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FIELD SAMPLING PLAN FOR GROUNDWATER MONITORING AT SANITARY WASTE LANDFILL NSA CRANE IN

7/1/2001

TETRA TECH

Field Sampling Plan
for
Ground Water Monitoring
at the
Sanitary Waste Landfill

Naval Surface Warfare Center
Crane Division
Crane, Indiana

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0048

July 2001

079912/P

FIELD SAMPLING PLAN FOR GROUND WATER MONITORING AT THE SANITARY WASTE LANDFILL

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
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, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0048

JULY 2001

PREPARED UNDER THE SUPERVISION OF

Date 7/10/01

RALPH R. BASINSKI, Q.E.P.
TASK ORDER MANAGER
TETRA TECH NUS, INC.

APPROVED FOR SUBMITTAL BY

Date 7/11/01

DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.

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1.0 INTRODUCTION

This Field Sampling Plan (FSP) for the Naval Surface Warfare Center Crane (NSWC Crane), Indiana, was prepared for the U.S. Department of the Navy (Navy) by Tetra Tech NUS, Inc. (TtNUS) under the Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) contract, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 048. A copy of this FSP is maintained at the NSWC Crane Environmental Division offices.

This FSP describes the standard sampling procedures to be used for the detection ground water monitoring program for the Sanitary Waste Landfill (SWL) at the NSWC Crane, Indiana. This FSP specifies requirements for all field sampling work that may be undertaken at the NSWC Crane facility. It serves as a stand-alone guide for use in the field by all members of the field team. All monitoring will comply with applicable Indiana regulations. Specifically, this FSP has been developed to meet the requirements described in 329 IAC 10-21-2 for sampling and analysis programs for municipal solid waste landfill ground water monitoring.

All field sampling activities will be conducted in accordance with the site security and health and safety plan developed for the field sampling activities described in this FSP (TtNUS, 1999).

This FSP consists of five sections. Section 1.0 presents this introduction. Section 2.0 provides a brief description of the background information at the site. Section 3.0 details the present ground water monitoring system. Section 4.0 provides detailed information on site-specific aspects of the environmental sampling procedures and field operations. Section 5.0 describes the contents of the field report and sampling and analysis report.

Field forms and standard operating procedures (SOPs) for these activities are included in Appendices A and B, respectively. Field meter manuals are provided in Appendix C. Boring logs and well construction sheets are included in Appendix D.

1.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section presents the project management for the ground water monitoring program to be conducted at the NSWC Crane SWL. Included in the following sections are the staffing and coordination requirements.

1.1.1 Project Organization Chart

At the direction of the Navy, TtNUS is responsible for the overall management and implementation of contract field activities. Personnel from the Navy will be actively involved and will coordinate with TtNUS personnel in a number of areas. The authorities and organizational relationship of key personnel are depicted in Figure 1-1. Corresponding addresses and telephone numbers of project personnel are given in Table 1-1. Responsibilities for program management, project management, field operations, and laboratory operations are discussed in the following sections. It is intended that the individuals named will perform the designated responsibilities. However, as with any organization, the specified person may not be able to perform the stated activities. The replacement person will have similar qualifications to the person specified.

1.1.2 Management Responsibilities

Navy Project Managers

The Navy engineer in charge (EIC), E. P. Johns, acts as the focal representative for the Navy, providing management, technical direction, and oversight for all NSWC Crane project activities performed by contractors and their subcontractors. In matters such as facilitation of access, oversight, etc., the Navy EIC is assisted by the facility permit manager (FPM), Tom Brent.

Program Manager

The TtNUS Navy Southern Division CLEAN program manager, Debbie Wroblewski, provides operations, technical, and administrative leadership and oversees and supports quality policies. The program manager assigns project task order managers (TOMs) and oversees their performance. The program manager also ensures the availability of technical and clerical resources for program operations and maintains consistency in procedures and projects among Contract Task Order (CTO) assignments. In these matters, the program manager is assisted by the TOMs.

Task Order Manager

The TtNUS TOM, Ralph Basinski, has the overall responsibility for ensuring that the project meets Indiana Department of Environmental Management (IDEM) objectives and TtNUS and Navy quality standards. The TOM is responsible for the preparation and distribution of the Quality Assurance Project Plan (QAPP),

FIGURE 1-1

PROJECT ORGANIZATION CHART
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

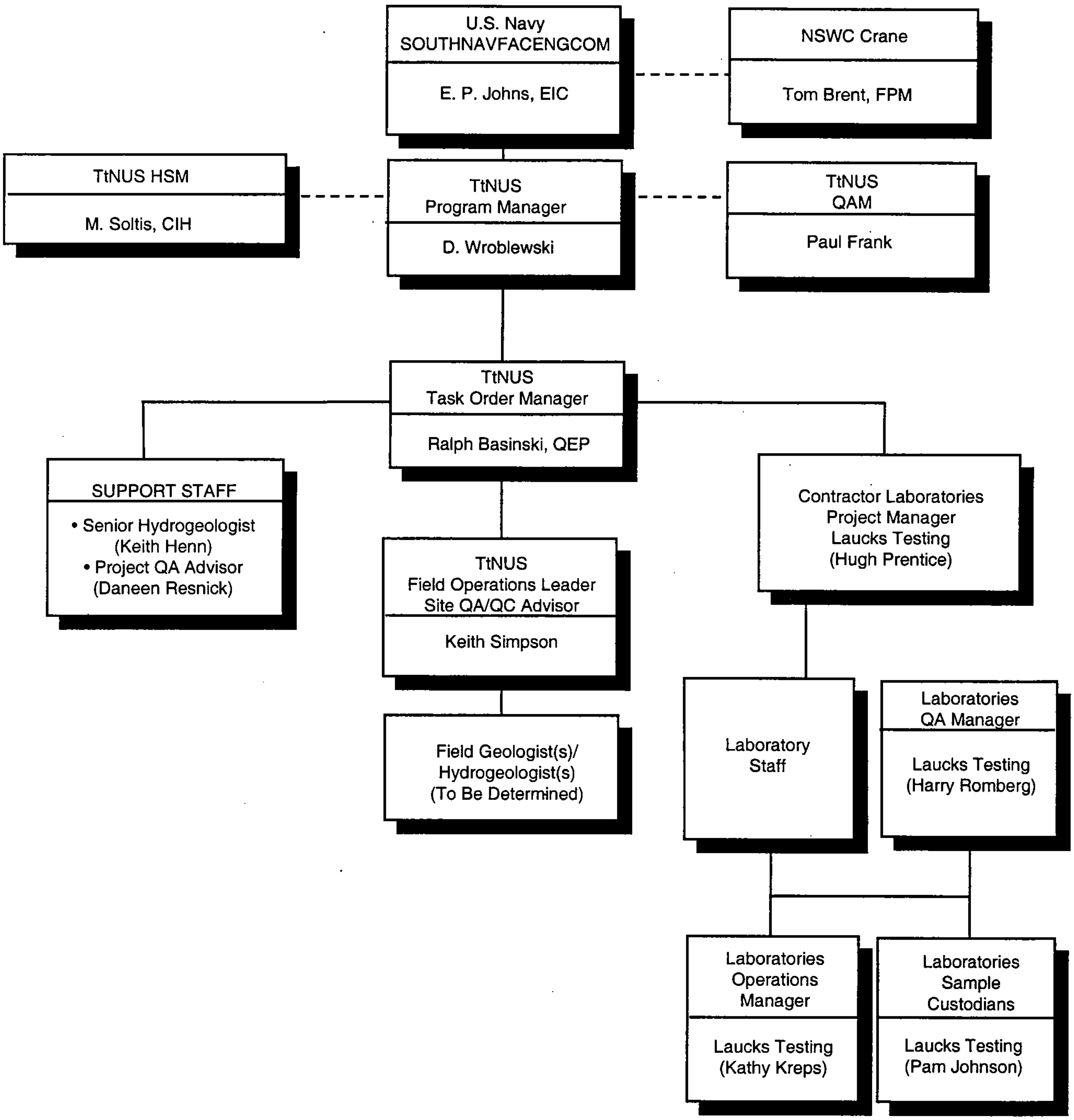


TABLE 1-1

CONTACT LIST
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

PERSON/ TITLE/ ORGANIZATION	ADDRESS	TELEPHONE
E. P. Johns Engineer In Charge U.S. Navy SOUTHNAVFACENGCOM	Department of Navy SOUTHNAVFACENGCOM Code 1828 2155 Eagle Drive Charleston, SC 29406	(803) 820-5523
Tom Brent Facility Permit Manager NSWC Crane	NSWC Crane Code 09510 B-2694 300 Highway 361 Crane, Indiana 47522-5009	(812) 854-6160
Debbie Wroblewski Program Manager Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8968
Paul Frank Quality Assurance Manager Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8950
Matt Soltis Health and Safety Manager Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8912
Ralph Basinski Task Order Manager Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8308
Keith Simpson Field Operations Leader & Site QA/QC Advisor Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8131
Keith Henn Senior Hydrogeologist Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8623
Daneen Resnick Project QA Advisor Tetra Tech NUS, Inc.	Tetra Tech NUS 661 Andersen Drive Pittsburgh, PA 15220-2745	(412) 921-8744
Hugh Prentice Project Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	(206) 767-5060
Harry Romberg Lab QA Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	(206) 767-5060
Kathy Kreps Lab Operations Manager Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	(206) 767-5060
Pam Johnson Lab Sample Custodian Laucks Testing	Laucks Testing 940 South Harney Street Seattle, WA 98053	(206) 767-5060

at the direction of the Navy EIC, to all parties connected with the project, including the laboratories. The TOM will report to the Navy EIC and is responsible for technical quality control and project oversight. Additional responsibilities of the TOM are as follows:

- Ensuring timely resolution of project-related technical, quality, safety, or waste management issues.
- Functioning as primary interface with the Navy EIC and Point of Contact (POC), field personnel, and laboratory POCs.
- Monitoring and evaluating subcontractor laboratory performance.
- Coordinating and overseeing work performed by field and office technical staff (including data validation, statistical evaluations, and report preparation).
- Coordinating and overseeing maintenance of all project records.
- Coordinating and overseeing review of project deliverables.
- Preparing and issuing final deliverables to the Navy.

Health and Safety Manager

The TtNUS health and safety manager (HSM), Matthew Soltis, is responsible for the following:

- Overseeing the development and review of the site security and health and safety plan
- Implementation of the site security and health and safety plan
- Assigning the site safety officer and supervising his/her performance
- Conducting health and safety audits
- Preparing health and safety reports for management review

1.1.3 Quality Assurance Responsibilities

This section identifies the quality assurance responsibilities for the NSWC Crane ground water monitoring program. Responsibilities of TtNUS personnel and the analytical laboratory are discussed.

TtNUS Quality Assurance Manager

The TtNUS quality assurance manager (QAM), Paul Frank, is responsible for overall quality assurance for the project, and reports directly to the Southern Division CLEAN program manager, Debbie Wroblewski. The QAM has the responsibility for the following specific activities:

- Developing, maintaining, and monitoring quality assurance policies and procedures.
- Providing training to TtNUS staff in quality assurance/quality control (QA/QC) policies and procedures.
- Conducting systems, performance, and project record audits to monitor compliance with environmental regulations, contractual requirements, project plan requirements, and corporate policies and procedures.
- Ensuring external audits of subcontracted laboratories and monitoring subcontractor quality controls and records.
- Assisting in the development of corrective action plans and ensuring correction of nonconformances reported in internal or external audits.
- Overseeing the responsibilities of the TtNUS site QA/QC advisor.
- Preparing quality assurance reports for management.

1.1.4 Laboratory Responsibilities

Laucks Testing Laboratories, Inc., of Seattle, Washington, will perform all ground water analyses.

The subcontracted laboratory shall have the responsibility for analyzing all ground water samples in accordance with the analytical methods and additional requirements specified in the attendant QAPP. It shall also be the responsibility of the analytical laboratories to properly dispose of unused sample aliquots. Responsibilities of key laboratory personnel are outlined in the following paragraphs.

Laboratory Project Manager

The responsibilities of the laboratory project manager, Hugh Prentice, include the following:

- Ensure that method- and project-specific requirements are properly communicated and understood by laboratory personnel.

- Monitor analytical and project QA requirements.

- Review data packages for completeness, clarity, and compliance with project requirements.

- Inform the TtNUS TOM of project status and any sample receipt or analytical problems.

Laboratory Operations Manager

Responsibilities of the laboratory operations manager include the following:

- Support the QA program within the laboratory
- Provide management overview of both production and quality-related laboratory activities
- Maintain adequate staffing to meet analytical and quality objectives
- Approve all laboratory SOPs and QA documents

The Laucks Testing Laboratories, Inc. laboratory operations manager for the NSWC Crane ground water monitoring program will be Kathy Kreps.

Laboratory Quality Assurance Officer (QAO)

The laboratory QAO will report directly to the laboratory operations manager. The laboratory QAO will be independent of laboratory production management to ensure that laboratory quality performance is assessed without schedule and cost considerations. The responsibilities of the laboratory QAO include the following:

- Define appropriate laboratory QA procedures and monitor overall laboratory QA.

- Stop work if a condition adverse to the quality of work is encountered, if QA or quality control (QC) procedures are not followed, or if analytical out-of-control events are encountered that have not been corrected.

- Approve and maintain document control of all QA documents and SOPs.

- Perform and/or implement internal system and performance audits and verify completion of corrective actions cited in audits.

- Direct laboratory participation in laboratory accreditation and certification programs.

The laboratory QAO for the NSWC Crane SWL ground water monitoring program will be Harry Romberg, of Laucks Testing Laboratories, Inc.

Laboratory Sample Custodian

The laboratory sample custodian will report to the laboratory operations manager. The responsibilities of the laboratory sample custodian include the following:

- Supervise the receipt, inspection, and log-in of all samples received by the laboratory.
- Manage sample storage facilities.
- Notify laboratory project manager of sample receipt, as well as any sample receipt problems.

The laboratory sample custodian for the NSWC Crane SWL ground water monitoring program will be Pam Johnson, Laucks Testing Laboratories, Inc.

Laboratory Technical Staff

Laboratory technical staff will be responsible for sample analyses based on the analytical methods and requirements specified in the attendant QAPP.

1.1.5 Field Responsibilities

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

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

TtNUS will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting may be held to discuss the operations completed and any problems encountered. The team will consist of a combination of the following personnel:

- Field operations leader (FOL)
- Site QA/QC advisor
- Field technical staff

The NSWC Crane field activities will be performed by TtNUS personnel overseen by Mr. Keith Simpson, the TtNUS field operations leader (FOL). A general discussion of the FOL's responsibilities follows.

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

- Functions as the communications link among field staff members, the site QA/QC advisor, the site safety officer, the facility permit manager, and the TOM.

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

- Coordinates and manages the field staff.

- Adheres to the work schedules provided by the TOM.

- Bears responsibility for maintenance of the site logbook and site records.

- Initiates field task modification requests when necessary.

- Identifies and resolves problems in the field, resolves difficulties in consultation with the facility permit manager, implements and documents corrective action procedures, and provides a means of communication between the field team and upper management.

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

- Ensures that field duplicates and field quality control blanks are collected with the proper frequency.

- Ensures that additional volumes of sample are supplied to the analytical laboratory at the proper frequency to accommodate laboratory QA/QC analyses.

- Ensures that measuring and test equipment (MTE) are calibrated, used, and maintained in accordance with applicable procedures.

- Acts as liaison between site personnel, laboratory personnel, and the QAM.

- Manages bottleware shipments; and oversees field preservation and in-field filtration activities.

Mr. Simpson (or his designee) will also serve as the site safety officer (SSO). The duties of the SSO are detailed in the site security and health and safety plan. As SSO, Mr. Simpson has stop-work authority, which can be executed upon the determination of an imminent safety hazard.

Field Staff

The field staff for this project will be drawn from the TtNUS pool of corporate resources. All the designated field team members are experienced professionals who posses the degree of specialization and technical competence required to effectively and efficiently perform the required work.

2.0 BACKGROUND INFORMATION

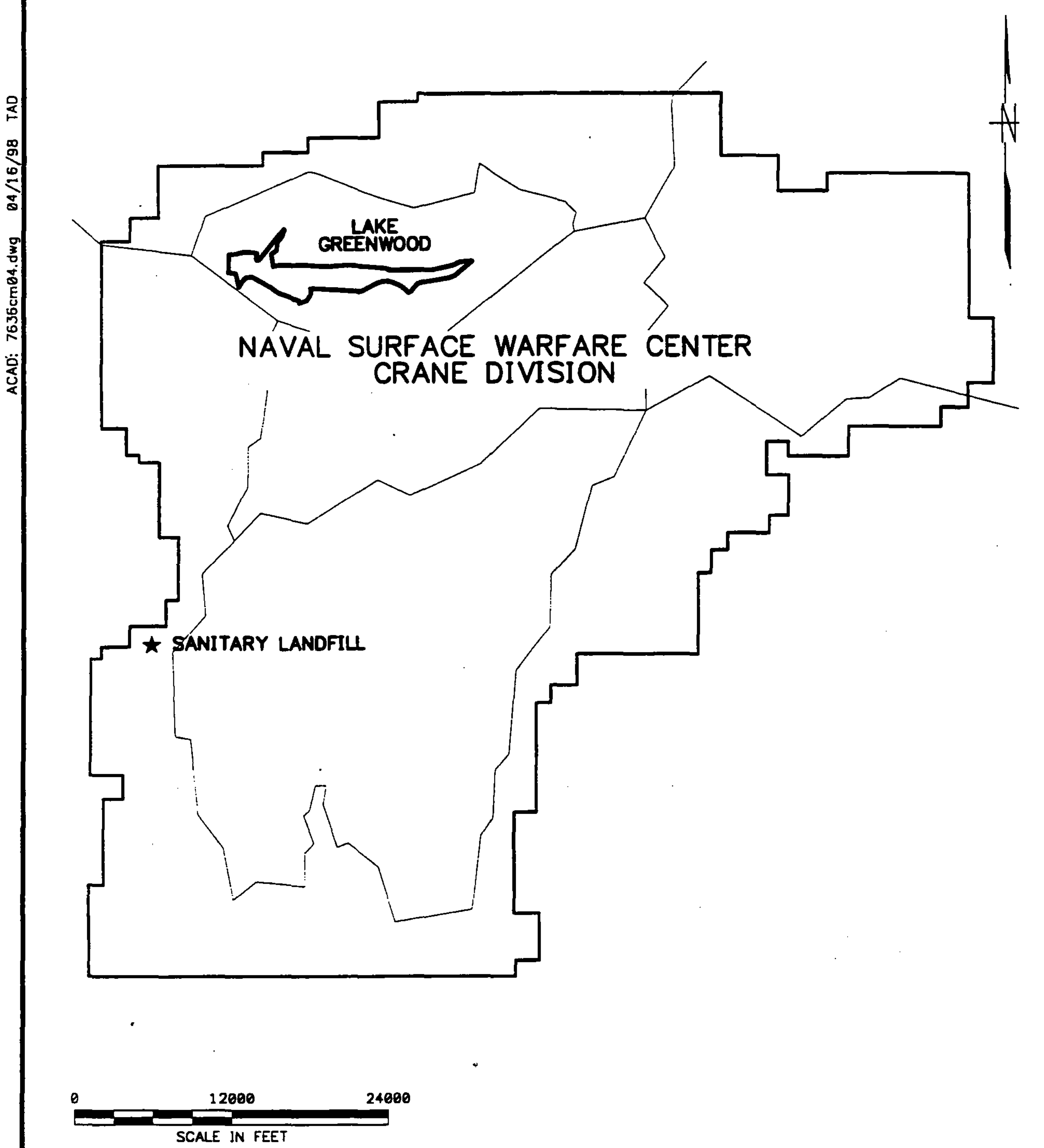
2.1 SITE LOCATION AND DESCRIPTION

The NSWC Crane is located in the southern portion of Indiana. It is approximately 65 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky and immediately east of Burns City and Crane Village, Indiana. NSWC Crane encompasses approximately 62,463 acres (approximately 98 square miles) of the northern portion of Martin County and smaller portions of Greene, Davies, and Lawrence Counties. A location map of the NSWC Crane facility is shown on Figure 2-1.

The SWL is located near the western boundary of NSWC Crane. Operations began at the active, 65-acre landfill in 1972. The landfill currently receives trash and garbage from production operations and residential and food preparation areas. Special approval was granted by the Indiana State Bureau of Health (ISBH) in 1981-1982 to bury neutralized lithium batteries in the SWL. The batteries were excavated in 1995. Ground water monitoring is required under NSWC Crane's Operating Permit (Permit Number 51-2), issued by the ISBH.

2.2 PHYSIOGRAPHY AND TOPOGRAPHY

NSWC Crane is located in the unglaciated area of the Crawford Uplands Physiographic Province. This region is described as a rugged, highly vegetated, dissected plateau that is bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west. The Mitchell Plain is described as a low dissected limestone plateau characterized by sinkholes and karst topographic features. The boundary between the Crawford Upland and the Mitchell Plain is marked by the highly irregular, eastern facing Chester Escarpment. Springs, caverns, caves, and other solution weathering features can be found along this escarpment and on the eastern edge of the NSWC Crane facility. The boundary between the Crawford Upland and the Mitchell Plain near the western boundary of NSWC Crane is gradual. Elevations on the Crawford Upland on the NSWC Crane property range from 500 feet national geodetic vertical datum (NGVD) to greater than 850 feet NGVD. Topographic relief in the Crawford Upland ranges from 100 feet to 350 feet. Greater relief exists in the eastern part of NSWC Crane near the Chester Escarpment.



DRAWN BY / DATE	Brown & Root Environmental	CONTRACT NO.	OWNER NO.
ASM 7/17/97		7651	----
CHECKED BY / DATE	LOCATION OF NAVAL SURFACE WARFARE CENTER CRANE DIVISION SANITARY WASTE LANDFILL CRANE, INDIANA	APPROVED BY / DATE	
COST/SCHED-AREA		APPROVED BY / DATE	
SCALE 1" = 12000'		DRAWING NO. FIGURE 2-1	REV. 0

FORM CADD NO. SOUTH_AV.DWG - REV 0 - 02/07/97

The SWL is located in an upland area in the west-central section of NSWC Crane, adjacent to its western boundary. The maximum elevation at the SWL is 716.3 feet above mean sea level (msl). The SWL is characterized by relatively gentle topographic relief, with existing elevations ranging from approximately 702 to 716 feet msl.

2.3 CLIMATOLOGY

NSWC Crane is located in a warm temperate climatic zone. In general, the summers are warm and humid, and winters are mild with occasional short cold periods. The temperature ranges from an average maximum July temperature of 89°F to an average minimum January temperature of 26°F. Precipitation is fairly evenly distributed throughout the calendar year, with the maximum precipitation occurring during the spring and early summer. The average annual precipitation received at the facility is 44 inches of precipitation, consisting of 42 inches of rain and 15 inches of snow. The average humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter. The RCRA Air Quality Assessment (B&R Environmental, 1997c) has additional details on climatology.

2.4 HYDROLOGY

The surface water drainage pattern at NSWC Crane is characterized by a dense, dendritic pattern, that flows generally to the south and southwest of the Base. Seven creeks drain the surface water at NSWC Crane into the East Fork of the White River.

Surface runoff at the SWL is to the west, southwest, and, to a certain extent, the northwest. Surface runoff from the SWL is diverted to intermittant drainageways in these directions. A man-made surface water impoundment is located approximately 600 feet southwest of the landfill.

Surface runoff collected in intermittent drainageways and flowing out of the surface water impoundment enters Seed Tick Creek 3,000 to 5,000 feet from the landfill boundaries. Seed Tick Creek flows in a south-southeastward direction, exiting the boundary of NSWC Crane. Seed Tick Creek eventually merges with Boggs Creek south of NSWC Crane.

2.5 GEOLOGY AND STRATIGRAPHY

The subsurface geology at NSWC Crane is generally characterized by thin overburden deposits overlying bedrock. The overburden deposits range in depth from the ground surface down to approximately 5 to 20 feet below ground surface and generally consist of two types: Pleistocene age unconsolidated deposits and unconsolidated residual soils derived from the decomposition of underlying bedrock (Dunbar, 1982). The Pleistocene age deposits consist of alluvial, colluvial, and marsh deposits containing silt, sand, and gravel and lacustrine deposits consisting of clay, silt, and sand. The unconsolidated residual soils were derived from the in-place weathering and decomposition of the underlying sedimentary bedrock. The residual soil deposits consist of clay, silt, and sand. This portion of Indiana was not glaciated, so there are no glacial deposits in evidence at the Crane facility.

Bedrock underlying the NSWC Crane facility consists of sedimentary rocks from the Lower Pennsylvanian age Raccoon Creek Group and the Upper Mississippian age Stephensport and West Baden Groups (Dunbar, 1982). The Lower Pennsylvanian rocks at the facility consist of shale, sandstone, and coal beds. The Upper Mississippian age rocks consist of limestone, shale, and sandstone. The geologic units encountered at the facility, in descending order (youngest to oldest), include the Mansfield Formation (Raccoon Creek Group), Hardinsburg Shale Formation (Stephensport Group), Golconda/Haney Limestone Formation (Stephensport Group), Indian Springs Shale Member, Big Clifty Group (Stephensport Group), Big Clifty Sandstone Member, Beech Creek Limestone Formation (Stephensport Group), Elwren Shale Formation (West Baden Group), Reelsville Shale and Limestone Formations (West Baden Group), Sample Shale and Sandstone Formations (West Baden Group), Beaver Bend Limestone Formation (West Baden Group), and finally the Bethel Shale and Sandstone Formations (West Baden Group); (Murphy and Wade, 1995, pp. 27-29, and Palmer, 1969). A stratigraphic column for the NSWC Crane facility is shown on Figure 2-2.

The bedrock surface beneath the SWL is composed of sandstone, shale, and limestone of the Pennsylvanian age Raccoon Group. Subsurface exploration at the landfill has included monitoring well installation and auger and split-spoon borings. Landfill area borings indicate approximately 4 to 16 feet of surficial soils comprised of silt, clay, and sandy clay, overlying sandstone, and shale bedrock with occasional stringers of coal.

Structurally, NSWC Crane is located on the eastern edge of the Illinois Structural Basin, where the Pennsylvanian and Mississippian age bedrock dips to the west-southwest at approximately 30 to 35 feet per mile (Dunbar, 1982).

PERIOD	EPOCH	THICKNESS (FEET)	LITHOLOGY	FORMATION	GROUP
PENN-SYL-VANIAN	POTTS-VILLE	150-300		MANSFIELD FM.	"RACCOON CREEK"
MISSISSIPPI	CHESTER	20-30		GLEN DEAN LS	STEPHENS-PORT
		30-40		HARDINSBURG SS	
		40-60		GOLCONDA/HANEY	
		25-40		BIG CLIFTY FM.	
		15-25		BEECH CREEK LS.	
		20-40		ELWREN FM.	WEST BADEN
		0-5		REELSVILLE LS.	
		20-40		SAMPLE FM.	
		10-20		BEAVER BEND LS.	
		12-30		BETHEL FM.	
	MERAMEC	15-20		PAOLI LS.	BLUE RIVER
		100-120		STE. GENEVIEVE LS.	
		100-120		ST. LOUIS LS.	
		90-100		SALEM LS.	SANDERS
		50-80		HARRODSBURG LS.	
	OSAGE	600-800		MULDRAUGH FM.	BORDEN

Figure 2-2 Stratigraphic column for rock units encountered at NSWC Crane
Naval Surface Warfare Center
Crane, Indiana

Final Report, RCRA Facility Investigation,
Phase III, Groundwater Release Characterization,SWMU 03/10,
Ammunition Burning Ground, Volume I, William L. Murhpy, May 1994-Figure 7
After Palmer, A.N., 1969, A Hydrologic Study of Indiana Karst, Ph.D. Thesis, Indiana Univ.

