  - HSA Drill rig sound levels range from 87 to 92 dBA- Time Weighted Average (TWA)
  - Generators – When generators are used as portable power sources for well development or sampling, the generator should be placed a sufficient distance from the operation to eliminate the noise hazard. The generators emit approximately 82 to 88 dBA.

- Steam Cleaners and pressure washers – Previous data indicate that these machines emit from 94 to 102 dBA.

Noise dosimetry may be performed to quantify noise levels associated with the type of rig selected to perform the subsurface investigation. In addition noise quantification may be performed to insure the hearing protection devices selected attenuation capabilities are sufficient for those noise levels produced. All noise monitoring will proceed in accordance with the Hearing Conservation Program.

- Chemical hazards (Contaminated environmental media exposure) – Historical information regarding groundwater contamination has been gathered and the maximum positive detection's have been identified. This information has been used to determine potential worker exposure during tasks such as monitoring well development and sampling. These contaminants represent maximum detected concentrations and are considered worst case scenario. Personal Protective Equipment (PPE) is to provide adequate shielding of the site personnel from the hazards. If necessary to qualify and quantify these hazards real-time monitoring instruments and personal sampling will be utilized. This information will be used to estimate employee exposure and to validate PPE selection.

- Chemical Warfare Agents (CWA) or Chemical Warfare Materials (CWM) – Historical information indicates that this site was an area used for the burial of decontaminated Mustard Gas containers and deactivated dispersion aerial bombs. Information from subsequent investigations of the area indicated that Mustard Gas was indeed recovered from the area as well as the dispersion unit which, had only been partially decontaminated. After multiple investigations Mustard Gas or Mustard Gas containers have not been encountered. Furthermore, various sampling events and laboratory analysis have failed to detect any Mustard gas. As a result, mustard gas is unlikely to be encountered during the proposed investigation activities associated with this HASP.

7.3 INSTRUMENTS TO BE USED FOR HAZARD MONITORING

The following instrument will be used for monitoring the hazards identified above.

7.3.1 Metrosonics dB-307 Noise Dosimeter or Equivalent

The db-307 is a dual purpose sound level meter and noise dosimeter. The instrument is calibrated in accordance with manufacturers instructions using a 102dBA acoustical calibrator. The instrument is calibrated pre- and post to monitoring activities in accordance with the Hearing Conservation program. Information regarding calibration is recorded either on the Noise Dosimetry Log or the Sound Level Measurement Log, relative to the type of monitoring being performed.

Frequency of Monitoring

Noise dosimetry and sound level measurements will be performed under the following circumstances:

- Noise source exists for which no similar data is available.
- Quantification is necessary to evaluate hearing protection attenuation capabilities.

Additional monitoring will only be performed if it is necessary to quantify other noise sources or through changes in procedure that may result in higher noise levels.

This monitoring will be conducted during intervals of the project, as deemed necessary, during the operation of powered equipment capable of generating noise sources over 85 dBA.

7.3.2 Chemical Contaminant Monitoring

Monitoring for airborne chemical contaminants released from environmental media will be performed during the following intrusive activities:

- Monitoring well installation
- Multi-media sampling and well development

Chemical air monitoring will be performed by the SSO using a photo-ionization detector (PID) as a primary screening instrument.

The PID was selected over the FID as a primary screening instrument due to its ease of use, maintenance requirements, and resource demand. In addition, many of the chlorinated solvents within the groundwater are diluted and contaminated. This may make detection through combustion of the sample and hence detection through flameionization, difficult and unreliable. Should it be determined through initial field application and performance, that the FID based on its relative response ratio to the contaminants in question is a better choice, then the instruments will be switched out.

7.3.3 Chemical Warfare Material (CWM) Monitoring

All site soil samples, selected groundwater samples, and all rinsate blanks collected in Round 1 were screened for mustard gas in the field and were analyzed for mustard gas in a fixed laboratory. Mustard gas

was not detected in any samples. As a result, there will be no need to screen samples collected during round 2 for mustard gas.

7.4 INSTRUMENT PREPARATIONS FOR FIELD SERVICE

All direct reading instruments will require calibration prior to use. The frequency of this calibration is stated below.

- Noise Dosimeter - Manufacturer yearly service and primary calibration
  In the field – Pre and Post secondary calibration to a yearly calibrated acoustical reference.

- PID/FID – Manufacturer yearly service and primary calibration
  In the field – Pre and Post secondary calibration to a reference gas

All instruments will be operated and calibrated in accordance to manufacturers instructions.

Calibration information will be recorded on the equipment calibration sheet provided as Figure 7-1.

7.5 INSTRUMENT MAINTENANCE

Maintenance activities to be conducted on site are as follows:

- Wiping down the outer shells of the monitoring equipment used – Daily
- Battery charging – Daily (As applicable)
- PID – Lamp Cleaning – Once per 10-day shift or as conditions dictate
- PID/FID – Filter Replacement – Daily

Maintenance greater than that mentioned above will require the attention of a certified technician and will not be performed on site.

