Doc. No.: CLEJ-00381-3.05-10/01/89

Work Plan

Product Recovery System Design Hadnot Point Fuel Farm Marine Corps Base Camp LeJeune, NC

Contract No. N62470-88-R-5255

Naval Facilities Engineering Command
Norfolk, Virginia

October 1989

O'BRIEN & GERE

Doc No: CLEJ-00381-3.05-10/01/89

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WORK PLAN

PRODUCT RECOVERY SYSTEM DESIGN
HADNOT POINT FUEL FARM
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT NO. N62470-88-R-5255

NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA

OCTOBER 1989

PREPARED BY:

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APPENDICES

SECTION 1 - INTRODUCTION

1.01 Site Description

Marine Corps Base (MCB) Camp Lejeune is located in Onslow County, North Carolina. The facility has a roughly triangular outline and covers approximately 170 square miles. Eleven miles of Atlantic shoreline form the eastern boundary of Camp Lejeune. The western and northeastern boundaries are U.S. Rt. 17 and State Rt. 24, respectively. The town of Jacksonville, North Carolina is the northern boundary of the base.

Construction of MCB Camp Lejeune began in 1941, at the Hadnot Point area, where major functions were centered. As the facility grew and developed, Hadnot Point became crowded with maintenance and industrial activities. The general Hadnot Point area is illustrated on Figure 1.

The Hadnot Point Industrial Area tank farm, the specific target of this hydrogeologic investigation, is located approximately 1200 feet to the southeast of Holcomb Boulevard, adjacent to Ash Street as depicted on Figure 1. The tank farm was constructed around 1941 and consists of 15 fuel storage tanks placed on grade (Figure 2). There is one (1) 600,000 gallon tank (Tank 10), six (6) 12,000 gallon tanks (Tanks 2, 3, 7, 8, 11 and 12), and eight (8) 15,000 gallon tanks (Tanks 1, 4, 5, 6 9, 13, 14 and 15). These tanks, except the 600,000 gallon tank, are completely covered over. The existing tanks are the original tanks that were installed in about 1941. The large 600,000 gallon tank contains diesel fuel, the other tanks contain leaded gasoline, unleaded gasoline and kerosene.

The area surrounding the tank farm is relatively flat, with the tank farm situated on a mound that extends approximately 10 feet above the surrounding grade. It is a highly developed area of the base. The natural drainage has been modified by extensive areas of asphalt and concrete, and by ditches and storm sewers. The surface waters in nearest proximity to the tank farm are Wallace Creek and the New River. Wallace Creek drains into the New River and ultimately drains into the Atlantic Ocean.

1.02 Purpose and Scope

O'Brien & Gere Engineers has been retained to provide the hydrogeological services necessary to design a product recovery system at the Hadnot Point Industrial Area tank farm.

The purpose of this Work Plan is to present and evaluate the background information that has been gathered regarding the history of the fuel losses and existing hydrogeologic data in the vicinity of Hadnot Point area and to identify additional information necessary to design a product recovery system.. A site investigation plan is proposed which includes monitoring well locations and the rationale for selecting those locations. A sampling and analysis plan is included as Appendix A which defines procedures to be used during sampling and analyses to be conducted on the samples. A health and safety plan for the hydrogeologic investigation has also been included as Appendix B, in accordance with both the OSHA Safety Regulations for Hazardous Waste Site Work (29 CFR 1910, 120) and the Safety and Health Guidelines for NACIP Confirmation Studies (revised February, 1986).

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SECTION 2 - HISTORY OF FUEL LOSSES

2.01 History of Fuel Losses

Available information regarding the history of fuel losses and leakage areas was reviewed in order to identify potential areas of petroleum product accumulation. The areas of investigation included the age of the tanks, locations of known losses, inventory records, and types and volumes of fuel losses. A summary of fuel losses is given in Table 1, and the fuel loss locations are shown on Figure 3.

As stated in Section 1.01, the tanks were installed in about 1941. The other information about the history of fuel losses at the HPFF is summarized in the Preliminary Report by Environmental Science and Engineering, Inc. (ESE), (1988) O'Brien & Gere (1988).

Review of this information indicates that between 23,150 gallons and 33,150 gallons of fuel product have been lost from the tank farm. In addition, there have been two recorded episodes of fuel loss where the amounts lost were unknown; in another case, the amount lost was not noticeable in inventory.

Of the 23,150-33,150 gallons of known lost product, 3,150 gallons were unleaded fuel. The 20,000-30,000 gallon loss that occurred in 1979 was comprised of unknown amounts of diesel and unleaded fuel; regular fuel may also have been lost. Of the two instances where unknown amounts of fuel were lost, one was diesel fuel and the other was unleaded fuel.

Inventory records do not reveal any known fuel losses from leakage of the tanks; most reported losses occurred through leaks in the transfer lines or through leaks in transfer line valves.

2.02 Regional Geologic Conditions

Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The Coastal Plain is underlain by unconsolidated deposits. The formations consist mostly of sand and clay with minor amounts of gravel. Some beds of marl and shell rock are reported. Regionally, these deposits dip gently southeastward in a thickening wedge that overlies the underlying bedrock.

The surficial deposits of the Coastal Plain are mostly permeable, unconsolidated sand and gravel. These surficial deposits, together with the updip parts of deeper aquifers, constitute the unconfined (water table) aquifer of the Coastal Plain.

A sequence of unconsolidated sedimentary deposits approximately 1400 to 1700 feet thick exists beneath Camp Lejeune. The following discussion of the site geology will be restricted to the uppermost 300 feet of the sequence, since these strata contain the aquifers which are the source of fresh water for the base. These deposits are comprised of unconsolidated and semiconsolidated materials (NCDNR & CD, 1980, Water and Air Research, 1983).

At the top of the sequence, undifferentiated Pleistocene and Recent sands and clays form the most seaward band of sediments. These deposits can reach a thickness of 35 feet.

The Yorktown Formation, of Pliocene age, underlies the Pleistocene and Recent deposits, outcropping in a bank east and south of Jacksonville. This unit consists of lenses of sand, clay, mark, and limestone; it can reach a thickness of 60 feet.

An unnamed formation of Oligocene age underlies the Yorktown Formation. This unit consists of fossiliferous limestone, calcareous sand, and clay. The Oligocene deposits vary in thickness from approximately 40 feet to more than 200 feet.

The Castle Hayne Limestone, of Eocene age, unconformably underlies the Oligocene deposits. This unit consists of shell limestone, marl, calcareous sand, and clay. In Onslow County, the Castle Hayne varies in thickness from 100 feet to more than 200 feet.

2.03 Regional Groundwater Flow Patterns

Some of the formations in the Coastal Plain are permeable and have been defined as aquifers. Most of these formations are of wide areal extent. Hydraulic connections between aquifers is common through the complex interbedding that is characteristic of Coastal Plain sediments. Most of the aquifers are not separate and independent hydrogeologic units; rather, each is part of a complex hydrologic system. This system may even include streams and lakes where the aquifers are at or near the land surface.

The aquifer system at Camp Lejeune consists of an unconfined (water table) aquifer and a semi-confined aquifer. The water table aquifer extends from the land surface to the first significant confining bed that is encountered (NCDNR & CD, 1980, Water and Air Research, 1983).

The semi-confined aquifer is composed of limestone and calcareous sands of the Yorktown Formation, the Oligocene deposits, and the Castle Hayne Limestone. The confining beds that form the bottom of the water table aquifer and that are present in the semi-confined aquifer consist of clay, sandy clay, silty clay, and occasionally dense limestone. These beds are discontinuous lenses and may be present at any depth (NCDNR & CD, 1980, Water and Air Research, 1983).

2.04 Site Geologic Conditions

The discussion of the site geology will be limited to the uppermost 25 feet of the unconsolidated soils, which is the maximum depth of the subsurface investigation from previous projects (ESE, 1988; O'Brien & Gere, 1988). The primary soils encountered during the investigation were fine and medium sands, mixed with lesser amounts of silt. Discontinuous, trace amounts of fine gravel were noted in the silty sand mixtures throughout the site. Clay stringers were found consistently throughout the silty sand mixtures with an occasional thin layer of clay (up to 2 feet thick). Minor amounts of naturally occurring organic materials, including organic silts and clays, peat, wood fragments, and plant debris were found in several of the borings, including MW-11, 13, 14 and 20, indicating the presence of a former coastal marshland. Up to 4 feet of miscellaneous fill material was found in borings that were adjacent to buildings and developed roads.

2.05 Site Groundwater Flow Patterns

Figure 4 shows the groundwater elevations measured in the twenty monitoring wells at the site on April 20, 1988. Because the presence of a floating product layer tends to depress the water table, due to hydrostatic pressure, the groundwater elevations in the wells containing a product layer were corrected to give elevations that would be representative of the aquifer without the effects of the floating product layer. The calculation used to correct the groundwater elevations takes into consideration the thickness of the product layer, the densities of the product and groundwater, and the soil properties. The correction factor is represented by the formula:

$Ec = E + (0.82 \times T)$, where

Ec = Corrected groundwater elevation:

E = Elevation of the groundwater under the influence of the product layer; and

T = Product thickness

Tables 2 and 3 have been complied summarizing the corrected and actual groundwater elevations and the product thickness data, respectively.

Due to the extreme variability of the product thickness (see Table 3) and the complex interbedded nature of the soils at the site, the groundwater gradient in the immediate vicinity of the HPFF cannot be precisely determined from the available data. The average regional groundwater gradient with in the HPIA has been interpreted to be approximately 0.20 feet per foot (ft/ft) (ESE, 1988). Groundwater movement in the shallow aquifer in this area is generally toward the southwest, towards the New River (ESE, 1988). Other factors that affect the actual and corrected groundwater elevations include the geologic conditions at the site, the complete assemblage of underground utilities shown, and the mounding of soils over the tanks. The presence of discontinuous lenses of clay and silty clay can cause localized semi-confined conditions in the unconfined aquifer, as well as localized perched water table conditions.

Although a precise determination of groundwater flow direction and gradient at HPFF cannot be made due to the aforementioned aquifer characteristics, the data from previous studies (ESE, 1988; O'Brien & Gere, 1988) shows a generalized trend in groundwater flow direction. The confirmation study conducted by ESE (1988) indicates that there is some unconformity in the groundwater contours in the HPFF area. Benzene and total hydrocarbon distribution in the groundwater at the HPFF, Figures 6 and 7, indicates that groundwater flow is in agreement with regional flow. However, groundwater flow at the HPFF is generally in a southwesterly direction but contains a slight component of groundwater flow in both the northwest and the southwest directions. This is consistent with the deviation in the contour lines noted in the ESE (1988) study.

2.06 Free-Phased Product

Free-phased product was detected floating on the groundwater in six of the monitoring wells installed at the site, including

MW-2, 7, 12, 15, 16, and 18. The product thickness data is summarized in Table 3. The thickness of the floating layer ranged from 0.24 feet in MW-15 to 15.34 feet in MW-16 on April 20, 1988. None of the other monitoring wells contained measurable product layers or visible sheens. The measured thickness of product in the well may represent approximately four times the actual thickness of the free-floating product on the groundwater surface due to the accumulation of product within the open well casing (CONCAWE, 1979). The actual thickness of the floating product layer on the water table is estimated to range from approximately 0.06 feet to 3.84 feet.

The product thickness data collected on April 20, 1988 is illustrated on Figure 5. It is apparent from the data collected to date that two separate product pools are present in the vicinity of the HPFF. One pool extends toward the northwest from the northwestern portion of the fuel farm, while the other pool exists at the southeastern edge of the fuel farm oriented on a northeast/southwest axis. The product pool northwest of the fuel farm is smaller in area, but thicker than the more widespread, thinner pool to the southeast.

Product samples were collected from MW-2, MW-7, MW-12, MW-16, and MW-18 on April 20, 1988. These samples were shipped to OBG Laboratories in Syracuse, NY for analysis using a Gas Chromatograph/Flame Ionization Detector (GC/FID) scan for petroleum hydrocarbon identification. The laboratory analyses identified the product as gasoline for all five of the monitoring wells sampled.

2.07 Soluble Constituents

The groundwater samples collected from the wells on April 20-21, 1988 were analyzed for petroleum hydrocarbons and solvents using the purge and trap/GC method. The analytical results are summarized in Table 4, and the laboratory reports are included in Appendix C. Figures 6 and 7 illustrate the iso-concentration contours of the benzene and total hydrocarbon concentrations, respectively.

Table 4 and Figures 6 and 7 indicate that the groundwater analyses are consistent with the location of the product pools. The most significant concentrations of benzene and total hydrocarbons (THC) were found in the wells containing product and those adjacent to the product pool. The wells containing product had benzene concentrations of 4,700 parts per billion (ppb) to 29,000 ppb. Wells not containing product had concentrations of benzene ranging from 1 ppb in MW-9 to 19,000 ppb in MW-1. Total hydrocarbon concentrations ranged from 43,000 ppb to 300,000 ppb in wells containing product, and from 10 ppb to 97,000 ppb in wells not containing product. Other compounds found within the groundwater include toluene, ethyl benzene, xylenes, and methyl tertiary butyl ethylene (MTBE). The concentrations of the individual compounds at each well are detailed in Table 4.

The size, shape, and axial orientation of the benzene and total hydrocarbon plumes identified at the HPFF coincide closely with the product pools. It is apparent that the source of the benzene, toluene, and xylenes (BTX) and total hydrocarbons in the groundwater is the free-phased gasoline floating on the groundwater as indicated on Figure 5.

The limits of the benzene concentrations are defined in MW-9, MW-3, and MW-4 on the southeast side of the fuel farm, by MW-5 and MW-11 to the northwest and MW-13 to the northeast. These wells were below the EPA Maximum Contaminant Limit (MCL) of 5 ppb for benzene in drinking water (40 CFR 141, 1987). The limits of benzene concentrations above the EPA MCL are undefined in those areas denoted by a dashed line on Figure 6.

The limits of the total hydrocarbon concentrations (i.e. 100 ppb) are defined by MW-9 to the south of the fuel farm, MW-4 on the east side, MW-13 to the north, and MW-5, 8, 11, and 14 on the west side of the fuel farm. The concentrations of total hydrocarbons above the 100 ppb level are undefined in those areas denoted by a dashed line on Figure 7.

The distribution of the other compounds found in the groundwater at the site is consistent with the benzene and total hydrocarbon concentrations, and iso-concentration contour maps would illustrate similar trends. Benzene, as well as toluene, ethylbenzene, and xylenes are components of gasoline, and indicate contamination by gasoline. MTBE is an additive to gasoline, and also indicates contamination by gasoline.

Only trace levels of chlorinated solvents not associated with petroleum hydrocarbons were detected within the groundwater, including 1 ppb of trichloroethylene (TCE) in MW-20, and 4 ppb of tetrachloroethylene (PERC) in MW-3. However, higher levels of these compounds as well as other chlorinated solvents were detected within the shallow groundwater in the other areas of the HPIA (ESE, 1988).

SECTION 3 - FIELD INVESTIGATIONS

3.01 General

The field investigations to be conducted at the HPFF are detailed below. These investigations are required to design a recovery system that will efficiently remove the plume(s) that exist at the HPFF. The following information will be obtained from the field study: define the extent of the free-phased and soluble product plume; provide design information as to the slot size for the recovery wells; determine design flow rates; and to estimate the zone of capture for the recovery wells.

3.02 Monitoring Well Installation

The proposed locations of the groundwater monitoring wells are based upon consideration of the hydrogeologic conditions and the assessment of petroleum leakage in the study area. The placement of the wells, as illustrated in Figure 8, has been selected to provide a more precise delineation of the extent of the product plume and to assist in evaluating the aquifer conditions during the pump test of the aquifer. Locations for eight (8) 2-inch PVC monitoring wells have been proposed to a depth of 25 feet and two (2) 6-inch PVC test/recovery wells have been proposed to a depth of 35 feet. The 2-inch monitoring wells will be constructed of schedule 40 flush joint threaded PVC well screen (0.020 slot) and riser. The 6-inch wells will be constructed of Schedule 40 PVC with the screen constructed of continuous slot wire wrapped PVC (0.020

slot size). All wells will be installed and constructed in accordance with NAVFAC guidelines and specifications, included in Appendix D.

During the drilling program, boreholes will be advanced using hollow stem auger and/or mud rotary drilling methods. Soil samples of the subsurface materials will be collected every five feet or change in formation throughout the borehole, using ASTM Method D-1586 for split spoon sampling.