2.6 HYDROGEOLOGY

Based on information reported by the Geotechnical Laboratory of the U.S. Army Engineer Waterways Experiment Station (Dunbar, 1984a), ground water occurs between approximately 4 and 24 feet beneath the SWL.

Ground water flow within the surficial soils and the shallow bedrock is primarily to the west and southwest. Based on the historical data, horizontal hydraulic gradients average approximately 0.020 feet per feet. Calculations of vertical hydraulic gradients between nested pairs of monitoring wells around the perimeter of the SWL indicate relatively strong downward gradients ranging between approximately 0.320 feet per feet and 0.890 feet per feet.

3.0 GROUND WATER MONITORING SYSTEM

3.1 MONITORING WELL LOCATIONS

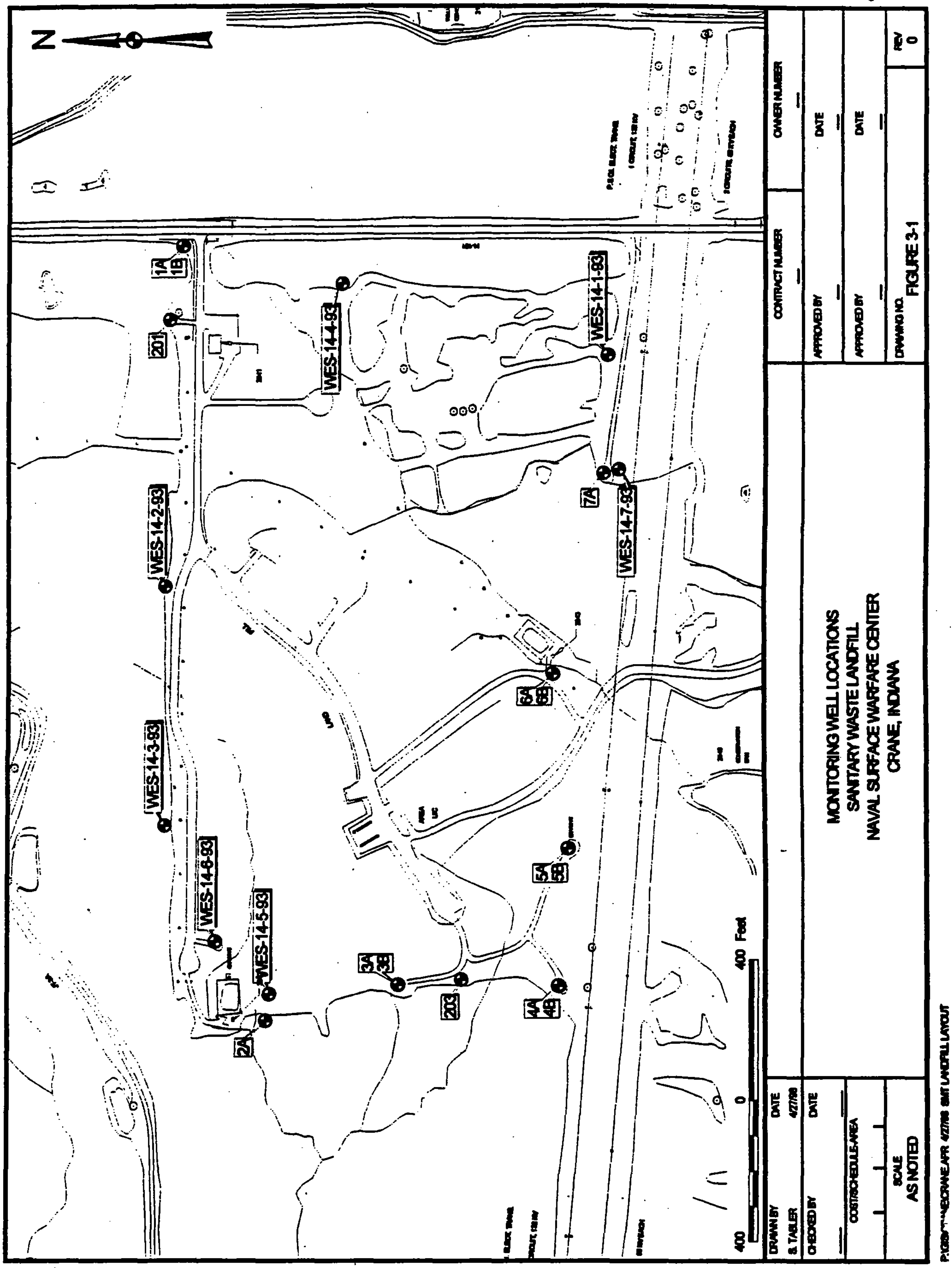
A total of 25 monitoring wells have been installed at the SWL. Currently, 21 wells comprise the ground water monitoring system, as described in Section G9 of the permit for the SWL. The locations of these wells are shown in Figure 3-1.

3.2 MONITORING WELL CONSTRUCTION DETAILS

Monitoring wells WES-14-1-93 through WES-14-7-93 are constructed of 2-inch polyvinyl chloride (PVC) pipe, with 10-foot screens. The remaining wells at the SWL are constructed of 4-inch PVC pipe, with 2- to 3-foot screens. Table 3-1 summarizes the construction details for the 21 wells.

3.3 SURVEYING

All existing ground water monitoring wells have been surveyed. Monitoring well horizontal locations are surveyed to the nearest 0.10 foot. Vertical elevations are referenced to the National Geodetic Vertical Datum (NGVD). Monitoring well elevations and ground surface elevations are surveyed to the nearest 0.01 foot. Vertical elevations of all monitoring wells will be resurveyed after retrofitting for installation of low-flow sampling pumps. All wells will be surveyed vertically to the nearest 0.01 foot at a measuring point where the uncapped well riser is notched and at the top of the protective casing. The vertical elevations will be referenced to the North American Vertical Datum 1988 (NAVD88).


N
1A
1B
201
WES-14-4-93
WES-14-1-93
WES-14-2-93
7A
WES-14-7-93
6A
6B
WES-14-3-93
5A
5B
WES-14-6-93
WES-14-5-93
3A
3B
203
4A
4B
2A
400
0
400 Feet
MONITORING WELL LOCATIONS
SANITARY WASTE LANDFILL
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
DRAWN BY
S. TABLER
DATE
4/27/98
CHECKED BY
DATE
COST/SCHEDULE-AREA
SCALE
AS NOTED
CONTRACT NUMBER
OWNER NUMBER
APPROVED BY
DATE
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DATE
DRAWING NO.
FIGURE 3-1
REV
0

TABLE 3-1

MONITORING WELL CONSTRUCTION DETAILS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2

Well I.D.	North Coordinate	East Coordinate	Ground Elevation(a) (ft)	Top of Casing Elevation(a,b) (ft)	Bottom of Screen (ft MSL)(c)	Overburden or Bedrock	Total Depth (ft BGS)
BACKGROUND (UPGRADIENT) WELLS							
MW201	1297737.3	3009109.1	713.04	715.16	704.66	Overburden	10.9
MW1A	1297699.3	3009321.6	712.59	715.04	695.74	Overburden	19.3
MW1B	1297700.7	3009321.6	712.68	714.99	673.79	Bedrock	41.25
DOWNGRADIENT WELLS							
MW203	1296908.9	3007200.8	679.83	681.54	669.54	Overburden	12.00
MW2A	1297461.8	3007085.2	670.83	673.20	631.70	Bedrock	41.50
MW3A	1297085.7	3007186.4	677.36	679.32	632.82	Bedrock	46.50
MW4A	1296635.3	3007183.4	687.18	689.53	642.03	Bedrock	47.50
MW5A	1296608.8	3007577.4	693.00	695.41	653.91	Bedrock	41.50
MW6A	1296651.4	3008083.7	687.72	690.08	648.08	Bedrock	42.00
MW7A	1296511.2	3008662.9	710.97	712.11	670.61	Bedrock	41.50
MW3B	1297087.5	3007186.9	677.39	679.34	669.34	Overburden	10.00
MW4B	1296637.6	3007183.7	687.10	689.50	663.10	Overburden	26.40
MW5B	1296611.6	3007577.3	693.01	695.36	677.86	Overburden	17.50
MW6B	1296653.4	3008084.5	687.72	690.09	675.59	Overburden	14.50
WES-14-1-93	1296499.9	3009004.1	707.42	709.39	666.59	Bedrock	42.80
WES-14-2-93	1297747.1	3008339.1	709.29	711.31	648.41	Bedrock	62.90
WES-14-3-93	1297746.7	3007642.9	703.46	705.21	663.21	Bedrock	42.00
WES-14-4-93	1297252.2	3009214.1	708.78	710.91	678.21	Bedrock	32.70
WES-14-5-93	1297450.9	3007159.9	673.66	675.74	635.14	Bedrock	40.60
WES-14-6-93	1297602.1	3007310.5	683.79	685.96	636.76	Bedrock	49.20
WES-14-7-93	1296470.2	3008674.2	708.61	710.52	667.52	Bedrock	43.00

TABLE 3-1

MONITORING WELL CONSTRUCTION DETAILS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
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Notes:

a Elevations measured to National Geodetic Vertical Datum (NGVD).
b Elevations are measured to the V-notch in the top of the PVC riser pipe. Survey was done in March 1999.
c Wells designated as "A" are constructed with 2-foot screens. Wells designated with "B" are constructed with 3-foot screens. Wells 201 and 203 have 2-foot screens. Wells WES-14-1-93 through WES-14-7-93 have 10-foot screens.

BGS = below ground surface.

4.0 GROUND WATER SAMPLING AND ANALYSIS AND FIELD OPERATIONS

The following sections describe the details concerning the monitoring wells to be sampled, frequency of sampling, sampling procedures, target constituents, and possible aquifer testing for the NSWC Crane facility, as outlined by the ground water monitoring requirements described in 329 IAC 10-21. SOPs are provided in Appendix B. The information in Appendix B is considered supplementary. If there is a conflict between this section and Appendix B, the procedure in this section takes precedence.

4.1 SELECTION OF MONITORING WELLS FOR SAMPLING AND ANALYSIS

A total of 21 monitoring wells will be sampled as described in this FSP. The ground water monitoring wells to be sampled have been identified in Section G9 of the permit issued by IDEM for the solid waste landfill. Section G11 of the permit also identifies upgradient or background monitoring wells. A description of the field sampling program is described below.

Table 4-1 lists each of the SWL ground water monitoring points and notes which wells are upgradient and which are downgradient. Table 4-2 describes the monitoring points and sample analyses that will be conducted on all monitoring wells for detection monitoring in compliance with 329 IAC 10-21-7. Table 4-3 lists the sample analyses that will be conducted for any wells subject to 329 IAC 10-21-10 assessment ground water monitoring. Monitoring wells are not identified on Table 4-3 because assessment monitoring is required only for wells in which statistically significant increases in downgradient concentrations have occurred and for wells located next to the wells where the increases occurred. Field parameters, including specific conductance, pH, temperature, dissolved oxygen, and static water level will be measured for all wells in the field during all sampling events.

4.2 SAMPLING AND ANALYSIS PROCEDURES

4.2.1 <u>Inspection of Existing Monitoring Wells</u>

Before each monitoring well is sampled, a brief inspection will be conducted to evaluate the following conditions:

- Condition of the protective casing
- Condition of the cement seal surrounding the protective casing

TABLE 4-1

SANITARY WASTE LANDFILL GROUND WATER MONITORING WELLS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA

Monitoring Points	Upgradient or Downgradient
MW201	Upgradient
MW1A	Upgradient
MW1B	Upgradient
MW203	Downgradient
MW2A	Downgradient
MW3A	Downgradient
MW4A	Downgradient
MW5A	Downgradient
MW6A	Downgradient
MW7A	Downgradient
MW3B	Downgradient
MW4B	Downgradient
MW5B	Downgradient
MW6B	Downgradient
WES-14-1-93	Downgradient
WES-14-2-93	Downgradient
WES-14-3-93	Downgradient
WES-14-4-93	Downgradient
WES-14-5-93	Downgradient
WES-14-6-93	Downgradient
WES-14-7-93	Downgradient

TABLE 4-2

SANITARY WASTE LANDFILL
DETECTION MONITORING (329 IAC 10-21-7)
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Wells	Field[(1)]	Volatile Organic Compounds[(2)]	Ammonia	Dissolved Metals[(3)]	Chloride	Sulfate	Total Dissolved Solids	Total Solids	Alkalinity	Bicarbonate	Carbonate
MW201	•	•	•	•	•	•	•	•	•	•	•
MW1A	•	•	•	•	•	•	•	•	•	•	•
MW1B	•	•	•	•	•	•	•	•	•	•	•
MW203	•	•	•	•	•	•	•	•	•	•	•
MW2A	•	•	•	•	•	•	•	•	•	•	•
MW3A	•	•	•	•	•	•	•	•	•	•	•
MW4A	•	•	•	•	•	•	•	•	•	•	•
MW5A	•	•	•	•	•	•	•	•	•	•	•
MW6A	•	•	•	•	•	•	•	•	•	•	•
MW7A	•	•	•	•	•	•	•	•	•	•	•
MW3B	•	•	•	•	•	•	•	•	•	•	•
MW4B	•	•	•	•	•	•	•	•	•	•	•
MW5B	•	•	•	•	•	•	•	•	•	•	•
MW6B	•	•	•	•	•	•	•	•	•	•	•
WES-14-1-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-2-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-3-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-4-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-5-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-6-93	•	•	•	•	•	•	•	•	•	•	•
WES-14-7-93	•	•	•	•	•	•	•	•	•	•	•

1 Field parameters consist of dissolved oxygen (DO), pH, specific conductance (SC), temperature (T), Turbidity, oxidation-reduction potential (ORP/Eh), water levels.
2 Volatile organic compounds include benzene; carbon tetrachloride; chlorobenzene; chloroethane; chloroform; 1,2-dichlorobenzene; 1,4-dichlorobenzene; 1,1-dichloroethane; 1,2-dichloroethane; 1,1-dichloroethene; cis-1,2-dichloroethene; trans-1,2-dichloroethene; 1,2-dichloropropane; cis-1,3-dichloropropene; trans-1,3-dichloropropene; ethylbenzene; bromomethane; chloromethane; methylene chloride; styrene; 1,1,1,2-tetrachloroethane; 1,1,2,2-tetrachloroethane; tetrachloroethene; toluene; 1,1,1-trichloroethane; 1,1,2-trichloroethane; trichloroethene; trichlorofluoromethane; vinyl chloride; and total xylenes.
3 Dissolved metals include cadmium, chromium, copper, sodium, zinc, calcium, iron, magnesium, manganese, potassium and lithium.

TABLE 4-3

SANITARY WASTE LANDFILL
ASSESSMENT MONITORING (329 IAC 10-21-10)
NAVAL SURFACE WARFACE CENTER
CRANE, INDIANA

PARAMETER
Volatile Organic Compounds
Semivolatile Organic Compounds
Polychlorinated Biphenyls
Metals (total and dissolved)
Mercury (total and dissolved)
Fluoride
Nitrate
Sulfide
Cyanide

TABLE 4-3

SANITARY WASTE LANDFILL
ASSESSMENT MONITORING (329 IAC 10-21-10)
NAVAL SURFACE WARFACE CENTER
CRANE, INDIANA

PARAMETER
Volatile Organic Compounds
Semivolatile Organic Compounds
Polychlorinated Biphenyls
Metals (total and dissolved)
Mercury (total and dissolved)
Fluoride
Nitrate
Sulfide
Cyanide

- Presence of any standing water around the protective casing
- Condition of dedicated sampling equipment
- Determination of static water level
- Determination of total depth of well, including a check to determine whether well is obstructed
- Determination of the presence of immisible layers
- Well security evaluation

Comparisons will be made between baseline conditions and sampling date conditions to determine whether significant changes have occurred that indicate well damage. When the well cap is opened prior to the determination of the static water level measurement, a reading of the ambient vapors within the well pipe will be taken using a photoionization detector/flame ionization detector (PID/FID). A record of all field observations will be maintained in a field logbook. SOP-1 describes inspection procedures.

4.2.2 Water Level Measurements

Water levels will be obtained from all monitoring wells each time the wells are sampled. Water level measurements for all wells will be made every sampling event before purging and sampling activities are conducted, to provide information regarding ground water flow patterns and flow gradients across the SWL site. Each round of water level measurements will be obtained within a 24-hour period.

Measurements will be taken with an M-scope (electrical water level indicator) using the top of the inner well casing as the reference point for determining depths to water. This well casing will be notched and marked so that the same point will be referenced for all measurements. Water level measurements will be recorded to the nearest 0.01 foot in the field logbook and on a ground water level measurement form, attached in Appendix A in accordance with SOP-9 found in Appendix B. Section 3.0 of SOP-2 (refer to Appendix B) provides a description of water level measurement procedures.

4.2.3 Aquifer Testing

If insufficient hydraulic conductivity data are available, aquifer testing (i.e., slug tests) will be performed on monitoring wells during a sampling round in the first year. Wells in which aquifer testing will be performed will be determined at a later time. Slug test(s) will be performed on wells screened in unconsolidated deposit aquifers. The slug test measures the hydraulic conductivity of the aquifer media in the immediate vicinity of the monitoring well screen/open borehole.

Before the slug test is performed, the static water level will be recorded, along with the well construction details, on a hydraulic conductivity testing data sheet. Both rising-head and falling-head tests will be performed by either inserting a solid slug into the well to raise water levels and then measuring the rate of decline in water level (falling-head test) or by removing a slug of water and measuring the rate of rise in the water level back to equilibrium (rising-head test). The changes in water level are induced as quickly as possible because the analysis assumes an instantaneous change in head. Falling-head tests are not performed where the water level is within the screened interval. In addition, because slug tests are very sensitive to borehole skin effects, the well must be developed properly prior to testing to obtain accurate data.

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

Raw data from the loggers and field records are used to calculate values of hydraulic conductivity for the aquifer in the immediate vicinity of the well screen or open borehole. The data will be analyzed using one or more of the following three methods (other methods have been developed and may be used where applicable):

- Hvorslev Method - Simple, straight-line method for partially to fully penetrating well screens
- Bouwer and Rice Method - Rigorous, straight-line method for complex well geometries
- Cooper, et al. Method - Type-curve method for low-permeability aquifers

4.2.4 Low-Flow Pump Installation

Dedicated, 1.66-inch diameter, low-flow, bladder-type pumps (Teflon and stainless steel) have been installed in all the monitoring wells prior to ground water testing. The pump was placed at the midpoint of the saturated well screen and, if possible, no less than 2 feet above the bottom of the well so as not to disturb any sediment that may accumulate near the bottom of the well. The pumps were certified contaminant free. This certification, as well as lot numbers, will be provided in an appendix of the initial ground water monitoring report. The total well depth was measured when the pumps were installed and any time a pump is removed for maintenance or replacement. SOP-3 describes pump installation, removal procedures, and replacement procedures.

4.2.5 Well Purging

Purging and sampling will be accomplished using low-flow techniques in accordance with SOPs 4 and 5, respectively. Copies of these SOPs are included in Appendix B. Low-flow purging and sampling is being implemented because this method will provide the least disturbance to the surrounding formation (i.e., less turbulence in sampling and hence less turbidity) and will allow for a more representative sample to be collected.

Prior to obtaining ground water samples, water levels will be measured using an electric water level indicator (M-scope) capable of 0.01-foot accuracy. Water levels will be monitored every 3 to 5 minutes as purging occurs. Each monitoring well will be purged and sampled using a dedicated, low-flow, 1.66-inch diameter bladder pump and dedicated Teflon or Teflon-lined polyethylene tubing. Initially, the pumping rate will be set at approximately 0.1 liters per minute, or lower if possible. The pumping rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. The pumping rates will be adjusted so as not to allow drawdown to exceed 0.3 foot during the purging. 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 work day. If possible, samples will be collected from these wells within the same 8-hour work day. If a well does not recover within a 24-hour period on a consistent basis (from one quarter to the next), the well may be deemed an improperly functioning well. If this occurs, IDEM will be notified and a replacement well may be installed. The replacement well, if one is needed, will be constructed using similar materials and screen length as the well it is replacing.

During purging, water quality parameters (pH, specific conductance, temperature, turbidity, and dissolved oxygen) will be measured and recorded every 5 to 10 minutes using a flow-through cell and a meter until all parameters have stabilized and the minimum purge volume has been removed (stabilized purge volume plus the extraction tubing volume). Water quality parameters listed above will be measured with a flow-through cell analyzer in accordance with SOP-4. A copy of this SOP is contained in Appendix B. Stabilization is considered to be achieved when 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%

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. If the above condition(s) have not been met within 4 hours of purging, this will be recorded on the field sample forms and the ground water sample will be collected.

Calibration and standard checks will be conducted on the flow-through cell in accordance with the manufacturer's instructions. The cell will be cleaned at each well prior to purging and during purging, as needed (e.g., when fluctuating turbidity readings are observed and confirmed by collection of a turbidity sample before the cell for comparison). If the cell needs to be cleaned during purging operations, pumping will continue and the cell will be disconnected for cleaning. Rinsing the cell with deionized water will be sufficient for cleaning. After cleaning is completed, the cell will be reconnected and monitoring activities will continue.

Precautions will be taken to prevent air entrapment and/or air leaks in the purging system so that potential problems with dissolved oxygen are minimized. Precautions will include taking care to fill the cell with water while minimizing air entrapment prior to initiating purging, and maintaining a full cell of water by pinching the discharge line and keeping the tubing (from the pump to the cell) elevated above the cell.

SOP-5, attached in Appendix B, describes ground water sample acquisition.

4.2.6 Sampling of Monitoring Wells

Low-flow sampling procedures will be employed at all of the wells at the SWL. The low-flow procedures are based on procedures described in the EPA ground water flow paper titled "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures" (EPA/540/S-95/504).

Monitoring wells will be purged and sampled during each event using a 1.66-inch diameter, low-flow, bladder-type pump and dedicated Teflon or Teflon-lined polyethylene tubing. After purging is completed, the flow-through cell will be disconnected and samples will be collected directly from the discharge of the pump. All sample containers will be filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. All sample bottles will be capped immediately after they are filled.

The potential for cross contamination of samples will be minimized by the installation of dedicated sampling equipment. However, as a general procedure and in the event that it is not possible to install dedicated sampling equipment at one or more wells, samples will be collected in order of increasing likelihood of contamination in the well supplying the sample. Upgradient ground water monitoring wells will be sampled before downgradient wells. If downgradient wells have not been verified to be contaminated, samples will be collected from downgradient wells farthest from the disposed waste, followed by wells increasingly close to the waste. Downgradient wells that have been verified to be contaminated will be sampled in sequence starting with the lowest level of contamination to increasingly higher levels of contamination. All samples will be collected in a sequence, that minimizes volatilization of compounds. Samples will be collected in the following order as directed by 329 IAC 10-21-2(a)(8)(B)(i) for detection monitoring:

1. Volatile organic compounds (VOCs)
2. Dissolved metals
3. Sulfate/chloride
4. Total solids/total dissolved solids
5. Alkalinity/bicarbonate/carbonate
6. Ammonia

Samples will be collected in the following order as directed by 329 IAC 10-21-2(a)(8)(B)(ii) for assessment monitoring:

1. Volatile organic compounds (VOCs)
2. Sulfide
3. Semivolatile organics
4. Dissolved metals
5. Total metals
6. All other constituents

Sample collection sequences to be used in the event that a ground water well cannot supply sufficient water volume for a full sample will be based on previous sample data (e.g., analytes below or near detection limits may be deleted).

Samples to be analyzed for volatile constituents will be taken first and immediately sealed in a pre-preserved container so that no headspace exists. For filtered inorganic samples, an in-line, 0.45-micron filter will be used. The filter will be pre-rinsed with approximately one liter of deionized water and attached to the discharge end of the pump tubing. Types of sample containers, sample volume, preservation requirements, and holding times for detection monitoring are summarized in Table 4-4. Types of sample

TABLE 4-4

SUMMARY OF SAMPLE ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES DETECTION MONITORING (329 IAC 10-21-7) NAVAL SURFACE WARFARE CENTER CRANE, INDIANA

Parameter	Sample Container	Container Volume	Preservation[1]	Maximum Holding Time[2]	Analytical Methodology
Ammonia (as N)	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C, H_2SO_4 to pH <2	28 days to analysis	EPA 350.1[7]
Volatile Organic Compounds [3]	Glass, black phenolic plastic screw cap, Teflon-lined septum	(3) 40 mL[5]	Cool to 4°C, dark, zero headspace, HCl to pH < 2	14 days to analysis	SW-846 Method 8260B[6,8]
Dissolved Metals [4]	Polyethylene bottle, plastic cap, plastic liner	1000 mL	HNO_3 to pH < 2	180 days to analysis	SW-846 Method 6010B, 6020[8]
Inorganic Anions (Chloride and Sulfate)	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C	Analyze as soon as possible (max 28 days)	SW-846 Method 9056[8]
Total Solids/Total Dissolved Solids	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C	7 days to analysis	EPA 160.3 and 160.1[7]
Alkalinity, Bicarbonate, and Carbonate	Polyethylene bottle, plastic cap, plastic liner	250 mL	Cool to 4°C	14 days to analysis	SM 2320B[9]

1 HCl = Hydrochloric acid, H_2SO_4 = Sulfuric Acid, NaOH = Sodium Hydroxide, HNO_3 = Nitric Acid
2 All holding times are measured from date of collection.
3 Volatile organic compounds include benzene, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene ethylbenzene, bromomethane, chloromethane, methylene chloride, styrene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, trichlorofluoromethane, vinyl chloride, and total xylenes.
4 Dissolved metals include cadmium, chromium, copper, sodium, zinc, calcium, iron, magnesium, manganese, potassium, and lithium.
5 Four additional 40 mL vials are required for samples designated for matrix spike/matrix spike duplicate analysis (minimum 1 in 20 samples).
6 Analysis will be performed using a 25 mL sample volume in order to achieve lower quantitation limits for groundwater samples.
7 U.S. EPA, 1983. Methods for Chemical Analysis of Water and Wastes.
8 U.S. EPA, 1986. Test Methods for Evaluating Solid Waste Physical/Chemical Methods. OSWER, Update III 6/97.
9 American Public Health Association, 1989. Standard Methods for the Examination of Water and Wastewater. APHA/AWWA/WPCF, 17th Edition.

containers, sample volume, preservation requirements, and holding times are summarized in Table 4-5 for assessment monitoring. Assessment monitoring is required by 329 IAC 10-21-10 only for wells where statistically significant elevations in concentration over background have occurred and for adjacent wells. Therefore, the number of wells to be sampled (if any) for assessment monitoring cannot be determined at this time.

After sampling, the discharge tubing will be drained (refer to Section 3.14 of SOP-5), especially during winter months, to prevent possible freezing. Care will be taken not to contaminate the exterior of the tubing (via c[illegible]t with the ground or clothing) during this activity.