FIGURE 7-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: _____ PROJECT NO.:_____

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

8.0 SITE OPERATIONS AND CONTROL

Site operations and control will be facilitated through the use of established work zones and security and control of those zones. These activities will minimize the impact and spread of contaminants brought to the surface through subsurface investigative methods as well as protect personnel and visitors within these zones during ongoing operations.

8.1 WORK ZONES

Tetra Tech NUS will delineate and use work zones in conjunction with decontamination procedures to prevent the spread of contaminants to other areas of the site. A three-zone approach will be used for work at this site; an Exclusion Zone, a Contamination Reduction Zone, and a Support Zone. These will be used to control access to the work areas, restricting the general public, avoiding potentials to spread any contaminants, and to protect individuals who are not cleared to enter by way of training and/or medical surveillance qualifications.

8.1.1 Exclusion Zone

An Exclusion Zone will be established at each sampling point/location. The purpose of the exclusion zone is to define a area where a more rigorous protocol for workers within what is determined to be an impact area. The impact area is that area which could be adversely impacted by either chemical, physical, or energetic hazards. Exclusion zone size and dimensions will vary based on activities. Impact areas dimensions will be influenced by the following considerations:

- Physical and topographical features of the site
- Weather conditions
- Field and analytical measurements of air and environmental contaminants
- Air dispersion calculations
- Physical, chemical and toxicological properties of the contaminants being investigated
- Tasks to be conducted
- Decontamination procedures
- Potential for exposure

As conditions change the dimensions of the exclusion zone will change. However, the following dimension represent a starting point from which the exclusion zones will be expanded:

- Monitoring well installation (Hollow stem auger). The exclusion zone for this activity will be set at the height of the mast, plus five feet surrounding the point of operation, with a minimum of 25 feet. This distance will also apply when subsurface soil sampling from behind these type rigs.

- Monitoring well development and sampling. The exclusion zone for this activity will be set at 10 feet surrounding the well head and discharge collection container.

- Surface water and sediments. The exclusion zone for this activity will be set at five feet surrounding the point of operation.

- Clearing and grubbing. The exclusion zone for this activity will be set at 10 feet surrounding someone with a brush hook or machete. 50 feet surrounding a person using a chainsaw or a chipping operation.

- Decontamination operation. The exclusion zone for this activity will be set at 25 feet surrounding the gross contamination wash and rinse as well as 25 feet surrounding the heavy equipment decontamination area.

- Investigative Derived Waste (IDW) area will be constructed and barricaded. Only authorized personnel will be allowed access.

All exclusion zones shall remain marked until the SSO has evaluated the restoration effort and has authorized changing the zone status.

Exclusion zones will be marked using barrier tape, traffic cones and/or drive poles. Signs will be posted to inform and direct site personnel and site visitors.

8.1.2 Contamination Reduction Zone

The contamination reduction zone will be split to represent two separate functions. The first function will be a control/supply point for supporting exclusion zone activities. The second function, which may take place a sufficient distance from the exclusion zone, is the decontamination of personnel and heavy equipment.

In order to move from the exclusion zone to a separate location the following activities will be used:

- As samplers move from location to location during sampling activities, dedicated sampling devices and PPE will be washed of gross contamination, removed, separated, and bagged. Personnel will use hygenic wipes, such as Handy Wipes, as necessary.

- Muddy over-boots and gloves may be required to go through a gross contamination wash at the exclusion zone.

- Potentially contaminated tooling will be wrapped, when necessary, for transport to the decontamination area.

- Upon completion of the assigned tasks all personnel will move through the central decontamination area to clean reusable PPE and field equipment. All personnel and field equipment will be frisked at the termination of decontamination procedures. Based on ambient conditions medical evaluations will take place at the termination point of the decontamination line. These evaluations will include pulse rate, oral temperature, breathing rate to evaluate physiological demands on site personnel. As stated earlier, these evaluations will be based on ambient conditions and acclimation periods.

8.1.3 Support Zone

The Support Zone will consist of a field trailer, storage, laydown areas, or some other uncontaminated, controlled point. The Support Zone for this project will include a staging area where site vehicles can be parked, equipment will be unloaded, and where food and drink containers will be maintained. In all cases, the support zones will be established in clean areas of the site.

8.2 SAFE WORK PERMITS

All Exclusion Zone work conducted in support of this project will be performed using Safe Work Permits (SWP) to guide and direct field crews on a task by task basis. An example of the Safe Work Permit is included in Figure 8-1. The daily meetings conducted by the FOL/SSO will further support these work permits. The use of these permits will ensure that site-specific considerations and changing conditions are incorporated into the planning effort. All SWP will require the signatures of either the FOL or the SSO. All personnel engaged in onsite activities must be made aware of the elements indicating levels of protection and precautionary measures to be used.

The use of these permits will establish and provide for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of

protection and control measures. The SWP will take precedence over the HASP when more conservative measures are required based on specific site conditions.

Upon completion of the work for which the SWP was assigned, the SWP will be turned into the FOL or the SSO. Concerns, complaints, and suggestions may be made on the reverse of the SWP for consideration by the FOL and/or the SSO.

The SWP and the HASP will serve as the primary reference for work place evaluations and audits conducted to determine if the task is being conducted under the direction conveyed by the HASP and the SWP.