Each soil sample will be screened in the field using a photoionization detector (PID) to identify the presence of petroleum product within the soils. This will provide a preliminary indication of the vertical and horizontal extent of petroleum contamination.

All wells will be developed following installation to remove fine-grained materials that may have entered the well during construction. This will be accomplished by one or a combination of the following: bailing; continuous low yield pumping; or air-lift pumping.

Equipment used for well installation that may have come in contact with potentially contaminated material will be decontaminated with a high pressure steam cleaner. Fluid generated from well development and equipment decontamination will be discharged to the ground.

3.03 Grain Size Analysis

Grain size analysis will be conducted on five (5) samples representative of the subsurface soils. The samples will be collected during the installation of the monitoring wells from depths that are consistent with screened internal of the monitoring wells and proposed recovery wells. The samples will be obtained from each of the product recovery wells and from three different monitoring wells installed in close proximity to the product plumes. One kilogram of the subsurface material will collected and shipped to a local testing facility for sieve analysis per ASTM D-422. These samples and analyses will then be used to assist in specifying the well screen and sand pack for the proposed recovery well(s).

3.04 Groundwater Elevation and Product Thickness Monitoring

Groundwater elevations and product thickness measurements will be collected from all of the HPFF monitoring wells on two separate occasions. Measurements will be obtained before any work is performed at the site and upon completion of well installation at HPFF. An oil/water interface probe will be used to measure product thickness and groundwater elevation to the nearest 0.01 ft. These measurements will be used to determine the hydraulic gradient, direction of groundwater flow, and assess the extent of free-phased product currently at the HPFF.

3.05 Aquifer Analysis

A short term pump tests will be performed on each of the 6-inch wells. The test will be conducted over an 8 hour period under the supervision of a hydrogeologist from O'Brien and Gere. This test will estimate design flow rates and determine the site specific aquifer transmissivity, hydraulic conductivity, zone of capture, and the pumping wells radius of influence. The well will be pumped with a submersible pump at a constant rate for the duration of the test. The pumping rate will be measured every 15 minutes during the aquifer testing. Water levels in the pumping and neighboring monitoring wells will be monitored at the following intervals: every five seconds for three minutes; every fifteen seconds for 7 minutes; every 60 seconds for 90 minutes; and then every 10 minutes for the duration of the aquifer test. Following the pump test, the residual-drawdown (recovery) rate will be measured until the aquifer has reached 95% recovery. The pump test data will then be tabulated and analyzed using Theis type curves and the Cooper and Jacob modification of the Theis equation.

3.06 Groundwater Sampling and Analysis

Groundwater samples will be collected from each of the newly installed monitoring wells on a single occasion in accordance with the procedures outlined in Appendix A. A total of ten (10) samples will be analyzed for volatile organic compounds and lead as described in the sampling and analysis plan, included as Appendix A.

3.07 Engineering Survey

A topographic survey will be completed at the site to establish the horizontal location and elevation of above-grade features at the site. The topographic survey will include the locations of catch basins, hydrants, power poles, manholes, roadways, buildings, tanks, fencing, monitoring wells, and any other indicators of subgrade utilities. The plan(s) will have a scale of one inch equal to twenty five feet and the topography will be indicated with contours lines at a two foot interval. Each monitoring well will have the following points surveyed: top of PVC inner casing; top of metal outer casing; and ground elevation. The survey will assist in the interpretation of groundwater flow and in the design and construction of the recovery system and treatment facility.

SECTION 4 - ENGINEERING REPORT

The engineering report will contain sections presenting and evaluating the data collected by the various feild investigations conducted at the site. A design and cost estimate for the proposed product recovery system and treatment facility will also be presented for review. A brief description of those topics to be included in the report is described below:

Site Investigation Analysis

The data generated during the field activities will be summarized with conclusions developed. Petroleum product plume configuration and location will be presented as well as projected groundwater quality in the area of the product pool(s).

Conceptual Design

The conceptual design will present a general description of the product recovery system. The site hydrogeology will be discussed, aquifer characteristics evaluated, and equipment requirements will be presented. Groundwater quality will be assessed and examined in terms of its treatability.

Basis of Design and Preliminary Layout

The conceptual design will be developed to the point of a basis of design. The basis of design will identify major unit operations, general equipment requirements, and materials of construction. In addition, a preliminary layout which locates recovery wells, product recovery equipment and groundwater treatment equipment will be included.

Cost Estimate

Based on the basis of design and layout, preliminary engineering cost estimate will be prepared for the recovery system and treatment facility.

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REFERENCES

Code of Federal Regulations, Chapter 40, Part 141, Subpart G - National Revised Primary Drinking Water Regulations: Maximum Contaminant Levels, Section 141.61. July, 1987.

Conservation of Clean Air and Water - Europe (CONCAWE), Report No. 3, 1979. Protection of Groundwater from Oil Pollution.

Environmental Science and Engineering, Inc., May 1988. Confirmation Study to Determine Existence and Possible Migration of Specific Chemicals In Situ.

Environmental Science and Engineering, Inc., May 1988. Feasibility Study for HADNOT Point Industrial Area, Camp LeJeune, North Carolina.

North Carolina Department of Natural Resources and Community Development, 1980. Groundwater Evaluation in the Central Coastal Plain of North Carolina.

O'Brien & Gere Engineers, Inc., December 1988. Contaminated Groundwater Study, Camp LeJeune, North Carolina.

Water and Air Research, Inc., April 1983. Initial Assessment Study of Marine Corps Base - Camp LeJeune, North Carolina.

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TABLE 1

HISTORY OF FUEL LOSSES
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

Location*	Date	Fuel Type	Amount of Loss	Notes
1	4/83	diesel	not noticeable in inventory	line leak (pinhole)
2	(1983)	diesel	unknown	surface seepage
3	3/82	unleaded	unknown	line leak (broken, repaired on same day)
4	1/86	unleaded	1,038 gallons	- - -
5	3/85	unleaded	1,618 gallons	valve leaks
6	(1979)	diesel, unleaded, possibly regular	20,000 - 30,000 gallons	line leak
-	8/87	unleaded	47 gallons	noticed in inventory
-	9/87	unleaded	447 gallons	noticed in inventory

* Locations correspond to Figure 3.

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Table 2
Well Specifications and Ground Water Elevation Data
Hadnot Point Fuel Farm
Camp Lejeune, NC

Well Number	Ground Elev. (ft.)	Casing Elev. (ft.)	Well Depth (ft.)	Corrected Ground Water Elevations* 3/15/88	4/20/88
MW-1	28.3	30.00	17.0	19.38	19.41
MW-2	30.0	31.68	17.0	18.41	18.53
MW-3	29.0	29.23	15.0	19.72	19.83
MW-4	29.8	31.61	15.0	21.69	21.73
MW-5	28.5	28.54	15.0	21.45	21.25
MW-6	27.8	29.95	15.0	19.26	19.20
MW-7	27.7	27.68	15.0	N/A	20.54
MW-8	26.6	26.35	15.0	20.12	20.18
MW-9	28.8	30.73	15.0	18.78	18.75
MW-10	28.1	28.01	15.0	18.26	18.42
MW-11	26.5	28.52	25.0	19.49	18.63
MW-12	26.9	28.62	25.0	20.47	19.36
MW-13	28.8	30.56	25.0	20.94	20.87
MW-14	27.7	27.87	25.0	19.72	20.05
MW-15	28.3	30.13	25.0	20.22	19.71
MW-16	28.4	30.33	25.0	18.67	18.74
MW-17	29.5	31.70	25.0	19.25	18.97
MW-18	29.9	31.80	25.0	18.68	18.86
MW-19	29.4	31.99	25.0	18.72	18.45
MW-20	26.8	31.01	25.0	20.84	19.65

*Corrected ground water elevations =
ground water elevation + (0.82 x product thickness).
N/A = Data not available.

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Table 3
Product Thickness Data
Hadnot Point Fuel Farm
Camp Lejeune, NC

Well Number	3/15/88	4/20/88
MW-1	----	----
MW-2	2.97	3.17
MW-3	----	----
MW-4	----	----
MW-5	----	----
MW-6	----	----
MW-7	N/A	0.35
MW-8	----	----
MW-9	----	----
MW-10	----	----
MW-11	----	----
MW-12	4.33	9.81
MW-13	----	----
MW-14	----	----
MW-15	0.86	0.24
MW-16	14.85	15.34
MW-17	----	----
MW-18	4.59	5.10
MW-19	----	----
MW-20	----	----

N/A = Data not available.
---- = No product layer detected.

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Table 4
Ground Water Sample Analysis
Hadnot Point Fuel Farm
Camp Lejeune, NC

Well No.	Date	BEN (ppb)	TOL (ppb)	EBEN (ppb)	XYL (ppb)	TCE (ppb)	PERC (ppb)	MTBE (ppb)	THC (ppb)
MW-1	4/20/88	19000	36000	3200	21000	<1000	<1000	<10000	97000
MW-2	4/21/88	29000	110000	11000	48000	<1000	<1000	<10000	300000
MW-3	4/20/88	<1	2	<1	4	<1	4	<10	480
MW-4	4/20/88	<1	<1	<1	2	<1	<1	<10	16
MW-5	4/20/88	<1	1	<1	2	<1	<1	<10	<10
MW-6	4/20/88	600	1700	1600	7100	<100	<100	<1000	13000
MW-7	4/21/88	28000	26000	2800	12000	<1000	<1000	<10000	68000
MW-8	4/20/88	19	1	<1	<1	<1	<1	<10	26
MW-9	4/20/88	<1	<1	2	8	<1	<1	<10	92
MW-10	4/20/88	51	1	9	14	<1	<1	<10	170
MW-11	4/20/88	1	1	<1	1	<1	<1	<10	<10
MW-12	4/21/88	19000	17000	1500	8400	<1000	<1000	<10000	50000
MW-13	4/20/88	2	2	2	8	<1	<1	<10	23
MW-14	4/20/88	6	<1	<1	2	<1	<1	<10	11
MW-15	4/21/88	4700	18000	2400	13000	<1000	<1000	<10000	43000
MW-16	4/21/88	28000	28000	1900	12000	<1000	<1000	<10000	79000
MW-17	4/21/88	11000	13000	2500	9100	<100	<100	2800	42000
MW-18	4/21/88	24000	42000	1900	12000	<1000	<1000	<10000	96000
MW-19	4/21/88	21	150	53	130	<1	<1	<10	640
MW-20	4/21/88	60	160	79	96	1	<1	<10	870

LEGEND: BEN - Benzene
TOL - Toluene
EBEN - Ethylbenzene
XYL - Xylenes
TCE - Trichloroethene
PERC - Tetrachloroethene
MTBE - MTBE
THC - Total Hydrocarbons

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Table 4
(continued)
Product Sample Analsis
Hadnot Point Fuel Farm
Camp Lejeune,NC

Well Number	Product Identification
MW-2	Gasoline
MW-7	Gasoline
MW-12	Gasoline
MW-16	Gasoline
MW-18	Gasoline

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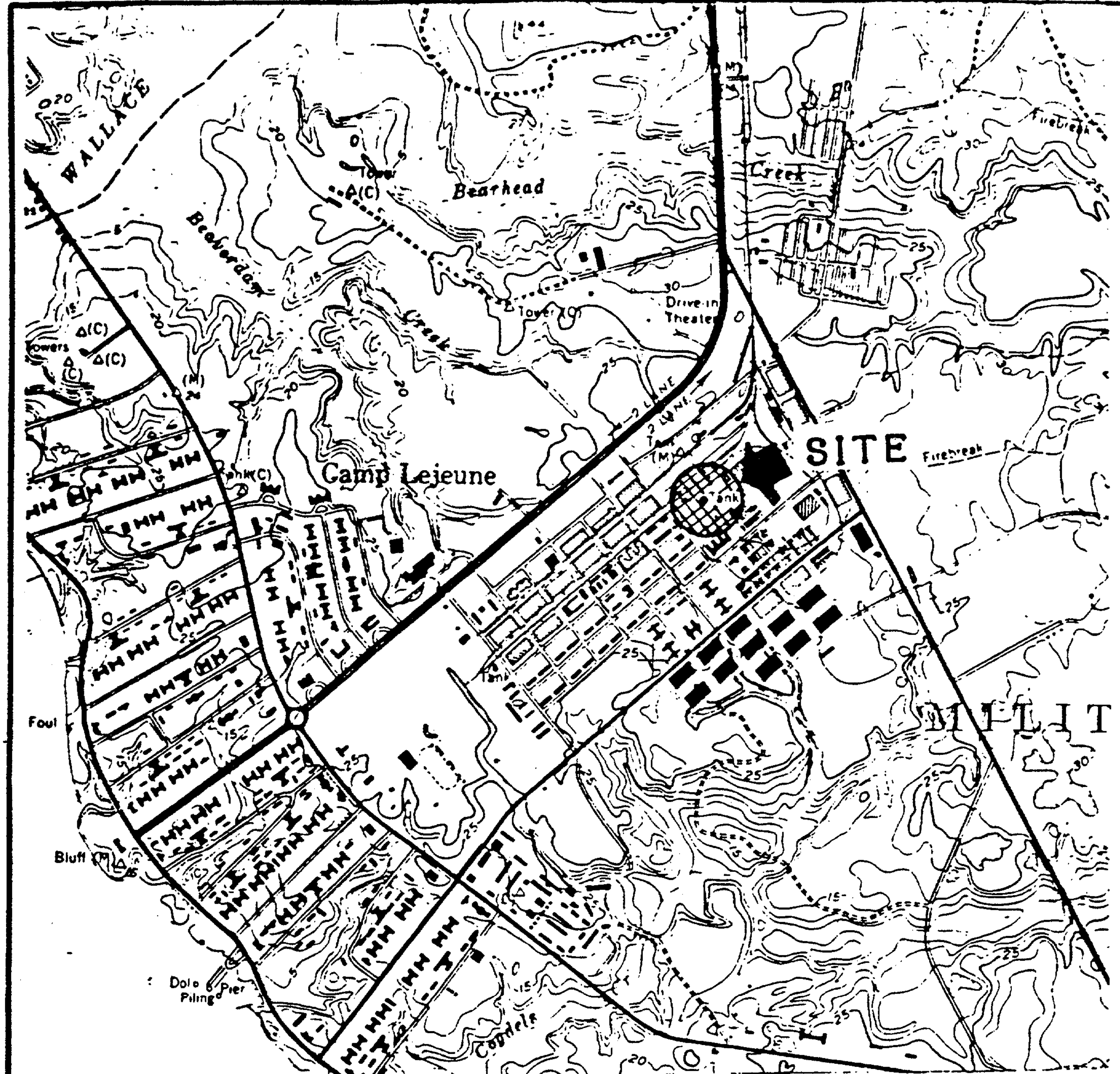
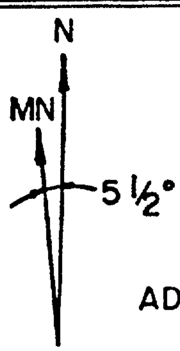


SITE LOCATION MAP

ADAPTED FROM USGS. 7.5 MIN. CAMP LEJEUNE, NC. QUADRANGLE (1952 PHOTOREVISED 1971)



SCALE 1" = 2000'
CONTOUR INTERVAL 5'

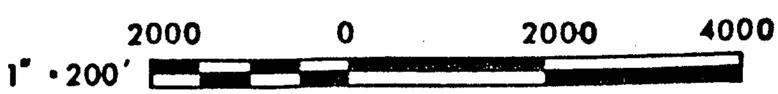
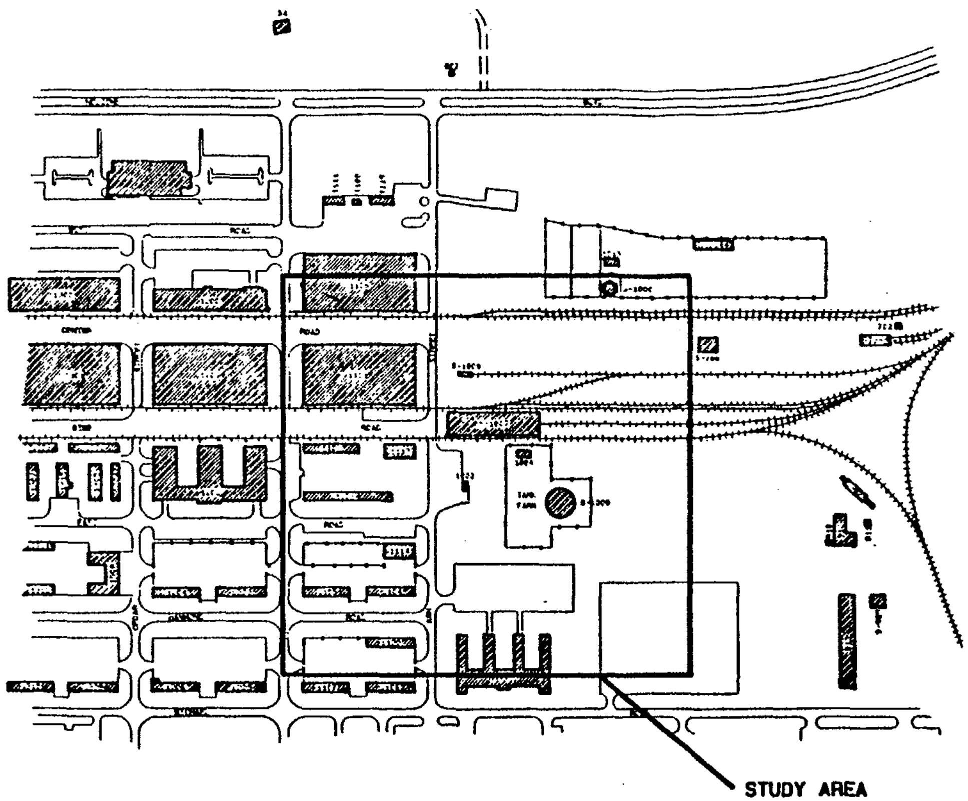


FIGURE 2

US NAVY
HADNOT POINT FUEL FARM
CAMP LEJEUNE, N.C.