4.2.7 Decontamination of Field Sampling Equipment

Since dedicated sampling equipment, pumps, and tubing, will be used at each well location, no decontamination water will be generated. However, if any non-dedicated equipment is required in field sampling activities, it will be decontaminated prior to and during sampling activities. Any decontamination water that is generated will be handled in the same manner as purge water, described in Section 4.2.8.

For any non-dedicated ground water sampling equipment, decontamination will be performed both prior to field sampling and between samples. The following decontamination steps will be conducted:

- Potable water rinse
- LiquiNox detergent wash
- Potable water rinse
- Deionized water rinse
- Air dry

SOP-6 describes decontamination of any non-dedicated field sampling equipment.

4.2.8 Residual Waste Management

Two types of potentially contaminated residual wastes are expected to be generated during the ground water monitoring program, namely personal protective equipment (PPE) and purge water. Based on the activities and types of contaminants present, none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Planned management of each of these residues is provided below:

TABLE 4-5

SUMMARY OF SAMPLE ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
ASSESSMENT MONITORING (329 IAC 10-21-10)
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Parameter	Sample Container	Container Volume	Preservation[1]	Maximum Holding Time[2]	Analytical Methodology
Volatile Organic Compounds	Glass, black phenolic plastic screw cap, Teflon-lined septum	(2) 40 mL	Cool to 4°C, dark, zero headspace, HCl to pH < 2	14 days to analysis	SW-846 Method 8260B
Semivolatile Organic Compounds	Amber glass black phenol plastic screw cap, Teflon-lined lid.	(4) 1000 mL	Cool to 4°C, dark	7 days to extraction, 40 days to analysis	SW-846 Method 8270C
Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)	Amber glass, black phenol plastic screw cap, Teflon-lined lid.	(4) 1000 mL	Cool to 4°C, dark	7 days to extraction, 40 days to analysis	SW-846 Method 8081
Herbicides	Amber glass, black phenol plastic screw cap, Teflon-lined lid	(4) 1000 mL	Cool to 4°C, dark	7 days to extraction, 40 days to analysis	SW-846 Method 8151A
Metals (Dissolved)	Polyethylene bottle, plastic cap, plastic liner	1000 mL	Filter on site; HNO_3 to pH < 2	180 days to analysis	SW-846 Method 6010B/6020
Metals (Total)	Polyethylene bottle, plastic cap, plastic liner	1000 mL	HNO_3 to pH < 2	180 days to analysis	SW-846 Method 6010B/6020
Mercury (Dissolved)	Polyethylene bottle, plastic cap, plastic liner	500 mL	Filter on site; HNO_3 to pH < 2	28 days to analysis	SW-846 Method 7470A
Mercury (Total)	Polyethylene bottle, plastic cap, plastic liner	500 mL	HNO_3 to pH < 2	28 days to analysis	SW-846 Method 7470A
Fluoride and Nitrate	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C	48 hours to analysis	SW-846 Method 9056
Sulfide	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C, add 4 drops 2N zinc acetate/100mL sample, pH > 9 with 6N NaOH, headspace free	7 days to analysis	SW-846 Method 9034
Cyanide	Polyethylene bottle, plastic cap, plastic liner	500 mL	Cool to 4°C, NaOH to pH > 12	14 days to analysis	SW-846 Method 9012A

1 HCl = Hydrochloric acid, HNO3 = Nitric Acid, NaOH = Sodium Hydroxide

PPE - All PPE will be placed in double plastic garbage bags and then in the trash receptacles at the facility.

Purge/Development Water - Purge/Development Water will be collected and discharged into the NSWC-Permitted Sanitary Sewer System.

4.2.9 Sample Identification System

All monitoring samples taken as part of this approved Field Sampling Plan at NSWC Crane will be properly labeled with a sample label affixed to the sample container. Each sample will be assigned a unique sample tracking number. The sample tracking number will consist of a four or five segment alphanumeric code that identifies the sample site location, quarter identifier, year, and, where applicable, whether the sample is filtered.

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

A	**NA or NNN**	**NA**	**NA**	**A**
Site ID	Location	Quarter and Resample event Code	Year	Filtered (When Applicable)

Character Type:

A = Alpha

N = Numeric

Site ID:

S = Sanitary Waste Landfill (SWL)

Location:

The location is the well number.

Quarter and Sample Event Code

The quarter during which a sample is taken shall be noted. The numbers 1, 2, 3, 4 correspond to the calendar quarter during which the initial sample was taken. Each sample event associated with a quarter is given a letter designation. The first scheduled event is always given the letter A. If it is necessary to conduct a confirmation sampling event for a monitoring point, the second sample associated with the monitoring point will be given the letter B, the third, C, etc. The quarter code for confirmation sampling events will be the same as the quarter to which the resampling applies. For example, if there is a need for confirmation sampling for a sample taken in the fourth quarter and the resampling will take place in the first quarter of the next calendar year, the quarter code would remain four and the year would not change.

Year

A two-digit number will be used to denote the year in which the sample was taken. The only exception will be for a confirmation sampling event associated with the sampling event occurring the previous year. For example,

1999	=	99
2000	=	00, etc.

Filtered

F = designates filtered dissolved; no entry in this segment signifies an unfiltered (total) sample.

Examples of Sample Nomenclature

A ground water sample collected for monitoring well 1A at the SWL during the second quarter sampling in 1999 for an unfiltered sample would be designated as

S 1A 2A 99.

A ground water sample collected from monitoring well 4B at the SWL during the second quarter sampling in 1999 for a filtered sample would be designated as

S 4B 2A 99 F.

A confirmation sample of this same well for a filtered sample would be designated as

S 4B 2B 99 F.

A ground water sample collected from monitoring well 14-6-93 at the SWL during the fourth quarter sampling in 2003 for an unfiltered sample would be designated as

S 14-6-93 4A 03.

A resample of this sample location taken in the first quarter of 2004 would be designated as

S 14-6-93 4B 03.

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

Field quality assurance/quality control (QA/QC) samples are described in Section 4.3 of this approved Field Sampling Plan. 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, date, and number of this type of QC sample taken on that date.

AA	**NNNNNN**	**NN**	**F**
QC Type	Date	Number per day	Filtered (When applicable)

The QC types are identified as:

RB	=	Rinstate Blank
TB	=	Trip Blank
FB	=	Field Blank
FD	=	Field Duplicate
AB	=	Ambient 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).

Matrix Spike and Matrix Spike Duplicate (MS/MSD) samples will be designated on the field documentation forms and chain-of-custody form.

Examples of Field QA/QC Nomenclature

A duplicate of a ground water sample obtained on June 3, 1999 would be designated as

FD 060399 01.

The third duplicate taken of a ground water sample (3 different monitoring points) obtained on November 17, 2003 would be designated as

FD 111703 03

SOP-7 describes sample identification nomenclature.

4.2.10 Sample Preservation, Shipping, and Handling

To prevent the possibility of cross contamination during sample collection and handling, surgical gloves will be worn whenever samplers' hands are in proximity of sample water, open sample containers, sampling equipment, and open wells. Also, contact between surgical gloves and samples will be avoided at all times.

Ground water samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Certain preservatives are effective on certain chemicals of interest. The sample preservatives required for each of the chemicals of interest are provided in Table 4-5. SOP-8, included in Appendix B, provides a detailed description of sample preservatives and procedures required for this sampling plan.

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. Table 4-4 provides a summary of sample handling considerations for the various analytical fractions. SOP-8, included in

Appendix B, provides a detailed description of sample handling, packaging, and shipping procedures and requirements required for this sampling plan.

Sample Shipment Procedures

The following procedures will be followed when shipping samples for laboratory analysis:

- Samples requiring cooling to 4°C will be promptly chilled with ice or Blue Ice and will be packaged in an insulated cooler for transport to the laboratory. A temperature blank will be included in each cooler to be used as a temperature indicator. Each temperature blank will be clearly identified by the field sampling team. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

- Only shipping containers that meet all applicable state and federal standards for safe shipment will be used. The outside of shipping containers will be marked "contains ice" as required by air couriers.

- Shipping containers will be sealed with nylon strapping tape, 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.

- The field chain-of-custody document will be taped to the top inside cover of the shipping container in a sealed plastic envelope.

- After samples have been collected, they will be sent to the laboratory within 24 hours. Shipment will be made by express mail, using a public courier.

Packaging and shipping procedures are included in SOP-8.

4.2.11 Chain-of-Custody/Documentation

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. Integrity of the samples collected during the site investigation will be the responsibility of identified persons from the time they are collected until they, or their derived data, are incorporated into the final report. Stringent chain-of-custody procedures described in the following sections will be followed to document sample possession. An example of the chain-of-custody form, which will be used to document this procedure, is included in Appendix A. The chain-of-custody procedure will be followed in accordance with SOP-9, included in Appendix B.

Field Custody

- The FOL is responsible for the care and custody of the samples collected until they are delivered to the analyzing laboratory or entrusted to a carrier.

- Ground water sample logs (see attached form in Appendix A) and/or other records, such as field notebooks, will be signed and dated in accordance with SOP-9. Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample, preservative, and name of sampler (see form in Appendix A).

- These forms will be filled out, in a legible manner, using waterproof ink, and will be signed by the sampler. Similar information will be provided on the sample label, which will be securely affixed to the sample bottle. The label will also include the general analyses to be conducted. In addition, sampling forms will be used to document collection, filtration, and preparation procedures. Copies of all forms used during field activities are provided in Appendix A.

Transfer of Custody and Shipment

The following procedures will be used when transferring custody of samples:

- Samples will be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody record. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed.

- Prior to shipment to the laboratory for analysis, samples will be properly packaged. Individual custody records will accompany each shipment. Shipping containers will then be sealed for shipment to the laboratory. The methods of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record.

- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment and a copy will be retained by the field sampler.

- Proper documentation will be maintained for shipments by common carrier.

Laboratory Sample Custody

To ensure the integrity of a sample from collection through analysis, it is necessary to have an accurate, written record that traces the possession and handling of the sample. This documentation is referred to as the sample chain-of-custody.

A sample is under custody if

- The sample is in the physical possession of an authorized person.

- The sample is in view of an authorized person after being in his/her possession.

- The sample is placed in a secure area by an authorized person after being in his/her possession.

- The sample is in a secure area, restricted to authorized personnel only.

Sample custody during collection and shipping is discussed in SOP-9, which is attached in Appendix B. Laboratory sample custody is discussed below.

When samples are received at the laboratory, the shipping manifest is signed and dated to acknowledge sample receipt. The sample custodian must examine the shipping containers and verify that the correct number of containers were received. The shipping containers are then opened and the enclosed sample paperwork is removed. Samples are removed from the shipping containers and the bottle condition and cooler temperature must be noted. The information on the chain-of-custody, the airbill, the containers, and the laboratory request is reviewed to note any discrepancies.

With the exception of ground water samples for metals analysis, all samples received by the laboratory must be stored at 4°C until analysis is performed. Laboratory holding times are specified by the laboratory contract and are presented in Table 4-5.

Field Recordkeeping

Various hard cover, bound record books are maintained for each field activity in accordance with SOP-9, contained in Appendix B. The Master Site Logbook serves as the overall record of field activities. Information recorded daily in the Master Site Logbook includes daily field activities, weather conditions, identity and arrival and departure times of personnel, and management issues. Field notebooks may also be maintained for the site. Information collected during well purging and sampling will be recorded on sample forms (Appendix A), which will also be referenced in the Master Site Logbook and/or field notebook.

Field Documentation Responsibilities

The FOL is responsible for the maintenance and security of all field records (e.g., sampling logs, calibration forms, Master Site Logbook) at the end of each work day. A copy of all forms used during field activities is included in Appendix A. Field notes will be included as an appendix to the quarterly monitoring reports.

At the completion of field activities, the FOL will send the project manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, daily logs, etc. The project manager will ensure that these materials are entered into the TtNUS document control system in accordance with appropriate administrative guidelines.

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

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

- If necessary, the project manager will discuss the change with the pertinent individuals (e.g., Navy remedial project manager, TtNUS quality assurance manager) and will provide a verbal approval or denial to the FOL for the proposed change. The U.S. Environmental Protection Agency and IDEM will be consulted by the Navy of any scope changes that may occur while field work is ongoing.

- The FOL will document the change on a task modification request form and forward the form to the TtNUS project manager at the earliest convenient time (e.g., end of the workweek).

- The TtNUS project manager will sign the form and distribute copies to the Navy remedial project manager, quality assurance manager, FOL, and project file.

- A copy of the completed task modification request form will be attached to the field copy of the affected document.

The possession of all records will be documented; however, only the project FOL or designee may remove field data from the site for reduction and evaluation.

4.3 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

The purpose of this section is to address the data objectives of field quality, QA/QC samples such as field blanks, field duplicates, rinsate blanks, trip blanks, ambient blanks, and matrix spikes/matrix spike duplicates. Table 4-6 contains a summary of water sample analysis and field quality control samples for detection monitoring sampling events. Table 4-7 provides a summary of the sample analysis and quality control samples for sampling events in which only background wells are sampled.

In the event that assessment monitoring is required, field duplicates will be collected at a minimum of one per ten samples. Rinsate blanks will be collected at a frequency of 1 per every 10 samples, with a minimum of one per day of sampling per sampling device/instrument. For precleaned, dedicated, or disposable equipment, one rinsate blank will be collected as a "batch blank." Trip blanks will be collected at a minimum of one per cooler containing samples for volatile organic analysis.

4.3.1 Source Water Blanks

Source water blanks are not anticipated unless new monitoring wells are installed or if non-dedicated bailers/bladder pumps are used for sampling. Source water blanks are obtained by sampling the analyte-free water and/or potable water source(s) used for decontamination of sampling equipment. If applicable, source water blanks are used to determine whether the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. If non-dedicated bailers/bladder pumps are

TABLE 4-6

SUMMARY OF SAMPLE ANALYSIS AND QUALITY CONTROL SAMPLES
DETECTION MONITORING
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2

Parameter[(1)]	Samples	Field Duplicates[(2)]	Rinsate Blanks[(3)]	Trip Blanks[(4)]	Ambient Blanks[(5)]	Matrix Spike/ Duplicates[(6)]	Total[(7)]
LABORATORY:							
Volatile Organic Compounds	21	3	NA	TBD	TBD	1/1	26+
Dissolved Metals	21	3	NA	NA	TBD	1/1	26+
Chloride/Sulfate	21	3	NA	NA	TBD	1/1	26+
TDS/TS	21	3	NA	NA	TBD	1/1	26+
Alkalinity/Bicarbonate/Carbonate	21	3	NA	NA	TBD	1/1	26+
Ammonia	21	3	NA	NA	TBD	1/1	26+
FIELD:							
Dissolved Oxygen	21	NA	NA	NA	NA	NA	21
pH	21	NA	NA	NA	NA	NA	21
Specific Conductivity	21	NA	NA	NA	NA	NA	21
Temperature	21	NA	NA	NA	NA	NA	21
Turbidity	21	NA	NA	NA	NA	NA	21
ORP	21	NA	NA	NA	NA	NA	21
Water Level	21	NA	NA	NA	NA	NA	21

1 See Table 4-2 for the list of chemicals analyzed and Table 4-4 for analytical methods.

2 Field duplicates will be collected at a minimum frequency of 1 per every 10 samples. Field duplicates are not applicable for field analyses (NA).

3 All sampling equipment used on site will be dedicated or disposable equipment. Therefore, only one rinstate blank will be collected as a "batch blank" when the dedicated pumps are installed. Rinsate Blanks are not applicable for field analyses (NA).

4 Trip blanks will be collected at a frequency of one per cooler containing samples for volatile organics analysis. Because the number of sample coolers shipped varies, totals are to be determined (TBD) and will range from one to a maximum of ten.

TABLE 4-6

SUMMARY OF SAMPLE ANALYSIS AND QUALITY CONTROL SAMPLES
DETECTION MONITORING
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 2 OF 2

5 Ambient blanks will be collected at the discretion of the FOL, (see Section 4.3.5) to delineate site conditions. Because site conditions vary, totals are to be determined (TBD). Ambient blanks are not applicable for field analyses (NA).

6 Matrix spike (MS) and duplicate samples will be collected at a frequency of 1 per 20 samples. For inorganics, an MS and a sample duplicate will be collected, and for organics, a MS and a matrix spike duplicate (MSD) will be collected. MS/MSDs and sample duplicates are not applicable for field analyses (NA).

7 Plus sign (+) indicates potential for the total number of samples to increase, due to TBD variables.

NA Not Applicable
TBD To be determined

TABLE 4-7

SUMMARY OF SAMPLE ANALYSIS AND QUALITY CONTROL SAMPLES
DETECTION MONITORING OF UPGRADIENT WELLS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2

Parameter(1)	Samples	Field Duplicates(2)	Rinsate Blanks(3)	Trip Blanks(4)	Ambient Blanks(5)	Matrix Spike/ Duplicates(6)	Total(7)
LABORATORY:							
Volatile Organic Compounds	3	1	NA	TBD	TBD	1/1	5+
Dissolved Metals	3	1	NA	NA	TBD	1/1	5+
Chloride/sulfate	3	1	NA	NA	TBD	1/1	5+
TDS/TS	3	1	NA	NA	TBD	1/1	5+
Alkalinity/Bicarbonate/Carbonate	3	1	NA	NA	TBD	1/1	5+
Ammonia	3	1	NA	NA	TBD	1/1	5+
FIELD:							
Dissolved Oxygen	3	NA	NA	NA	NA	NA	3
pH	3	NA	NA	NA	NA	NA	3
Specific Conductivity	3	NA	NA	NA	NA	NA	3
Temperature	3	NA	NA	NA	NA	NA	3
Turbidity	3	NA	NA	NA	NA	NA	3
ORP/eH	3	NA	NA	NA	NA	NA	3
Water Level	3	NA	NA	NA	NA	NA	3

1 See Table 4-2 for the list of chemicals analyzed and Table 4-4 for analytical methods.

2 Field duplicates will be collected at a minimum frequency of 1 per every 10 samples. Field duplicates are not applicable for field analyses (NA).

3 All sampling equipment used on site will be dedicated or disposable equipment. Therefore, only one Rinsate Blank will be collected as a "batch blank" when the dedicated pumps are installed. Rinsate Blanks are not applicable for field analyses (NA).

4 Trip blanks will be collected at a frequency of one per cooler containing samples for volatile organics analysis. Because the number of sample coolers shipped varies, totals are to be determined (TBD) and will range from one to a maximum of ten.

TABLE 4-7

SUMMARY OF SAMPLE ANALYSIS AND QUALITY CONTROL SAMPLES
DETECTION MONITORING OF UPGRADIENT WELLS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 2 OF 2

5 Ambient blanks will be collected at the discretion of the FOL, (see Section 4.3.5) to delineate site conditions. Because site conditions vary, totals are to be determined (TBD). Ambient blanks are not applicable for field analyses (NA).

6 Matrix spike (MS) and duplicate samples will be collected at a frequency of 1 per 20 samples. For inorganics, an MS and a sample duplicate will be collected, and for organics, a MS and a matrix spike duplicate (MSD) will be collected. MS/MSDs and sample duplicates are not applicable for field analyses (NA).

7 Plus sign (+) indicates potential for the total number of samples to increase, due to TBD variables.

NA Not Applicable
TBD To be determined

used or if new wells are installed, one source water blank will be collected for each source of water used for decontamination.

4.3.2 Field Duplicates

Field duplicates are two samples collected into two identical sets of sample bottles in the same order as described in Section 4.2.6. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis methods employed. Field duplicates will be collected at a minimum frequency of 1 per every 10 samples. Field duplicates are not applicable for field analyses. Duplicates will be analyzed for the same parameters in the laboratory and will be labeled so as to make the identity of the duplicate unknown to the laboratory (see Section 4.2.9).

4.3.3 Rinsate Blanks

Collection of equipment rinsate blanks is not anticipated during this monitoring program unless new monitoring wells are installed or non-dedicated equipment (i.e., bailers) are used for sampling during this investigation. Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split-spoon, corer, etc.) after decontamination and then placing it in the appropriate sample containers for analysis. Equipment rinsate blanks are analyzed for the same parameters as the field samples. Equipment rinsate blanks will be used to assess the effectiveness of decontamination procedures. Equipment rinsate blanks will be collected at a frequency of 1 per every 10 samples, with a minimum of one per day of sampling per nondedicated sampling device/instrument. For pre-cleaned, dedicated, and/or disposable equipment (i.e., sample tubing, bladder pumps, etc.), one rinsate blank will be collected and analyzed at a frequency of one per lot or "batch blank" for a specific equipment type. This will occur only when the dedicated pumps are installed. Rinstate blanks will not be collected once dedicated sampling equipment is installed in the wells at the SWL. Rinsate blanks are not applicable for field analyses.

4.3.4 Trip Blanks

Trip blanks are used to assess the potential for contamination resulting from contaminant migration into sample bottles/jars during sample shipment and storage. Trip blanks pertain to VOCs only. Trip blanks are prepared from laboratory-grade organic free water by the laboratory prior to the sampling event, shipped to the site with the sample containers, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment with other VOC samples and sent for analysis.

There should be one trip blank included in each sample shipping container (i.e., cooler) that contains VOCs. At no time after trip blank preparation are the sample containers opened before they reach the laboratory. Because the number of sample coolers shipped varies, the total number of trip blanks is to be determined in the field.

4.3.5 Ambient Blanks

Ambient blanks are collected in the field and analyzed to check for interfering contaminants that could potentially be present in ambient air at the sampling site (e.g., volatile organic compounds or particulates). Ambient blanks are collected at the sampling locations(s) by placing analyte-free water directly into the same types of containers, preserved, and stored in the same manner as field samples. The exposure of ambient blanks to ambient conditions should be similar to the ambient exposure of field samples. Blanks will be collected based on conditions at the time of sampling, at the discretion of the FOL, to delineate site conditions. Because site conditions vary, the total number of ambient blanks is to be determined in the field. Ambient blanks are not applicable for field analyses.

4.3.6 Matrix Spikes/Duplicates

Matrix spikes are investigative samples analyzed to provide information about the effect of the sample matrix on the digestion and measurement methodology. All matrix spikes for organic analyses are performed in duplicate and, as previously defined, are referred to as MS/MSD samples. Matrix spike (MS) and duplicate samples will be collected at a frequency of 1 per every 20 samples; for inorganics, a MS and a sample duplicate will be collected, and for organics, a MS and a matrix spike duplicate (MSD) will be collected. MS/MSDs and sample duplicates are not applicable for field analyses.

4.4 ANALYTICAL LABORATORY CAPACITY

Careful coordination with the analytical laboratory will be required throughout the project so as not to exceed the capacity of the laboratory to perform the analysis. The schedule for analysis will be developed jointly with the laboratory at the time that the bottle request is made for a sampling round.

4.5 CALIBRATION PROCEDURES AND FREQUENCY

Instruments used in the field and in the laboratory will be calibrated according to the procedures described below. Several monitoring instruments will be used during field activities, including the following:

- In-line flow-through cell.
- Electronic water level meter.
- Photoionization detector/flame ionization detector (PID/FID) organic vapor detector.
- Water quality meter (combination temperature probe, specific conductance meter, pH meter, turbidity meter).

The electronic water level meter (M-scopes) will be calibrated prior to field use and periodically at the discretion of the FOL. They will be calibrated by comparison of M-scope markings with a steel tape measure. As a rule, the PID/FID organic vapor detector will be calibrated at the beginning of each day.

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

4.6 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The FOL will supervise and check on a daily basis that the monitoring wells are installed and developed correctly, field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.

- The data validator will review (on a timely basis) the data packages submitted by the laboratory. The data validator will check that the data were obtained through the approved methodology, that the appropriate level of QC effort and reporting was conducted, that holding times were met, and that the results are in conformance with the QC criteria. On the basis of these factors, the data validator will evaluate the data quality and limitations.

- The project manager will oversee the FOL and data validator and check that management of the acquired data proceeds in an organized and expeditious manner.

- A formal audit of the field sampling procedures may be conducted in addition to the auditing that is an inherent part of the daily project activities.

- The auditors will check that sample collection, sample handling, decontamination protocols, and instrument calibration and use are in accordance with the approved project SOPs. The auditors will also check that the field documentation logs and chain-of-custody forms are being filled out properly.

4.7 PREVENTIVE MAINTENANCE

TtNUS has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The equipment manager keeps an inventory of the equipment in terms of item (model and serial number), quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness are checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness.

- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.

- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before it is taken to the job site and during field activities.

5.0 REPORTS

This section describes the reports that will be prepared and submitted to IDEM.

5.1 FIELD REPORTS

Field reports will be prepared for each sampling event in accordance with 329 IAC 10-21-2(b)(12). The FOL will be responsible for preparing the field report. The Field Report will contain the following information in each ground water monitoring well sampled:

1. The time and date each well was purged and sampled.

2. The location of each well that was sampled, including indicating the well as upgradient or downgradient of the solid waste boundary.

3. The condition of well heads and well security devices.

4. The weather conditions during sample collection.

5. The condition of purged water with regard to odor, turbidity, and the conditions of the collected sample.

6. The in-situ temperature, in degrees Celsius, of the ground water as measured in line or immediately after removal of water from the well.

7. The static water elevations, referenced to mean sea level and measured to the nearest one-hundredth (0.01) foot.

8. The equipment used to purge and sample the well.

9. The source and type of all field equipment calibration standards.

10. The type of equipment used for purging and for collection of samples and, where applicable, the cord's chemical composition.

11. A copy of the chain-of-custody for the sample.

12. The location and elevation of the referenced measuring mark on the well casing used to measure the static water elevations.

13. The time equipment was decontaminated at each well location.

14. The reaction of the ground water to the preserving agent when the sample is containerized.

The FOL designee will be responsible for preparation of the field report.

5.2 SAMPLING AND ANALYSIS REPORT

After each sampling event, a report will be prepared and submitted to IDEM in accordance with 329 IAC 10-21-1(t). The report will be submitted within 60 days of the completion of the sampling event and will contain the following information:

1. All static water elevations measured to the nearest 0.01 foot.

2. Ground water potentiometric-surface maps, or flow maps, as specified in subsection 329 IAC 10-21-1(p).

3. Two unbound laboratory certified reports, including one original copy, that include the following information:

    - The detection limit for each chemical constituent
    - The date samples were collected
    - The date samples were received by the laboratory
    - The date samples were analyzed by the laboratory
    - The date the laboratory report was prepared
    - The method of analysis used for each constituent
    - The sample identification number for each sample
    - The results of all sample analyses

- The results of all laboratory quality control sample analyses, including
  blanks
  spikes
  duplicates
  standards

4. Field report sheets as described in FSP Section 5.1 rule for each ground water monitoring well sampled and the field chain of custody form for each sample as described in FSP Section 4.2.11.

5. A report correlating sample identification numbers with the corresponding well identification number and blank identification numbers.

6. An explanation of how the well sampling sequence, as described in 329 IAC 10-21-2(a)(6), was established for the sampling event.

7. The statistical evaluation report.

8. When requested by IDEM, one copy of the results of the laboratory analyses on computer diskette or by other electronic means will be submitted to IDEM. The electronic format of the submission will be established by IDEM.

9. When requested by IDEM, the following information will be submitted:

   - Raw data
   - Laboratory bench sheets
   - Laboratory work sheets
   - Chromatograms
   - Instrument printouts
   - Instrument calibration records

REFERENCES

B&R Environmental, 1992. RCRA Facility Investigation, Phase I Environmental Monitoring Reports, Solid Waste Management Units #15/06, #14/00, and #16/16, Naval Surface Warfare Center Crane, Crane Division, Crane, Indiana. Pittsburgh, Pennsylvania.