8.3 SITE MAP

Once the areas of contamination, access routes, topography, dispersion routes are determined, a site map will be generated and adjusted as site conditions change. This map will be posted to illustrate up-to-date information of contaminants and adjustment of zones and access points. This map will be posted at the field support trailer.

8.4 BUDDY SYSTEM

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

8.5 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

Tetra Tech NUS personnel will provide MSDSs for all chemicals brought on-site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application or the substances on-site. The MSDSs will be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request. The SSO will be responsible for implementing a site-specific Hazard Communication Program. This includes collection of MSDSs, creation and maintenance of an accurate Chemical Inventory Listing, addressing container labeling and personnel training issues, and other aspects as defined in that appendices.

8.6 COMMUNICATION

It is anticipated that site personnel will be working in close proximity during proposed field activities. In the event that site personnel are in isolated areas or are separated by significant distances, a supported

means of communication between field crews will be utilized. Two-way radio communication devices, if needed, will be used only with NSWC Crane approval.

External communications will be accomplished utilizing telephones at predetermined and approved locations or through cellular phones. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of site activities, the FOL will determine and arrange for telephone communications, if it is determined a cellular means will not be used.

The hand-held radios and cellular phones which will be used if permitted are as follows:

Motorola HT-1000	Power Output 5 watts
Cellular Phone	Power Output 5 watts

There are several aspects associated with emergency alerting procedures that must be taken into account at NSWC Crane. These are as follows:

- Due to the physical setting (size and remoteness) of the sites where field activities will be conducted, readily available means of communication are not always available.

- In addition, again based on the size of the facility and location, there are limited cellular communication points on Base where a signal may be obtained. This also limits communication capabilities.

- Lastly, due to the schedule that Tetra Tech NUS, Inc. will work (10 days on; 4 days off) the potential exists for field personnel to be present during holidays; off days, and after hours. Primary safe places of refuge that would normally be accessed in the event of an emergency during normal working hours will be closed during these periods.

In order to overcome these restrictions, the Base Environmental Office may allocate a Public Works/Fire/Security Radio to be used in support of this field effort. This radio will be available throughout the project to allow field personnel to establish a direct link to NSWC security and emergency services.

8.7 SITE VISITORS

Potential site visitors that may be encountered during the performance of the field work could include the following:

- Personnel invited to observe or participate in operations by Tetra Tech NUS.
- Regulatory personnel (i.e., DOD, ILEM, EPA, OSHA, etc.)
- Southern Division Navy personnel
- Other authorized visitors

All non-DOD personnel working on this project are required to gain initial access to the base by coordinating with the TtNUS TOM or designee and following established base access procedures.

Once access to the base is obtained, all personnel who require access to Tetra Tech NUS work sites (areas of ongoing operations) will be required to obtain permission from the FOL and the Base Contact. Upon gaining access to the work site, all site visitors wishing to observe operations in progress will be required to meet the minimum requirements as stipulated below.

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individuals name (proper identification required), who they represent, and the purpose for the visit. **The FOL is responsible for ensuring that site visitors are escorted at all times.**

- All site visitors will be required to produce the necessary information supporting clearance on to the site. This includes information attesting to applicable training (40-hours of HAZWOPER training required for all Southern Division Navy Personnel), and medical surveillance as stipulated in Section 8.3, of this document. In addition, to enter the sites operational zones during planned activities, all visitors will be required to first go through site-specific training covering the topics stipulated in Section 4.2 of this HASP.

Once the site visitors have completed the above items they will be permitted to enter the site and applicable operational areas. All visitors are required to observe the protective equipment and site restrictions in effect at the work areas visited. Any and all visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause all on-site activities to be terminated until that visitor can be removed. Removal of unauthorized visitors will be accomplished with

support form the Base Contact, if necessary. At a minimum, the Base Contact will be notified of any unauthorized visitors.

8.8 SITE SECURITY

As this activity will take place at a Navy facility, the first line of security will be provided by the base gate restricting the general public. The second line of security will take place at the work site referring interested parties to the FOL and Base Contact.

Security at the work areas will be accomplished using field personnel. This is a multiple person operation, involving multiple operational zones. Tetra Tech NUS personnel will retain complete control over active operational zones.

The Base Contact will serve as the focal point for base personnel and interested parties and will serve as the primary enforcement contact.

FIGURE 8-1
SAFE WORK PERMIT

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

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

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

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐

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

Modifications/Exceptions: _____

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

Chemicals of Concern	Action Level(s)	Response Measures

VI. Additional Safety Equipment/Procedures

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

Modifications/Exceptions: _____

VII. Procedure review with permit acceptors

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

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐Yes ☐No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____

9.0 SPILL PREVENTION AND CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

This program applies to the single or aggregate accumulation of bulk storage materials (over 55-gallons). As the classification of certain materials such as IDW is unknown, all materials will be treated as hazardous, pending laboratory certification to the contrary. The types of materials for which this program will apply are as follows:

- Investigative Derived Wastes (IDW) such as decontamination fluids, soil cuttings, and purge and well development waters
- Resource Storage – Limited fuel and lubricant storage

9.2 POTENTIAL SPILL AREAS

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

- Resource deployment
- Waste transfer
- Central staging

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

9.3 CONTAINMENT AREAS

In order to facilitate leak and spill inspection and response, and to minimize potential hazards which may impact the integrity of the storage containers, the staging area for these substances will be structured as follows:

9.3.1 IDW

- 55 Gallon Drums (United Nations 1A2 configurations) – 4 Drums to a Pallet; labels and the retaining ring bolt and nut on the outside of each drum to facilitate easy access; Minimum 3 feet between each row of pallets. Size and dimensions will be restricted to the estimated volume plus 10 percent for rain

water and container displacement. The decision to construct a bermed and lined area will be the decision of project management .