HADNOT POINT
INDUSTRIAL AREA

Doc No: CLEJ-00381-3.05-10/01/89



LEGEND

FENCE

BUILDINGS

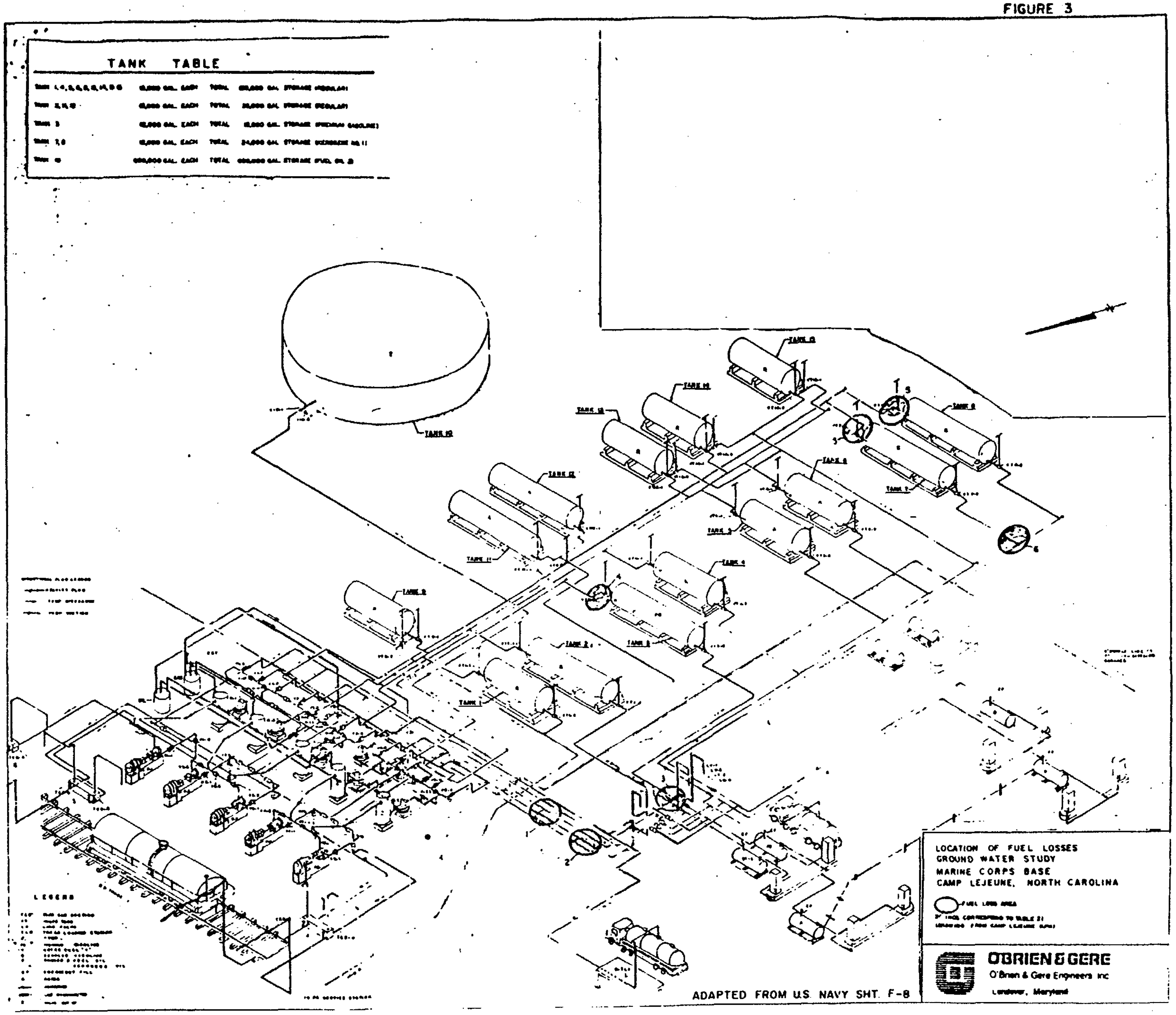
RAILROAD TRACKS

0 400 800

HORIZ. SCALE IN FEET

O'BRIEN & GERE
ENGINEERS, INC.
Syracuse, New York

FIGURE 3

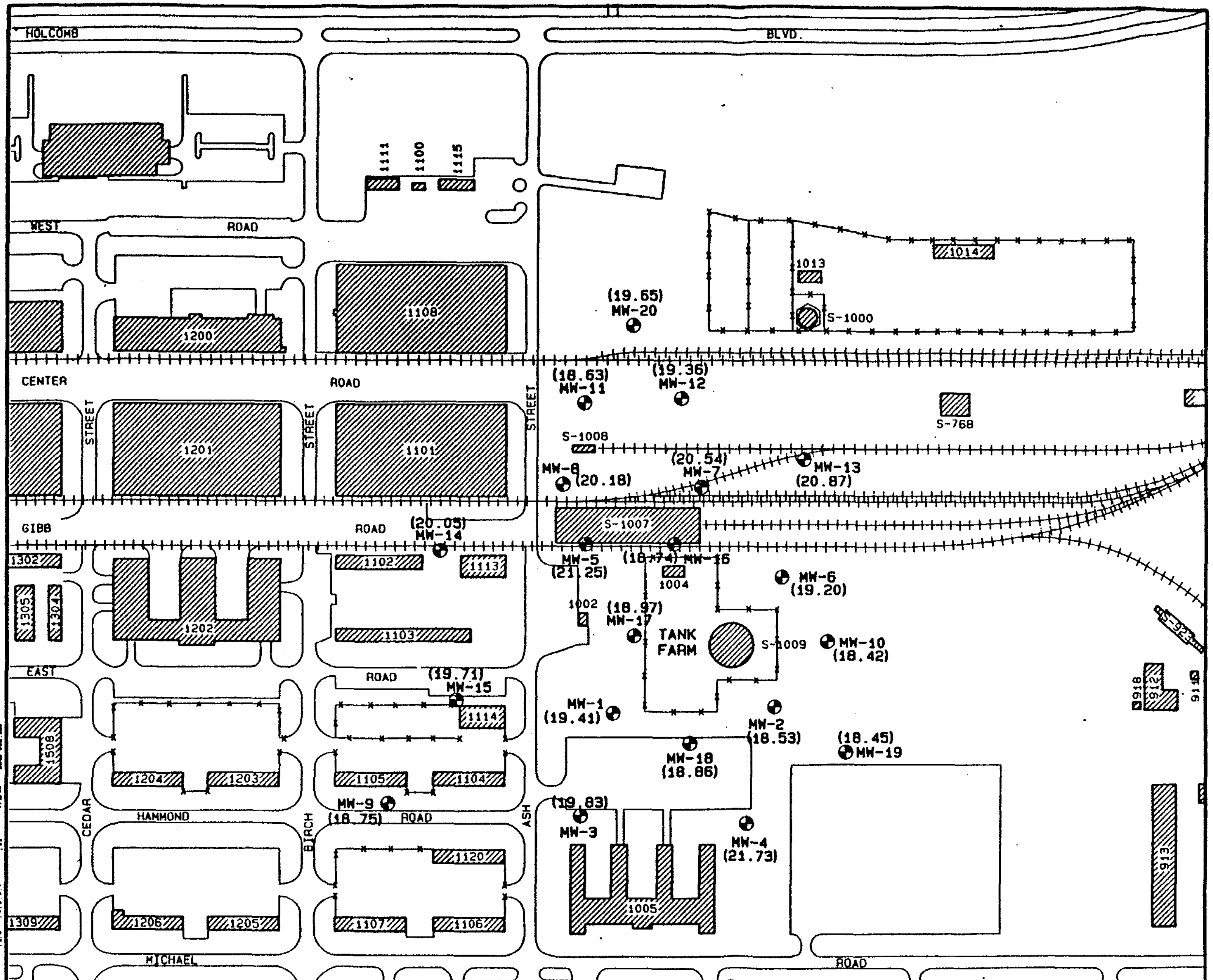


Doc No: CLEJ-00381-3.05-10/01/89

FIGURE 4

US NAVY
HADNOT POINT FUEL FARM
CAMP LEJEUNE, N.C.

CORRECTED GROUND WATER ELEVATIONS 4/20/88



LEGEND

- MONITOR WELL
- (19.65) GROUND WATER ELEVATION IN FEET ABOVE MSL

0 200 400
HORIZ. SCALE IN FEET

OBRIEN & GERE ENGINEERS, INC.
Syracuse, New York

Doc No: CLEJ-00381-305-10/01/89

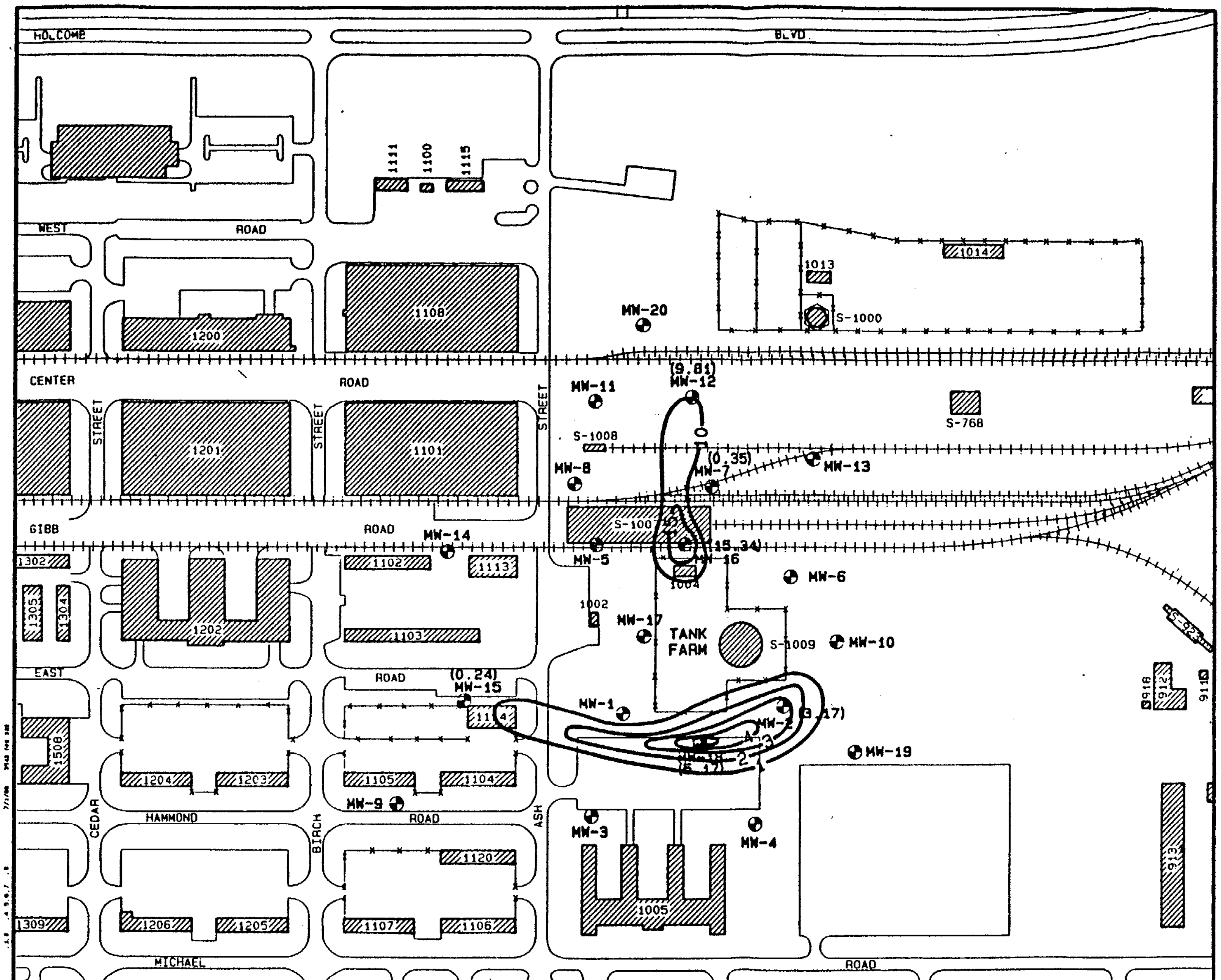


FIGURE 5

US NAVY
HADNOT POINT FUEL FARM
CAMP LEJEUNE, N.C.

PRODUCT THICKNESS
4/20/88

LEGEND

MONITOR WELL

PRODUCT THICKNESS CONTOUR (FEET)

0 200 400
HORIZ. SCALE IN FEET

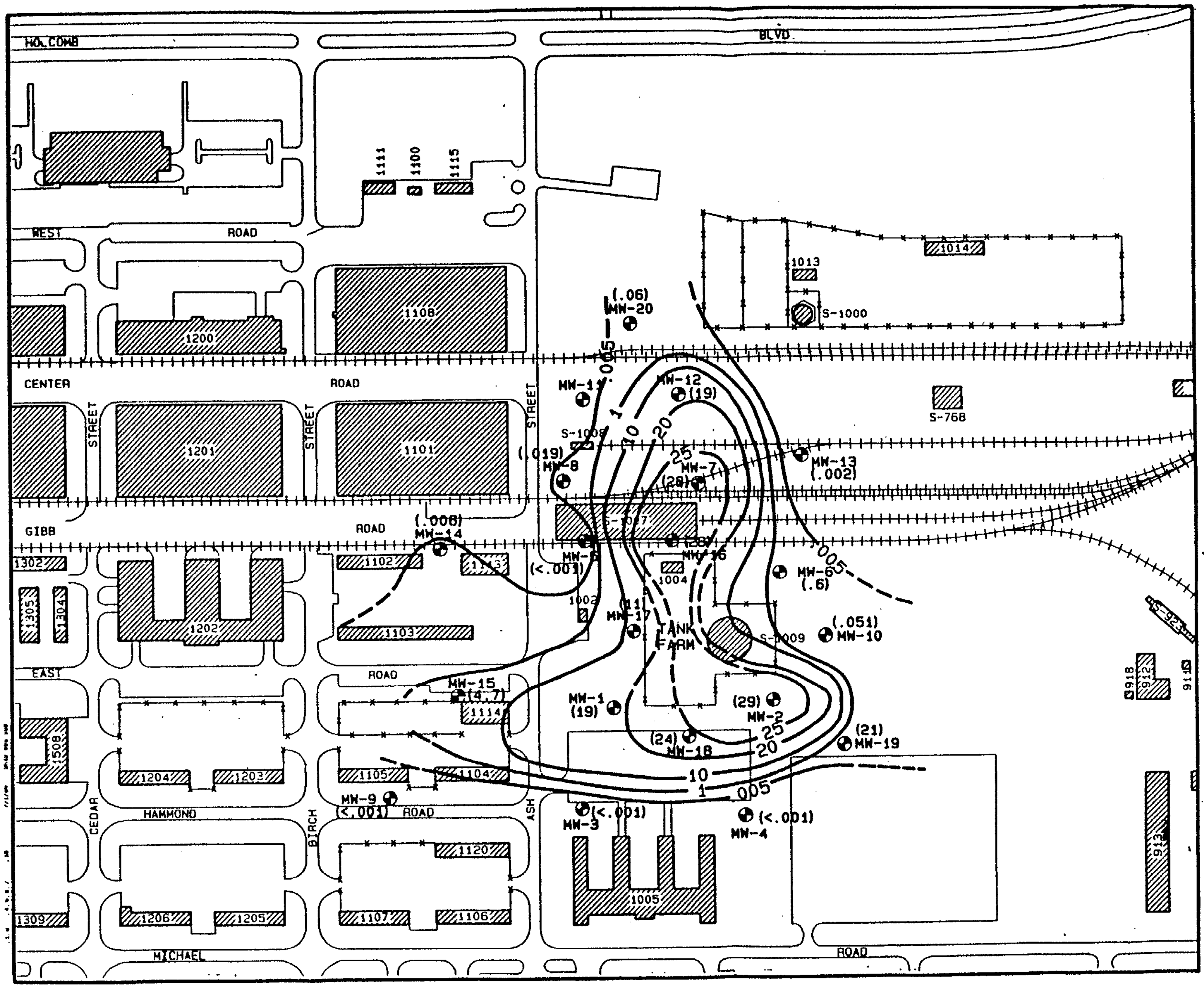
O'BRIEN & GERE
ENGINEERS, INC.
Syracuse, New York

Doc No: CLEJ-00381-3.65-10/01/89

FIGURE 6

US NAVY
HADNOT POINT FUEL FARM
CAMP LEJEUNE, N.C.