Dunbar, Joseph B., 1982. Hydrogeologic Investigation of Waste Disposal Sites at the Naval Weapons Support Center, Crane, Indiana. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Dunbar, Joseph, 1984. Landfill Hydrogeology, NWSCC, Indiana, Geotechnical Laboratory. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

NEESA (Naval Energy and Environmental Support Activity), May 1983. Initial Assessment Study of Naval Weapons Support Center Crane, Indiana. Port Hueneme, California.

NFESC, February 1996. Naval Installation Restoration Laboratory Quality Assurance Guide. NFESC Interim Guidance Document.

Palmer, Arthur N., 1969. A Hydrologic Study of Indiana Karst, Ph.D. Thesis. Indiana University.

Rust Environment and Infrastructure, July 1997. Environmental Data Assessment Memorandum for SWMUs #03/10, #06/09, and #07/09, Naval Surface Warfare Center, Crane Division. Minneapolis, Minnesota.

TtNUS (Tetra Tech NUS, Inc.), February 1999. Health and Safety Plan for Field Sampling Plan for Groundwater Monitoring at the Ammunition Burning Grounds Old Rifle Range, Demolition Range, Old Jeep Trail, and Sanitary Waste Landfill, Naval Surface Warfare Center, Crane Division, Crane, Indiana. Pittsburgh, PA.

U.S. EPA (Environmental Protection Agency), March 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory Office of Research and Development. Cincinnati, Ohio.

U.S. EPA (Environmental Protection Agency), 1986. Test Methods for Evaluating Solid Waste; Physical/Chemical Methods (SW-846). Third edition, up to and including Update III. Office of Solid Waste and Emergency Response, Washington, DC.

APPENDIX A

FIELD FORMS

MONITORING WELL INSPECTION FORM

Well ID: ________________

Time: ________________ **Date:** __________ **Inspector's Name:** ____________________________

Inspection Item	Types of Problems	Status		Observation
		S	U	
Well Tag	Is it in-place, legible			
Well security	Condition protective case, cap, lock			
Well pad	Concrete or gravel & condition			
Well seal	Condition of...			
Area Immediately around well pad	Record any evidence of/or standing water in area of well			
Dedicated sampling equipment	Condition of...			
PVC Riser	Condition of riser & survey reference point			

Comments:

Signature(s)____________________________

Note: S= Satisfactory, U= Unsatisfactory
Check one, if unsatisfactory explain

NSWC Crane
Field Form
Revision: 1
January: 1999

WATER LEVEL MEASUREMENT FORM

Project Name: NSWC Crane
Location: Crane, IN
Weather Conditions: ______________________

Project No.: CTO 48
Personnel: ______________________
Measuring Device: ______________________
Remarks: ______________________

Well ID	Date	Time	Water Level *	Thickness of Free Product *	PID Reading ppm		Comments
					RP	BZ	

* All measurements to the nearest 0.01 foot

Signature(s): ______________________

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME/MODEL : ______________________

PROJECT NAME : NSWC Crane

MANUFACTURER : ______________________

PROJECT NUMBER : CTO 48

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

Instrument Rented From: ______________________

LOW FLOW PURGE DATA FORM

PROJECT SITE NAME: NSWC CRANE

PROJECT NUMBER: CTO 48

WELL ID.: ______________________

DATE: ______________________

Time (Hrs.)	Water Level (Ft. below TOC)	Pump Rate (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Comments

SIGNATURE(S): ______________________

PAGE___OF___

CHAIN OF CUSTODY RECORD

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

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

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS:	

Order No. 70440 (0693)

GROUNDWATER SAMPLE LOG FORM

Tetra Tech NUS, Inc.

Project Site Name:	NSWC Crane	Sample ID No.:	
Project No.:	7769/CTO 48	Sample Location:	
		Sampled By:	
		C.O.C. No.:	

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: ______
[ ] QA Sample Type: ______

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

SAMPLING DATA:

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

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
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
Volatile Organic Compounds (VOC)	HCl/4°C	(3) 40 mL Glass Vials	
Dissolved Metals	HNO_3/4°C	(1) 1000mL Polyethylene	
Sulfate, Chloride,TS, TDS, Alk, Bicarb, Carb	4°C	(1) 1000mL Polyethylene	
Ammonia	H_2SO_4/4°C	(1) 500mL Polyehtylene	

OBSERVATIONS / NOTES:

Reaction to Preservative:

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

APPENDIX B

STANDARD OPERATING PROCEDURES

The field sampling techniques in Section 4.0 of this FSP are the primary procedures. The information contained in this Appendix is considered supplementary to the procedures in Section 4.0. If there is a conflict between Section 4.0 and Appendix B, the procedures in Section 4.0 take precedence.

SOP Number	**Title**
SOP-1	Inspection of Existing Monitoring Wells
SOP-2	Measurment of Water Levels in Monitoring Wells
SOP-3	Pump Installation and Removal
SOP-4	Well Purging and Stabilizatoin
SOP-5	Monitoring Well Sampling
SOP-6	Decontamination of Field Sampling Equipment
SOP-7	Sample Identification Nomenclature
SOP-8	Sample Preservation, Packaging and Shipping
SOP-9	Sample Custody and Documentation of Field Activities

STANDARD OPERATING PROCEDURE NUMBER 1
INSPECTION OF EXISTING MONITORING WELLS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish procedures for the inspection of existing monitoring wells.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for inspection of existing monitoring wells.

Monitoring Well Inspection Form: A copy of the monitoring well inspection form can be found in Appendix A.

Bound Field Log Book

Well keys

3.0 INSPECTION PROCEDURES

3.1 Record the well identification (ID), date, and time on the Monitoring Well Inspection Form.

3.2 Record the condition of the well ID tag. Is the tag in place and legible?

3.3 Record the condition of the protective casing, caps, and lock. Has the casing, cap, and/or lock been tampered with? Has the well been damaged in anyway or does it show signs of deterioration?

3.4 Record the condition of the concrete or gravel pad. NSWC Crane wells will have either a concrete or gravel pad. Check the condition of the pad and note any changes. Are concrete pads cracking or heaving? If a gravel pad is present, is there any erosion or plant growth in the pad area?

3.5 Record the condition of the cement seal surrounding the protective casing. Has the seal cracked or pulled away from the protective casing? Record any visible signs of deterioration in the area of the seal.

3.6 Record the presence of depressions and/or standing water around the casing or pad.

3.7 Unlock the well cap.

3.8 Record the condition of dedicated sampling equipment. All wells have dedicated sample pumps installed. Confirm that the pump is in place and appears to be in working order (as a final check the pump will be operated during sampling).

3.9 Inspect and record the condition of the PVC riser pipe and the surveyed reference point. The surveyed reference point is a V-notch on the top of the PVC riser pipe.

STANDARD OPERATING PROCEDURE NUMBER 2
MEASUREMENT OF WATER LEVELS IN MONITORING WELLS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish procedures for determining water levels in monitoring wells.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

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 included in Appendix A.

Bound Field Log Book

Photoionization detector (PID) with an 11.7 eV lamp: The manual for the operation of the PID is found in the site-specific Health and Safety Plan (HASP).

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.

Interface meter: The interface meter must have a cable of sufficient length to reach below the water surface and be capable of measurements of 0.01 feet. The interface meter is required only if analytical data from the previous round indicated the presence of Light Non-Aqueous Phase Liquids (LNAPL). Interface meters would be used in place of the electronic water level indicators.

Decontamination supplies: SOP-6 describes decontamination procedures including 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 identification (ID), date, and time (using military time) on the Ground Water Level Measurement Form. A copy of this form can be found in Appendix A.

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. Calibrate the PID in accordance with the calibration procedures described in the HASP.

2. Insert the PID sample inlet straw through the opening in the pump cap assembly and approximately three inches into the riser pipe.

3. Record the PID reading on the Ground Water Level Measurement Form. If the reading is below concentrations specified in the site-specific HASP, proceed to step 3.6. If the reading is above the concentration specified in the HASP, measure the concentration in the breathing zone. If the concentration in the breathing zone is below the concentration specified in the HASP, proceed to Step 3.6. If the reading is above 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 Insert the water level meter probe (or interface meter probe) through the opening in the pump cap assembly. (The probe must be decontaminated before use according to the procedures in SOP 6).

3.7 Slowly lower the probe into the well riser pipe until an audible and/or visible signal is produced, indicating contact with the water surface. (If the interface probe is used, the first audible and/or visible signal will indicate the LNAPL layer and the second signal will be the water layer).

3.8 Read the ground water level measurement from the top of the inner casing at the surveyed reference point to the nearest 0.01 foot. (If the interface probe is used, the LNAPL and ground water level measurements are both read).

3.9 Record the water level measurement on the Ground Water Level Measurement Form. (If the interface probe is used, record the readings for the LNAPL layer and the water layer).

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 following the procedures outlined in SOP-6.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in Section 4.2.8 of this approved Field Sampling Plan.

STANDARD OPERATING PROCEDURE NUMBER 3
PUMP INSTALLATION AND REMOVAL

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish procedures for installation of low-flow bladder pumps into monitoring wells. This SOP also establishes the procedure for the removal of these pumps from wells when necessary for well or pump maintenance and reinsertion of the pump into the well.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow pump installation and removal.

Bound Field Log Book

Plastic sheeting

Surgical gloves

Well key

Teflon®-lined PVC bladder pump: Well Wizard® Pump model P1150, constructed of polyvinyl chloride (PVC) and Teflon®, manufactured by QED Environmental Systems or equivalent. The pump dimensions are 1.66 inches in diameter and 19.5 inches in length, with a pump volume of 0.130 liters.

Teflon®-lined polyethylene tubing

Sample-line freeze protector

Sample discharge adapter

2-inch well cap assembly

3.0 PUMP INSTALLATION PROCEDURES

3.1 Obtain information on the total depth of the well, static water level, depth of the screened interval, and the length of the screen.

3.2 Calculate the length of Teflon®-lined tubing necessary to position the pump within the screened interval of the monitoring well (the pump supplier will assist with this task). The pump will be set at the midpoint of the screened interval.

3.3 Order the Teflon®-lined bladder pump from the manufacturer with Teflon®-lined tubing factory-cut to length and attached to both the pump and well cap. Specify the required tubing length. Also specify that the pump must be tested for U.S. EPA priority pollutant parameters.

3.4 When the pump assembly (pump, attached tubing, and well cap) is received from the manufacturer, remove the pump from the protective shipping bag. Examine the pump assembly. Examine all fittings and connections for tightness. Check the threaded PVC screen to insure that it is snug.

3.5 Each pump will be accompanied by a certification from the manufacturer. Record on the certification the identification of the well in which the pump is to be installed. Record in the Field Log Book the manufacturer's name, date of manufacturer's certification, pump model, batch serial number, and identification of the well in which the pump was installed.

3.6 Place the pump assembly into the shipping bag or lay the pump on clean plastic next to the monitoring well into which the pump assembly is to be installed. Wear clean, disposable surgical gloves while handling the pump assembly.

3.7 Unlock the well.

3.8 Insert the pump into the 2-inch PVC riser pipe of the well. While holding the tubing, slowly lower the pump, taking care not to kink the pump tubing. When the tubing is inserted to it's complete length, suspend the pump and tubing assembly on the top of the riser pipe using the attached well cap assembly. Wear clean, disposable surgical gloves while handling the pump assembly.

3.9 Replace the outer protective cap and lock the well.

4.0 PUMP REMOVAL AND REPLACEMENT PROCEDURES

4.1 Spread approximately ten square feet of clean plastic sheeting next to the well.

4.2 Unlock and open the well.

4.3 Pulling on the well cap assembly, slowly remove the pump and tubing from the well. As the tubing is being removed from the well, coil the tubing into a manageable size. When the tubing, pump, and cap have been removed from the well, secure the coil of tubing using string or plastic wire ties and lay it on the plastic sheeting. Wear clean, disposable surgical gloves while handling the pump assembly.

4.4 If the pump is to be removed from the site and later reinserted into the well, attach a label to the pump. On the label record the identification of the well from which the pump was removed. Place the pump and tubing into a plastic bag and also label the outside of the bag. Wear clean, disposable surgical gloves while handling the pump assembly.

4.5 If the pump is removed for more than a short time (e.g. a few hours) and will not be removed from the location of the monitoring well, place the pump, tubing, and cap into a clean plastic bag until the pump is reinstalled.

4.6 Reinsertion of the pump is accomplished by following steps 3.7, 3.8, and 3.9.

4.7 Record activities in the bound Field Log Book.

STANDARD OPERATING PROCEDURE NUMBER 4
WELL PURGING AND STABILIZATION

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the procedure for well purging and stabilization utilizing low-flow techniques.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

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

Low-Flow Purge Data Form: A copy of this form is included in Appendix A.

Ground Water Sample Log Form: A copy of this form is included in Appendix A .

Bound Field Log Book

Photoionization detector (PID) with an 11.7 eV lamp

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 the dedicated 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, turbidity, oxidation-reduction potential (ORP), temperature, and specific conductance.

Flow-through cell adapter for water quality meter

Purge water containers: Eight-gallon plastic containers with lids.

Graduated cylinder and stopwatch: Used to calculate flow rate.

Decontamination supplies: SOP 6 describes required decontamination supplies.

3.0 PROCEDURES FOR WELL PURGING

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

3.2 Follow steps 3.1 through 3.9 in SOP 2 to obtain a static water level measurement of the well to be purged. Record the information on the Ground Water Sample Log Form and the Low-Flow Purge Data Form. 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 from the Monitoring Well Inventory Report, April 1998.

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

$$\mathbf{V = (0.163)(T)(r^2)}$$

where:

V	=	Static casing volume of well in gallons.
T	=	Length of water column in well in feet (vertical feet of water).
0.163 or 0.653	=	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) constant = 0.163, for wells of 2-inch radius (4-inch diameter) constant = 0.653gallons per foot of water column. All wells at the SWL site are either 2" or 4" diameter.

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 1.5 to 6.0 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.

3.11 Record on the Low-Flow Purge Data Form every five to ten minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, and dissolved oxygen) measured by the water quality meter. Clean the flow-through cell as needed during purging (e.g., when fluctuating turbidity readings are observed and confirmed by collection of a turbidity sample before the cell for comparison). 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 would be 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%

If the above conditions have not been met after the well has been purged for four hours, purging will be considered complete and sampling can begin.

3.15 Rinse the flow-through cell and water quality meter probes with deionized water and pack the cell and meter for transport.

STANDARD OPERATING PROCEDURE NUMBER 5
MONITORING WELL SAMPLING

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the procedure for monitoring well sampling. Low-flow sampling techniques are used for ground water sampling at the Sanitary Waste Landfill (SWL). Each monitoring well sampled at the SWL is equipped with a dedicated, 1.66-inch diameter bladder pump and dedicated Teflon-lined polyethylene tubing. Therefore, this procedure is designed for sampling using dedicated sampling equipment.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

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 can be found in Appendix A.

Bound Field Log Book

Labeled sample containers: See SOP 7 for sample identification procedures.

0.45 micron filter assembly: These are single-use filters used to filter samples.

Electronic Programmable Controller, model 400: The programmable controller regulates the dedicated bladder pump.

Cylinder of compressed nitrogen with regulator: Compressed gas is the power source for the dedicated bladder pump.

Plastic storage bags

Shipping containers

3.0 MONITORING WELL SAMPLING PROCEDURES

3.1 Prior to sampling the well, the inspection procedures described in SOP-1, the water level measurements described in SOP-2, and the well purging procedures described in SOP-4 must be completed. Initiate sampling when the well is stabilized in accordance with SOP-4.

3.2 Record the sample start time (using military time) on the Ground Water Sample Log Form.

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. 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.

3.4 Cap each container immediately after filling.

3.5 Affix the appropriate label to the sample container.

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

3.7 Repeat steps 3.1 through 3.5 for each sample container collected.

3.8 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.

3.9 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. Tables 4-4 and 4-5 of this approved Field Sampling Plan includes information on preservation requirements. All samples will be collected in the following sequence (where applicable):

Volatile organic compounds (VOCs)
Sulfide
Semivolatile organics (SVOCs)
Dissolved Metals
Total Metals
Cyanide

Pesticides/PCB's

Herbicides

Sulfate

Nitrate

Total solids/total dissolved solids

Alkalinity/bicarbonate/carbonate

Ammonia

Chloride

3.10 Sample containers for volatile constituents (VOCs) must be completely filled so that no headspace exists in the container.

3.11 Use a single use, disposable, in-line 0.45-micron filter cartridge to collect filtered samples. Attach the filter cartridge to the discharge end of the pump tubing. Prior to filling containers with filtered sample, rinse the filter cartridge with approximately 100-ml of water from the well being sampled. Direct the discharge from the filter cartridge into the sample bottle and collect the filtered sample.

3.12 Types of sample containers, sample volume, preservation requirements, and holding times are summarized in Table 4-4 and 4-5 of this Field Sampling Plan. All sample containers will be supplied by the laboratory, and the laboratory will pre-preserve all sample containers, where appropriate.

3.13 After sampling has been completed, follow the instructions in the pump manual "How to Use the Freeze Protection Kit", and complete the freeze protection steps.

3.14 Remove the sample discharge tubing by unscrewing it from the well cap. Store the tubing in the well (suspended in the well cap access hole). Care must be taken not to contaminate the exterior of the tubing (via contact with the ground or clothing) while conducting this activity. Wear clean, disposable surgical gloves while handling the discharge tubing.

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

3.16 All equipment should be cleaned and packed into the sample vehicle, along with the sample cooler for transport.

STANDARD OPERATING PROCEDURE NUMBER 6
DECONTAMINATION OF FIELD SAMPLING EQUIPMENT

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the procedures to be followed when decontaminating non-dedicated field sampling equipment.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Field Log Book

Potable water

Deionized water

LiquiNox detergent

Brushes, spray bottles, paper towels, etc.

3.0 DECONTAMINATION PROCEDURES

3.1 Decontaminate non-dedicated sampling equipment 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 Log Book.

3.8 Containerized decontamination solutions will be managed in accordance with the procedures described in section 4.2.8 of this approved Field Sampling Plan.

STANDARD OPERATING PROCEDURE NUMBER 7
SAMPLE IDENTIFICATION NOMENCLATURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish a consistent sample nomenclature system that will facilitate subsequent data management. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Maintenance of consistency between sample events (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints.
- Ease of identification and direct link to site, location, quarter, event, and year.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Pen with indelible ink

Sample container labels

3.0 SAMPLE IDENTIFICATION NOMENCLATURE

3.1 MONITORING SAMPLES

All monitoring samples taken as part of this approved Field Sampling Plan at NSWC Crane will be properly labeled with a sample label affixed to the sample container. Each sample will be assigned a unique sample tracking number. The sample tracking number will consist of a four or five segment alpha-numeric code that identifies the sample site, location, quarter identifier, year, and, where applicable, whether the sample is filtered.

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

A	**NNA** or **NNNNN**	**NA**	**NN**	**A**
Site ID	Location	Quarter and resample event code	Year	Filtered (When applicable)

Character Type:

A	=	Alpha
N	=	Numeric

Site ID:

S	=	Sanitary Waste Landfill (SWL)

Location:

The location is the well number (monitoring point) ID. The well number is used to identify the location of monitoring wells. Note the WES is dropped from the WES 14-N-93 series wells.

Quarter and Sample Event Code

The quarter during which a sample is taken shall be noted. The numbers 1, 2, 3, 4 correspond to the calendar quarter during which the initial sample was taken. Each sample event associated with a quarter is given a letter designation. The first scheduled event is always given the letter A. If it is necessary to conduct a confirmation sampling event or for upgradient well sampling that falls in the same quarter for a monitoring point, the second sample associated with the monitoring point will be given the letter B, the third C, etc. The quarter code for confirmation sampling events will be the same as the quarter to which the resampling applies. For example, if there is a need for confirmation sampling for a sample taken in the fourth quarter and the resampling will take place in the first quarter of the next calendar year, the quarter code would remain a four and the year would not change.

Year

A two-digit number will be used to denote the year in which the sample was taken. The only exception will be for a confirmation-sampling event associated with the sampling event occurring the previous year. For example,

1999 = 99
2000 = 00 etc.

Filtered

F = Filtered dissolved; no entry in this segment signifies an unfiltered (total) sample.

3.1.1 Examples of Sample Nomenclature

A ground water sample collected from monitoring well 1A at the SWL during the second quarter sampling in 1999 for an unfiltered sample would be designated as

S 1A 2A 99.

A ground water sample collected from monitoring well 4B at the SWL during the second quarter sampling in 1999 for a filtered sample would be designated as

S 4B 2A 99 F.

A confirmation sample of this same well for a filtered sample would be designated as

S 4B 2B 99 F.

A ground water sample collected from monitoring well WES 14-6-93 at the SWL during the fourth quarter sampling in 2003 for an unfiltered sample would be designated as

S 14693 4A 03.

A resample of this same location taken in the first quarter of 2004 would be designated

S 14693 4B 03.

3.2 FIELD QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) SAMPLE NOMENCLATURE

Field quality assurance/quality control (QA/QC) samples are described in Section 4.3 of this approved Field Sampling Plan. 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 taken, and the number of this type of QC sample taken on that date.

AA	**NNNNNN**	**NN**	**F**
QC Type	Date	Number per day	Filtered (When applicable)

The QC types are identified as:

RB = Rinsate Blank
TB = Trip Blank
FB = Field Blank
FD = Field Duplicate
AB = Ambient Blank

The sampling time recorded on the chain-of-custody form and labels 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).

Matrix Spike and Matrix Spike Duplicate (MS/MSD) samples will be designated on the field documentation forms and chain-of-custody form.

3.2.2 Examples of Field QA/QC Nomenclature

A duplicate of a ground water sample obtained on June 3, 1999 would be designated as

FD 060399 01.

The third duplicate taken of a ground water sample (three different monitoring points) obtained on November 17, 2003 would be designated as

FD 111703 03.

STANDARD OPERATING PROCEDURE NUMBER 8
SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for sample preservation, packaging, and shipping to be used in handling ground water samples obtained for chemical analysis at NSWC Crane.

The NSWC Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

Shipping labels

Custody seals

Chain-of-custody (COC) forms

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 Table 4-4 and 4-5 of this approved Field Sampling Plan establishes requirements for sample preservation. The laboratory provides pre-preserved sample containers (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 (used during sample shipment).

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 the sample container is properly identified (SOP 7) on the label and the lid securely fastened, and the container sealed in a ZipLoc bag.

3.4 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. If the cooler is questionable for shipping, the cooler must be discarded.

3.6 Place the sample container into a shipping cooler in an upright position (containers will be upright, with the exception of the 40-ml vials). Continue filling the cooler with samples and packing material until the cooler is full and the movement of the sample containers is limited.

3.7 Place a temperature blank in the cooler. If the cooler contains samples to be analyzed for VOC's, place a trip blank into the cooler.

3.8 Fill in the voids between the sample containers with ice and continue filling the cooler with ice to the top, using a minimum of eight pounds of ice for a medium-size cooler.

3.9 Place the original (top) signed copy of the COC(s) form inside a large ZipLoc bag. Tape the bag to the inside of the lid of the shipping cooler.

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 (a total of two signed custody seals must be used per cooler). 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 all of the shipping information. Overnight (e.g. FedEx Priority Overnight) courier services will be used for all sample shipments. Include the air bill number on the COC(s).

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 (See Table 4-4 and 4-5 of the approved FSP)

STANDARD OPERATING PROCEDURE NUMBER 9
SAMPLE CUSTODY AND DOCUMENTATION OF FIELD ACTIVITIES

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the procedures for sample custody and documentation of field sampling and field analysis activities. Example forms are provided in Appendix A.

The Naval Surface Warfare Center (NSWC) Crane Environmental Protection Department must approve any deviations from this procedure.

2.0 FIELD FORMS LIST

The following log books, forms, and labels are required.

Site Log Book

Field Log Book

Sample label

Chain-of-Custody

Custody seal

Equipment Calibration Log

Monitoring Well Inspection Form

Water Level Measurement Form

Low-Flow Purge Data Form

Ground Water Sample Log Form

3.0 PROCEDURES

This section describes custody and documentation procedures. All entries made into the log books, 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 Log Book

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

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

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

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

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

Information recorded daily in the site log book 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 log book must be signed and dated by the Field Operations Leader (FOL).

Upon completion of the fieldwork or when completely filled, the Site Log Book is stored in the NSWC Crane records repository.

3.2 Field Log Books

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

Upon completion of the fieldwork or when completely filled, Field Log Books are stored in the NSWC Crane records repository.

3.3 Sample Label

Adhesive sample container labels must be completed and applied to every sample container.

3.4 Chain-of-Custody Form

The Chain-of-Custody (COC) is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. Each COC is numbered. This form must be used for any samples collected for laboratory chemical analysis. The original (top) signed copy of the COC(s) 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 against the enclosed COC(s). Any problems are noted on the enclosed COC form (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. The COC form is signed and retained by the laboratory and becomes part of the sample's corresponding analytical data package.

Each COC is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example COC.

3.5 Custody Seal

The Custody Seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for 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 coolers) containing environmental samples. The laboratory sample custodian will examine the Custody Seal for evidence of tampering and will notify the task manager 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.

Each calibration log is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example Equipment Calibration Log.

3.7 Monitoring Well Inspection Form

The Monitoring Well Inspection Form is used to document the inspections conducted in accordance with SOP-1.

Each inspection form is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example Monitoring Well Inspection Form.

3.8 Water Level Measurement Form

The Water Level Measurement Form is used to document the determination of water levels in monitoring wells in accordance with SOP-2.

Each form is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example Water Level Measurement Form.

3.9 Low-Flow Purge Data Form

The Low-Flow Purge Data Form is used to document field measurements made while purging wells to stabilization in accordance with SOP-4.

Each data sheet is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example Low-Flow Purge Data Form.

3.10 Ground Water Sample Log Form

The Ground Water Sample Log Form is used to document the samples taken from a monitoring well after the well is purged. This sheet is used in conjunction with SOP-5.

Each log sheet is placed into a binder and stored in the NSWC Crane records repository. Appendix A contains an example Ground Water Sample Log Form.

APPENDIX D

BORING LOGS AND MONITORING WELL CONSTRUCTION SHEETS

WELL ID	BORING LOGS	WELL CONSTRUCTION LOGS
MW 201	YES	NA
MW 1A	NA	NA
MW 1B	NA	NA
MW 203	YES	NA
MW 2A	NA	NA
MW 3A	NA	NA
MW 4A	NA	NA
MW 5A	NA	NA
MW 6A	NA	NA
MW 7A	NA	NA
MW 3B	NA	NA
MW 4B	NA	NA
MW 5B	NA	NA
MW 6B	NA	NA
WES-14-1-93	YES	YES
WES-14-2-93	YES	YES
WES-14-3-93	YES	YES
WES-14-4-93	YES	YES
WES-14-5-93	YES	YES
WES-14-6-93	YES	YES

NA Boring Logs and well construction logs are not available for the Sanitary Waste Landfill.

BORING NO. WES-14-1-9?