- Storage Tank – Polyethylene Construction – Tank shall be placed into a bermed enclosure of sufficient size to accommodate 110% of anticipated volume (Largest container plus 10% for rainwater and container displacement).

Regardless of container types selected, the staging area will be identified as a Satellite Storage Area with proper signage, points of contact in the event of an emergency, alternate contacts, and identification of stored material (i.e, Purge or decontamination waters, soil cuttings, etc.).

An Inventory Log will be maintained by the FOL regarding types of IDW and volumes generated. An updated Inventory List will be provided by the FOL to the designated Emergency Response Agency during days off and between shifts or phases of operations.

9.3.2 Flammable/POL Storage

Flammable Storage [i.e., fuels, decontamination solvents (Isopropanol)] and Petroleum/oil/lubricants (POL) will require proper dispensing containers and necessary storage for cumulative volumes in excess of 25 gallons. Storage and dispensing will comply with the following requirements:

- All fuels, which will be stored and dispensed from portable containers, will utilize safety cans.
- All portable hand held storage containers will be labeled per Hazard Communication requirements.
- Larger volumes stored for fueling equipment will be stored in approved mobile Above Ground Storage Tanks with secondary containment capable of holding the tank volume plus 10%.
- All portable flammable liquid storage tanks will be properly grounded and will have bonding capabilities for the transfer of loading and off-loading of its contents.
- All dispensing locations will be supported by a Fire Extinguisher positioned no closer than 50 feet from the storage tank, properly mounted and identified.
- The storage location will be well marked with proper signage, protective bumper poles and will have straight through access/egress for vehicles.

9.4 MATERIALS HANDLING

To minimize the hazards associated with moving drums and containers (i.e, lifting, pinch and compression points) material handling will be supported in the following manner:

- A drum cart with pneumatic tires will be required, if drums are used for IDW storage. This cart will be used to relocate drums within the staging and satellite storage location.

- In addition, a mechanized means such as a suitably equipped skid loader or back-hoe will be provided to move IDW containers from the field location to the staging and satellite storage location. This piece of equipment will also be used in site clearance and restoration as deemed appropriate and necessary.

Other means of material handling will be evaluated by the SSO based on their ability to minimize or eliminate material handling hazards.

9.5 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk-around by the personnel staging or disposing of drums or in the Resource Deployment area will be conducted during working hours to visually determine that storage vessels are not leaking. If a leak is detected, the FOL will be notified and the Spill Containment/Control Response Plan as specified in Section 9.8 will be engaged. All inspections will be documented in the project logbook.

9.6 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed in the procedures for incipient spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and/or the SSO will serve as the Spill Response Coordinators for this operation, should the need arise. Personnel through the course of this project will be drilled as part of testing the EAP.

9.7 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment that will be maintained at the staging areas at all times for the purpose of supporting this Spill Containment/Control Plan.

- Sand, clean fill, vermiculite, or other non combustible absorbent (Oil-dry)
- Extra Drums (55-gallon U.N. 1A2) should the need to transfer material from leaking containers arise.
- Pumps (Gas or Electric necessary for transferring liquids from leaking containers)/tubing
- Drum Repair Kit
- Shovels, rakes, and brooms
- Container labels
- Personal Protective Equipment

- Nitrile outer gloves
- Splash Shield
- Impermeable over-boots
- Rain suit

9.8 SPILL CONTAINMENT/CONTROL RESPONSE PLAN

This section describes the procedures the Tetra Tech NUS field personnel will employ upon the detection of a spill or leak.

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

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

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

- Recontainerize spills, including 2-inch of top cover (if over soils) impacted by the spill. Await test results for treatment or disposal options.

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

Although it is not anticipated that drums and containers of an unknown origin will be unearthed as this investigation of environmental media proceeds, this spill and containment procedure would also support that activity.

10.0 CONFINED SPACE ENTRY

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

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.
- A Permit-Required Confined Space is one that:
- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space operations, consult the SSO or call the PHSO. If confined space operations are to be performed this HASP will require modification to address, detailed procedures training requirements, and emergency rescue.

11.0 MATERIALS AND DOCUMENTS

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

- A complete copy of this HASP
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for all chemicals brought on site, including decontamination solutions, fuels, sample preservatives, calibration gases, etc.
- Follow-up Reports
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- Emergency Reference Form (Section 2.0, extra copy for posting)

11.1 MATERIALS TO BE POSTED AT THE SITE

The following documentation is to be posted at the site for quick reference purposes. In situations where posting of these documents is not feasible (such as no office trailer), these documents should be filed in a transportable file container and immediately accessible. The file should remain in the FOL's possession.