BENZENE CONCENTRATIONS
4/20/88 TO 4/21/88



LEGEND

MONITOR WELL

BENZENE CONCENTRATION CONTOUR (PPM)

0 200 400

HORIZ. SCALE IN FEET

O'BRIEN & GERE
ENGINEERS, INC.
Syracuse, New York

Doc No: CLEJ-00381-3.05-10/01/89

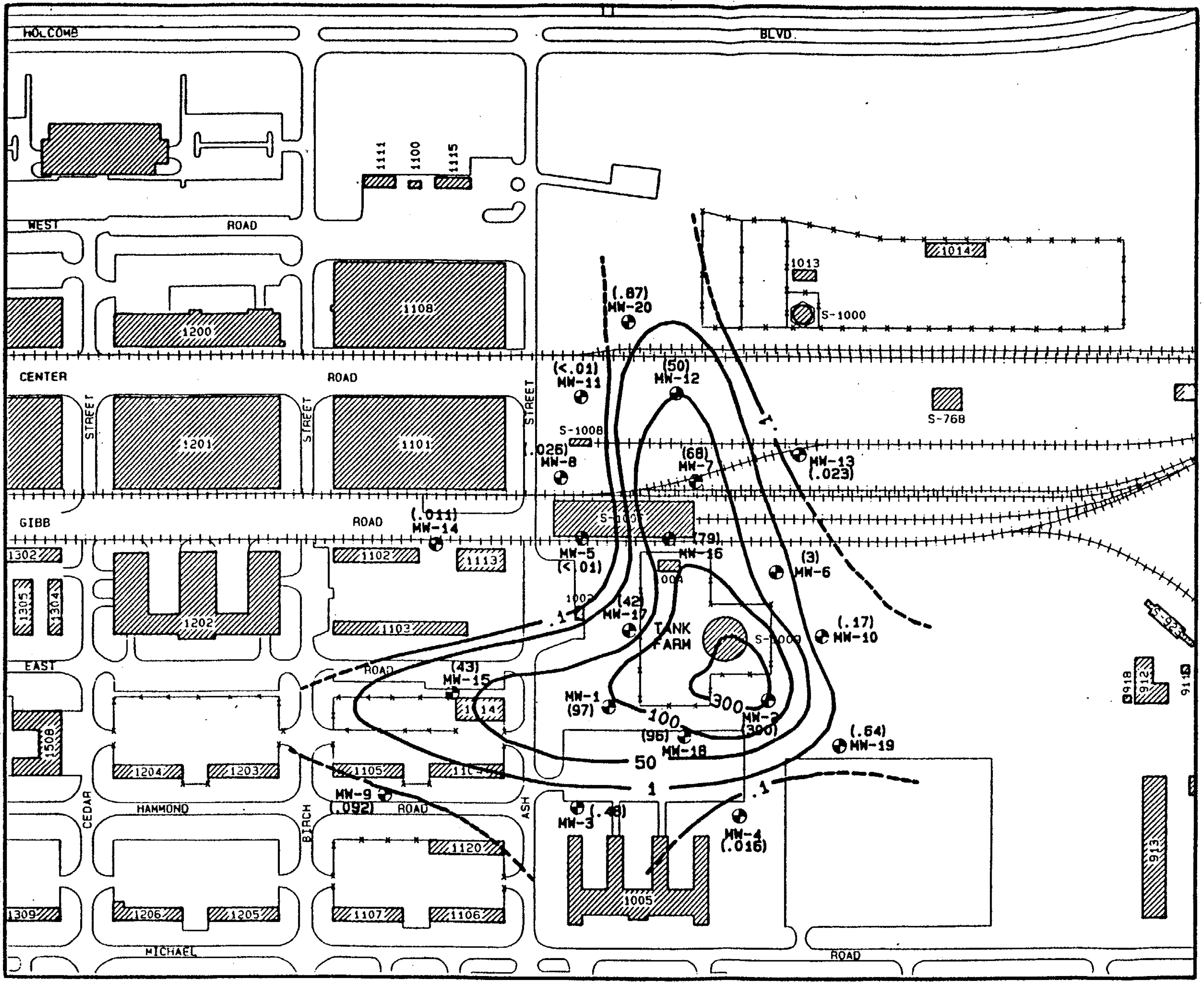


FIGURE 7

US NAVY
HADNOT POINT FUEL FARM
CAMP LEJEUNE, N.C.

TOTAL HYDROCARBONS
4/20/88 TO 4/21/88

LEGEND

MONITOR WELL

TOTAL HYDROCARBON CONTOUR (PPM)

0 200 400

HORIZ. SCALE IN FEET

O'BRIEN & GERE ENGINEERS, INC.
Syracuse New York

Doc No: CLEJ-00381-3.05-10/01/89

Doc No: CLEJ-00381-3.05-10/01/89

Doc No: CLEJ-00381-3.05 - 10/01/89

Doc No: CLEJ-00381-3.05-10/01/89

FIGURE 8

To be finalized at Work Plan Review Meeting after acquiring current product thickness and groundwater elevational data.

Doc No: CLEJ-00381-3.05-10/01/89

APPENDIX A

Doc No: CLEJ-00381-3.05 -10/01/89

GROUNDWATER SAMPLING AND ANALYSIS PLAN

Sampling

Use of the following procedures for sampling cf groundwater observation wells is dependent upon the size and depth of the well to be sampled and the presence of immiscible petroleum product in the well. To obtain representative groundwater samples from wells containing only a few gallons of groundwater and no product present, the bailing procedures are preferred. To obtain representative groundwater samples from wells containing more than a few gallons if an immiscible product layer is apparent, the pumping procedure generally facilitates more representative sampling. Each of these procedures is explained in detail below.

1. Identify the well and record the location on the Groundwater Sampling Field Log, Attachment A.

2. Put on a new pair of disposable gloves.

3. Cut a slit in the center of the plastic sheet, and slip it over the well creating clean surface onto which the sampling equipment can be positioned.

4. Clean all meters, tools, equipment, etc., before placing on the plastic sheet.

5. Using an electric well probe, measure the depth of the water tube and the bottom of the well. Record this information in the Groundwater Sampling Field Log.

6. Clean the well depth probe with an acetone soaked towel and rinse it with distilled water after use.

7. Compute the volume of water in the well, and record this volume on the Groundwater Sampling Field Log.

8. Attach enough polypropylene rope to a bailer to reach the bottom of the well, and lower the bailer slowly into the well making certain to submerge it only far enough to fill one-half full. The purpose of this is to recover any oil film, if one is present on the water table.

9. Pull the bailer out of the well keeping the polypropylene rope on the plastic sheet. Empty the groundwater from the bailer into a glass quart container and observe its appearance. NOTE: This sample will not undergo laboratory analysis, and is collected to observe the physical appearance of the groundwater only.

10. Record the physical appearance of the ground water on the Groundwater Sampling Field Log.

11. Lower the bailer to the bottom of the well and agitate the bailer up and down to resuspend any material settled in the well.

12. Initiate bailing the well from the well bottom. All groundwater should be dumped from the bailer into a graduated pail to measure the quantity of water removed from the well.

13. Continue bailing the well throughout the water column and from the bottom until three times the volume of groundwater in the well has been removed, or until the well is bailed dry. If the well is bailed dry, allow sufficient time (several hours to overnight) for the well to recover before proceeding with Step 13. Record this information on the Groundwater Sampling Field Log.

14. Remove the sampling bottles from their transport containers and prepare the bottles for receiving samples. Inspect all labels to insure proper sample identification. Sample bottles should be kept cool with their caps on until they are ready to receive samples. Arrange the sampling containers to allow for convenient filling.

15. To minimize agitation of the water in the well, initiate sampling by lowering the bailer slowly into the well making certain to submerged it only far enough to fill it completely. Fill each sample container following the instructions listed in the Sample Containerization Procedures, Attachment B. Return each sample bottle to its proper transport container.

16. If the sample bottles cannot be filled quickly, keep them cool with the caps on until they are filled. The vials labeled "volatiles" analysis should be filled from one bailer then securely capped. Add 0.2 ml of a mixture of 1 part A.C.S. reagent grade, concentrated hydrochloric acid (approximately 38%) to 1 part of organic-free water to each 40 ml VOA vial. This will adjust the pH to less than 2. Carefully fill the 40 ml VOA vials to minimize agitation. This is usually done by pouring the sample into a tilted VOA vial. Cap the VOA vial, turn it upside down and check for air bubbles. If properly filled,

there should be no visible air bubbles. Filter samples for metals analysis through a 0.45 micron filter and adjust the pH to less than 2 with A.C.S. reagent grade, concentrated (approximately 69-71%) nitric acid. Alternatively, metals samples may be filtered in the laboratory. If this option is selected, do not add the nitric acid preservative. Return each sample bottle to its proper transport container. Samples must not be allowed to freeze.

17. Record the physical appearance of the groundwater observed during sampling on the Groundwater Sampling Field Log.

18. After the last sample has been collected, record the data and time, and, and if required, empty one bailer of water from the surface of the water in the well into the 200 ml beaker and measure and record the pH , conductivity and temperature of the groundwater following the procedures outlined in the equipment operation manuals. Record this information on the Groundwater Sampling Field Log. The 200 ml beaker must then be rinsed with distilled water prior to reuse.

19. Begin the Chain of Custody Record.

20. Replace the well cap, and lock the well protection assembly before leaving the well location.

21. Place the polypropylene rope, gloves, rags and plastic sheeting into a plastic bag for disposal.

22. Clean the bailer by rinsing with control water and then distilled water. Store the clean bailer in a fresh plastic bag.

<u>Sampling Procedures (PUMP)</u>

1. Identify the well and record the location on the Groundwater Sampling Field Log.

2. Put on a new pair of disposable gloves.

3. Cut a slit in the center of the plastic sheet, and slip it over the well creating a clean surface onto which the sampling equipment can be positioned.

4. Clean all meters, tools, equipment, etc., before placing on the plastic sheet.

5. Using an electric well probe, measure the depth of the water tube and the bottom of the well. Record this information in the Groundwater Sampling Field Log.

6. Clean the well depth probe with an acetone soaked towel and rinse it with distilled water after use.

7. Compute the volume of water in the well, and record this volume on the Groundwater Sampling Field Log.

8. Attach enough polypropylene rope to a bailer to reach the bottom of the well, and lower the bailer slowly into the well making certain to submerge it only far enough to fill one-half full. The purpose of this is to recover any oil film, if one is present on the water table.

9. Pull the bailer out of the well keeping the polypropylene rope on the plastic sheet. Empty the groundwater from the bailer into a glass quart container and observe its appearance. NOTE: This sample will not undergo laboratory analysis, and is collected to observe the physical appearance of the groundwater only.

10. Record the physical appearance of the groundwater on the Groundwater Sampling Field Log.

11. Prepare the submersible pump for operation. A pump with a packer inflated above the screened interval is preferred.

12. Lower the bailer to just below the top of the water column and pump the groundwater into a graduated pail. Pumping should continue until sufficient well volumes have been removed or the well is pumped dry. If the well is pumped dry, allow sufficient time for the well to recover before proceeding with Step 16. Record this information on the Groundwater Sampling Field Log.

13. Remove the sampling bottles from their transport containers and prepare the bottles for receiving samples. Inspect all labels to insure proper sample identification. Sample bottles should be kept cool with their caps on until they are ready to receive samples. Arrange the sampling containers to allow for convenient filling.

14. With submersible pump raised to a level just below the surface of the water in the well, fill each sample container. Always fill the vials labeled "volatiles" (40 ml VOA vials) first. Filter samples for metals analysis and add nitric acid, as previously discussed in the "Bailer" section, to adjust the pH to less than 2. Alternatively, metals samples may be filtered in the laboratory. If this option is selected, do not add the nitric acid preservative. Preserve the volatiles samples with hydrochloric acid as previously discussed in the "Bailer" section. Return each sampling bottle to its proper transport container.

15. If the sample bottle cannot be filled quickly, keep them cool with the caps on until they are filled. The vials labeled "volatiles" analysis should be filled first, then securely capped. NOTE: samples must not be allowed to freeze.

16. Record the physical appearance of the groundwater observed during sampling on the Groundwater Sampling Field Log.

17. After the last sample has been collected, record the data and time, and, and if required, empty one bailer of water from the surface of the water in the well into the 200 ml beaker and measure and record the pH, conductivity and temperature of the groundwater following the procedures outlined in the equipment operation manuals. Record this information on the Groundwater Sampling Field Log. The 200 ml beaker must then be rinsed with distilled water prior to reuse.

18. Begin the Chain of Custody Record. A separate form is required for each well with the required analysis listed individually.

19. Remove the submersible pump from the well and clean the pump and necessary tubing both internally and externally. Cleaning is comprised of rinses with a source water and acetone or methanol mixture, and distilled water using disposable towers and separate wash basins. The pump should then be returned to its covered storage box.

20. Replace the well cap, and lock the well protection assembly before leaving the well location.

21. Place the gloves, towels, disposable shoe covers and plastic sheet into a plastic bag for disposal.

<u>Analyses</u>

A total of ten (10) samples will be analyzed for volatile organic compounds utilizing USEPA Methods 601 and 602 to assess the extent of soluble petroleum hydrocarbons (i.e., benzene, toluene, and xylene) and chlorinated solvents within the groundwater. Each will be analyzed for total lead by induction coupled argon plasma (ICAP).

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The following eight wells will be sampled: monitoring well 22GW1 (ESE, 1988); the two recovery wells and 5 newly installed monitoring wells as indicated on the proposed well location map. For quality assurance/quality control purposes, one field blank and one replicate sample will be analyzed for each parameter. All analyses will be conducted by a laboratory in the Tidewater Virginia area with validation to be conducted by an independent laboratory.

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APPENDIX B

Doc No: CLEJ-00381-3.05-10/01/89

HEALTH AND SAFETY PLAN

General

This Health and Safety Plan was developed in accordance with the OSHA Safety Regulations for Hazardous Waste Site Work (29 CFR 1910.120) and the Safety and Health Guidelines for NACIP Confirmation Studies, (revised February 1986). All personnel involved in the field investigation must adhere to all portions of this plan. The field investigation consists of ground water monitoring well installation, in-situ hydraulic conductivity tests, ground water elevation monitoring, product thickness monitoring, and ground water sampling.

Medical Program

The OSHA Safety Regulations for Hazardous Waste Site Work (29 CFR 1910.120) are applicable to this field investigation. All persons participating in the field investigation will meet the requirements of 29 CFR 1910.120 which may include an occupational history, a medical history, a medical surveillance examination, and annual follow-up examinations.