Project [illegible]
Date: Start 10/14/9? Complete 10/15/9?
Location N See Attached E [illegible]
Drilling Agency U.S. [illegible] W.E.S.
Driller Elastic Inspector Patton
Drill Type Failing Holemaster
Drill Method 3" Shelby, HQ Core
Thickness of Overburden 7.5'
Depth Drilled into Rock [illegible]
Total Depth of Boring [illegible]
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed Yes
Surface Elevation
Datum for Surface El.

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	0.5, 1.0	Reddish Brown, SILTY CLAY, Damp, Stiff (0.0–1.1)	CL		2.3'	1	3" Shelby			3" Shelby Tubes
	1.5, 2.0, 2.5	Reddish Brown to Light Gray, SILTY CLAY w/ SILT Laminae, Moist, Stiff to V. Stiff	CL			2	1			Push / Sec / Depth / Pressure / Rec 1 / 20 / 0–2.5 / 150 / 2.3' 2 / 30 / 2.5–5.0 / 225 / 2.0' 3 / 34 / 5.0–7.5 / 400 / 1.4' 4 / 69 / 7.5–9.1 / 1000 / 1.1' 5 / 140 / 9.1–9.9 / 800 / 0.4'
	3.0, 3.5, 4.0, 4.5		CL		2.0'	3	3" Shelby 2			
	5.0, 5.5, 6.0, 6.5		CL		1.4'	4	3" Shelby			Key B/P = Bedding Plane Mech = Mechanical Break (W) = Weathering ss = Sandstone
	7.0	Top of Rock (1.1–7.5)	CL			5	3			
(W) SHALE	7.5, 8.0	Reddish Brown to Light Gray, Severely Weathered Rock SILTY CLAY, Some Structure, Moist, V. Stiff (7.5–8.3)	CL			6	3" Shelby			
	8.5, 9.0	Reddish Brown to Light Gray, Severely Weathered Rock w/ Rock Structure and Rock Fragments (8.3–9.1)			1.1	7	4			Cleaned out boring to 10.1' and set 6" P.V.C. to 10.1 w/ 1.1' of stickup
SHALE	9.5, 10.0	Reddish Brown, SHALE, Soft, Thin Bedded, Severely Weathered w/ CLAY Bands Between Rock Beds. (9.1–9.9)			0.4'	8	3" Shelby 5			

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLU[ID]
>> - TOTAL LOSS OF DRILL FLUI[D]

ORL FORM 1202

BORING NO. WES-14-1-[illegible]

BORING NO. WES-14-1-93

Instrumentation Installed
Project
Surface Elevation
Date:Start / / Complete / /
Datum for Surface El.
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
SHALE	10	Broken CLAY; B/P Open; Broken CLAY/SHALE; CLAY, SS and SH Laminae; SS; Broken; Core Loss 0.25			92% / 0.43	Box 1	HQ Core			Run 1 Cored 3.0' Rec 2.75 Loss 0.25 Time 8:30-8:45
	11	B/P Open; B/P Rock								
	12	B/P Open; CLAY w/ SS Laminae; B/P Open; SS Laminae 0.05 to 0.1'								100% Drill Water Return for all Core Runs
	13	B/P Open; SS; B/P; CLAY Laminae; Core Loss 0.4								
	14	SS Laminae 0.02; SS Laminae 0.02; CLAY Laminae 0.01; B/P Open CLAY								
		SHALE, Reddish Brown to Brownish Yellow, Moderate Weathering, Soft, Thin Bedded, w/ Thin Beds and Laminae of Friable Reddish Brown Sandstone and CLAY Laminae								
Sandstone	15	CLAY Laminae B/P Open; CLAY Laminae B/P Open; Core Loss 0.			88% / 0.30					Run 2 Cored 10' Rec 8.75 Loss 1.25 Time 8:55-9:20
	16	B/P Open; B/P Open; B/P Open								
	17	Core Loss 0.1'; CLAY B/P Open; B/P Open; SH Laminae 0.01'; B/P Open								
	18	B/P; Mech; B/P SS; B/P								
	19	B/P; SH w/ CLAY; CLAY Laminae; Very porous SS								
	20	B/P								

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-1-93

Instrumentation Installed

Surface Elevation

Datum for Surface El.

Project

Date:Start / / Complete / /

Location N E

Drilling Agency

Driller Inspector

Drill Type

Drill Method

Thickness of Overburden

Depth Drilled into Rock

Total Depth of Boring

Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	20	SH; SH Laminae 0.01 to 0.02'; SH Laminae 0.04 to 0.01'; Loss 0.15'; Broken; B/P Open				Box 1	HQ Core			
	21–22	B/P; B/P; Core Loss 0.5'				Box 2				
Sandstone	23–24	CLAY Laminae; Mech; SH Laminae; CLAY Laminae 0.01'; Red Stain; SH Laminae 0.02'; Core Loss 0.2'			98%/0.85					Run 3 Cored 9.4; Rec 9.2' Loss 0.2'; Time 9:40 – 10:35; Bailed Boring dry after core run
	25–27	CLAY Laminae; B/P; B/P; B/P; B/P								
	27–29	B/P; B/P; CLAY Laminae 0.01'; CLAY Laminae								
	29–30	B/P; CLAY Laminae 0.03'; B/P; Broken Mech; B/P; B/P								

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ____ HOURS AFTER COMPLETION > - PARTIAL LOSS OF DRILL FLUID >> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-1-

BORING NO. WES-14-1-93

Instrumentation Installed

Project

Surface Elevation

Date: Start / / Complete / /

Datum for Surface El.

Location N E

Drilling Agency

Driller Inspector

Drill Type

Drill Method

Thickness of Overburden

Depth Drilled into Rock

Total Depth of Boring

Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
Sandstone	30	CLAY Laminae 0.01'					HQ Core			
		B.P.								
		SANDSTONE, Reddish Brown to Light Brown w/ Occ Light Gray Streaks, Moderate Weathering, Medium Hard, Fine Grained, Friable, Thin to Medium Bedded, w/ CLAY and SHALE Laminae								
	31									
		B/P								
	32	B/P				Box 2				
		B/P								
		B/P								
										Run 4 Cored 10.0'
		Mech				Box 3				Rec 9.9' Loss 0.1
										Time 11:15 - 11:55
	34	Mech								Bailed Boring Dry after run
	35	Red Stain								Water rose to a depth of 32.5' in 90 minutes
	36	Mech			99%/0.73					
		Mech								
	37	Mech								
		B/P, Red Stain, B/P								
		Red Stain, B/P								
	38	Red Stain, B/P, Mech								
		Red Stain w/ CLAY Laminae 0.01'								
		B/P								
	39	Core Loss 0.1								
		Mech								
	40	Red Stain								

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION ⇨ - PARTIAL LOSS OF DRILL FLUID ➾ - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-1-92

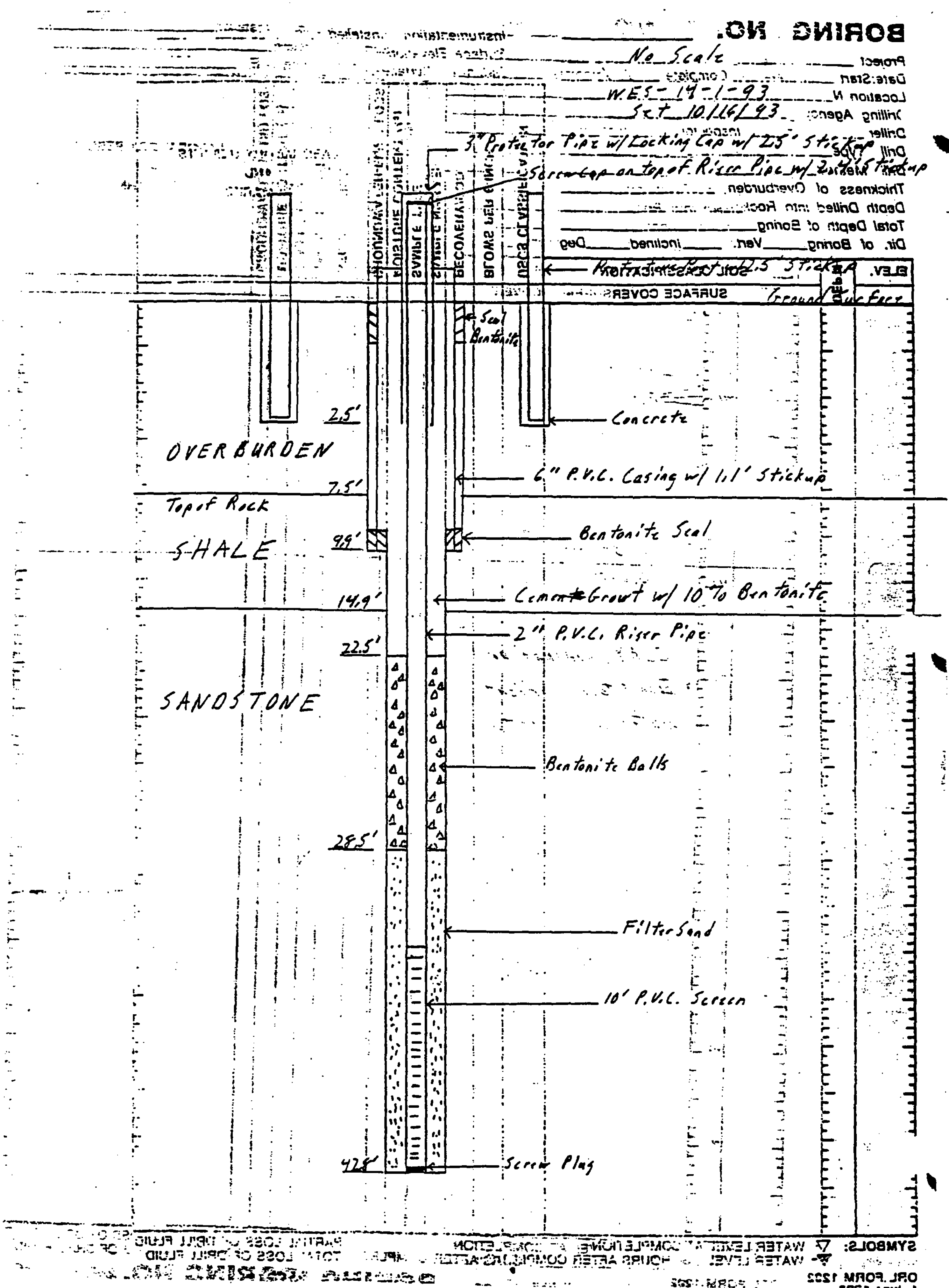
Project	Instrumentation Installed
Date:Start / / Complete / /	Surface Elevation
Location N E	Datum for Surface El.
Drilling Agency	
Driller Inspector	
Drill Type	
Drill Method	
Thickness of Overburden	
Depth Drilled into Rock	
Total Depth of Boring	
Dir. of Boring Vert. Inclined Deg	

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
Sandstone	40	iron stain; iron stain; B.P.; 41 B.P.; Mech.; Lt gray streaks; 42 B/P; B/P; B/F; Lt Gra, Streaks				Box 3	HQ Core			
	43	B.O.H.								
	44–50	CLAY Laminae and Iron Stains indicate water movement.								

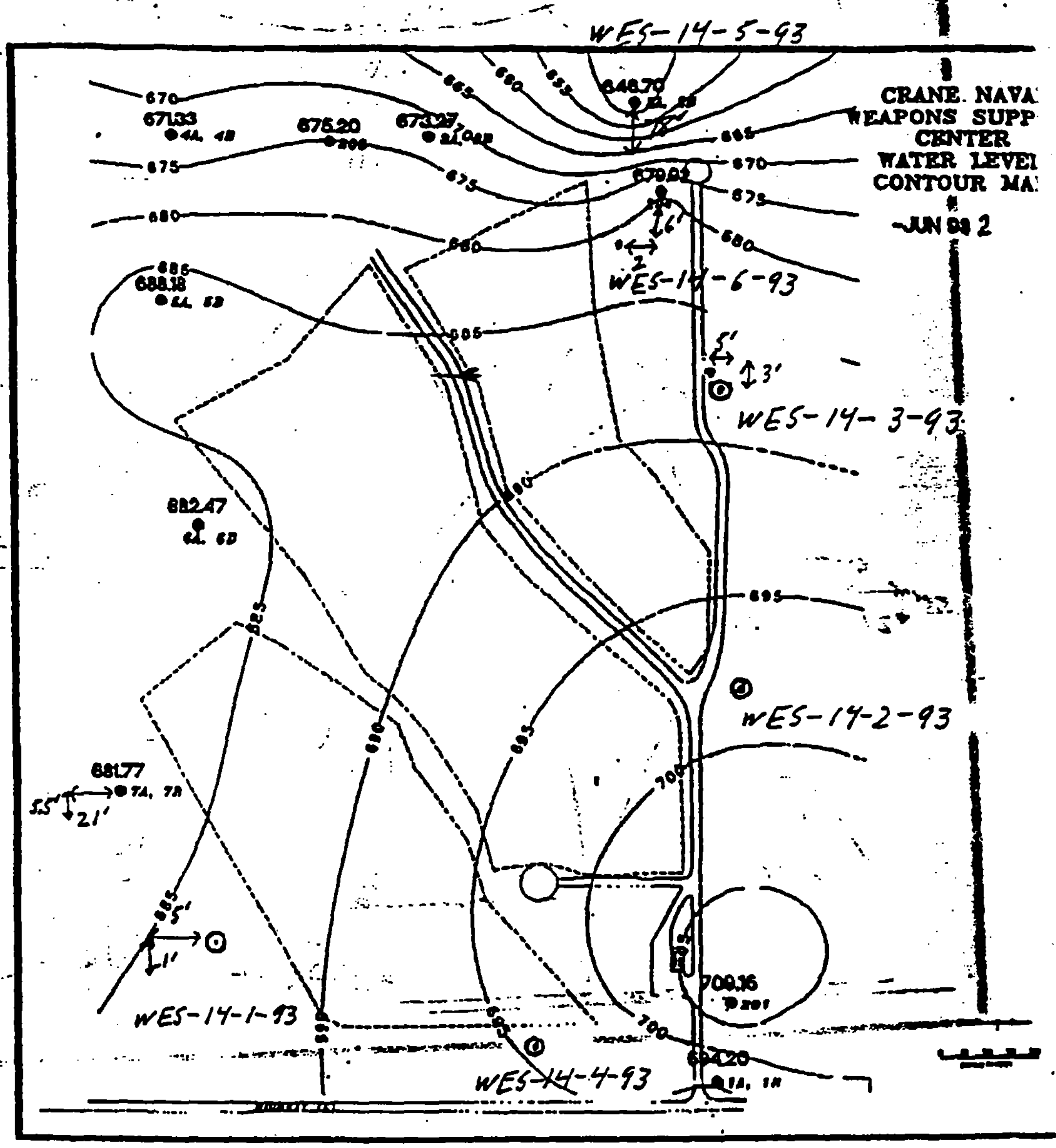
SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
>- PARTIAL LOSS OF DRILL FL[UID]
>>- TOTAL LOSS OF DRILL FLU[ID]

ORL FORM 1202

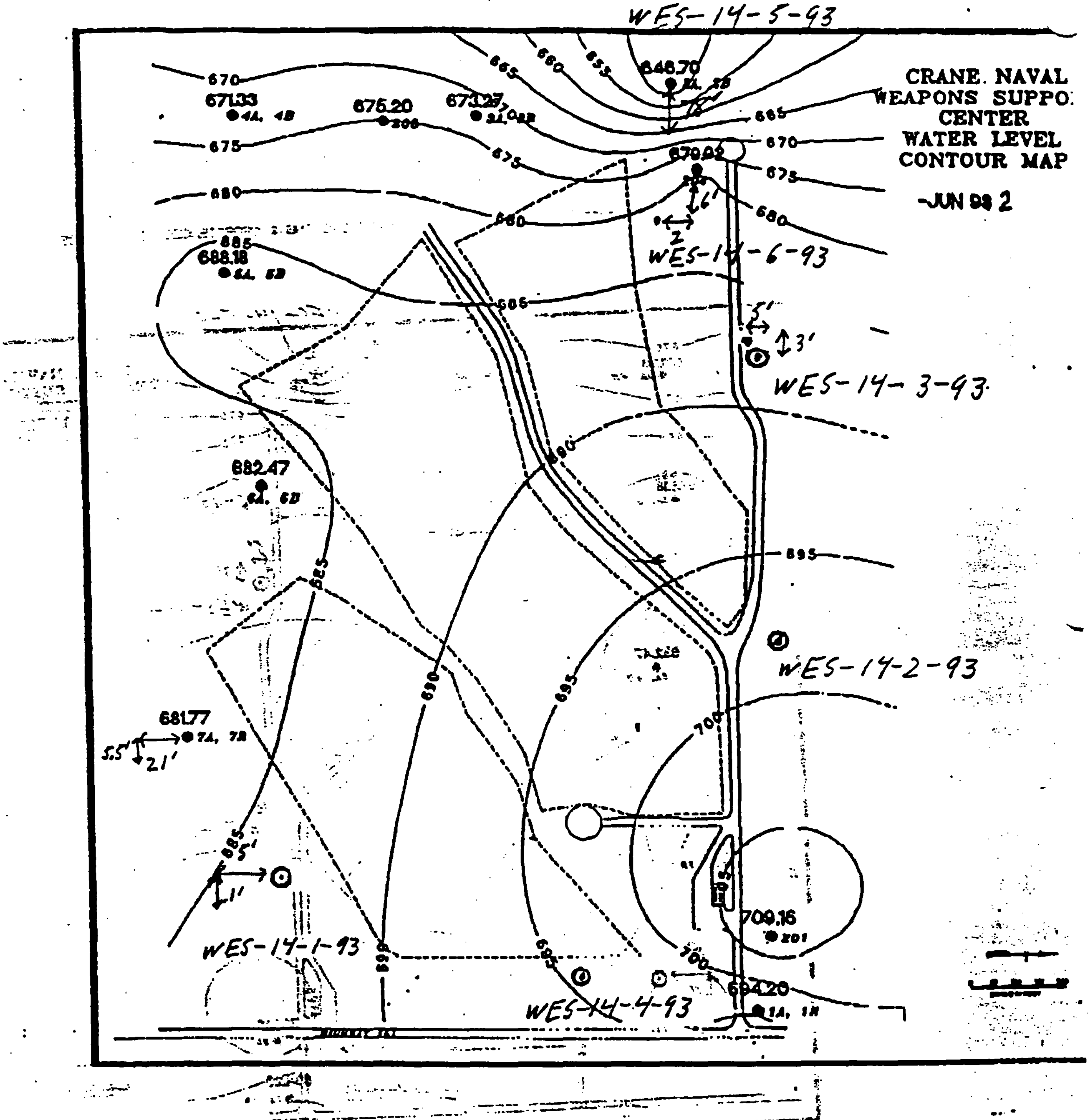
BORING NO. WES-14-1-



BORING NO.
Project
No Scale
Date:Start
Complete
Location N
WES-14-1-93
Drilling Agency
Set 10 ¼ 93
Driller
Drill Type
Dia. Material
3" Protector Pipe w/ Locking Cap w/ 2.5' Stickup
Screw Cap on top of Riser Pipe w/ 2.4' Stickup
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg
ELEV.
SOIL CLASSIFICATION
SURFACE COVERS
Protective Post w/ 2.5' Stickup
Ground Surface
Seal Bentonite
2.5'
Concrete
OVERBURDEN
7.5'
6" P.V.C. Casing w/ 1.1' Stickup
Top of Rock
SHALE
9.9'
Bentonite Seal
14.9'
Cement Grout w/ 10% Bentonite
22.5'
2" P.V.C. Riser Pipe
SANDSTONE
Bentonite Balls
28.5'
Filter Sand
10' P.V.C. Screen
42.8'
Screw Plug
SYMBOLS: WATER LEVEL AT COMPLETION
WATER LEVEL HOURS AFTER COMPLETION
PARTIAL LOSS OF DRILL FLUID
TOTAL LOSS OF DRILL FLUID
DRL FORM 1222



LOCATION OF PROPOSED MONITORING WELLS ⊙



LOCATION OF PROPOSED MONITORING WELLS ⊙

BORING NO. WES-14-2-93

Project Lone Monitoring Wells, Land Fill
Date:Start / / Complete / /
Location N ____ E ____
Drilling Agency ____
Driller ____ Inspector ____
Drill Type ____
Drill Method ____
Thickness of Overburden ____
Depth Drilled into Rock ____
Total Depth of Boring ____
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ____
Surface Elevation ____
Datum for Surface El. ____

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	10	Start HQ Core								Washed with core barrel from 10' to 10.7'.
SHALE (CLAY)	11–13	SHALE (11); Severely Weathered SHALE (CLAY); 12 Mech; Core Loss 0.1			96%/0.92	Box 1	HQ Core			Run 1 Cored 2.4' Rec 2.3 Loss 0.1' Time 9:15 - 9:30
	13–17	SHALE; Mech; Mech; Mech; Mech; Mech; Mech. SHALE (CLAY), Reddish Brown to Brownish Yellow, Severely Weathered, Very Soft to Soft, Thin Bedded w/ Occ Thin Beds of Shale and Sandstone. 16 Red Sandstone, Soft. (10.7 - 17.0)			94%/0.90					Run 2 Cored 10.0 Rec 9.4' Loss 0.6' Time 9:45 - 10:20
SHALE	17–20	B/P; B/P; Core Loss 0.1; Mech. SHALE, Tan, Light Gray, to Reddish Brown, Moderate Weathered, Soft, Thin Bedded w/ Occ Thin Bedded Soft Sandstone and Sandy CLAY and SANDY Shale. Ss Reddish Brown to Light Brown; B/P; Ss Reddish Brown to Light Brown; Joint 60° Iron deposit on Joint; Ss Reddish Brown to Light Brown								Key: B/P = Bedding Plane; Mech = Mechanical Break; ss = Sandstone; SH = Shale; Lt = Light; Jt = Joint

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-2-93

BORING NO. WES-14-2-93

Instrumentation Installed
Surface Elevation
Datum for Surface El.

Project Crane Monitoring Wells, Land Fill
Date: Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled Into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	20	B/P				Box 1	HQ Core			
		Sandy CLAY								
	21	Core Loss 0.5'								
		Sandy Shale								
Shale	22	Mech Reddish Brown to Tan				Box 2				
		B/P open								
	23	Sandstone Red Soft								Run 3 Cored 9.8' Rec 9.4' Loss 0.4'
		CLAY 0.02								
	24	Sandstone, Light Gray to Red ironstain								Time 10:45 - 11:40
		Sandstone Red; B/P Open								
		CLAY Laminae 0.01								
	25	60° Jt w/ Clay and iron deposit								
		Core Loss 0.4'								
Sandstone		Ss Light Gray, w/ occ Ironstain								Sandy Shale deposits are gradational features from shale to sandstone
	26	SH; SH 0.01'			96% / 0.83					
		Ss Lt Gray								
	27	Sandy SH								Bailed dry produce No water in an 2 hour period.
		SS								
		SH; SS; SH								
	28	SS								
		B/P								
		B/P								
	29	B/P Sandy SH								
		B/P SS								
		Sandy SH								
		SH								
	30	SS B/P								

SANDSTONE, Light Gray, Moderate Weathered, Soft, Fine Grain, Thin Bedded, w/ occ Light Gray, Shale and Sandy Shale

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>>> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-Z-93

Project: Crane Monitoring Wells Landfill
Date: Start / / Complete / /
Location N _____ E _____
Drilling Agency _____
Driller _____ Inspector _____
Drill Type _____
Drill Method _____
Thickness of Overburden _____
Depth Drilled into Rock _____
Total Depth of Boring _____
Dir. of Boring _____ Vert. _____ Inclined _____ Deg

Instrumentation Installed _____
Surface Elevation _____
Datum for Surface El. _____

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Shale	30	SS; Sandy SH					HQ Core			
	31	B/P; B/P; Mech; B/P; B/P; SS				Box 2				
	32	B/P; Very Sandy SH; B/P								
	33	B/P; SS Lt. Gray			96% / 0.90	Box 3				Run 4 Cored 9.9' Rec 9.5 Loss 0.4' Time 14:00 - 14:50
	34	SHALE, Light Gray, Soft, Moderate Weathered, Thin Bedded w/ Occ Light Gray, Thin Bedded Sandstone and Sandy Shale								
	35	SS Lt Gray; Sandy Shale Lt Gray; SS Lt Gray								Bailed Dry 10/18/93 Checked 9:00 10/19/93 Boring dry
	36	Sandy Shale; Mech; Mech; SS Whitish Gray w/ Black Bands; B/P								
	37	SH w/ SS Laminae								
Sandstone	38	B/P; SS Red; CLAY 0.03'								
	39	B/P CLAY; CLAY; B/P; Red; B/P								
	40									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION; ▼ WATER LEVEL ____ HOURS AFTER COMPLETION; > - PARTIAL LOSS OF DRILL FLUID; >> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-2-93

Project	Crane Monitoring Wells, Landfill
Date:Start	1-1
Complete	1-1
Location N	
E	
Drilling Agency	
Driller	
Inspector	
Drill Type	
Drill Method	
Thickness of Overburden	
Depth Drilled into Rock	
Total Depth of Boring	
Dir. of Boring	Vert. Inclined Deg
Instrumentation Installed	
Surface Elevation	
Datum for Surface El.	

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Sandstone	40	Mech					HQ Core			
	41	Loss 0.2'								
		Organic Laminae Black								
	42	Numerous Organic Laminae Black								
		B/P				Box 3				
		B/P iron stain								
	43									Run 5 Cored 9.9' Rec 9.7' Loss 0.2'
		B/P								
	44	Mech								Time 8:10 - 8:40
		Mech								
		Broken Mech				Box 4				
		iron stained Vugs								20% Water Loss
	45									
		Fracture								
	46	SANDSTONE, Light Brown, Light Gray, and Yellow Stain w/ Iron Stain, Soft, Fine Grain, Friable, Thin to Medium Bedded, w/ Occ Light Gray Thin Bedded SHALE, Also with Thin Coal Beds and CLAY Laminae			98%/0.87					
	47									
		B/P								
	48									
		B/P								
		B/P								
	49	B/P								
		B/P								
	50									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION >> PARTIAL LOSS OF DRILL FL[UID] >> TOTAL LOSS OF DRILL FLU[ID]

BORING NO. WES-14-2-93

Project Crane Monitoring Wells Landfill

Date:Start / / Complete / /

Location N________ E________

Drilling Agency________

Driller________ Inspector________

Drill Type________

Drill Method________

Thickness of Overburden________

Depth Drilled into Rock________

Total Depth of Boring________

Dir. of Boring____Vert. ____Inclined____Deg

Instrumentation Installed________

Surface Elevation________

Datum for Surface El.________

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
Sandstone	50						HQ Core			
		B/P								
	51	B/P								
		Red Iron Stain								
		B/P CLAY								
		Core Loss 0.2'								
	52	Numerous Coal Laminae								
		B/P								
		Iron Stain								
	53	B/P								Run 6 Cored 10.1' Rec 10.1 Loss 0.0
		Coal Laminae 0.01'				Box 4				
		B/P								
		CLAY 0.01'								
		B/P								
	54	Coal 0.01'								Time 9:40 - 10:35
		B/P								
		mech								
	55	mech								
		mech								
	56	Red Stain				Box 5				
		B/P								
		B/P								
	57				100% / 0.90					
		B/P								
	58	Coal Fragments								
		B/P								
		mech								
	59	mech								
		Red								
	60	mech								

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ____ HOURS AFTER COMPLETION

> - PARTIAL LOSS OF DRILL F
>> - TOTAL LOSS OF DRILL F

ORL FORM 1202

7

BORING NO. WES-14-

BORING NO. WES-14-2-93

Instrumentation Installed
Surface Elevation
Datum for Surface El.