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

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

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

Site Clearance Posting - This list is found within the training section of the HASP (See Figure 4-1). This list identifies all site personnel, dates of training (including site-specific training), medical surveillance, etc. and indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

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

Site Maps – A periodically updated map will be posted in the Office trailer and at the entry to the Mustard Gas Burial Grounds. This map will be updated periodically by the FOL and/or the SSO. The information to be contained shall include control zones, points of entry, site layout information, the position of ongoing operations. As contaminant level are determined this information will also be added to the map.

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

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

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

Placards and Labels - Where chemical inventories have been separated, because of quantities and incompatibilities, these areas will be conspicuously marked using Department of Transportation (DOT) placards and acceptable [Hazard Communication 29 CFR 1910.1200 (f)] labels. The Tetra Tech NUS FOL shall ensure the following materials/documents are taken to the project site and utilized as required.

Signs and Postings – Signs and posting for regulated areas (i.e., Satellite Waste Accumulation Area, All Visitors Report to the Site Office Trailer, Exclusion Zone, etc.)

12.0 GLOSSARY

µR/hr	micro-rem per hour
ACGIH	American Conference of Governmental Industrial Hygienist
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm^2	square centimeters
CO_2	Carbon dioxide
cpm	counts per minute
CPR	Cardio Vascular Resuscitation
CSP	Certified Safety Professional
CTO	Contract Task Order
CWA	Chemical Warfare Agent
CWM	Chemical Warfare Material
dBA	Decibles
DI	De-Ionized Water
DO	Dissolved Oxygen
DPT	Direct Push Technology
DRI	Direct Reading Instruments
EAP	Emergency Action Plan
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
eV	electron Volts
Fe	Iron
FID	Flame Ionization Detector
FOL	Field Operations Leader
G-M	Geiger-Muller
H_2S	Hydrogen sulfide
HAS	Hollow Stem Auger
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HSM	Health and Safety Manager
IDEM	Indiana Department of Environmental Management
IDLH	Immediately Dangerous to Life and Health
IDW	Investigative Derived Waste

IP	Ionization Potential
KeV	kilo electron volts
mg/m^3	milligrams per cubic meter
MGMB	Mustard Gas Burial Grounds
MSDS	Material Safety Data Sheet
N/A	Not Available
NAD	Naval Ammunition Depot
NIOSH	National Institute Occupational Safety and Health
NSWC	Naval Surface Warfare Center
ORP	Oxidation-Reduction Potential
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PCE	Tetrachloroethene
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
PID	Photo Ionization Detector
POL	Petroleum/oil/lubricants
PPE	Personal Protective Equipment
PPM	Parts Per Million
PVC	Poly Vinyl Chloride
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SSO	Site Safety Officer
STEL	Short Term Exposure Limit
SWMU	Solid Waste Management Unit
SWP	Safe Work Practice/Permit
SWP	Safe Work Permit
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leachate Procedure
TLD	Thermoluminescent dosimeters
TOM	Task Order Manager
TtNUS	Tetra Tech NUS
TWA	Time Weighted Average
UN	United Nations
UXO	Unexploded Ordnance
WP	Work Plan

ATTACHMENT I

INJURY/ILLNESS PROCEDURE AND REPORT FORM

CASE NO. _____

TETRA TECH NUS, INC.

INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

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

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

ADDITIONAL QUESTIONS REGARDING WORKER'S COMPENSATION:

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

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

WHO IS COVERED:

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

CASE NO. _____

WHAT IS COVERED:

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

CASE NO. _____

TETRA TECH NUS, INC.
INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

To: Corporate Health and Safety Manager
Human Resource Administrator

Prepared by: _____

Position: _____

Project Name: _____

Office: _____

Project No. _____

Telephone: _____

Information Regarding Injured or Ill Employee:

Name: _____

Office: _____

Home address: _____

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

_____

Marital status: _____

Home telephone: _____

Date of birth: _____

Occupation (regular job title): _____

Social Security No.: _____

Department: _____

Date of Accident: _____ **Time of Accident:** _____

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

Street address: _____

City, state, and zip code: _____

County: _____

Narrative Description of How Accident Occurred: (Be specific. Explain what the employee was doing and how the accident occurred.)

TETRA TECH, INC.
INJURY/ILLNESS REPORT

Did employee die? Yes ☐ No ☐
Was employee performing regular job duties? Yes ☐ No ☐
Was safety equipment provided? Yes ☐ No ☐
Was safety equipment used? Yes ☐ No ☐
Note: Attach any police reports or related diagrams to this accident report.