Education and Training Program

The OSHA Safety Regulations for Hazardous Waste Site Work (29 CFR 1910.120) are applicable to this field investigation which may require that certain personnel be trained in the areas of health and safety. This training, if required, should include general safety practices and procedures, safety equipment use and maintenance, and site investigation safety decision making.

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Site Work Control Plan

The field investigation may pose several potential hazards. On-site drilling may encounter soils that contain elevated levels of petroleum hydrocarbon constituents, including benzene, toluene, and xylene. The inhalation of vapors containing high levels of volatile organic compounds (VOCs) may be a hazard during all phases of the field investigation. The use of heavy equipment may also present hazards for workers using or working near this equipment.

Safety Protocols and Procedures

The levels of VOCs in the ambient air must be monitored with a photoionizer organic vapor detector at regular intervals whenever a worker is in an area that may potentially contain VOCs. In addition, the ambient air must be monitored with a combustion meter at regular intervals to ensure that explosive gasses are not present in dangerous quantities.

When VOC levels are at or below 5 ppm above background levels, Level D protective equipment, as defined in the USEPA Personnel Protection and Safety Manual, must be worn by all field personnel. Level D protective equipment is as follows:

- coveralls or work clothes
- steel toed boots
- hard hat

When VOC levels are detected in excess of 5 ppm above background levels at the breathing zone of equipment operators, the level of protection to be worn by all field personnel will be immediately upgraded to Level C protective equipment, as defined in the USEPA Personnel Protection and Safety Manual. Level C protective equipment is as follows:

- Tyvek protective suits
- full-face or half-face respirator with organic vapor cartridges

  (full-face is preferred)
- rubber gloves
- rubber overboots
- steel toed boots

Decontamination Procedures

Decontamination procedures are intended to prevent the contamination of any areas outside of the work zone. All contaminated equipment and machinery to be reused shall be decontaminated prior to the removal from the work site. Any Tyveks or other disposable personnel protective equipment that may have been used shall be disposed of at a location specified by the Navy.

Emergency Planning

In the event of fire, explosion, or hazardous material release, the MCB Camp LeJeune Fire Department will be immediately contacted at the emergency phone number of x 3333.

In the event of injury or other medical emergency, the MCB Camp LeJeune Naval Hospital ambulance will be immediately contacted at the emergency phone number of x 4551.

Doc No: CLEJ-00381-3.05-10/01/89

APPENDIX C

LABORATORIES, INC.

Laboratory Report

CLIENT NAVY JOB NO. 3543.004.517

DESCRIPTION Camp Lejeune - Hadnot Point

Results reported as ppb

DATE COLLECTED 4-20 & 21, 1988 DATE REC'D. 4-22-88 DATE ANALYZED 4-29 to 5-3, 1988

Description	MW#1	MW#2	MW#3	MW#4	MW#5	MW#6	MW#7	MW#8	MW#9	MW#10	MW#11	MW#12
Sample #	G7934	G7935	G7936	G7937	G7938	G7939	G7940	G7941	G7942	G7943	G7944	G7945
Petroleum Hydrocarbons and Solvents by Purge & Trap/GC												
BENZENE	19000.	29000.	<1.	<1.	<1.	600.	28000.	19.	<1.	51.	1.	19000.
TOLUENE	36000.	110000.	2.	↓	1.	1700.	26000.	1.	<1.	1.	1.	17000.
ETHYLBENZENE	3200.	11000.	<1.	↓	<1.	1600.	2800.	<1.	2.	9.	<1.	1500.
XYLENES	21000.	48000.	4.	2.	2.	7100.	12000.	<1.	8.	14.	1.	8400.
TRICHLOROETHENE	<1000.	<1000.	<1.	<1.	<1.	<100.	<1000.	<1.	<1.	<1.	<1.	<1000.
TETRACHLOROETHENE	<1000.	<1000.	4.	<1.	<1.	<100.	<1000.	<1.	<1.	<1.	<1.	<1000.
1,2-DICHLOROETHANE	1000.	<1000.	<1.	<1.	<1.	<100.	1000.	<1.	<1.	1.	<1.	2000.
MTBE	<10000.	<10000.	<10.	<10.	<10.	<1000.	<10000.	<10.	<10.	<10.	<10.	<10000.
TOTAL HYDROCARBONS	97000.	300000.	480.	16.	<10.	13000.	68000.	26.	92.	170.	<10.	50000.
COMMENTS	Gasoline	Gasoline	Gasoline	-	-	Gasoline	Gasoline	-	Gasoline	Gasoline	-	Gasoline

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted

Comments:

Doc No: CLEJ-00381-3.05-10/01/89

LABORATORIES, INC.

Laboratory Report

CLIENT NAVY JOB NO. 3543.004.517

DESCRIPTION Camp Lejeune - Hadnot Point

Results reported as ppb

DATE COLLECTED 4-20 & 21, 1988 DATE REC'D. 4-22-88 DATE ANALYZED 4-29 to 5-3, 1988

Description	MW#13	MW#14	MW#15	MW#16	MW#17	MW#18	MW#19	MW#20	Replicate	Wash Blank	Q C Trip Blank
Sample #	G7946	G7947	G7948	G7949	G7950	G7951	G7952	G7953	G7954	G7955	G7961
Petroleum Hydrocarbons and Solvents by Purge & Trap/GC											
BENZENE	2.	6.	4700.	28000.	11000.	24000.	21.	60.	12000.	<1.	<1.
TOLUENE	2.	<1.	18000.	28000.	13000.	42000.	150.	160.	35000.	↓	↓
ETHYLBENZENE	2.	<1.	2400.	1900.	2500.	1900.	53.	79.	2400.	↓	↓
XYLENES	8.	2.	13000.	12000.	9100.	12000.	130.	96.	11000.	↓	↓
TRICHLOROETHENE	<1.	<1.	<1000.	<1000.	<100.	<1000.	<1.	1.	<1000.	<1.	<1.
TETRACHLOROETHENE	<1.	<1.	<1000.	<1000.	<100.	<1000.	<1.	<1.	<1000.	<1.	<1.
1,2-DICHLOROETHANE	<1.	<1.	<1000.	1800.	200.	<1000.	<1.	<1.	<1000.	<1.	<1.
MTBE	<10.	<10.	<10000.	<10000.	2800.	<10000.	<10.	<10.	<10000.	<10.	<10.
TOTAL HYDROCARBONS	23.	11.	43000.	79000.	42000.	96000.	640.	870.	62000.	<10.	<10.
COMMENTS	-	-	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline		-

Doc No: CLEJ-00381-3.05-10/01/89

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted

Comments:

June 9, 1988

[illegible]

Doc No: CLEJ-00381-3.05-10/01/89

OBG LABORATORIES, INC.

Laboratory Report

CLIENT: NAVY | JOB NO. 3543.004.517

DESCRIPTION: Camp Lejeune - Hadnot Pt.

DATE COLLECTED: 4-20-88 | DATE REC'D.: 4-22-88 | DATE ANALYZED: 6-3-88

Description	Sample #	Petroleum Identification		
MW-2 Product	G7956	Gasoline		
MW-7 Product	G7957	Gasoline		
MW-[illegible] Product	G7958	Gasoline		
MW-16 Product	G7959	Gasoline		
MW-18 Product	G7960	Gasoline		

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/ℓ (ppm) unless otherwise noted

Comments:

Authorized: [signature]

OBG Laboratories, Inc.

Doc No: CLEJ-06381-3.05-10/01/89

APPENDIX D

MONITORING WELL INSTALLATION PROCEDURES

Drilling and Sampling Procedures

All monitoring wells will be installed using the hollow stem auger drilling method. A drill crew shall consist of an experienced driller and a driller assistant to work on each rig. A geologist experienced in hazardous waste site investigations shall be on site to supervise the drilling and monitor for safety control. The well depths will be specified by the supervising hydrogeologist, however, the wells shall not exceed a maximum depth of 25 feet. A potable water source on base will be designated by the government.

During the drilling samples of the encountered subsurface materials shall be collected at a minimum of every five feet and/or change in material at the discretion of the supervising hydrogeologist. The sampling method employed shall be ASTM-D-1586/Split Barrel Sampling for standard penetration tests. Upon retrieval of the sampling barrel, the collected sample shall be placed in glass jars labelled and retained for future reference. The hydrogeologist will prepare a descriptive log of each boring which will include: soil texture, odor, moisture content, depth to ground water and any visual indications of contamination. Additionally, the supervising hydrogeologist will monitor organic vapors using an HNU PID to assess the presence of contaminated soil and assess site safety conditions and the need for respiratory protection while drilling.

Monitoring Well Completion

After the completion of the soil sampling and drilling to the specified depth, a monitoring well will be installed in accordance with the attached well detail. The wells will be constructed of either two inch or four inch diameter, flush joint threaded, Schedule 40 or 80, PVC well screen and casing. A ten to twenty foot section of PVC well screen with a .020 slot size will be used in each well. The well casing and screen assembly will be placed into the borehole to the specified depth and a suitable sand pack will be placed in the annular space around the screen, extending two feet above the top of the screen. The sand pack shall consist of a well sorted silica sand that allows a maximum of ten percent of the material to pass through the screen slots. A one foot thick layer of bentonite pellets will be installed on top of the sand pack. A grout mixture consisting of two parts sand, one part cement and up to ten percent bentonite will be thoroughly mixed with the specified amount of water and place in the annular space above the sand pack.

In non-traffic areas, and when the casing will not cause an obstruction, a four inch diameter protective steel casing shall be installed over the PVC casing and extend at least 2.5 feet into the ground and two to three feet above the ground surface, as shown on Figure 7. The steel casing will be provided with a vented hinged locking cap for security. In areas of heavy traffic or when the casing may cause an obstruction, the protective casing will be grouted inside a 12-inch diameter watertight manhole that is flush with the ground surface, as shown on Figure 8. A concrete apron measuring five feet by five feet by 0.5 feet will be constructed around each well. The concrete will consist of

3,000 psi ready mixed concrete and will be crowned 3/4-inch above the existing surface to promote surface runoff away from the wall. The above ground wells will be protected with three Schedule 40 steel pipes, three inch ID, imbedded in a minimum of 2.5 feet of 3,000 psi concrete. The concrete to secure the three pipes will be poured at the same time as the five feet by five feet by 0.5 feet concrete apron and be an integral part of the pad. The steel pipes will be filled with concrete and painted day-glow yellow. Each well will be properly labelled by metal stamping on the exterior of the locking cap or manhole cover and by labelling the exterior of the security pipe. A sign reading "Not for Potable Use or Disposal" shall be firmly attached to each well. Well permits by state agencies will be the responsibility of the drilling contractor.

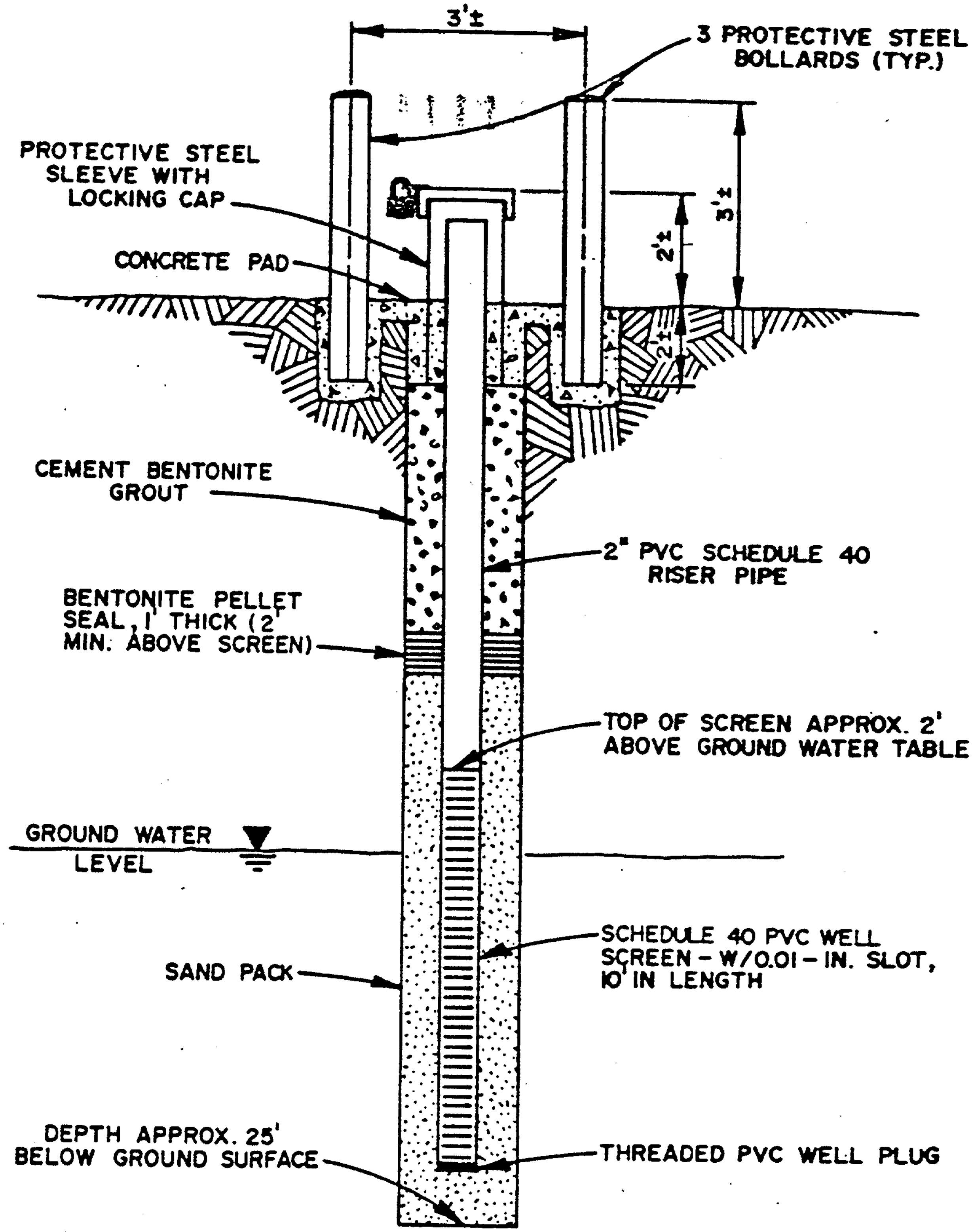
Well Development

Following well construction each monitoring well will be developed or cleared of fine grained materials and sediments that have settled in or around the well to ensure the well screen is transmitting a representative flow groundwater. The development will be accomplished using either the bailing or continuous low-yield pumping methods. Well development discharge may be disposed of on the ground surface near each well.

Decontamination

All drilling equipment including augers, drilling rods and split spoon sampling equipment, will be cleaned between each drilling location using a high pressure steam cleaner to avoid potential cross contamination of the monitoring wells. Wash water will not be contained and allowea to seep into the ground locally, unless otherwise directed by the E.I.C.