Project Crane Monitoring Wells Landfill
Date: Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	60					Box 5	HQ Core			
		Mech								
		Coal Laminae w/ Iron Stain								
		B/P								
	61	SHALE Light Gray								
		Sandstone w/ SHALE								
		SH Laminae 0.01 to 0.07'								
	62	Mech								
		Iron Stain w/ Coal 0.03 to 0.05'								
		SHALE Lt Gray								
		Jt 40° w/ CLAY along plane								
	63	B.O.H.								
	64									
	65									
	66									
	67									
	68									
	69									
	70									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION >- PARTIAL LOSS OF DRILL FLUID >>- TOTAL LOSS OF DRILL FLUID

BORING NO.

Project: No Scale

Date: Start _____ Complete _____

Location: WES = 14-2-93

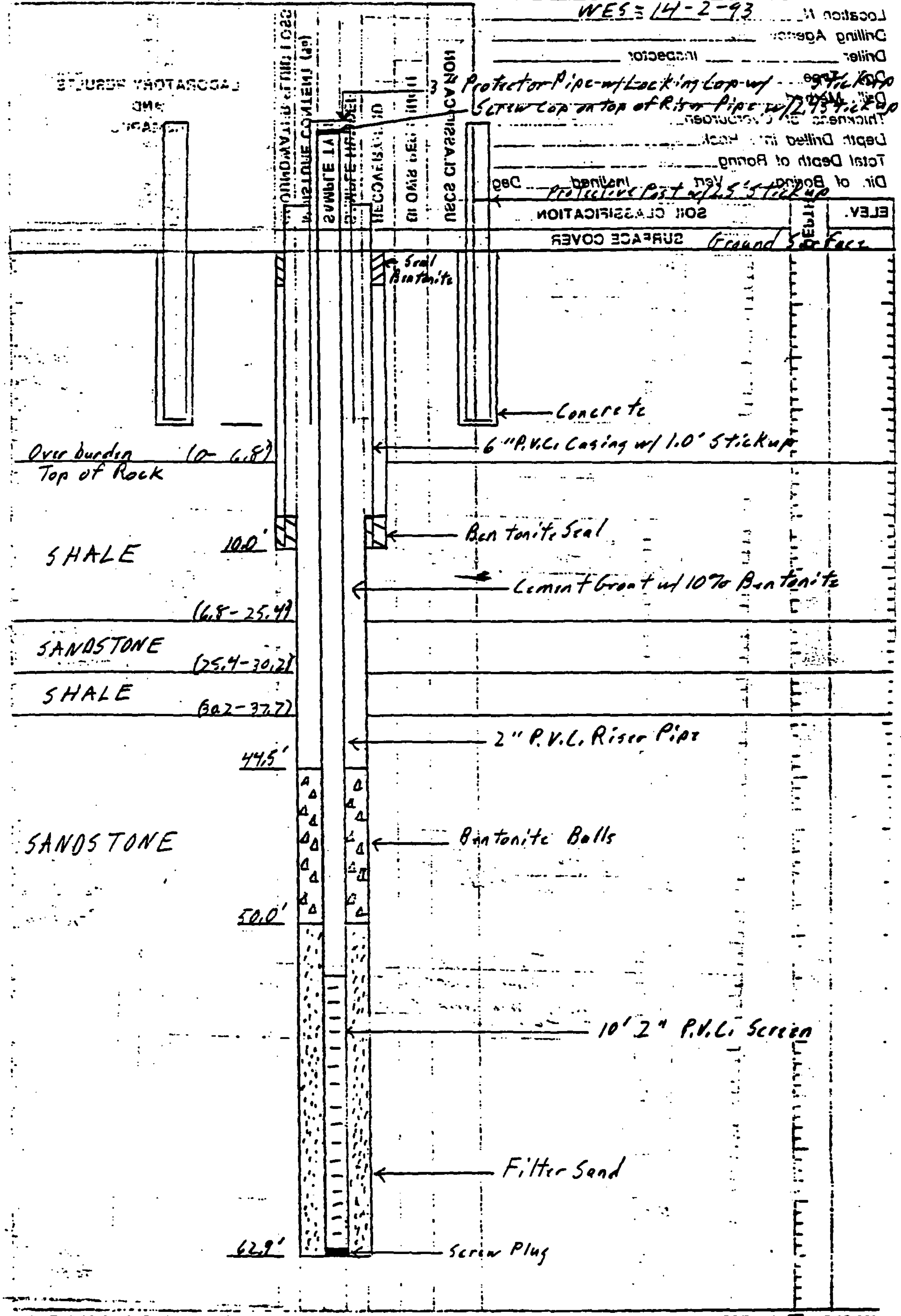
Drilling Agency: _____

Driller: _____ Inspector: _____

Instrumentation Installed: _____

Surface Elevation: _____

Datum for Surface Elev.: _____



SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION

PARTIAL LOSS OF DRILL FLUID
TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-2-93

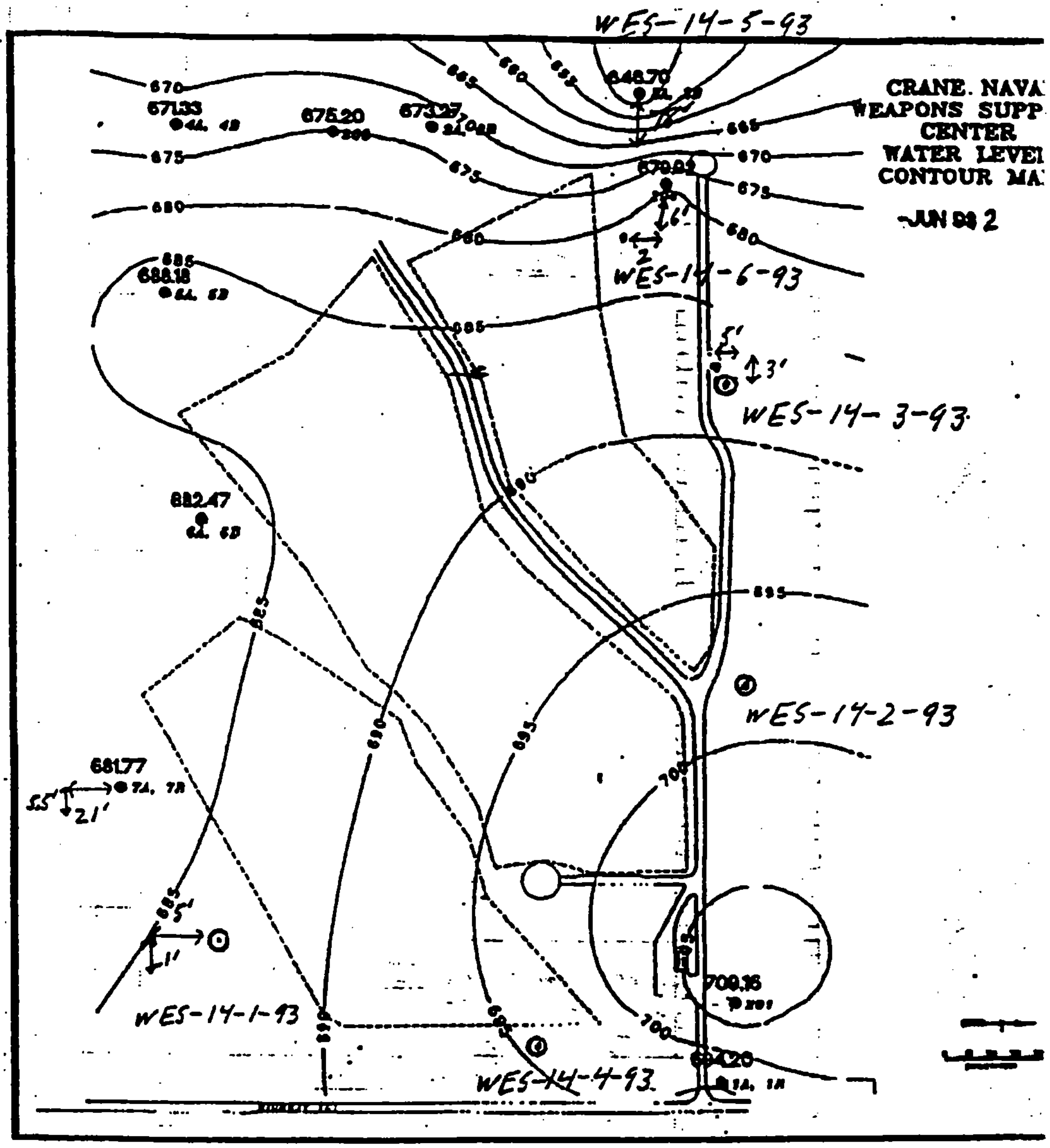
Project: Groundwater Monitoring Well - Landfill
Date: Start 10/16/93 Complete 10/ /93
Location N: See Attached E: Sheet
Drilling Agency: U.S.A.C.E. W.E.S.
Driller: Brown Inspector: Parsons
Drill Type: Failing Holemaster
Drill Method: 3" Shelby, 3" Splitspoon, HQ
Thickness of Overburden: 6.8'
Depth Drilled into Rock: 56.1'
Total Depth of Boring: 62.9'
Dir. of Boring: X Vert. ____ Inclined ____ Deg

Instrumentation Installed: Yes
Surface Elevation:
Datum for Surface El.:

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	0.0–1.6	Dark Brown to Light Brown, SILTY CLAY, Moist, Med Stiff (0.0-1.6)	CL		2.3	1	3" Shelby 1			3" Shelby Tube Push Sec Depth Pressure Rec 1 20 0-2.5 500 2.3 2 50 2.5-3.5 1000 0.8
	1.6–2.5	Reddish Brown to Light Gray, SILTY CLAY w/ SILT Laminae, Moist, Med Stiff (1.6-2.5)	CL		–	2				
	2.5–3.5	Reddish Brown to Light Gray, SILTY CLAY w/ SILT Laminae, Dry, V. Stiff	CL		0.8	3	3" Shelby 2			
	3.5–5.5	(2.5-5.5)	CL	7 / 5 / 12 / 13	2.0	4	3" Splitspoon			3" Splitspoon, 30.. Hammer, 76" Drop
	5.5–7.0	Reddish Brown to Light Gray, SILTY CLAY w/ Rock Frags, Dry, Very Stiff Top of Rock	CL	8 / 9 / 8	1.7	5	3" Splitspoon			Set 6" P.V.C. Casing to 10' with 1.0' Stickup
	7.0–7.5	Reddish Brown to Light Gray, Severely Weathered SHALE, SILTY CLAY, Dry, Very Stiff		13		6				
	7.5–9.5			8 / 10 / 42 / 30	1.5	7	3" Splitspoon			
	9.5–10.0									Cleanout from 9.5 to 10' to set Casing.

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLU[ID]
>> - TOTAL LOSS OF DRILL FLUI[D]

ORL FORM 1202



LOCATION OF PROPOSED MONITORING WELLS ⊙

BORING NO. NE[illegible]-19-[illegible]-93

Project	[illegible] Landfill
Date: Start	10/21/93
Complete	10/21/93
Location N	[illegible]
E	[illegible]
Drilling Agency	[illegible]
Driller	Brown
Inspector	[illegible]
Drill Type	Failing Holemaster
Drill Method	3" Shelby, 3" Drive Tube, HQ Core
Thickness of Overburden	7.8'
Depth Drilled into Rock	34.9'
Total Depth of Boring	42.7'
Dir. of Boring	X Vert. ___ Inclined ___ Deg
Instrumentation Installed	Yes
Surface Elevation	
Datum for Surface El.	

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	0.0	Light Brown, SILTY CLAY, w Roots, Moist, Medium Stiff (0.0-1.9)	CL		2.5	1	3" Shelby 1			3" Shelby Tube
	2.0	Reddish Brown to Light Gray, SILTY CLAY, Dry, Very Stiff to Hard (1.9-7.0)	CL		1.3	2, 3	3" Shelby 2			
	4.5				2.5	4	3" Shelby 3			Set 6" P.V.C. Casing to a depth of 11.3' w/ 1.05 stickup
	7.0	Light Brown to Tan, SILTY CLAY, Dry, Very Stiff; Top of Rock (7.0-7.8)	CL		1.0	5, 6	3" Shelby 4			
SHALE	8.0	Light Brown to Tan, SHALE, (SILTY CLAY) Severely Weathered, Soft, w/ Occ'l Fine Sand Laminae.		10, 44		7	3" Drive			3" Splitspoon 300 lb Hammer 46" Drop
	9.0			8, 10, 45		8	3" Drive			

Push	Sec	Depth	Pressure	Rec
1	40	0.0-2.5	600	2.5
2	60	2.5-4.3	600	1.3
3	50	4.3-6.8	600	2.5
4	66	6.8-7.8	500	

Key
B/P = Bedding Plane
Mech. = Mechanical Break
Lt = Light

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL F[LUID]
>> - TOTAL LOSS OF DRILL FLU[ID]

ORL FORM 1202

BORING NO. NE[illegible]-19-3

BORING NO. NES-14-3-93

Project Clear Monitoring Wells Landfill

Date: Start / / Complete / /

Location N ______ E ______

Drilling Agency ______

Driller ______ Inspector ______

Drill Type ______

Drill Method ______

Thickness of Overburden ______

Depth Drilled into Rock ______

Total Depth of Boring ______

Dir. of Boring ______ Vert. ______ Inclined ______ Deg

Instrumentation Installed ______

Surface Elevation ______

Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	10.0	7.8-10.8		40						Cleaned out boring for Casing to 11.3
	11	Start HQ Core								
Sandstone	12, 13	B/P Iron Stain; B/P; Broken w/ Iron Stain; Core Loss 0.3'; Broken; Red Iron; B/P; B/P; B/P — Red	←		83%/ 0.17	Box 1	HQ Core			Run 1 Cored 1.8' Rec 1.5 Loss 0.3' Time 3:00-3:20 20% Drill Water Loss
	14, 15	B/P Iron Soft w/ Sand; Core Loss 1.1; SANDSTONE, Light Gray, Red to Reddish Brown, Soft, Friable, Fine Grain; SandStone w/ Coal Lt Gray Shale; Coal 0.05' (11.3 - 15.0); Shale								Run 2 Cored 9.5 Rec 6.8 Loss 2.7 Time 3:40- 4:25 20% Drill Water Loss
	16, 17, 18	B/P w/ Iron Stain; B/P Solutioning; B/P; Mech; B/P; B/P; SANDSTONE, Light Gray, Soft, Friable, Fine Grain. Slightly Weathered, Thin to Medium Bedded w/ Thin Beds of Soft Shale			72%/ 0.35					
	19, 20	B/P w/ Iron Stain (15.0-18.8'); B/P; Yellow; B/P CLAY Laminae; Shale; CLAY Laminae; Very Porous; CLAY Laminae								

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION

> - PARTIAL LOSS OF DRILL FLU
>> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-3-93

Instrumentation Installed
Surface Elevation
Datum for Surface El.

Project
Date:Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	20	B/P								
		B/P								
		B/P Iron Stain				Box 1				
Sandstone	21	Core Loss 1.6'								21' to 22' Fall In
	22									
		Iron Sandstone Deposit								Run 3 Cored 6.9' Rec 6.7' Loss 0.2' Time 8:00 to 8:4
	23	Core Loss 0.2'				Box 2				
	24	B/P CLAY								
	25	B/P CLAY								
		B/P CLAY								
	26	Red								
		CLAY 0.03'			97% / 0.77					
		B/P Broken 0.05'								
	27	CLAY B/P								
		B/P Broken								
		Broken CLAY								
	28	CLAY B/P								
		Broken								
		B/P								Vertical Fracture 28.5 to 29.2'
	29	Broken w/ CLAY								
		B/P								
	30	Core Loss 0.5								Run 4 Cored 3.1' Rec 2.3' Loss 0.8

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL F
>> - TOTAL LOSS OF DRILL F

ORL FORM 1202

BORING NO. WES-14-3

BORING NO. WES-14-3-93

Instrumentation Installed
Surface Elevation
Datum for Surface El.

Project
Date:Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
Sandstone	30	Loss 0.1'; Loss 0.2'; B/P; CLAY B/P Broken								Iron Stain along Bedding Planes, 30 to 34'
	31	B/P; Fracture; B/P; CLAY B/P; B/P				Box 2				20% Water Loss Time 8:55-9:10
	32	B/P W/CLAY; Core Loss 0.2'; Broken; Iron								Run 5 Cored 10.1 Rec 9.9 Loss 0.2
	33	Mech; Iron Stain								Time 9:25-10:10
	34	Mech; Iron Stain; B/P				Box 3				No Water Loss. Could not bail boring dry. Bailed for 30 minutes.
	35	B/P W/CLAY; B/P								Water rose to within 13 ft of surface in 2 hours.
	36	JT 60° W CLAY; Shale; Core Loss 0.2"; B/P			98% / 0.70					
	37	B/P; Mech								
	38	B/P; B/P								
	39	B/P								
	40	CLAY B/P								

SANDSTONE, Reddish Brown to Light Brown with Red Iron Stain, Soft, Slightly Weathered, Fine Grain, Friable, Thin to Medium Bedded, W/ Occ CLAY along Bedding Plane and CLAY Lined Joint and Iron Sandstone Deposit

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
<> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-?-93

Project ______
Date:Start __/__/__ Complete __/__/__
Location N______ E______
Drilling Agency______
Driller ______ Inspector ______
Drill Type______
Drill Method______
Thickness of Overburden______
Depth Drilled into Rock______
Total Depth of Boring______
Dir. of Boring____Vert. ____Inclined____Deg

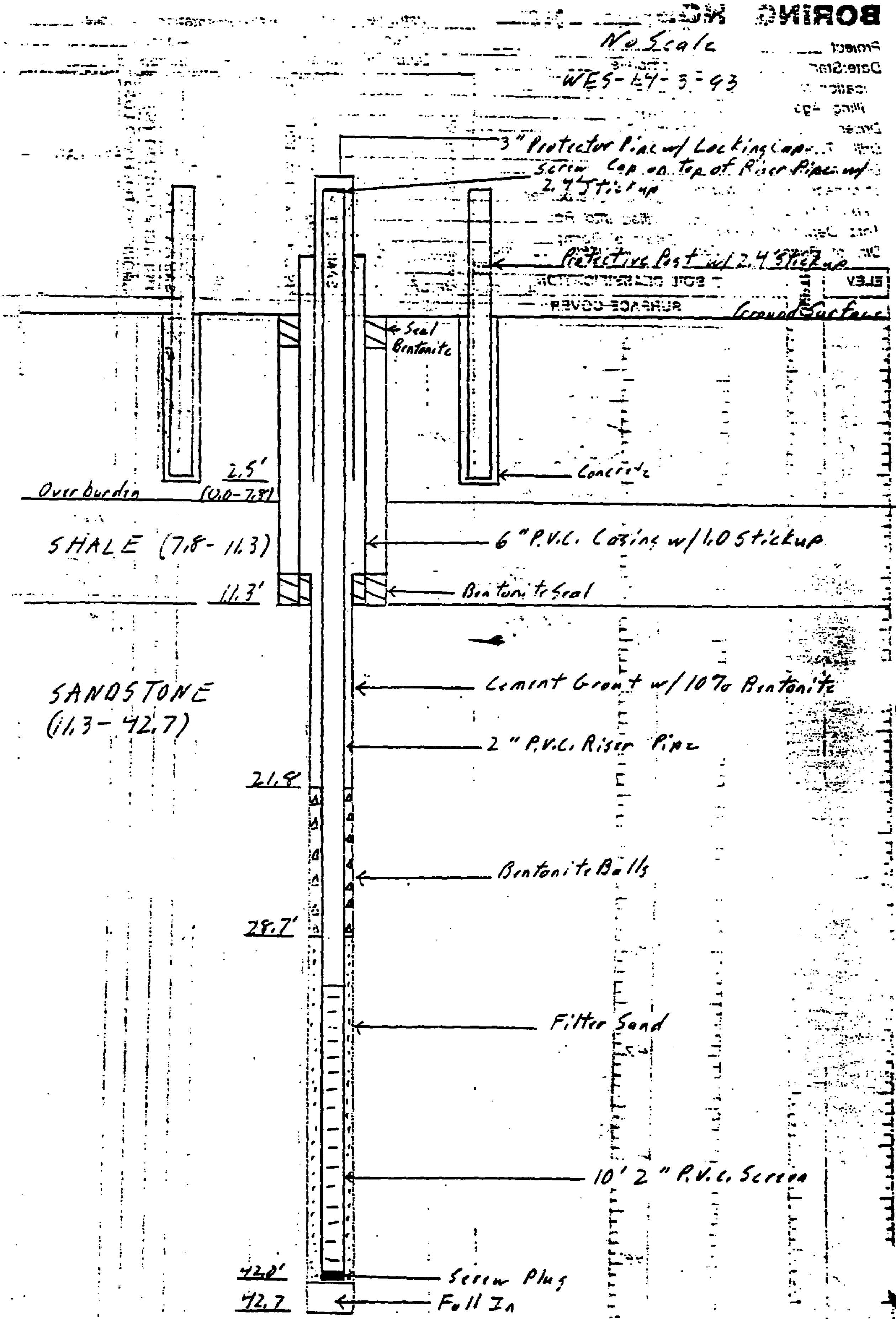
Instrumentation Installed______
Surface Elevation______
Datum for Surface El.______

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Sandstone	40	B:P; B/P; B/P				Box 3	HQ core			
	41	05.0-41.0 SANDSTONE, Reddish Brown, w/ Black Mica Soft, Friable, Fine Grain, Thin Bedded; B/P; B/P; B/P; B/P								
	42	41.0-42.0 SANDSTONE, Grayish White, Calcareous, w/ Mica, V. Fine Grain, Moderate Hard 42.0-42.7; Mech								Boring drilled to 42.7' Fallin occurred after removing HQ wireline string. Set Instrument at 42.0'.
	43	B.O.H.								
	44									
	45									
	46									
	47									
	48									
	49									
	50									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION

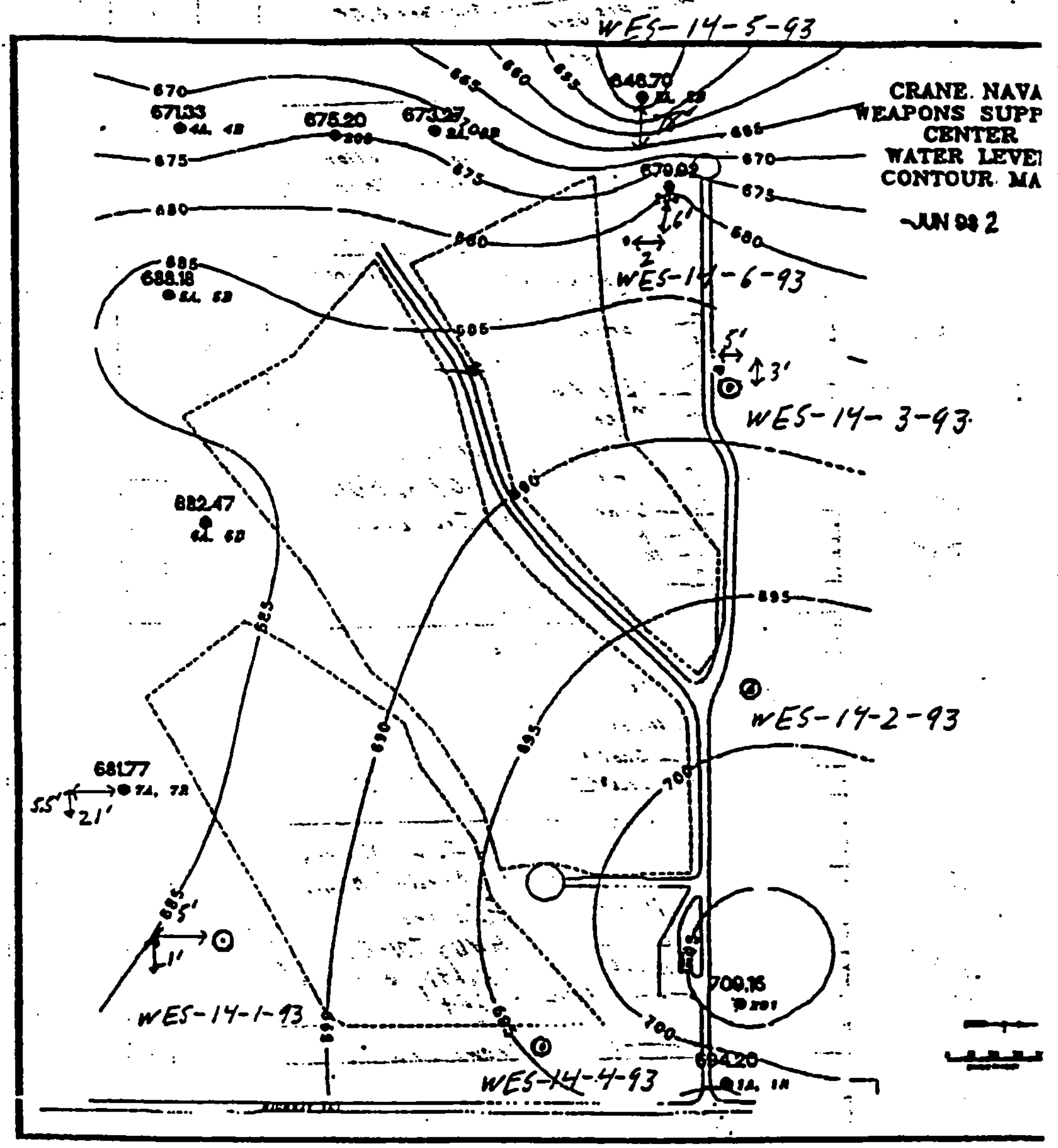
> - PARTIAL LOSS OF DRILL F
>> - TOTAL LOSS OF DRILL F

ORL FORM 1202



No Scale
WES-E4-3-93
3" Protector Pipe w/ Locking Cap
Screw Cap on top of Riser Pipe w/ 2.4' Stickup
Protective Post w/ 2.4' Stickup
Ground Surface
Seal Bentonite
2.5'
Overburden (0.0-7.8)
Concrete
SHALE (7.8-11.3)
6" P.V.C. Casing w/ 1.0 Stickup
11.3'
Bentonite Seal
SANDSTONE (11.3-42.7)
Cement Grout w/ 10% Bentonite
2" P.V.C. Riser Pipe
21.8
Bentonite Balls
28.7'
Filter Sand
10' 2" P.V.C. Screen
42.0'
Screw Plug
42.7
Fall In

10/13/93 15:12 EQUAKE ENGRING & GEOSCIENCES DIV 005



LOCATION OF PROPOSED MONITORING WELLS ⊙

BORING NO. WES-14-4-93

Project ______
Date: Start / / Complete / /
Location N ______ E ______
Drilling Agency ______
Driller ______ Inspector ______
Drill Type ______
Drill Method ______
Thickness of Overburden ______
Depth Drilled into Rock ______
Total Depth of Boring ______
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ______
Surface Elevation ______
Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								

- Shale (elev. 10–14.7): depth 10 to 14.7
  - 10 — Shale w/ Clay Laminae 0.04'
  - B/P Open — Sandstone 0.05'
  - B/P Open
  - B/P Open
  - 11 — Clay; Broken
  - CLAY 0.03'
  - Mech
  - 12 — Mech
  - Broken w/ CLAY Laminae
  - Mech
  - Broken
  - 13 — B/P Open
  - Mech
  - Sandstone w/ Shale Laminae 0.01' to 0.04'
  - 14 — Sandstone w/ Iron Lined Vugs
  - B/P Open
  - Mech
  - CLAY 0.03'
  - Broken Red Shale (9.7 – 14.7')
  - Description: SHALE, Reddish Brown to Yellow, Moderately Weathered, Soft, w/ Occ CLAY and Sandstone
  - Sample type: HX Core
  - Recovery/RQD: 100%/0.70
  - Remarks: Run 2 Cored 1.0' Rec 1.0 Loss 0.0 Time 10:20 – 10:40
- Shale (elev. 14.7–17.7): depth 14.7 to 17.7
  - 15 — Red Sandstone
  - Mech
  - Mech
  - Broken
  - Sandstone — Coal 0.02'
  - 16 — Mech
  - Mech
  - 17 — Coal 0.01'
  - Mech
  - Broken
  - B/P
  - Reddish Brown Shale
  - Description: SHALE, Light Gray w/ occ Reddish Brown SHALE and SANDSTONE, Slightly Weathered, Soft
  - Sample type: HQ Core
  - Recovery/RQD: 80%/0.51
  - Remarks: Start HQ Core. Run 3 Cored 10.0 Rec 8.0 Loss 2.0' Time 11:20 – 11:55
- Sandstone (elev. 17.7–20): depth 17.7 to 20
  - 18 — B/P Open
  - B/P w/ CLAY
  - B/P
  - B/P w/ Iron
  - 19 — B/P w/ CLAY
  - B/P
  - B/P
  - 20 — B/P

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-4-93

Project Crane Monitoring Well, Landfill
Date:Start / / Complete / /
Location N ___ E ___
Drilling Agency ___
Driller ___ Inspector ___
Drill Type ___
Drill Method ___
Thickness of Overburden ___
Depth Drilled into Rock ___
Total Depth of Boring ___
Dir. of Boring ___ Vert. ___ Inclined ___ Deg

Instrumentation Installed ___
Surface Elevation ___
Datum for Surface El. ___

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Sandstone	20–23	B/P; Broken; Core Loss 2.0'; SANDSTONE, Reddish Brown To Light Brown, Slightly Weathered, Fine Grain, Friable, Soft, Thin Bedded.; B/P				Box 2	HQ Core			Coal Fragments in drill cuttings in core loss area.
	23	B/P w/ Iron Deposit; Siltstone; B/P Open Iron Deposit	←							Run 4 Cored 10.0' Rec 10.0 Loss 0.0 Time 12:10 - 12:50
Shale	23–30	Red Shale; Mech; Sandstone Laminae 0.02'; SS 0.05'; SS 0.03'; SS 0.05' w/ Coal Laminae; Coal Laminae; SS; SS; SS 0.05'; SS; SS; Coal 0.01'; Mech; SS w/ Coal Laminae; SS; B/P; B/P; Shale w/ Sandstone Laminae 0.01 to 0.04'; B/P; Mech; SHALE, Light Gray to Dark Gray, Slightly Weathered, Soft, Thin Bedded w/ Laminae and Thin Beds of Lt Gray Sandstone and Coal; B/P Open; Mech; B/P Open; SS; SS; SS 0.03'; Mech; Coal 0.01'; B/P; SS 0.05'; SS 0.04'; B/P; SS 0.06'			100%/0.89					

SYMBOLS: ▽ - WATER LEVEL AT COMPLETION
▼ - WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL F[LUID]
>> - TOTAL LOSS OF DRILL FLU[ID]

BORING NO. WES-14-4-93

Project Great Monitoring Wells, Landfill
Date:Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

Instrumentation Installed
Surface Elevation
Datum for Surface El.