Witness(es):

Name:

Address:

Telephone:

Describe the Illness or Injury and Part of Body Affected:

Name the Object or Substance which Directly Injured the Employee:

Medical Treatment Required:

☐ No ☐ Yes ☐ First Aid Only

Physician's Name: _____

Address: _____

Hospital or Office Name: _____

Address: _____

_____

Telephone No.: _____

Lost Work Days:

☐ No. of Lost Work Days _____

Last Date Worked _____

Time Employee Left Work _____

Date Employee Returned to Work _____

☐ No. of Restricted Work Days _____

☐ None

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

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

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

Date of Report: _____ Time of Report: _____

	Printed Name	Signature	Telephone No.	Date
Project or Office Manager				
Site Safety Coordinator				
Injured Employee				

To be completed by Human Resources:

Date of hire: Hire date in current job:

Wage information: $ _____ per _____ (hour, day, week, or month)

Position at time of hire:

Shift hours:

State in which employee was hired:

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

Temporary job end date:

To be completed during report to workers' compensation insurance carrier:

Date reported: Reported by:

TeleClaim phone number:

TeleClaim account number:

Location code:

Confirmation number:

Name of contact:

Field office of claims adjuster:

ATTACHMENT II

EQUIPMENT INSPECTION CHECKLIST

EQUIPMENT INSPECTION

COMPANY:_____ **UNIT NO.**_____

FREQUENCY: Inspect daily, document prior to use and as repairs are needed.

Inspection Date: ____/____/____ Time: _____ Equipment Type:_____
(e.g., bulldozer)

	Good	Need Repair	N/A
Tires or tracks	❒	❒	❒
Hoses and belts	❒	❒	❒
Cab, mirrors, safety glass	❒	❒	❒
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	❒	❒	❒
- Is the equipment equipped with audible back-up alarms and back-up lights?	❒	❒	❒
Horn and gauges	❒	❒	❒
Brake condition (dynamic, park, etc.)	❒	❒	❒
Fire extinguisher (Type/Rating -_____)	❒	❒	❒
Fluid Levels:			
- Engine oil	❒	❒	❒
- Transmission fluid	❒	❒	❒
- Brake fluid	❒	❒	❒
- Cooling system fluid	❒	❒	❒
- Windshield wipers	❒	❒	❒
- Hydraulic oil	❒	❒	❒
Oil leak/lube	❒	❒	❒
Coupling devices and connectors	❒	❒	❒
Exhaust system	❒	❒	❒
Blade/boom/ripper condition	❒	❒	❒
Accessways: Frame, hand holds, ladders, walkways (non-slip surfaces); guardrails?	❒	❒	❒
Power cable and/or hoist cable	❒	❒	❒
Steering (standard and emergency)	❒	❒	❒

Safety Guards:

	Yes	No
– Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?_____	❒	❒
– Hot pipes and surfaces exposed to accidental contact?_____	❒	❒
– All emergency shut offs have been identified and communicated to the field crew?_____	❒	❒
– Have emergency shutoffs been field tested? _____	❒	❒
– Results?_____	❒	❒
– Are any structural members bent, rusted, or otherwise show signs of damage?_____	❒	❒
– Are fueling cans used with this equipment approved type safety cans?_____	❒	❒

- Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use?_____ ❒ ❒

Portable Power Tools:

- Tools and Equipment in Safe Condition?_____ ❒ ❒
- Saw blades, grinding wheels free from recognizable defects (grinding wheels have been sounded)? ❒ ❒
- Portable electric tools properly grounded?_____ ❒ ❒
- Damage to electrical power cords?_____ ❒ ❒
- Blade guards in place?_____ ❒ ❒
- Components adjusted as per manufacturers recommendation?_____ ❒ ❒

Cleanliness:

- Overall condition (is the decontamination performed prior to arrival on-site considered acceptable)?_____
- Where was this equipment used prior to its arrival on site?_____
- Site Contaminants of concern at the previous site?_____
- Inside debris (coffee cups, soda cans, tools and equipment) blocking free access to foot controls?_____

Operator Qualifications (as applicable for all heavy equipment):

- Does the operator have proper licensing where applicable, (e.g., CDL)?_____
- Does the operator, understand the equipments operating instructions?_____
- Is the operator experienced with this equipment? _____
- Does the operator have emotional and/or physical limitations which would prevent him/her from performing this task in a safe manner?_____
- Is the operator 21 years of age or more?_____

Identification:

- Is a tagging system available, for positive identification, for tools removed from service?___

Additional Inspection Required Prior to Use On-Site

	Yes	No
Does equipment emit noise levels above 90 decibels?	❒	❒
If so, has an 8-hour noise dosimetry test been performed?	❒	❒

- Results of noise dosimetry:_____
- Defects and repairs needed:_____
- General Safety Condition: _____
- Operator or mechanic signature:_____

Approved for Use: ❒ Yes ❒ No

_____
Site Safety Officer Signature

ATTACHMENT III

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by all on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Name of Next Kin _____

Drug or other Allergies _____

Particular Sensitivities _____

Do You Wear Contacts? _____

Provide a Checklist of Previous Illnesses or Exposure to Hazardous Chemicals _____

_____

_____

What medications are you presently using? _____

_____

_____

Do you have any medical restrictions? _____

_____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

_____

I am the individual described above. I have read and understand this HASP.

_____ _____

Signature Date

ATTACHMENT IV

SAFE WORK PERMITS

SAFE WORK PERMIT
MONITORING WELL INSTALLATION AND CONSTRUCTION

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

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

I. Work limited to the following (description, area, equipment used): Monitoring Wells are to be installed via HSA drilling.