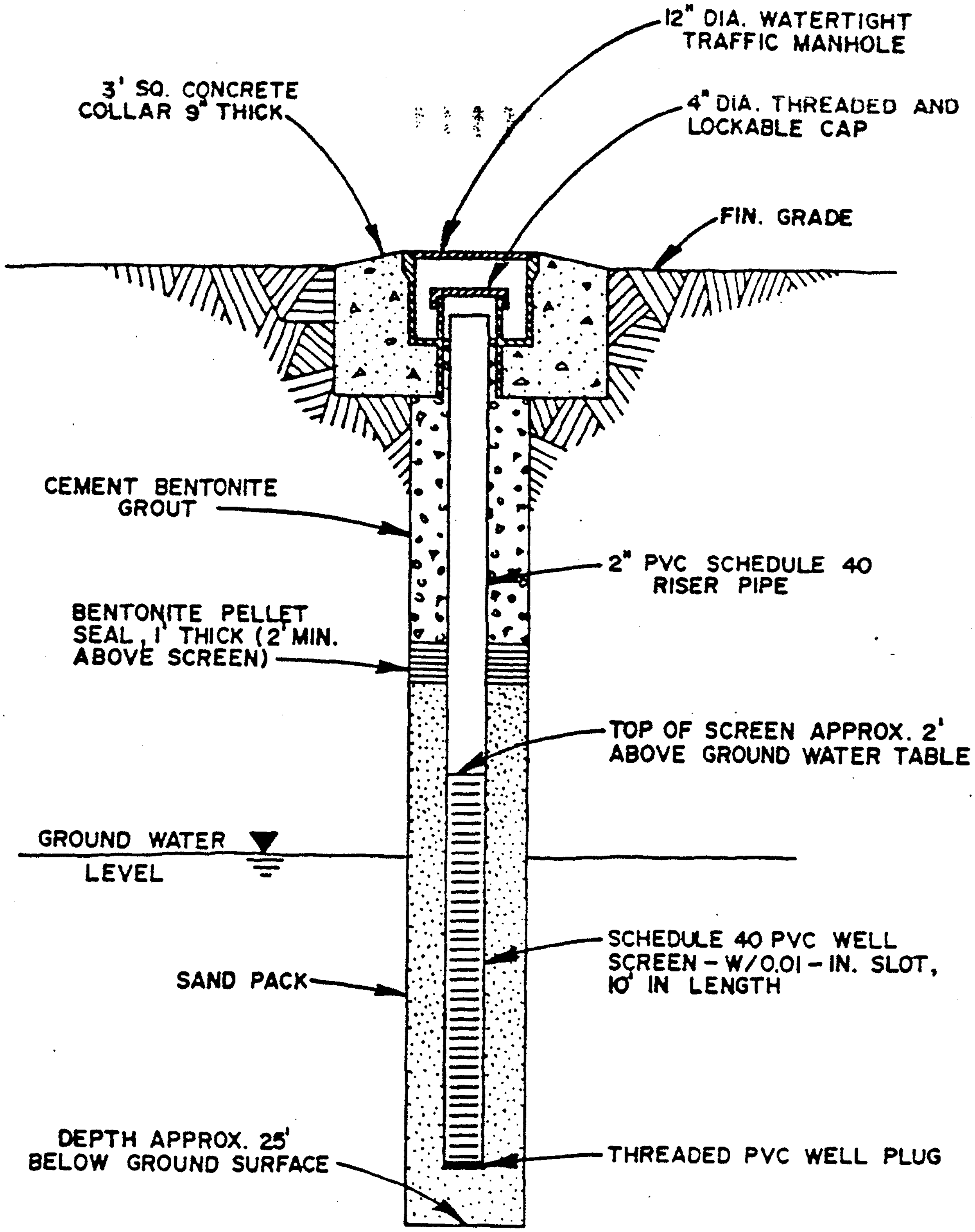
Doc No: CLEJ-00381-3.05-10/01/89



MONITORING WELL CONSTRUCTION DETAIL
(NON TRAFFIC AREA)

NOT TO SCALE

Doc No! CLEJ-00381-3.05-10/01/89



MONITORING WELL CONSTRUCTION DETAIL
(TRAFFIC AREA)
NOT TO SCALE

Doc No: CLEJ-00381-3.05-10/01/89

APPENDIX E

Doc No: CLEJ-06381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING NO. MW1 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs. FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:

BORING CO.: ATEC
FOREMAN: Sanford Sweetey
OBG GEOLOGIST: Mike Wittner

BORING LOCATION:
GROUND ELEVATION:
DATES: STARTED: 2/24/88 ENDED: 2/24/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	BLOWS /6"	PENETRN/ RECOVERY	"N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	3-4-5-5	24/18	9	18-5" dry, dark brown grading to tan-buff, silty SAND: 5-0" dry, tan, clayey SAND HNV:4					
5	2	5-7	4-4-5-6	24/24	9	24-21" dry, darkbrown, clayey SAND 21-0" dry, white - lt, tan, fine SAND HNV:60					
10	3	10-12	7-10-8-8	24/18	18	18-15" damp, dirty brown, clayey SAND 15-0" damp, white, med. SAND strong odor HNV: 140					
15	4	15-17	11-13-15 18	24/	28	damp, white & tan with some gray streaks, med. SAND HNV:180					

* water table approx. 9' BGL

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING NO. MW2 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:
BORING CO.: ATEC FOREMAN: Sanford Sweetey OBG GEOLOGIST: Mike Wittner	BORING LOCATION: GROUND ELEVATION: DATES: STARTED: 2/24/88 ENDED: 2/24/88	

DEPTH	SAMPLE No.	SAMPLE DEPTH	SAMPLE BLOWS /6"	SAMPLE PENETRN/ RECOVERY	SAMPLE "N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	5-6-4-4	24/20	10	dry, tan fine SAND: one "charred" black spot - coal chunk? HNV: 100/10-20					
5	2	5-7	4-6-11-12	24/24	17	24-21" dry, brown, fine SAND with silt 21-0" dry, brown, fine SAND; odor HNV: 100/10					
10	3	10-12	1-3-5-10	24/24	8	24-12" sl. damp, white-gray, fine SAND with some iron staining 12-4" sl. damp, white-gray, sandy CLAY; odor 4-0" same as 24-12"					
15	4	15-17	4-5-9-9	24/	14	HNV:50-100 wet, white-lt, gray, fine SAND odor HNV: 100-150					

water table approx. 13' BGL

Note if HNV reading is in following format: x/y, x= initial peak, y= steady state

Doc No: CLEJ-00381-305-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING NO. MW3 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:

BORING CO.: ATEC FOREMAN: Sanford Sweetey OBG GEOLOGIST: Mike Wittner	BORING LOCATION: GROUND ELEVATION: DATES: STARTED: 2 25/88 ENDED: 2 /25/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	BLOWS /6"	PENETRN/ RECOVERY	"N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS*
0	1	0-2	3-4-4-3	24/20	8	dry, dirty brown and tan, fine SAND HNV: <1					
5	2	5-7	3-5-7-10	24/24	12	24-21" dry, dirty brown, silty fine SAND 21-0" dry to sl. damp. tan and white-gray, fine-med, SAND HNV: <1					
10	3	10-12	4-4-4-2	24/12	8	12-3" damp, tan-brown, fine-med SAND 3-0" damp, gray to brown, fine SAND HNV: <1					
15	4	15-17	6-9-13-13	24/24	22	sl, damp, lt, gray, fine-med. SAND HNV:<1					

* water table approx. 10.5' BGL
when drilled from 5' to 10', changed from white sand to tan sand
when drilled from 10' to 15', changed from tan sand to brown sand

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING NO. MW 4 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:
BORING CO.: ATEC FOREMAN: Sanford Sweetey OBG GEOLOGIST: Mike Wittner		BORING LOCATION: GROUND ELEVATION: DATES: STARTED: 2/25/88 ENDED: 2/25/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	BLOWS /6"	PENETRN/ RECOVERY	"N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	3-4-6-5	24/21	10	dry, tan, lt. olive green, and dirty brown, fine SAND HNV:<1					
5	2	5-7	8-13-21 28	24/18	34	dry, white-lt, gray, fine-med. SAND HNV:<1					
10	3	10-12	1-1-1-1	24/12	2	damp, white-lt. tan, clayey and sandy SILT HNV:<1					
15	4	15-17	2-4-6-8	24/24	10	24-22" damp, brown, find SAND 22-20" damp, gray, fine SAND 20-17" damp, gray, CLAY 17-12" damp, gray, fine SAND 12-11" damp, gray, CLAY 11-10" damp, gray, fine SAND 10-0" damp, tan to orange tan, fine SAND HNV:<1					

* water table approx. 9.5' BGL

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.

TEST BORING LOG

REPORT OF BORING NO. MW5 — SHEET 1 OF 1

PROJECT LOCATION: Camp Lejeune
CLIENT: Navy

SAMPLER
TYPE: split spoon
HAMMER: 140 lbs
FALL: 30 inches

GROUND WATER
DEPTH — DATE — ELEV.
DEPTH — DATE — ELEV.

FILE NO.:

BORING CO.: ATEC
FOREMAN: Sanford Sweetey
OBG GEOLOGIST: Mike Wittner

BORING LOCATION:
GROUND ELEVATION:
DATES: STARTED: 2/25/88 ENDED: 2/25/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	BLOWS /6"	PENETRN/ RECOVERY	"N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	4-7-28	24/12	35	12-2" surface gravel & concrete					
			10			2-0" sl. damp, brown, organic layer-original soil surface; wood lose in spoon tip-from railroad tie? HNV: 0					
5	2	5-7	2-1-2-2	24/20	3	sl. damp, lt. gray-lt green, sandy CLAY HNV:<1					
10	3	10-12	3-3-3-4	24/18	6	damp to wet, med, gray, fine SAND HNV:<1					
15	4	15-17	6-6-9-9	24/18	15	wet, tan, fine SAND HNV:<1					

water table approx. 10.5' BGL

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-6 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/01/88 Ended: 3/01/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	3-5	24/13	11	Brown MEDIUM/FINE SAND, little silt, damp, medium dense, slight petroleum odor.					1	
			6-5									
5	2	5-7	2-4	24/24	9		5.5'				1	
			5-7			Gray with light brown mottling FINE/MEDIUM SAND, some silt, moist, loose, slight petroleum odor.						
						Groundwater encountered at 9.5 ft.						
10	3	10-12	7-11	24/18	23	- Grading to medium SAND with some fine sand and little silt. Strong gasoline/ petroleum odor. Wet.					150	
			12-13									
15	4	15-17	4-8	24/19	18	- Same, petroleum odor and product present					165	
			10-10									
						Bottom of Hole at 17.0 ft.						
20												

Doc. No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-7 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. ...t: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/01/88 Ended: 3/01/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	11-7	24/24	12	Sand and GRAVEL ROAD FILL.					45	
			5-5			light gray FINE/MEDIUM SAND, some silt, moist, medium dense. Strong petroleum odor due to petroleum staining.	0.7'					
5	2	5-7	3-3	24/20	6	- Grading to MEDIUM/FINE SAND with little silt. Some light brown mottling, loose. Slight petroleum odor.					120	
			3-3									
						Groundwater encountered ~ 8.0 ft.						
10	3	10-12	2-5	24/19	9	- Mottled gray/light brown medium sand, some fine sand. Sand is wet with gasoline/petroleum product, strong odor. 0.3' layer of black petroleum soaked sand at 11.7' to 12.0'.					180	
			4-3									
15	4	15-17	2-2	24/24	8	- Same, with some dark gray mottling. Petroleum product and odor present.					195	
			6-7									
						Bottom of Hole at 17.0 ft.						
20												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-8 Sheet 1
Project Location: Hadnot Point Tank Farm, Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/01/88 Ended: 3/01/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	14-11	24/19	20	SAND and GRAVEL ROAD FILL.						
			9-9			Dark brown with light brown mottling FINE/MEDIUM SAND, little silt, trace fine gravel, occasional wood/plant fragment, damp, medium dense.	0.5'				4	
						- Grading to black black/dark gray fine/medium sand, softer with higher fine content, moist.						
5	2	5-7	1-2	24/23	5						3	
			3-3			Light gray MEDIUM/FINE SAND, little silt, moist, soft, slight petroleum odor.	6.5'					
						Groundwater encountered at ~ 9.0 ft.						
10	3	10-12	2-4	24/24	8	- Grading to medium sand with some fine sand, little silt, wet.					2	
			4-5									
15	4	15-17	4-4	24/23	7	- Same					1	
			3-4									
						Bottom of Hole at 17.0 ft.						
20												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG [redacted]	REPORT OF BORING NO. MW9 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:

BORING CO.: ATEC FOREMAN: Sanford Sweetey OBG GEOLOGIST: Mike Wittner	BORING LOCATION: GROUND ELEVATION: DATES: STARTED: 2/25/88 ENDED: 2/25/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	SAMPLE BLOWS /6"	SAMPLE PENETRN/ RECOVERY	SAMPLE "N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	1-2-5-5	24/12	7	damp, tan with some brown spots, fine SAND HNV:<1					
5	2	5-7	5-9-11-14	24/24	20	damp, tan and white, fine SAND HNV:<1					
10	3	10-12	2-4-9-13	24/22	13	22-18" sl. damp, orange-tan and dirty brown, fine SAND 18-0" sl. damp, lt. gray with discontinuous rusty lines, CLAY HNV:<1					
15	4	15-17	2-3-5-10	24/24	8	24-12' wet, white-very lt. tan, silty CLAY 12-0" wet, white-very lt. tan, fine-med. SAND HNV:<1					

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	REPORT OF BORING NO. MW10 SHEET 1 OF 1
PROJECT LOCATION: Camp Lejeune CLIENT: Navy	SAMPLER TYPE: split spoon HAMMER: 140 lbs FALL: 30 inches	GROUND WATER DEPTH DATE ELEV. DEPTH DATE ELEV. FILE NO.:

BORING CO.: ATEC FOREMAN: Sanford Sweetey OBG GEOLOGIST: Mike Wittner	BORING LOCATION: GROUND ELEVATION: DATES: STARTED: 2/25/88 ENDED: 2/25/88

DEPTH	SAMPLE No.	SAMPLE DEPTH	BLOWS /6"	PENETRN/ RECOVERY	"N" VALUE	SAMPLE DESCRIPTION	STRATUM CHANGE DEPTH	EQUIPMENT INSTALLED		EQUIPMENT INSTALLED	RMKS
0	1	0-2	11-10-8-	24/20	18	20-18" gravel & pavement					
			10			18-17" dry, brown, fine SAND					
						17-0' dry, tan-med, brown clayey and sandy SILT tight material HNV:<1					
5	2	5-7	7-10-13	24/24	23	dry, dirty brown (top 1"), white and orange tan, fine SAND (white matl.) and med. SAND (orange tan, brown matl.) HNV: <1					
			15								
10	3	10-12	8-10-12-	24/20	22						
			13			wet, tan, fine SAND HNV: 1-1.5					
15	4	15-17	4-8-11-	24/18	19	wet, white, fine-med, SAND odor HNV:25/10-15					
			13								

*

water table approx. 9.5' BGL

Doc No: CLEJ-00381-305-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-11 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. ...t: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date / Depth Date / File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/02/88 Ended: 3/02/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Sp Cond	HNU	Rmks*
0	1	0-2	5-10	24/19	28	Light brown SAND and GRAVEL ROAD FILL.					0.5	
			18-18				1.5'					
						Mottled grayish brown MEDIUM/FINE SAND, little silt, moist, medium dense.						
5	2	5-7	2-2	24/17	4	- Grading to mottled gray MEDIUM SAND, some fine sand, little silt, soft, very moist, with occasional plant and wood fragments.					0	
			2-3									
10	3	10-12	2-3	24/18	7	- Grading with more medium sand, wet, medium dense.					0	
			4-5									
15	4	15-17	2-3	24/21	5	- Same, slight solvent or chemical odor.					0	
			2-4									
20	5	20-22	3-3	24/24	6	- Grading with little fine sand, very wet.					55	
			3-3									
25	6	25-27	WOH/12"	24/22	1	- Grading to darker gray, strong solvent odor.					110	
			1/12"									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-305-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-12 Sheet 1
Project Location: Hadnot Point Tank Farm, Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320
Boring Co.: ATEC Assoc., Inc. Foreman: Sanford Sweetey OBG Geologist: John C. Brod		Boring Location: Ground Elevation: Dates: Started: 3/07/88 Ended: 3/07/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	10-12	24/20	28	Dard brown SAND and GRAVEL ROAD FILL.					1	
			16-23			Grayish brown FINE/MEDIUM SAND, little silt and fine/medium gravel, trace coarse sand and coarse gravel, damp, medium dense.	0.5'					
							1.8'					
5	2	5-7	2-2	24/15	5						1	
			3-3									
							8.5'					
10	3	10-12	2-2	24/18	4	Gray FINE SAND, some medium sand and silt, very moist, soft.					1	
			2-3									
15	4	15-17	2-2	24/19	5	- Grading to FINE/MEDIUM SAND, some silt, trace fine gravel, wet, medium stiff. Some layering of dark gray medium/fine sand present.					2	
			3-2									
						Gray CLAY, little silt, damp, medium stiff, high plasticity.	18.5'				*	
20	5	20-22	9-10	24/20	22	Light gray MEDIUM/FINE SAND, little silt, wet, medium dense. Petroleum/gasoline odor and product present.	20.5'				150	
			12-15									
25	6	25-27	2-2	24/24	5	- Grading with less silt, some dark gray mottling, saturated with gasoline.					125	
			3-1									
						Bottom of Hole at 27.0 ft.						
30												

* Water above confining clay layer had no noticable product of odor. Material below the confining layer was saturated with gasoline.