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	30	Shale w/ Sandstone Laminae 0.01 to 0.05'				Box 2				
		Mech w/ Coal Laminae Less than 0.01'								
	31	Mech								
		Mech				Box 3				
	32	Mech								Bailed dry and water rose to 21 Ft of surface in 45 minutes
		Mech								
		Sandstone w/ Shale Laminae 0.01 to 0.05 and Coal Less than 0.01'								
		B.O.H.								
	33									
	34									
	35									
	36									
	37									
	38									
	39									
	40									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> PARTIAL LOSS OF DRILL FLUID
>> TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-4-93

BORING NO.

Project No Scale

Date Start ... Completed

Location N. WES-84-4-93

Drilling Agency

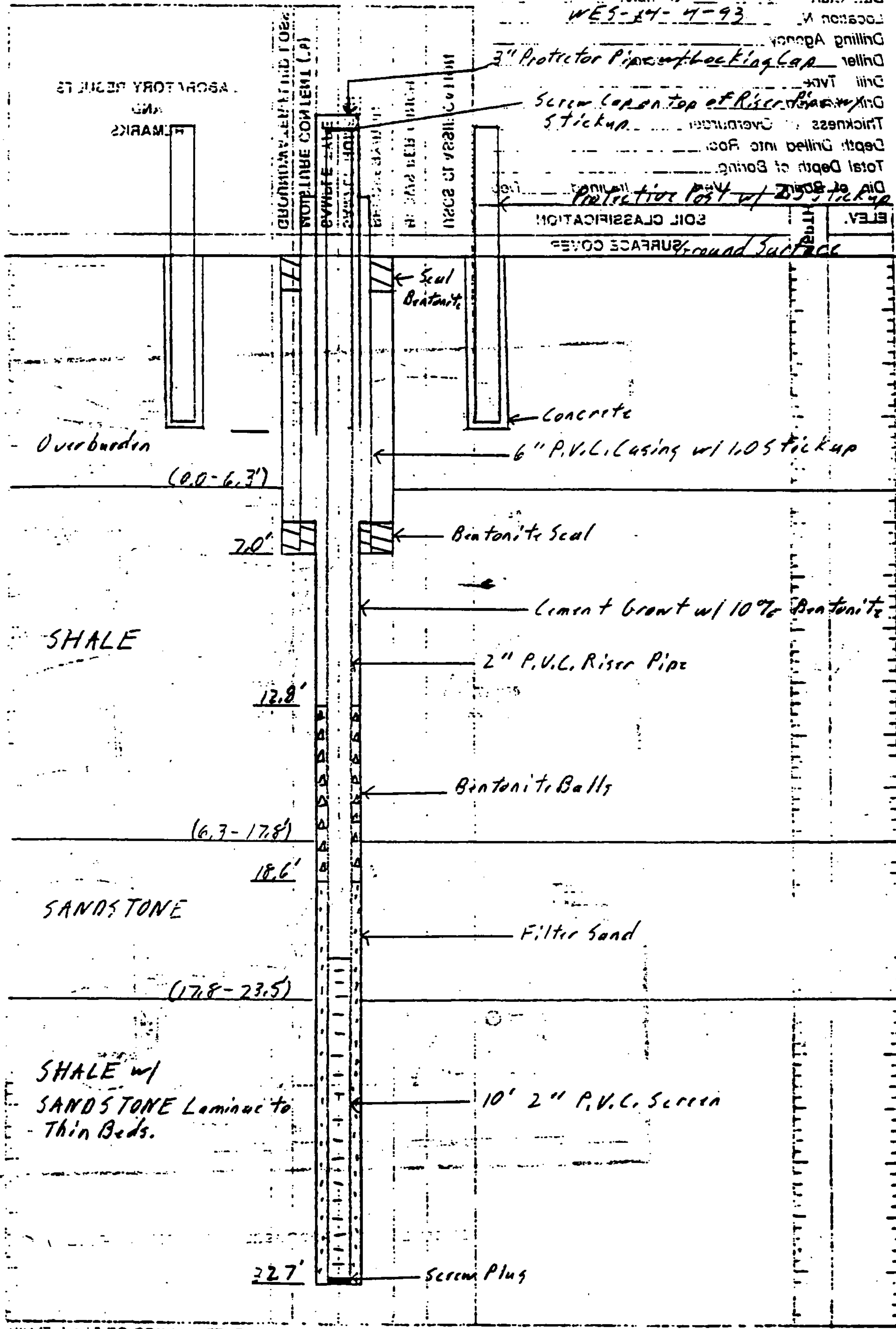
Driller

Drill Type

Thickness of Overburden

Depth Drilled into Rock

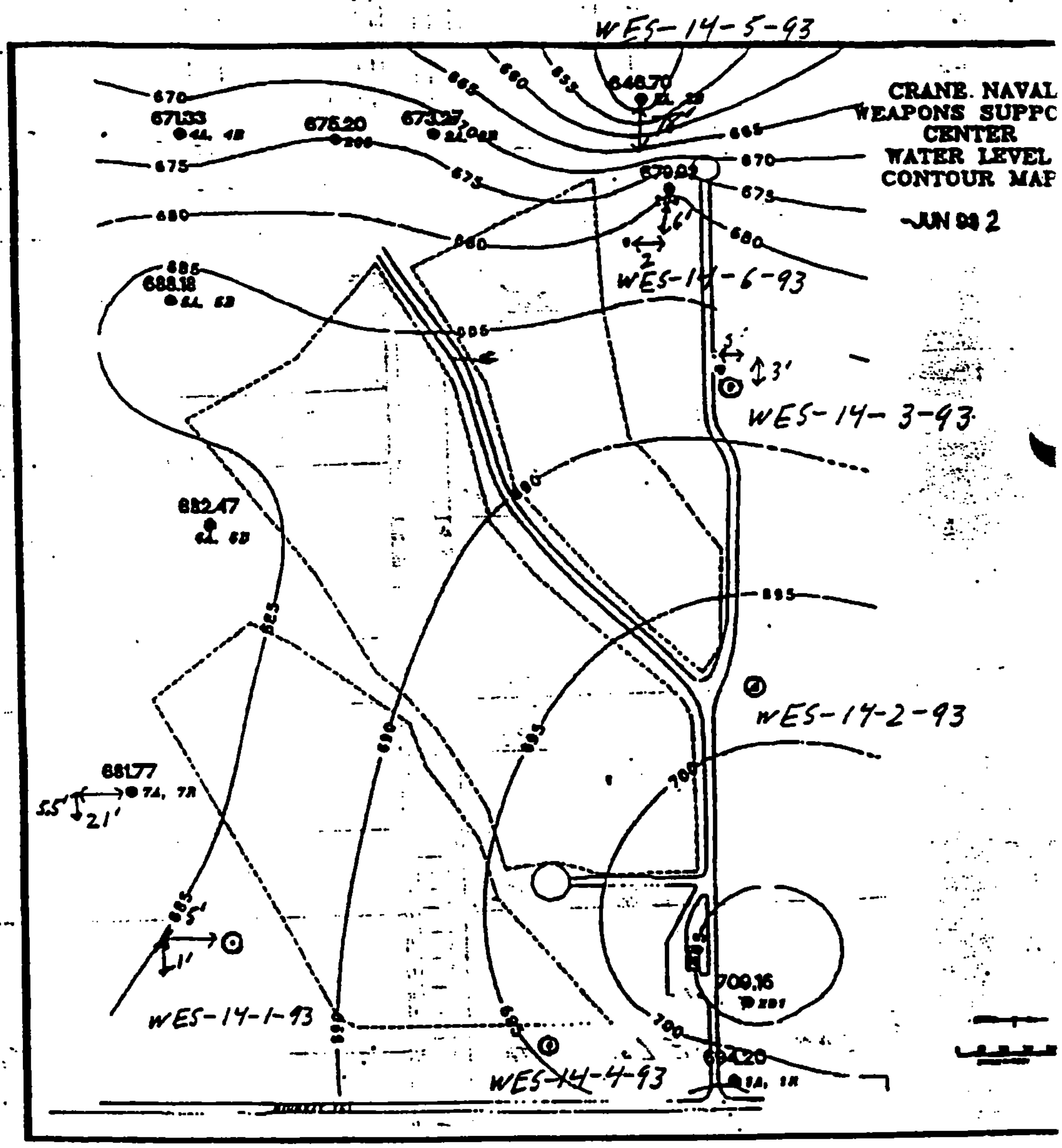
Total Depth of Boring



SYMBOLS: WATER LEVEL AT COMPLETION; WATER LEVEL ... HOURS AFTER COMPLETION

PARTIAL LOSS OF DRILL FLUID; TOTAL LOSS OF DRILL FLUID

ORL FORM 1202



LOCATION OF PROPOSED MONITORING WELLS ⊙

BORING NO. WES-14-5-93

Project: Gree Monitoring Wells, Landfill
Date: Start 10/27/93 Complete 10/27/93
Location N See Attached E Sheet
Drilling Agency U.S.A.C.E. W.E.S.
Driller Brown Inspector Parsons
Drill Type Failing Holemaster
Drill Method 3" Shelby Tube, 4" Rockbit, HX, HQ
Thickness of Overburden 0.9'
Depth Drilled Into Rock 39.7'
Total Depth of Boring 40.6'
Dir. of Boring X Vert. ___ Inclined ___ Deg

Instrumentation Installed Yes
Surface Elevation
Datum for Surface El.

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	0.0–0.5	Dark Brown to Reddish Brown, SILTY CLAY, Moist, Stiff. T.O.R. (0.0-0.9')	CL		1.3'	1	3" Shelby			3" Shelby Tube
SHALE	1.0–1.5	Reddish Brown to Light Gray, SHALE (CLAY), Severely Weathered with Thin Sandstone Beds (0.9-1.6')				2				Push Depth See Pressure Rec 1 0-66 40 600 1.3
	2.0–6.5	SHALE, Reddish Brown to Yellow, Soft, Severely Weathered to Slightly Weathered w/ Occ Thin Beds of Fine Grain Sandstone. (1.6-6.9)					Rockbit			4" Rockbit to 6.9' to enable drill rig to use HX core barrel. Set 6" P.V.C. Casing to 1.6' with 1.0' stickup. Key: B/P = Bedding Plane; Mech = Mechanical Break; SS = Sandstone
Sandstone	7.0–10.0	SANDSTONE, Light Brown to Reddish Brown. 7.0 – Red Stain; 7.5 – B/P Open w/ CLAY; Red Stain; 8.0 – B/P CLAY 0.02'; B/P CLAY; B/P CLAY 0.04'; 8.5 – B/P CLAY 0.03'; 9.0 – B/P CLAY 0.01'; B/P; B/P w/ SHALE 0.05'; 9.5 – Red Stain			100% / 0.74	Box 1	HX Core			Run 1 Cored 5.0' Rec 5.0 Loss 0.0 Time 10:33-10:55

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ___ HOURS AFTER COMPLETION
>- PARTIAL LOSS OF DRILL FLUID >>- TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-5-93

Project ______ Date:Start / / Complete / /
Location N______ E______
Drilling Agency______
Driller ______ Inspector ______
Drill Type______
Drill Method______
Thickness of Overburden______
Depth Drilled into Rock______
Total Depth of Boring______
Dir. of Boring____ Vert. ____ Inclined____ Deg

Instrumentation Installed______
Surface Elevation______
Datum for Surface El.______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	10	CLAY 0.01' Iron Stain; Sandy Shale; SS B/P w/ CLAY (6.9-10.5)					HX Core			
Sandstone	11	Shale Mech Lt Gry; CLAY SS 0.01'; CLAY; Shale w/ CLAY; Shale w/ SS and CLAY Broken Laminae								
	12	B/P w/ CLAY; Iron Stain — SANDSTONE Light Gray w/ Red Iron Stain					HQ Core			Run 2 Cored 10.2' Rec 10.2 Loss 0.0 Time 11:05 - 11:40
	13	B/P w/ CLAY 0.04'; Shale (10.5-13.2'); SS Iron Stain w/ Shale Laminae Lt Brn; Broken w/ CLAY Laminae Iron Stain								
	14	B/P; Iron Stain; Mech — SANDSTONE, Light Brown								
	15	B/P; B/P; B/P; Iron Stain (13.2-15.8')								
	16	B/P; B/P; Vugs; B/P; Iron Stain				Box 1				
	17	B/P; B/P; B/P w/ CLAY			100%/0.62					
	18	B/P; Mech; B/P Broken				Box 2				
	19	B/P; B/P								
	20	B/P Broken								

SYMBOLS: ▽ - WATER LEVEL AT COMPLETION ▼ - WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID >> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-5-9

BORING NO. WES-17-5-93

Project Crane Monitoring Wells Landfill
Date:Start / / Complete / /
Location N _____ E _____
Drilling Agency _____
Driller _____ Inspector _____
Drill Type _____
Drill Method _____
Thickness of Overburden _____
Depth Drilled into Rock _____
Total Depth of Boring _____
Dir. of Boring _____ Vert. _____ Inclined _____ Deg

Instrumentation Installed _____
Surface Elevation _____
Datum for Surface El. _____

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	20	B/P; B/P				Box 2	HQ Core			
	21	B/P; B/P								
Sandstone	22	Vertical Fracture; B/P; SANDSTONE, Reddish Brown, Light Brown to Light Gray w/ Iron Stain in places, Slightly Weathered, Moderate Hard, Friable, Fine Grain, Thin to Medium Bedded w/ Occ Shale, Coal and CLAY Laminae.								Run 3 Cored 10.3 Rec 10.0 Loss 0.3 Time 1:30-2:10 Inner Barrel measured with Core barrel Bottom of Hole was pulled
	23	B/P								
	24	B/P								
	25	Light Gray w/ Iron Stain; B/P; Black Mica; Mech								
	26	B/P								
	27	B/P; Iron Stain; B/P (15.9-27.9')			97% / 0.79					
	28	B/P; B/P; SANDSTONE, Light Gray w/ Iron Stain								
	29	B/P				Box 3				
	30	Iron Stain along Crossbedding								

SYMBOLS: ▽ - WATER LEVEL AT COMPLETION
▼ - WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-17-5-93

BORING NO. WES-14-5-93

Project: Crane Monitoring Wells, Landfill
Date: Start / / Complete / /
Location N ____ E ____
Drilling Agency ____
Driller ____ Inspector ____
Drill Type ____
Drill Method ____
Thickness of Overburden ____
Depth Drilled into Rock ____
Total Depth of Boring ____
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ____
Surface Elevation ____
Datum for Surface El. ____

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Sandstone	30	B/P; Iron stain along Cross Bedding; B/P				8 & 3	HQ			
	31	B/P; B/P								Core Loss between bedding planes
	32	B/P; Core Loss 0.3								
		B/P								Run 4 Cored 8.2' Rec 7.8' Loss 0.4
	33	Mech; Light Gray to Reddish Brown (Iron Stain)								Time 2:25 - 2:56
	34	B/P								
	35	B/P (27.9-35.1')								
		Sandstone Light Gray								
		B/P								
	36	Coal Laminae 0.01; Shale Dk Gray, Soft; SS 0.02'; CLAY 0.03'; SS; SS; Shale w/ SS 0.01' Laminae; Coal 0.01'; Shale w/ CLAY on Contacts			95%/ 0.67					
	37	Mech; SS w/ Coal Laminae Less than 0.01'; B/P								
		B/P								
	38	B/P; Core Loss 0.2'; B/P								
	39	Core Loss 0.2'; B/P; 20% Coal Laminae 0.01' to 0.02'; B/P								
	40									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION
>- PARTIAL LOSS OF DRILL FLUID
>>- TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-5-93

BORING NO. WES-14-5-93

Project Crane Monitoring Wells Landfill
Date: Start / / Complete / /
Location N E
Drilling Agency
Driller Inspector
Drill Type
Drill Method
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring Vert. Inclined Deg

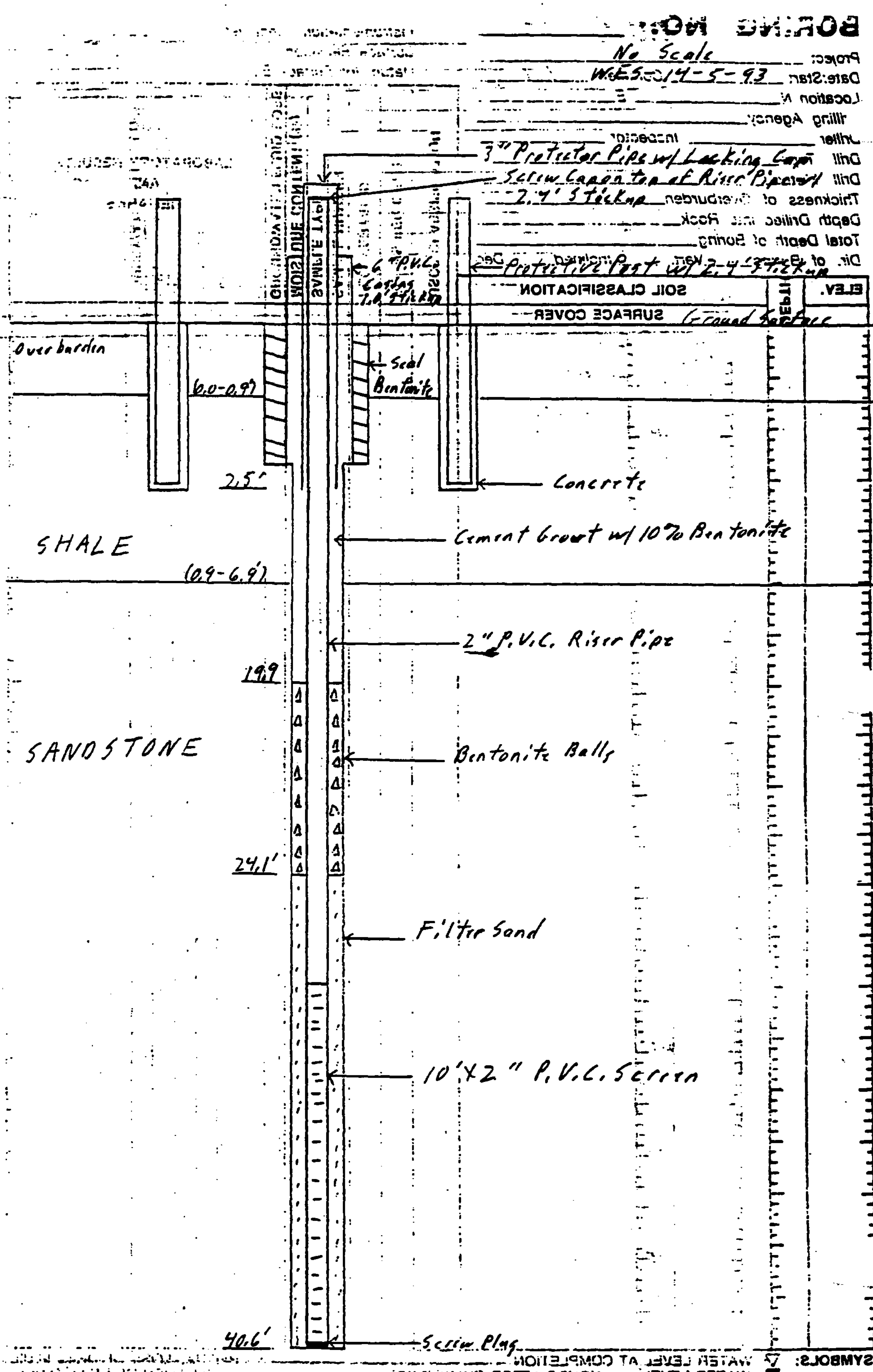
Instrumentation Installed
Surface Elevation
Datum for Surface El.