Equipment Type: To be determined

Monitoring Equipment Required: PID with 10.6 eV Lamp,

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

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

Modifications/Exceptions: _____

V. Chemicals of Concern	Action Level(s)	Response Measures
Chlorinated Solvents	>5 ppm	Retreat to an unaffected Area until reading return To background levels.

VI. Additional Safety Equipment/Procedures

Hardhat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio (At least one radio per crew)	☐ Yes	☐ No
Splash Shield	☐ Yes	☒ No	Signs and Barricades	☐ Yes	☐ No
Splash suit/coveralls (Type: Tyvek)	☐ Yes	☐ No	Gloves (Type – Nitrile)	☒ Yes	☐ No
Steel toe/shank Workboots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☐ No

Modifications/Exceptions: Splash Suit – Sampler - Tyvek unless saturation of work clothes are anticipated; Driller/Drillers Helper – Impermeable Rain suit. Hearing Protection – During operation of noise sources (i.e., drill rigs, etc.) The plugs and muffs identified for use shall be used in combination with one another for noise sources in excess of 105 dBA. All zones and entry control points will be clearly demarcated. Gloves – Samplers -Nitrile gloves (surgeons style) for incidental contact; Driller/Drillers Helper – nitrile gloves. Work rest regimens will be based on ambient conditions and acclimatization progress

VII. Procedure review with permit acceptors

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

Emergency Alarms – Verbal, Radio, air horn. Evacuation route – Up or cross wind to primary location, See attached site map. Assembly points – See attached site map

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☒	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☒	☐	☐
Emergency Equipment Staged	☒	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☒ No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: Follow all safe work practices when working in and around the drill rig. Even and prepare the ground in and around the drill location to eliminate tripping hazards especially approaching rotating equipment.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
MULTI-MEDIA SAMPLING – GROUND AND SURFACE WATER, SOILS, SEDIMENTS, AND SEEPS

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

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

I. Work limited to the following (description, area, equipment used): Sample acquisition will occur through direct pour or direct fill of the sample containers. This sampling includes surface waters, sediments, and monitoring wells (groundwater) and natural attenuation sampling.

Equipment Type: _____

Monitoring Equipment Required: PID with 10.6 eV Lamp

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

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

Modifications/Exceptions: _____

V. Chemicals of Concern

Chemicals of Concern	Action Level(s)	Response Measures
Chlorinated Solvents	>5 ppm	Retreat to an unaffected Area until reading return To background levels.

VI. Additional Safety Equipment/Procedures

Hardhat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio (At least one radio per crew)	☐ Yes	☐ No
Splash Shield	☐ Yes	☒ No	Signs and Barricades	☐ Yes	☒ No
Splash suit/coveralls (Type: Tyvek)	☐ Yes	☐ No	Gloves (Type – Nitrile)	☒ Yes	☐ No
Steel toe/shank Workboots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Hard hat – As conditions (overhead hazards) or work zone requirements dictate. Splash Suit – Sampler - Tyvek unless saturation of work clothes are anticipated; Reflective Vests when sampling near traffic patterns; Hearing Protection – When sampling near noise sources (i.e., drill rigs, generators, etc.). Gloves – Samplers -Nitrile gloves (surgeons style) for incidental contact. Double layer gloves for added protection.

VII. Procedure review with permit acceptors

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

Portable eyewash for remote sampling locations; Emergency Alarms – Verbal, Radio, air horn. Evacuation route – Up or cross wind to primary location, See attached site map. Assembly points – See attached site map.

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☒	☐
Equipment and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☐	☒	☐
Emergency Equipment Staged	☒	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☒ No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: Follow all safe work practices when working in and around the drill rig. Avoid uneven and unstable terrain when and where possible. Use multiple persons or pack lighter loads and make more trips to remote sampling locations. Upon sample completion - Bag all equipment for transport to central decontamination location. Personal Decontamination - Use Handi-Wipes or similar product between remote sampling locations, until you have access to the central decontamination unit. See Table 5-1 regarding precautions associated with handling sharps when engaged in Natural Attenuation sampling.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
DECONTAMINATION OF HEAVY AND SAMPLING EQUIPMENT

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

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

I. Work limited to the following (description, area, equipment used): Decontamination of Heavy and sampling equipment will take place at the central decontamination location. All equipment decontaminated will be evaluated visually and scanned with the PID to insure contaminant and decontamination solvent free.

Equipment Type: Steam cleaner, 25°Fan tip for pressurized systems over 3000 psi, scrub brushes; generator; collection pumps and hoses

Monitoring Equipment Required: PID with 10.6 eV Lamp,

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☒ Level A ☐

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

Modifications/Exceptions: Decontamination will be initiated in Level D.