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-13 Sheet 1
Project Location: Hadnot Point Tank Farm, Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/09/88 Ended: 3/09/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	11-7	24/18	15	Tan SAND and GRAVEL ROAD FILL.					5	
			8-11			Dark brown SILT and FINE SAND, trace medium sand, some wood fragments, roots and organic material, moist, medium dense.	1.0'					
5	2	5-7	4-5	24/0	9	- No recovery -					—	
			4-4				7.5'					
10	3	10-12	2-1	24/19	3	Gray FINE/MEDIUM SAND, some silt, occasional clay stringer, very moist, soft.					1	
			2-4									
15	4	15-17	5-9	24/13	23	- Grading to MEDIUM/FINE SAND, little silt wet, medium dense.					2	
			14-15									
20	5	20-22	2-2	24/21	5	- Grading to FINE/MEDIUM SAND, loose.					1	
			3-4									
25	6	25-27	5-7	24/23	21	Dark gray SILT, some clay and fine sand.	25.5'				1	
			14-15			Brown ORGANIC SILT/PEAT, wood fragments, roots, little fine sand, moist stiff.	26.0'					
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-14 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. :: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc. Foreman: Sanford Sweetey OBG Geologist: John C. Brod	Boring Location: Ground Elevation: Dates: Started: 3/08/88 Ended: 3/08/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	8-9	24/7	11	Grayish brown SAND and GRAVEL ROAD FILL, some silt, medium dense, dry.					1	
			3-4									
							4.0'					
						Grayish brown with tan mottling, FINE SAND, some silt, little medium sand, moist, medium dense.						
5	2	5-7	10-11	24/22	20						6	
			9-8									
						- Occasional chunks of wood/organic matter						
10	3	10-12	3-1	24/16	2		11.0'				1	
			1-2			Gray FINE SAND and SILT, trace medium sand, wet, soft. Occasional clay stringer.						
						- - - - - - - - - - - - - - - -						
						Light gray FINE/MEDIUM SAND, little silt, wet, loose.						
15	4	15-17	1-2	24/21	4		16.0'				1	
			2-3			Dark brown ORGANIC SILT/PEAT, wood fragments, roots, moist, soft.						
						- Thin layer of organic clay.						
20	5	20-22	1-2	24/16	8		21.0'				2	
			6-15			Light gray FINE/MEDIUM SAND, little silt, wet, medium dense.						
25	6	25-27	3-4	24/8	7	- Same with some dark gray discoloration and brown mottling. Petroleum odor.					15	
			3-3									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-15 Sheet 1
Project Location: Hadnot Point Tank Farm, Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc. Foreman: Sanford Sweetey OBG Geologist: John C. Brod	Boring Location: Ground Elevation: Dates: Started: 3/08/88 Ended: 3/08/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	2-3	24/16	6	Brown FINE SAND, little medium sand and silt, moit, loose.					3	
			3-2									
							5.2'					
5	2	5-7	2-1	24/19	4	Gray FINE SAND, some medium sand, little silt, moist, loose.					2	
			3-7									
10	3	10-12	5-10	24/19	22	- Grading to FINE/MEDIUM SAND, little silt, wet, medium dense.					18	
			12-15									
15	4	15-17	6-12	24/18	22	- Same, with brown mottling and discoloration, petroleum/disel fuel odor.					14	
			10-9									
20	5	20-22	2-2	24/24	5	Gray MEDIUM/FINE SAND with occasional clay stringer, loose. Strong petroleum/gasoline odor, material saturated with gasoline.					138	
			3-4									
25	6	25-27	3-3	24/24	6	- Same					95	
			3-4									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-16 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date / Depth Date / File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/10/88 Ended: 3/10/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	2-2	24/13	4	Tan SAND and GRAVEL FILL					4	
			2-3			Grayish tan with some dark brown mottling FINE/MEDIUM SAND, some silt, moist, medium stiff, petroleum odor.	0.8'					
5	2	5-7	4-5	24/15	12	Gray FINE SAND, some silt and medium sand wet, medium dense. Petroleum product and odor.					150	
			7-7									
10	3	10-12	4-5	24/15	12	- Grading to FINE/MEDIUM SAND, little silt, occasional clay stringer.					165	
			7-7									
15	4	15-17	2-2	24/24	6	Light gray SILT, some clay and fine sand, moist, soft petroleum odor.	15.5'				190	
			4-4									
						- Grading with more fine sand.						
20	5	20-22	4-5	24/17	13						135	
			8-8			Light gray FINE/MEDIUM SAND, little silt, wet, medium dense. Saturated with gasoline.	21.0'					
25	6	25-27		24/19		Dark gray/black FINE/MEDIUM SAND, some silt, wet, medium dense. Color due to petroleum discoloration.	25.6'				150	
						Bottom of Hole at 27.0 ft.						
30												

Doc. No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-17 Sheet 1
Project Location: Hadnot Point Tank Farm, Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/09/88 Ended: 3/09/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	2-5	24/23	12	Mottled grayish brown FINE/MEDIUM SAND, some silt, trace fine gravel, moist, medium dense. Petroleum odor and discoloration.					35	
			7-7									
5	2	5-7	3-3	24/19	8	Light gray FINE/MEDIUM SAND, some silt, moist, loose. Petroleum odor.	5.5'				5	
			5-5									
10	3	10-12	3-9	24/21	19	- Grading to MEDIUM/FINE SAND, little silt, reddish tan discoloration due to presence of gasoline product.					150	
			10-11									
15	4	15-17	3-5	24/15	10	- Same, with grayish tan color.					55	
			5-7									
20	5	20-22	5-7	24/22	16	- Grading to MEDIUM SAND, some fine sand, little silt, occasional clay stringer, strong gasoline odor.					175	
			9-11									
25	6	25-27	3-5	24/24	11	- Grading with slightly more silt and fine sand.					125	
			6-6									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-18 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc. Foreman: Sanford Sweetey OBG Geologist: John C. Brod	Boring Location: Ground Elevation: Dates: Started: 3/11/88 Ended: 3/11/88

Depth	Sample No	Sample Depth in ft.	Blows /6"	Penetr/ Recovry	"N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	2-3	24/16	6	Olive brown FINE SAND and SILT, little medium sand, trace fine gravel, damp, medium stiff, odor.					25	
			3-4									
							3.5'					
5	2	5-7	5-6	24/22	14	Mottle light gray/tan FINE/MEDIUM SAND, little silt, moist, medium dense. Slight odor.					2	
			8-11									
10	3	10-12	3-6	24/18	11	- Grading with some silt, less tan mottling, petroleum odor.					150	
			5-3									
15	4	15-17	3-6	24/16	12	- Same, with occasional clay stringer, wet strong petroleum odor.					155	
			6-8									
20	5	20-22	2-3	24/24	5	- Grading to FINE SAND, some medium sand and silt, loose. Solvent/petroleum odor.					125	
			2-4									
25	6	25-27	4-3	24/19	6	- Same, with layers of medium sand.					11	
			3-3									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-3.05-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-19 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. Client: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date; Depth Date; File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/14/88 Ended: 3/15/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	7-7	24/11	13	Tan SAND and GRAVEL ROAD FILL						
			5-5			Light brown FINE SAND, little silt and medium sand, moist, medium dense.	1.0'					
5	2	5-7	7-11	24/21	24	Light gray FINE SAND, little silt and mediumsand, moist, medium dense.	5.0'					
			13-17									
10	3	10-12	2-3	24/20	9	- Grading to FINE/MEDIUM SAND, little silt, loose.						
			6-6									
15	4	15-17	2-4	24/22	10	- Grading to MEDIUM/FINE SAND, little silt, some layering of medium sand, some tan mottling, wet, medium dense.						
			6-10									
20	5	20-22	1-4	24/20	8	- Same, with color changing to orange/ brown.						
			4-5									
25	6	25-27	3-3	24/24	6	- Same						
			3-3									
						Bottom of Hole at 27.0 ft.						
30												

Doc No: CLEJ-00381-305-10/01/89

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: MW-20 Sheet 1
Project Location: Hadnot Point Tank Farm Camp Lejeune, N.C. ...nt: U.S. Navy	SAMPLER Type: Split Spoon Hammer: 140 lbs. Fall: 30 inches	Ground Water Depth Date Depth Date File No.: 3543.002.320

Boring Co.: ATEC Assoc., Inc.
Foreman: Sanford Sweetey
OBG Geologist: John C. Brod

Boring Location:
Ground Elevation:
Dates: Started: 3/14/88 Ended: 3/14/88

Depth	Sample No	Sample Depth in ft.	Sample Blows /6"	Sample Penetr/ Recovry	Sample "N" Value	Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing pH	Field Testing Sp Cond	Field Testing HNU	Rmks*
0	1	0-2	2-4	24/16	9	Tan FINE SAND, some medium sand (FILL)					<1	
			5-4			Dark brown SILT and FINE SAND, little medium sand and fine gravel, little organic material and wood fragments, moist, medium dense.	0.5'					
							4.0'					
5	2	5-7	1-1	24/22	3	Grayish brown FINE SAND, some silt and medium sand, some interbedding of gray silty clay, trace fine gravel, moist, soft.					<1	
			2-2									
10	3	10-12	1-1	24/2	3	- Same					<1	
			2-1									
15	4	15-17	4-2	24/19	5	- Grading to gray FINE/MEDIUM SAND, little silt, trace fine gravel and organic material, wet, loose.					<1	
			3-2									
20	5	20-22	6-6	24/17	12	- Grading to MEDIUM/FINE SAND, little silt occasional thin silty clay layer, medium dense.					1	
			6-8									
25	6	25-27	WOH/24"	24/14	---	- Grading to dark gray MEDIUM SAND, some fine sand, little silt, wet, very loose.					<1	
						Bottom of Hole at 27.0 ft.						
30												

* WOH = Weight of Hammer.

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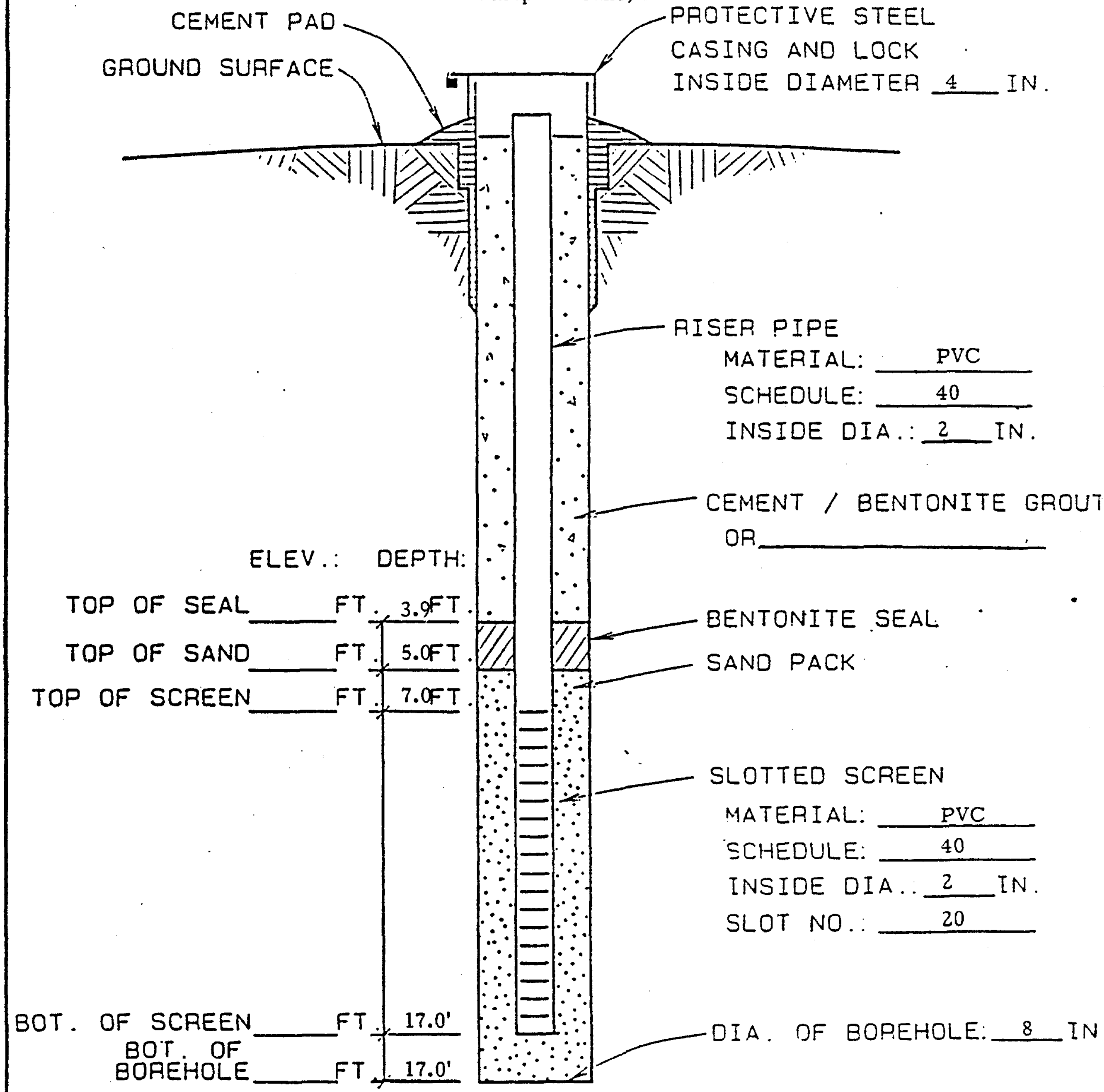
APPENDIX F

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-1



TYPICAL OVERBURDEN MONITORING WELL

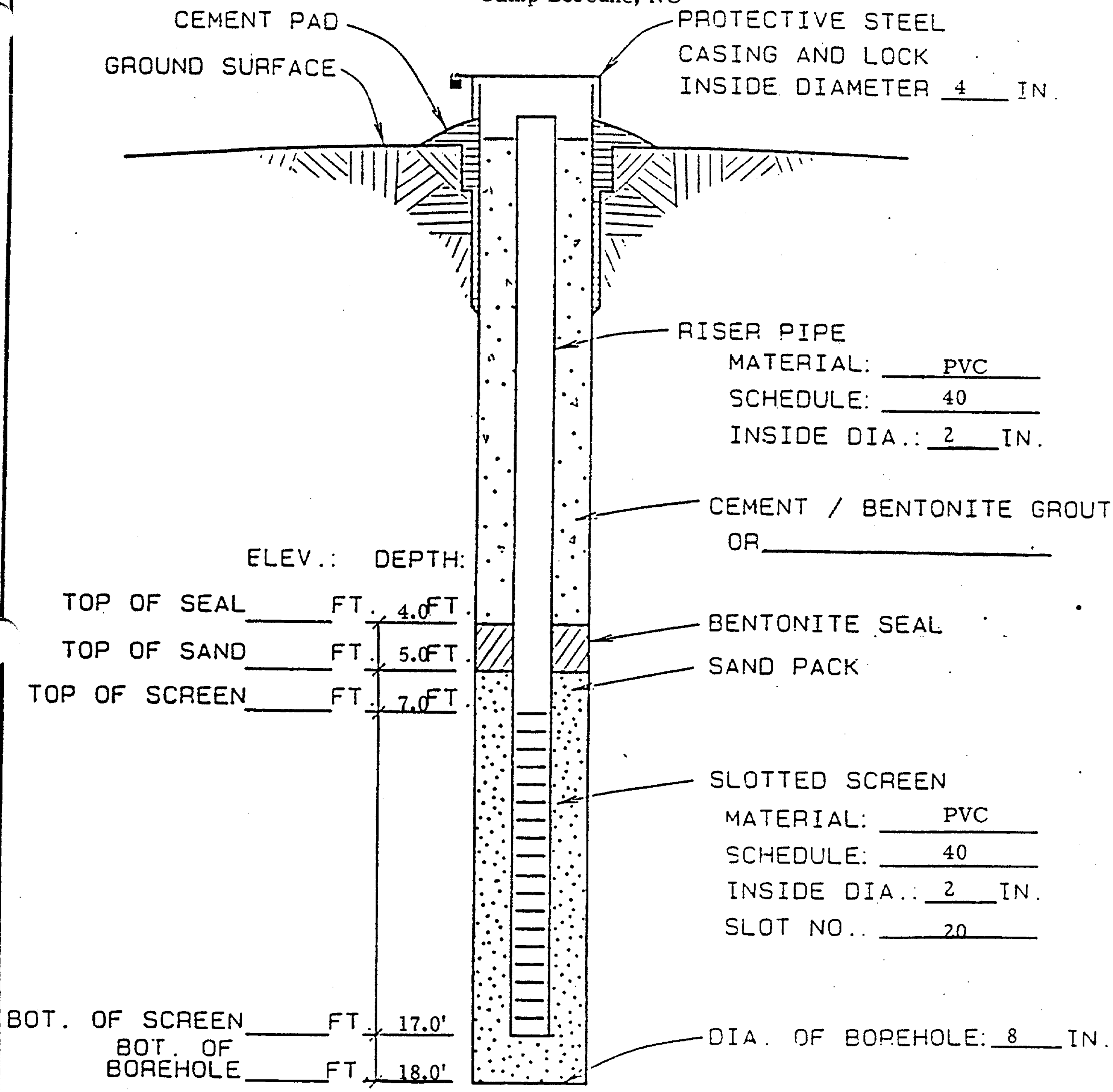
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-2