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
Sand-Stone	40	B/P mech				Box 3	HQ			
		B.O.H.								
	41									
	42									
	43									
	44									
	45									
	46									
	47									
	48									
	49									
	50									

SYMBOLS: ▽ - WATER LEVEL AT COMPLETION
▼ - WATER LEVEL ___ HOURS AFTER COMPLETION
\> - PARTIAL LOSS OF DRILL FLU
\>> - TOTAL LOSS OF DRILL FLUI

ORL FORM 1202

BORING NO. WES-14-5-9


No Scale
WES-14-5-93
3" Protector Pipe w/ Locking Cap
Screw Cap on top of Riser Pipe
2.4' Stickup
6" P.V.C. Casing
Protective Post w/ 2.4' Stickup
Ground Surface
Overburden
Seal Bentonite
(0.0-0.9')
2.5'
Concrete
SHALE
Cement Grout w/ 10% Bentonite
(0.9-6.9')
2" P.V.C. Riser Pipe
19.9
SANDSTONE
Bentonite Balls
24.1'
Filter Sand
10' X 2" P.V.C. Screen
40.6'
Screw Plug

BORING NO. WES-14-6-93

Project Crane Monitoring Wells, Landfill
Date: Start / / Complete / /
Location N ______ E ______
Drilling Agency ______
Driller ______ Inspector ______
Drill Type ______
Drill Method ______
Thickness of Overburden ______
Depth Drilled into Rock ______
Total Depth of Boring ______
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ______
Surface Elevation ______
Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	10	Iron Stain; CLAY 0.03'; SHALE Lt Gray; B/P; SANDY CLAY; Iron Stain; B/P				BOX 1	HX			Key: B/P = Bedding Plane; Mech = Mechanical Brea[k]; Lt = Light
	11	B/P; B/P w/ CLAY								
	12	B/P w/ Iron Stain; Broken								
	13	SANDSTONE, Light Brown, Reddish Brown and Light Gray; Iron Stain; B/P; Broken; Iron Stain; CLAY 0.03'; SHALE, Lt Gray			93% / 0.41		HQ			Run 2 Cored 5.4' Rec 5.0' Loss 0.4'; Time 11:20 - 11:45
	14	B/P; SHALE; CLAY B/P; B/P Sandstone 0.04'; CLAY 0.03' B/P; CLAY 0.04 B/P; CLAY 0.02 B/P								
	15	CLAY; SHALE, Lt Gray, Soft; Iron Stain; B/P; SHALE, Lt Gray								Run Stopped Short due to core barrel vibration
	16	CLAY; CLAY 0.01'; Broken								
	17	B/P; Core Loss 0.2' (17.4 - 17.?); B/P								
	18	Iron Stain along Cross bedding; B/P; Iron Stain in Laminae and in spots 18.8 - 19.5, 20.6 - 21.6', 22.2 - 23.0'; B/P			96% / 0.19	BOX 2				Run 3 Cored 5.2 Rec 5.0 Loss 0.2; Time 1:20 - 1:50
	19	B/P; B/P; B/P								
	20	Core Loss 0.05'								

SYMBOLS: ▽ - WATER LEVEL AT COMPLETION
▼ - WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL F[LUID]
>> - TOTAL LOSS OF DRILL FL[UID]

ORL FORM 1202

BORING NO. WES-14-6[-93]

BORING NO. WES-14-6-93

Project Ceane Monitoring Wells, Landfill
Date:Start / / Complete / /
Location N______ E______
Drilling Agency______
Driller______ Inspector______
Drill Type______
Drill Method______
Thickness of Overburden______
Depth Drilled into Rock______
Total Depth of Boring______
Dir. of Boring______ Vert. ______ Inclined ______ Deg

Instrumentation Installed______
Surface Elevation______
Datum for Surface El.______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	20	Core Loss 0.15'; B/P; B/P				Box 2	HQ			
	21	B/P; B/P; SANDSTONE, Light Gray to Brownish Red, and Iron Stain; B/P								
	22	B/P; B/P; B/P								
	23	Mech; Iron Stain 23' to 30.5'			95% / 0.84					Run 4 Cored 9.2' Rec 8.7' Loss 0.5
	24	B/P; Light Gray Laminae								Time 9:30-10:20
	25	Light Gray; Light Gray Laminae; B/P								
	26	B/P; Light Brown; SANDSTONE, Light Brown, Reddish Brown and Light Gray and Iron Stain, Slighty Weathered, Fine Grain, Friable, Medium Hard, Thin to Medium Bedded w/ Thin Bedded to Laminae of Soft SHALE and CLAY								
	27	B/P; B/P; Core Loss 0.2'								
	28	B/P; B/P; B/P; Core Loss 0.2'								
	29	B/P; Core Loss 0.3'				Box 3				
	30									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-6-93

BORING NO. WES-14-6-93

Project Crane Monitoring Wells, Landfill

Date: Start / / Complete / /

Location N ___ E ___

Drilling Agency ___

Driller ___ Inspector ___

Drill Type ___

Drill Method ___

Thickness of Overburden ___

Depth Drilled into Rock ___

Total Depth of Boring ___

Dir. of Boring ___ Vert. ___ Inclined ___ Deg

Instrumentation Installed ___

Surface Elevation ___

Datum for Surface El. ___

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	30					Box 3	HQ			
		Lt Gray Laminae								
	31	B/P								
		B/P								
		Iron Stain								
	32	B/P								
		B/P								Run 5
		B/P Iron Stain 0.05'								Cored 10.3
	33	B/P Iron Stain Laminae								Rec 10.3 Loss 0.0
		B/P								Time
		Light Gray								10:35 - 11:20
		Iron Stain Laminae								
		B/P SHALE Reddish Brown to Black								
	34	SS 0.03'								
		B/P CLAY								
		SHALE Light Gray to Black								
		CLAY								
	35	B/P Coal Laminae Less than 0.01'								
		CLAY 0.01'								
		Iron Stain w/ Light Gray								
		CLAY 0.01'								
	36	B/P Black SHALE w/ CLAY								
		Open Scattered Fractures								
		Iron Laminae and spots 35.8' to 40.5'								
	37				100% / 0.23					
	38									
		B/P								
	39									
		CLAY Laminae 0.01'								
		SHALE Laminae 0.01'								
		B/P								
	40									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-6-93

BORING NO. WES-14-6-93

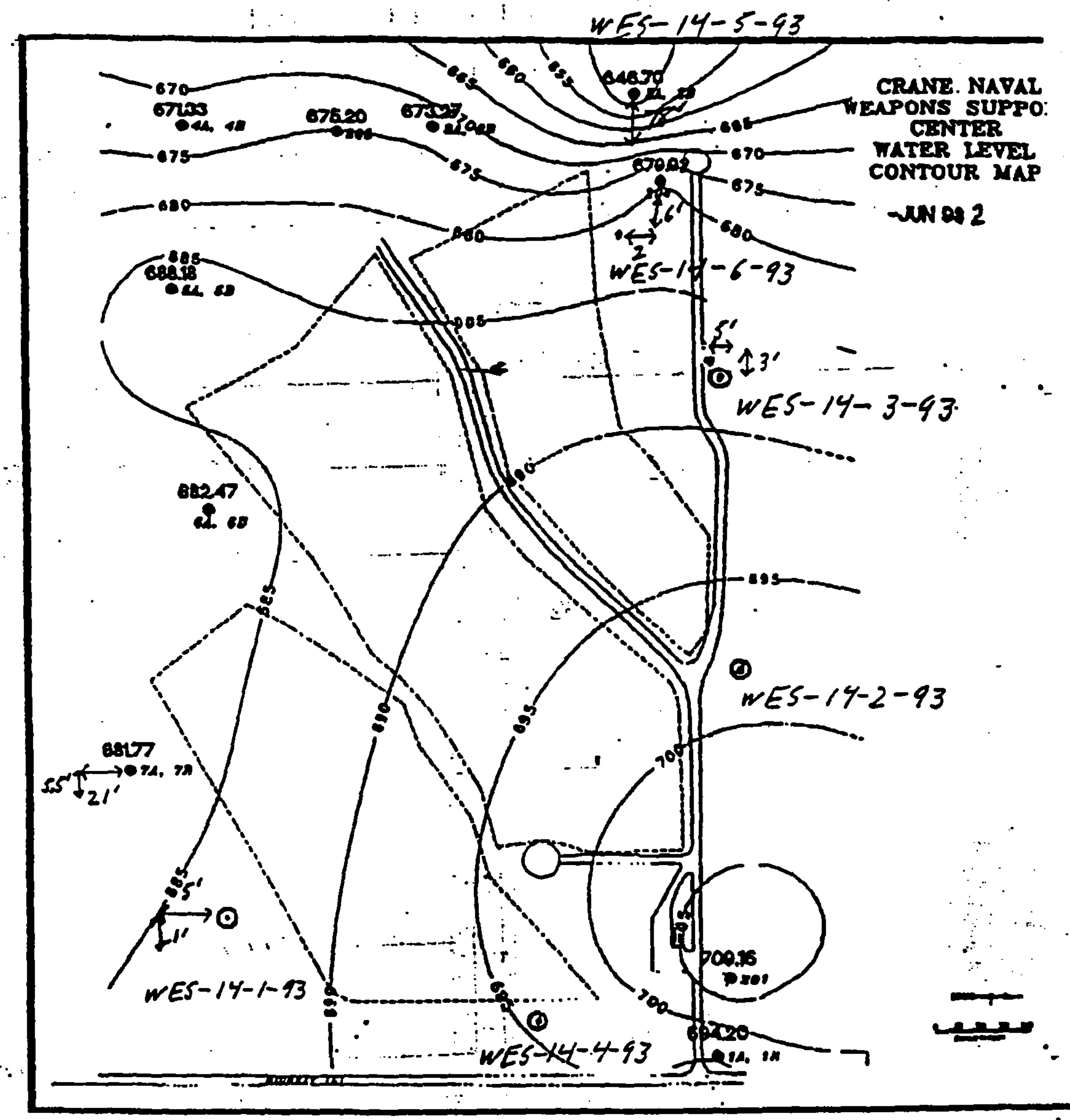
Project Crane Monitoring Wells, Landfill
Date: Start / / Complete / /
Location N ____ E ____
Drilling Agency ____
Driller ____ Inspector ____
Drill Type ____
Drill Method ____
Thickness of Overburden ____
Depth Drilled Into Rock ____
Total Depth of Boring ____
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ____
Surface Elevation ____
Datum for Surface El. ____

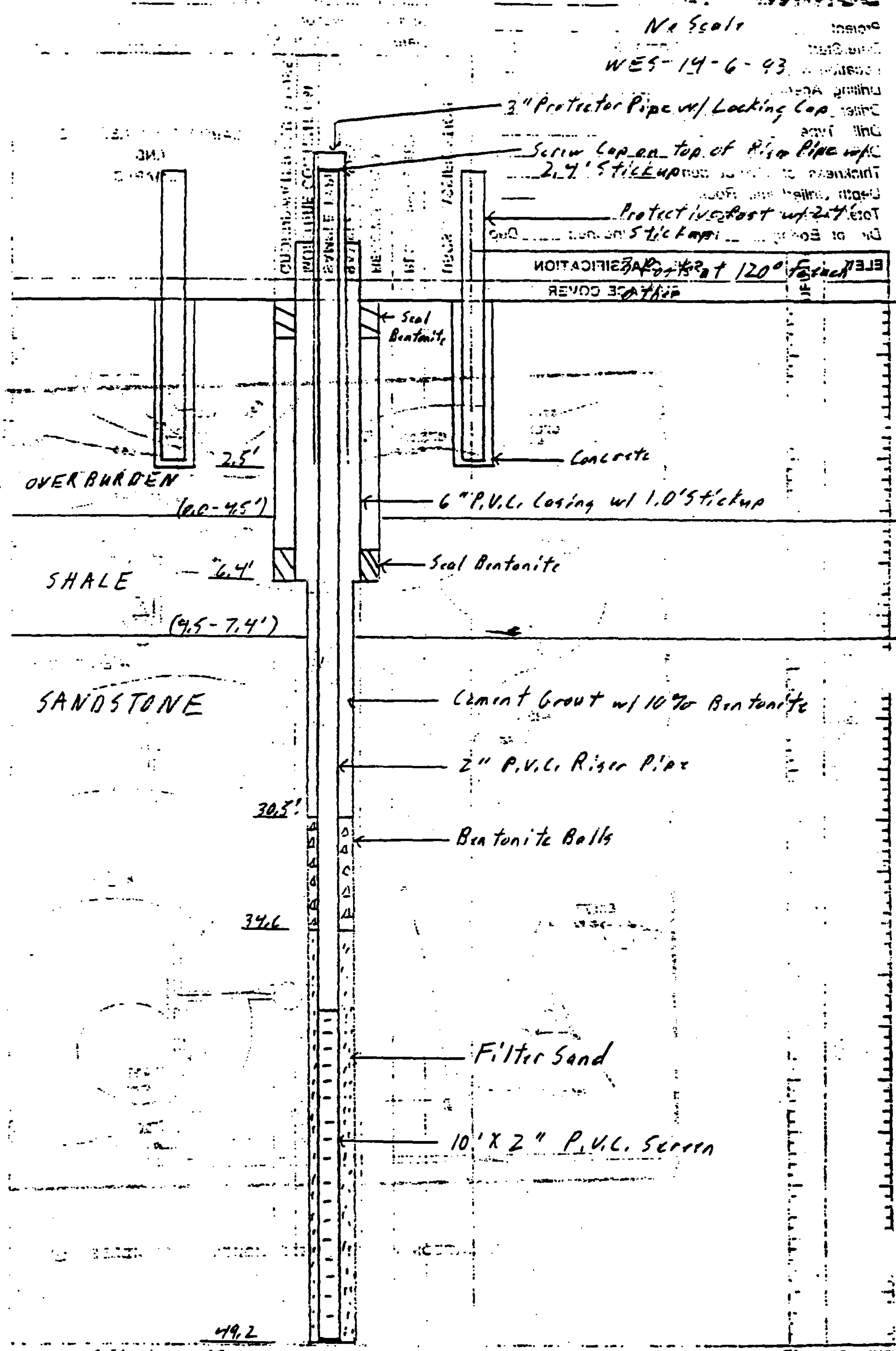
ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	40	B/P; Iron Stain (37.8-40.5'); B/P				Box 3	HQ			
	41	SANDSTONE, Light Gray; B/P; Iron Laminae; B/P; Coal Laminae; B/P				Box 4				Bailed after Run 5. 6 ft of water in boring after 45 minutes
	42	Yellow Stain; B/P; Undersize Core; Core Loss 0.4'								Run 6 Cored 6.7 Rec 6.2 Loss 0.5
	43	Undersize Core; Core Loss 0.1'								Time 12:45 - 1:10
	44	Mech; Iron stain 60% 44.1 to 45.0'; B/P								
	45	Iron Stain 0.1'								
	46	B/P; Iron Stain 46.5 to 48.4'			92% / 0.84					
	47	B/P								
	48	Mech; CLAY Filled Vug; B/P								
	49	Coal Laminae (40.5-49.2'); B.O.H.								
	50									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION ▼ WATER LEVEL ____ HOURS AFTER COMPLETION > - PARTIAL LOSS OF DRILL FLUID >> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202



LOCATION OF PROPOSED MONITORING WELLS ⊙



No Scale
WES-14-6-93
3" Protector Pipe w/ Locking Cap
Screw Cap on top of Riser Pipe w/ 2.4' Stickup
Protective Post w/ 2.4' Stickup
Posts at 120° from each other
Seal Bentonite
2.5'
Concrete
OVERBURDEN (0.0-4.5')
6" P.V.C. Casing w/ 1.0' Stickup
SHALE
6.4'
Seal Bentonite
(4.5-7.4')
SANDSTONE
Cement Grout w/ 10% Bentonite
2" P.V.C. Riser Pipe
30.3'
Bentonite Balls
34.6
Filter Sand
10' X 2" P.V.C. Screen
49.2

BORING NO. WES-14-7-93

Project: Crane Monitoring Wells, Landfill
Date: Start 10/29/93 Complete 10/30/93
Location N: See Attached E: Sheet
Drilling Agency: U.S.A.C.E. W.E.S.
Driller: Brown Inspector: Parsons
Drill Type: Failing Holemaster
Drill Method: 3" Shelby Tubes, HX and HQ Core
Thickness of Overburden
Depth Drilled into Rock
Total Depth of Boring
Dir. of Boring: X Vert. Inclined Deg

Instrumentation Installed: Yes
Surface Elevation
Datum for Surface El.

ELEV.	DEPTH	SOIL CLASSIFICATION	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
		SURFACE COVER								
	0.0–2.0	Dark Brown, SILTY CLAY, Dry to Damp, Medium Stiff to Stiff (0.0–2.0)	CL		2.4	1	3" Shelby			3" Shelby Tube
	2.0–5.6	Reddish Brown to Light Gray, SILTY CLAY, Moist, Stiff to Very Stiff	CL		1.5	2, 3	3" Shelby			
	5.6	Top of Rock (2.1–5.6)				4	3" Shelby			Set 6" P.V.C. Casing at 13' with 1' Stick
SHALE	5.6–10.0	Yellow Brown, Reddish Brown to Light Gray, Severely Weathered SHALE, (Silty Clay), Damp to Dry, Very Stiff to Hard (Soil Classification) w/ Thin Bedded to Laminae of Sandstone			1.3	5	3" Shelby			
	7.0–8.0				0.7	6	3" Shelby			
	8.0–9.0				0.8	7	3" Shelby			
	9.0–10.0				0.6	8	3" Shelby			

Push	Depth	Sec	Pressure	Rec
1	0.0-2.5	70	200	2.4
2	2.5-5.0	50	700	1.5
3	5.0-7.0	55	800	1.3
4	7.0-8.0		700	0.7
5	8.0-9.0		700	0.8
6	9.0-10.0		800	0.6
7	10.0-12.0		700	0.5

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

BORING NO. WES-14-7-93

Project Crane Monitoring Wells; Landfill
Date: Start / / Complete / /
Location N ____ E ____
Drilling Agency ____
Driller ____ Inspector ____
Drill Type ____
Drill Method ____
Thickness of Overburden ____
Depth Drilled into Rock ____
Total Depth of Boring ____
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ____
Surface Elevation ____
Datum for Surface El. ____

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	10–12				0.5	9	3" Shelby			Key B/P = Bedding Plane MECH = Mechanical Break
	12–13	Augered 12' To 13' Material Same Severely Weather SHALE (5.6–13.0)			–	–	Auger			Augered from 12' to 13'
Shale	13–14.8	Core Loss 1.6' SHALE, Reddish Brown to Light Gray, Soft, Severely to Moderately Weathered. SHALE, Soft Severely Weathered (13.0–14.8') B/P				Box 1	4Q			Run 1 Cored 10.0' Rec 8.4' Loss 1.6' Time 10:05 – 10:30
Sandstone	14.8–20	Sandstone Vert Fracture Open CLAY SHALE Laminae open B/P 0.01' to 0.05' B/P Open w/ CLAY 0.01' CLAY 0.03' B/P B/P Red Stain 15.1 – 15.8, 16.6 – 17.8 B/P B/P CLAY Filled Vug B/P CLAY 0.01' B/P CLAY 0.01' B/P B/P B/P B/P			84% / 0.31					

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ___ HOURS AFTER COMPLETION

> - PARTIAL LOSS OF DRILL FLU
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-7-9

BORING NO. WES-14-7-97

Project: Crane Monitoring Wells Landfill

Date: Start / / Complete / /

Location N ______ E ______

Drilling Agency ______

Driller ______ Inspector ______

Drill Type ______

Drill Method ______

Thickness of Overburden ______

Depth Drilled into Rock ______

Total Depth of Boring ______

Dir. of Boring ______ Vert. ______ Inclined ______ Deg

Instrumentation Installed ______

Surface Elevation ______

Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/RQD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
Sandstone	20	BIP; CLAY Laminae Less than 0.01'; CLAY Lines BIP				Box 1	HQ			
	21	BIP; SANDSTONE, Reddish Brown, Light Brown to Light Gray w/ Iron Stain, Medium Hard, Slightly Weathered, Thin to Medium Bedded, Friable, Fine Grain, w/ SHALE and CLAY Laminae; BIP; Broken								
	22	BIP; BIP w/ CLAY Less than 0.01'								
	23	Mech; Lt Gray Sandstone; Iron Laminae 0.02'; BIP (SS w/ SHALE and CLAY Filled Vugs); CLAY Laminae 0.01'	←							Run 2 Cored 10.0' Rec 7.4 Loss 2.6' Time 11:00 - 11:45
	24	BIP; BIP BIP CLAY 0.03'			74%/ 0.45	Box 2				
	25	BIP; BIP CLAY 0.01'; BIP; Broken								
	26	Broken; Core Loss 0.6								
	27	BIP; BIP; BIP; Iron Stain								
	28	Broken; BIP w/ CLAY Less than 0.01'								
	29	Iron Stain; BIP; Broken; Core Loss 0.35								
	30									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION; ▼ WATER LEVEL ____ HOURS AFTER COMPLETION; > - PARTIAL LOSS OF DRILL FLUID; >> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WES-14-

BORING NO. WEC-14-7-93

Project Crane Monitoring Wells Landfill
Date:Start / / Complete / /
Location N ______ E ______
Drilling Agency ______
Driller ______ Inspector ______
Drill Type ______
Drill Method ______
Thickness of Overburden ______
Depth Drilled into Rock ______
Total Depth of Boring ______
Dir. of Boring ____ Vert. ____ Inclined ____ Deg

Instrumentation Installed ______
Surface Elevation ______
Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
	30	Core Loss 1.25'				Box 2	HQ			
	31	B/P w/ CLAY; Iron Deposit; B/P w/ CLAY								Bailed Boring Dry after completion of Run one to two feet of water in bottom of hole after an hour.
	32	B/P; Light Gray w/ Iron Stain								
	33	Mech; Light Gray								Run 3 Cored 10.0' Rec 9.7' Loss 0.3 Time 1:30 – 2:10
	34	B/P; Iron Stain; B/P; Iron Deposit								
	35	B/P Iron Stain 34.6 – 36.2'			97%/0.93	Box 3				40% Loss of Drill fluid during core run.
	36	Iron Stain along Cross bedding; B/P; Core Loss 0.2'; B/P; B/P w/ CLAY Less than 0.01'; Light Gray; Iron Stain; Open Fracture								
	37	Light Gray; Core Loss 0.1'; Gray; Iron Stain								
	38	B/P w/ Iron Stain								
	39	Mech; Iron Stain and spots of Light Gray; B/P								
	40									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION; ▼ WATER LEVEL ____ HOURS AFTER COMPLETION; > - PARTIAL LOSS OF DRILL FLUID; >> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WEC-14-7-93

Project [illegible] Monitoring [illegible] Landfill
Date:Start / / Complete / /
Location N ______ E ______
Drilling Agency ______
Driller ______ Inspector ______
Drill Type ______
Drill Method ______
Thickness of Overburden ______
Depth Drilled into Rock ______
Total Depth of Boring ______
Dir. of Boring ______ Vert. ______ Inclined ______ Deg

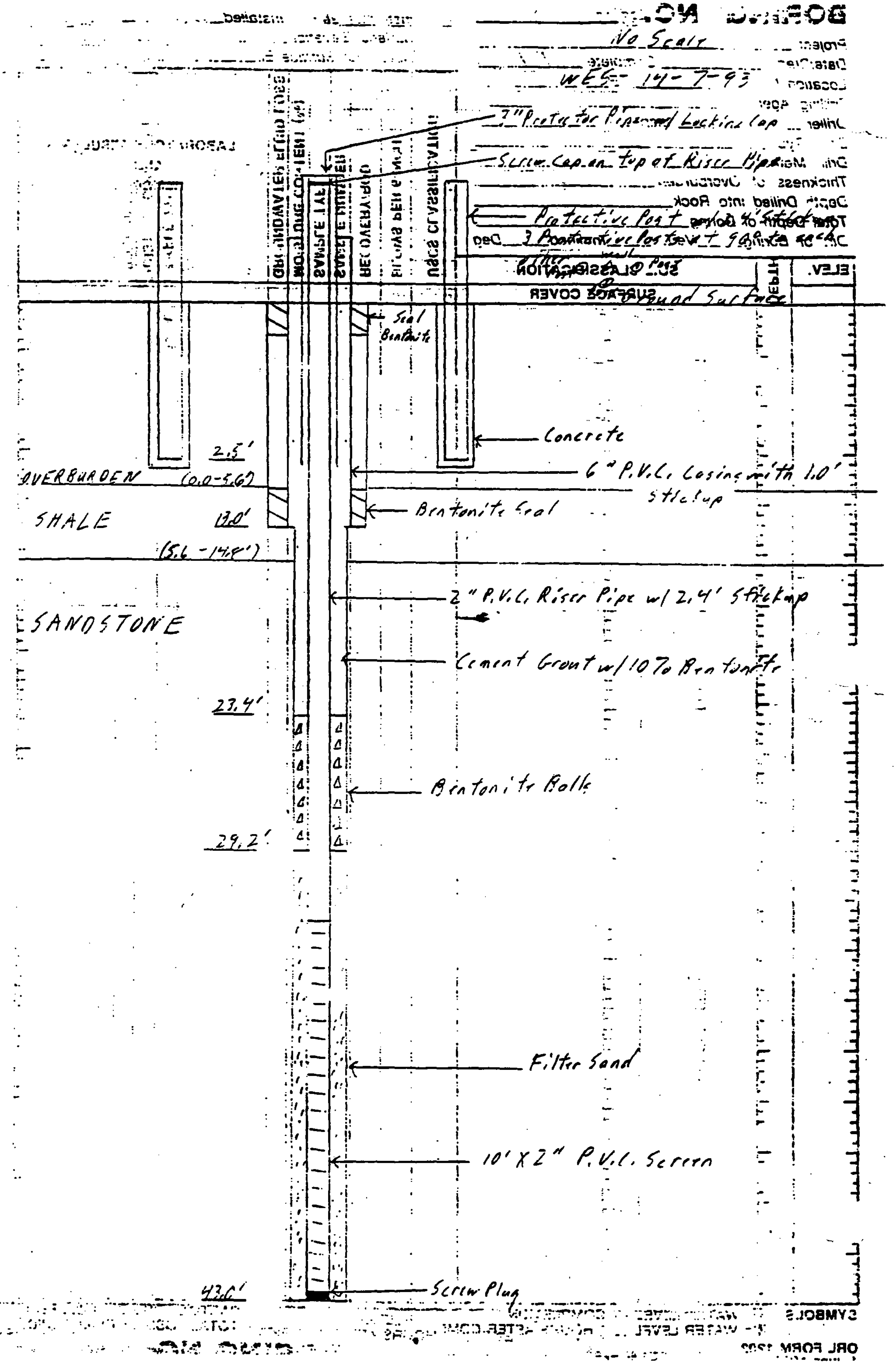
Instrumentation Installed ______
Surface Elevation ______
Datum for Surface El. ______

ELEV.	DEPTH	SOIL CLASSIFICATION / SURFACE COVER	USCS CLASSIFICATION	BLOWS PER 6-INCH	RECOVERY/ROD	SAMPLE NUMBER	SAMPLE TYPE	MOISTURE CONTENT (%)	GROUNDWATER-FLUID LOSS	LABORATORY RESULTS AND REMARKS
S a n d s t o n c	40	B/P; B/P — Iron Stain; B/P				Box 3	HQ			
	41	(14.8 - 41.1)								
		Iron Deposit 0.07'								
	42	B/P; Mech; Mech — SANDSTONE Light Brown								
	43	(41.1 - 43.07) B.O.H.								
	44									
	45									
	46									
	47									
	48									
	49									
	50									

SYMBOLS: ▽ WATER LEVEL AT COMPLETION
▼ WATER LEVEL ____ HOURS AFTER COMPLETION
> - PARTIAL LOSS OF DRILL FLUID
>> - TOTAL LOSS OF DRILL FLUID

ORL FORM 1202

BORING NO. WEC-14-7-93



No Scale
WES- 14-7-93
2" Protective Pipe and Locking Cap
Screw Cap on top of Riser Pipe
Protective Post
3 Protective Posts
Ground Surface
Seal Bentonite
Concrete
2.5'
OVERBURDEN (0.0-5.6')
6" P.V.C. Casing with 1.0' Stickup
SHALE 13.0'
Bentonite Seal
(5.6-14.8')
SANDSTONE
2" P.V.C. Riser Pipe w/ 2.4' Stickup
Cement Grout w/ 10% Bentonite
23.4'
Bentonite Balls
29.2'
Filter Sand
10' X 2" P.V.C. Screen
43.6'
Screw Plug

ATEC Associates, Inc.
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RECORD OF SOIL EXPLORATION

Form

Reply To:

Home Office: Indianapolis
Offices: Atlanta/ Baltimore/Birmingham/Cincinnati/Dallas/Freeport/ Houston/Louisville/Salisbury/Washington, DC/York
Affiliates: Beckley/Norfolk/Riyadh

CLIENT U. S. Navy — BORING NO. 203
PROJECT NAME Landfill — JOB NO. D-79873 — DATE 11-29-79
PROJECT LOCATION Crane, Indiana — STATION
BORING METHOD HSA — FOREMAN R. Jones
ROCK CORE DIA. in. — INSPECTOR
SHELBY TUBE O.D. in.

SOIL CLASSIFICATION SURFACE ELEVATION—	Stratum Depth, Ft.	Ground Water	Depth Scale, Ft.	SPT ** Sample No.	SPT ** Blows/6 in. 3-6 in. Increments	SPT ** Recovery, %	Shelby Tube No.	BORING & SAMPLING NOTES
Top soil	0.3							
Brown moist stiff SILTY CLAY							1	Pushed Shelby Tube from 3.0' to 5.0'
			5					Set Observation well to 7.0'
Auger refusal @ 7.0'	7.0							
Bottom test boring @ 7.0'								

BORING METHOD
HSA — HOLLOW STEM AUGER

GROUND WATER
▽ NOTED ON RODS ______ FT.

*THESE SHELBY TUBE SAMPLES OBTAINED
BORING ______ DRILLED A

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RECORD OF SOIL EXPLORATION

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Affiliates: Beckley/Norfolk/Riyadh

CLIENT U. S. Navy — BORING NO. 201
PROJECT NAME Landfill — JOB NO. D-79873 — DATE 11-25-79
PROJECT LOCATION Crane, Indiana — STATION
BORING METHOD HSA — FOREMAN R. Jones
ROCK CORE DIA. ____ in. — INSPECTOR
SHELBY TUBE O.D. ____ in.

SOIL CLASSIFICATION SURFACE ELEVATION—	Stratum Depth, Ft.	Ground Water	Depth Scale, Ft.	SPT** Sample No.	SPT** Blows/6 In. 3–6 In. Increments	SPT** Recovery, %	Shelby Tube No.	BORING & SAMPLING NOTES
Top soil	0.3							
Brown slightly moist very stiff CLAYEY SILT (ML)								Sandstone ledge 6.3' to 6.4'
			5	1	4 8/10	50		Back filled with gravel and set Bentonite Seal
Auger refusal @ 6.9'	6.9							Set Observation well to 6.9'
Bottom test boring @ 6.9'			10					

BORING METHOD — GROUND WATER — *THESE SHELBY TUBE SAMPLES OBTAINE