V. Chemicals of Concern	Action Level(s)	Response Measures
Chlorinated Solvents	>5 ppm	Retreat to an unaffected Area until reading return To background levels.
Decontamination	No action level	Follow precautions specified on the MSDS

VI. Additional Safety Equipment/Procedures

Hardhat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio (At least one radio per crew)	☐ Yes	☒ No
Splash Shield	☒ Yes	☐ No	Signs and Barricades	☒ Yes	☐ No
Splash suit/coveralls (Type: See Below)	☒ Yes	☐ No	Gloves (Type – Nitrile)	☒ Yes	☐ No
Steel toe/shank Workboots	☒ Yes	☐ No	Work/rest regimen	☒ Yes	☐ No

Chemical Protective Over-boots (Type: Neoprene) ☒ Yes ☐ No

Modifications/Exceptions: Splash Suit – Decon personnel – Hooded Rain suit; Hearing Protection – During operation of noise sources (i.e., steam cleaner etc.) All zones and entry control points and stations will be clearly demarcated. Gloves – Butyl with nitrile inner gloves. Work rest regimens will be based on ambient conditions and acclimatization progress

VII. Procedure review with permit acceptors

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

Emergency Alarms – Verbal, Radio, air horn. The Central Decontamination Unit is the primary emergency refuge location.

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☒	☐	☐
Emergency Equipment Staged	☒	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☒ No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: Review MSDSs for all decontamination solvents prior to use. Drying racks will be used to stabilize heavy equipment pieces such as auger flights.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
REMOVAL OF VEGETATION (CUTTING SIGHT LINES FOR SURVEYING AND EQUIPMENT ACCESS)

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

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

I. Work limited to the following (description, area, equipment used): Vegetation removal will largely consist of brush and scrub removal using a brush hook or machete. In certain cases chain saws and chippers may be required.

Equipment Type: Brush Hooks; Machete; Chain saws; Chipper

Monitoring Equipment Required: Noise Dosimetry and Sound Level measurements at the SSO's discretion

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

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

Modifications/Exceptions: None anticipated

V. Physical Hazards of Concern	Action Level(s)	Response Measures
Noise	>85 dBA	Hearing Protection
Noise	>105 dBA	Hearing Protection (Plugs and Muffs)

VI. Additional Safety Equipment/Procedures

Hardhat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio (At least one radio per crew)	☐ Yes	☒ No
Splash Shield	☒ Yes	☐ No	Signs and Barricades	☐ Yes	☒ No
Splash suit/coveralls (Type: Tyvek)	☐ Yes	☐ No	Gloves (Type – Leather or canvas)	☒ Yes	☐ No
Steel toe/shank Workboots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Chemical Protective Over-boots (Type: Neoprene) ☒ Yes ☐ No

Modifications/Exceptions: Hard hat – As conditions (overhead hazards) or work zone requirements dictate or when dropping trees greater than 8 feet in height. Hearing Protection – See Section V, above. When sampling near noise sources (i.e., drill rigs, generators, etc.). Gloves – Leather or canvas work gloves. Chain saw operation requires chain saw chaps and a screened visor.

VII. Procedure review with permit acceptors

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

Emergency Alarms – Verbal, Radio, air horn. Evacuation route – Up or cross wind to primary location, See attached site map. Assembly points – See attached site map

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☒	☐
Equipment and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☐	☒	☐
Emergency Equipment Staged	☒	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☒ No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: All chipper operation require two persons; Felling trees with a girth greater than 4 inch girth requires a two man operation. Always provide a cleared escape route when felling trees. Equipment (brush hooks, machetes, and chain saws will be kept sharp to avoid forcing cuts. Equipment inspections will be performed on chippers, chain saws, and hand tools every day. For additional information, see Table 5-1.

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT
GEOGRAPHICAL SURVEYING

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

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

I. Work limited to the following (description, area, equipment used): Geographical Surveys - This activity will encompass traversing the site recording horizontal and vertical location in comparison to established reference points and controls.

Equipment Type: Survey equipment

Monitoring Equipment Required: None

II. Names: _____

III. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

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

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required

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

Modifications/Exceptions: None anticipated

V. Chemicals of Concern	Action Level(s)	Response Measures
None	None	Follow HASP Direction

VI. Additional Safety Equipment/Procedures

Hardhat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☐ Yes	☒ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio (At least one radio per crew)	☒ Yes	☐ No
Splash Shield	☐ Yes	☒ No	Signs and Barricades	☐ Yes	☒ No
Splash suit/coveralls (Type: Tyvek)	☐ Yes	☐ No	Gloves (Type – Leather or canvas)	☐ Yes	☐ No
Steel toe/shank Workboots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Chemical Protective Over-boots (Type: Neoprene) ☒ Yes ☐ No

Modifications/Exceptions: Hard hat – As conditions (overhead hazards) or work zone requirements dictate. Splash Suit – Tyvek coveralls may be required depending on the time of the year (i.e., Ticks, poisonous plants); Reflective Vests when working near traffic patterns; Snake chaps when moving through heavy brush.

VII. Procedure review with permit acceptors

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

Emergency Alarms – Verbal, Radio, air horn. Evacuation route – Up or cross wind to primary location, See attached site map. Assembly points – See attached site map

VII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Equipment and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☒
Emergency Equipment Staged	☒	☐	☐

VIII. Additional Permits required (Hot work, confined space entry, excavation, etc.). ☐ Yes ☒ No
If yes, See SSO for appropriate permit

IX. Special instructions, precautions: Establish rope ladders or other means suitable to traverse terrain greater than 45° angle. Adhere to requirements setforth in Table 5-1 Removal of vegetation for safety measures for clearing site lines.

Permit Issued by: _____ Permit Accepted by: _____