TYPICAL OVERBURDEN MONITORING WELL

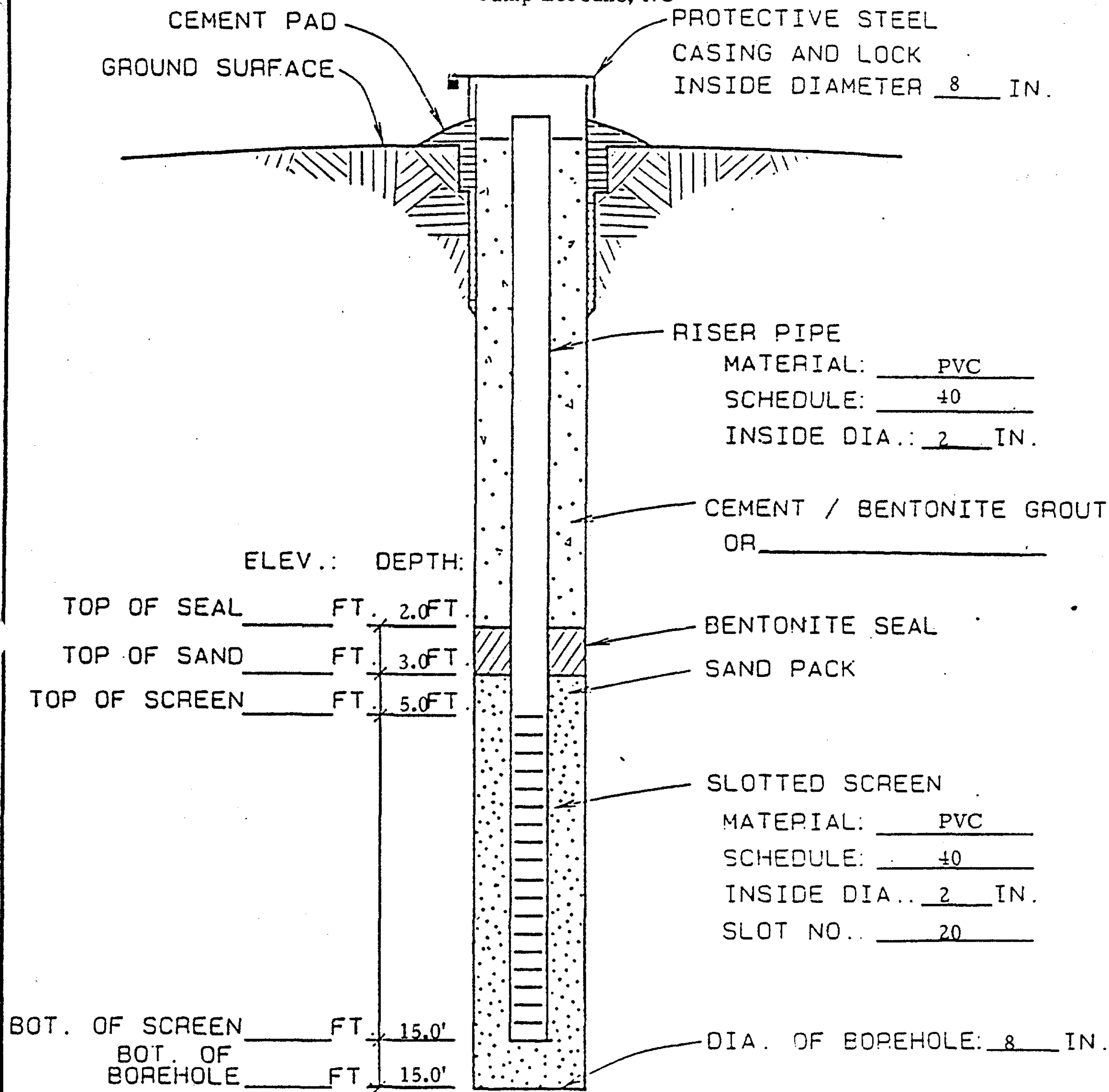
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-3



TYPICAL OVERBURDEN MONITORING WELL

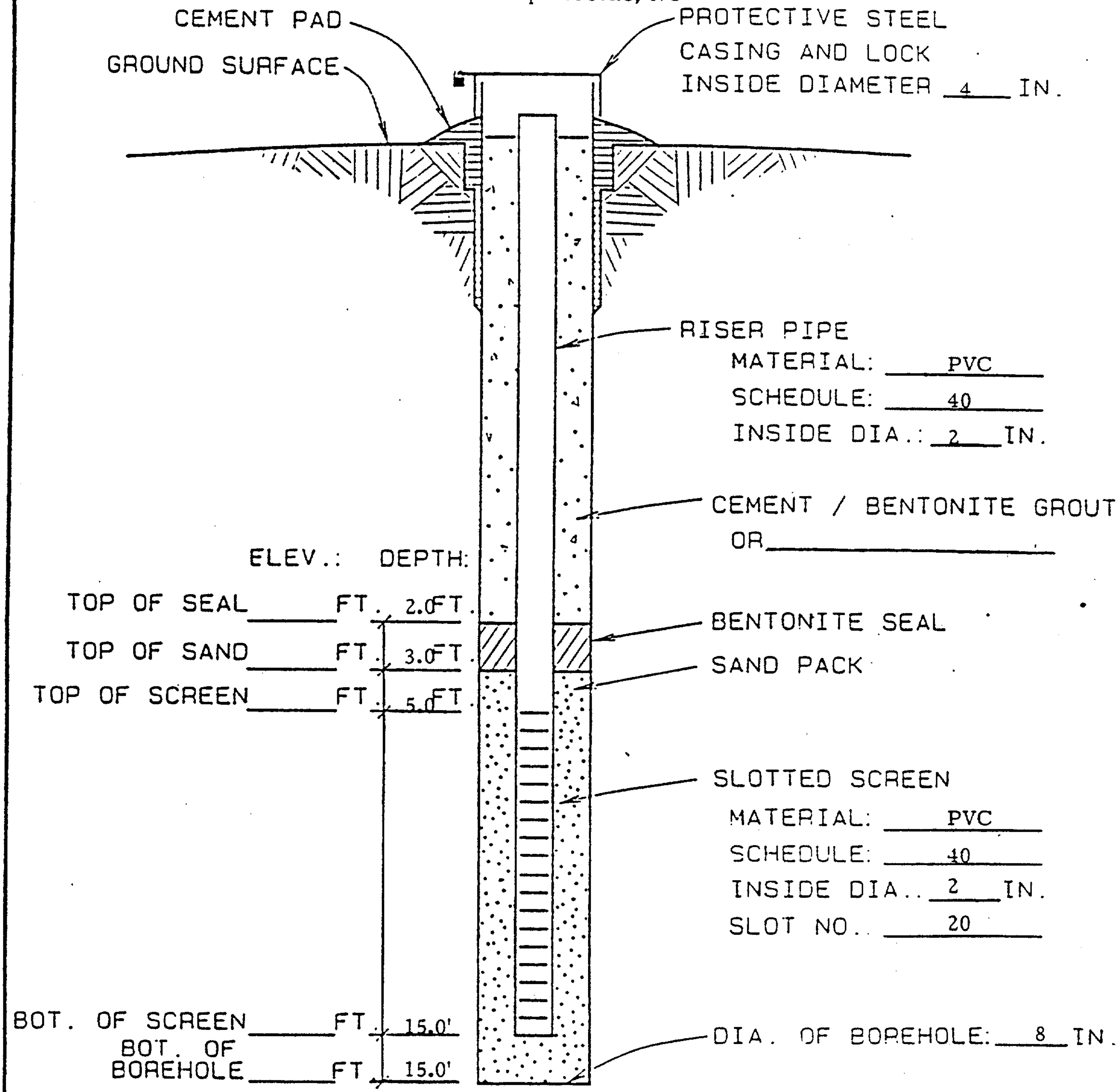
N.T.S.

Doc No: CLEJ-06381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-4



TYPICAL OVERBURDEN MONITORING WELL

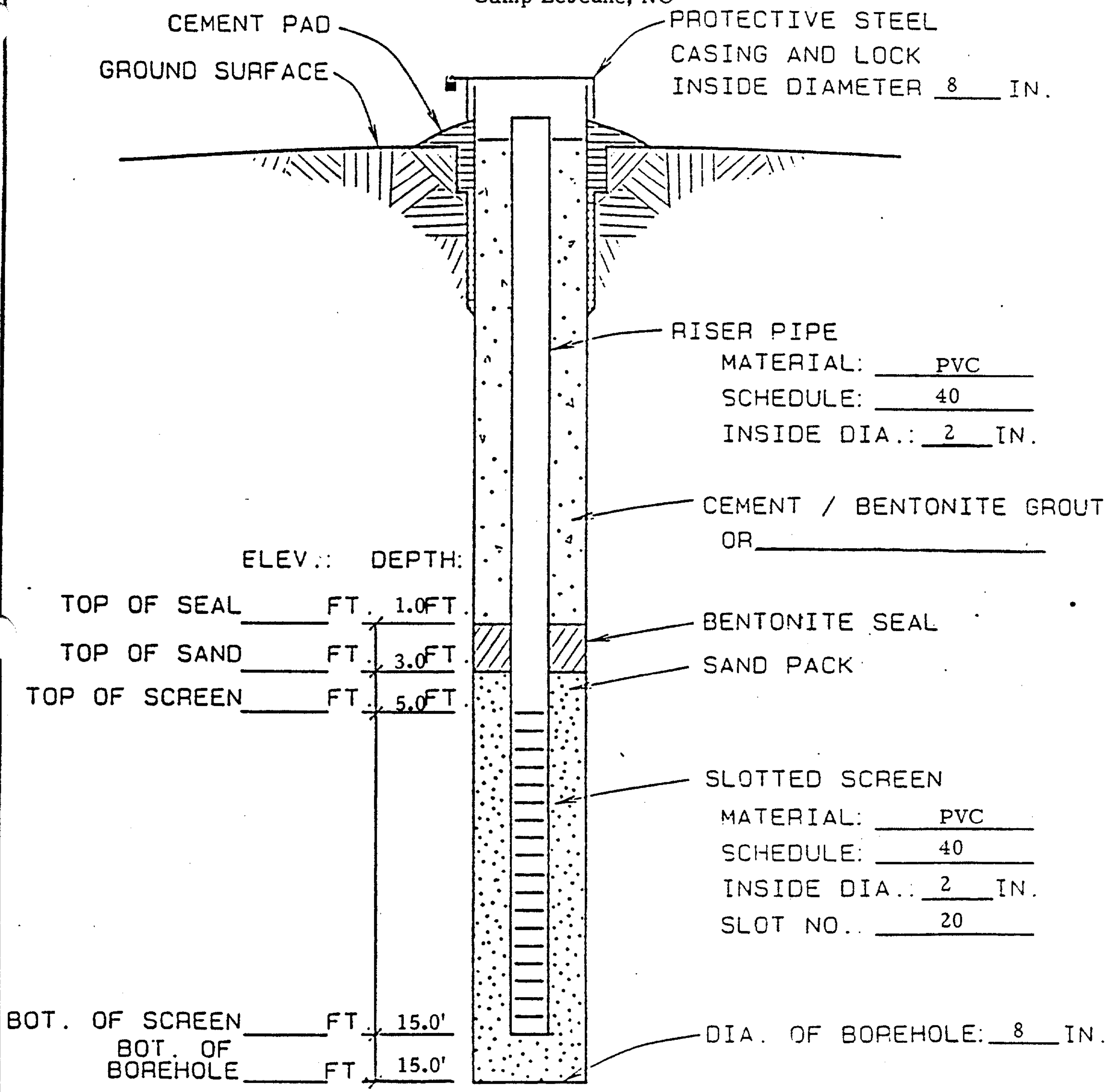
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-5



TYPICAL OVERBURDEN MONITORING WELL

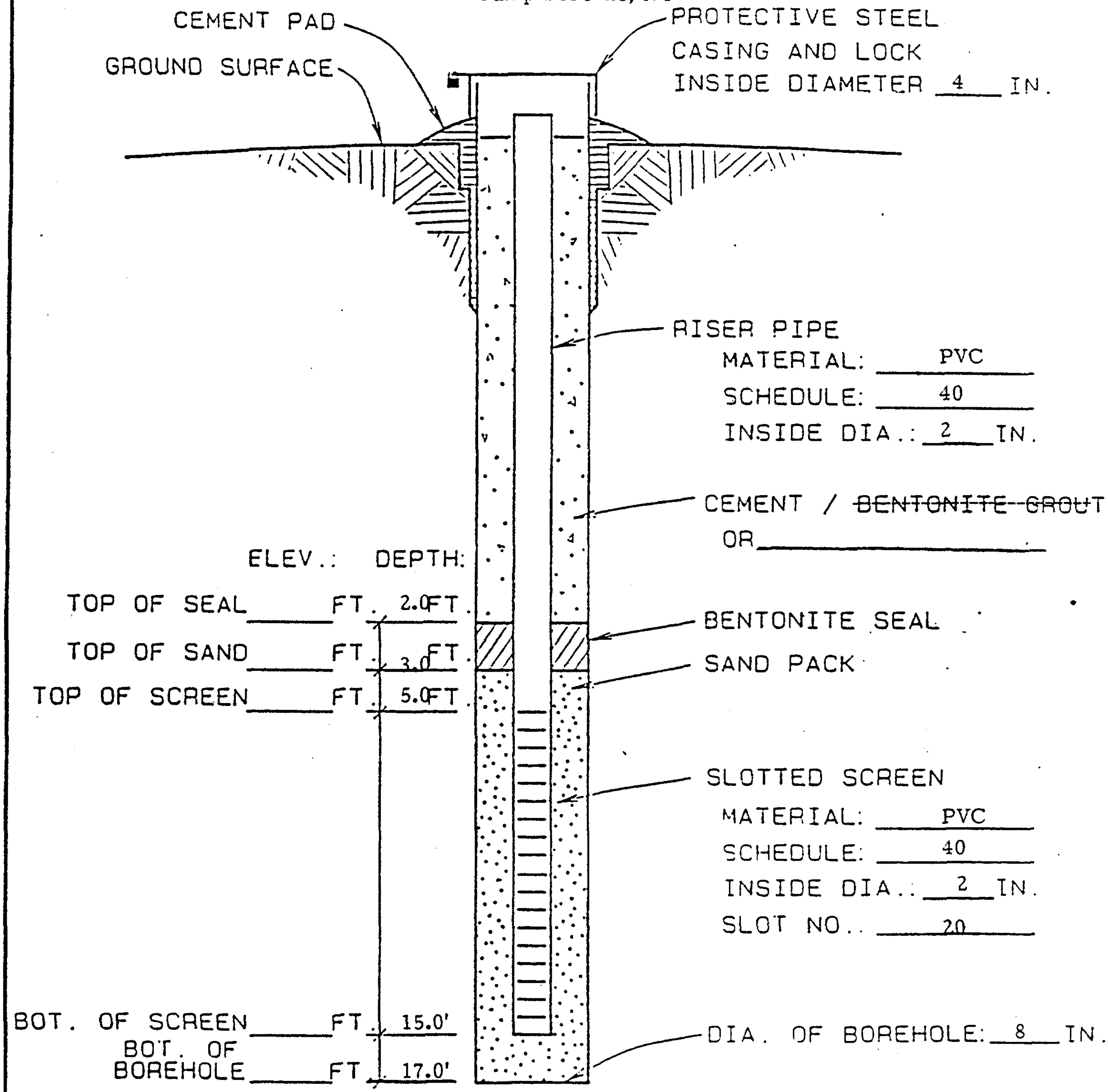
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-6



TYPICAL OVERBURDEN MONITORING WELL

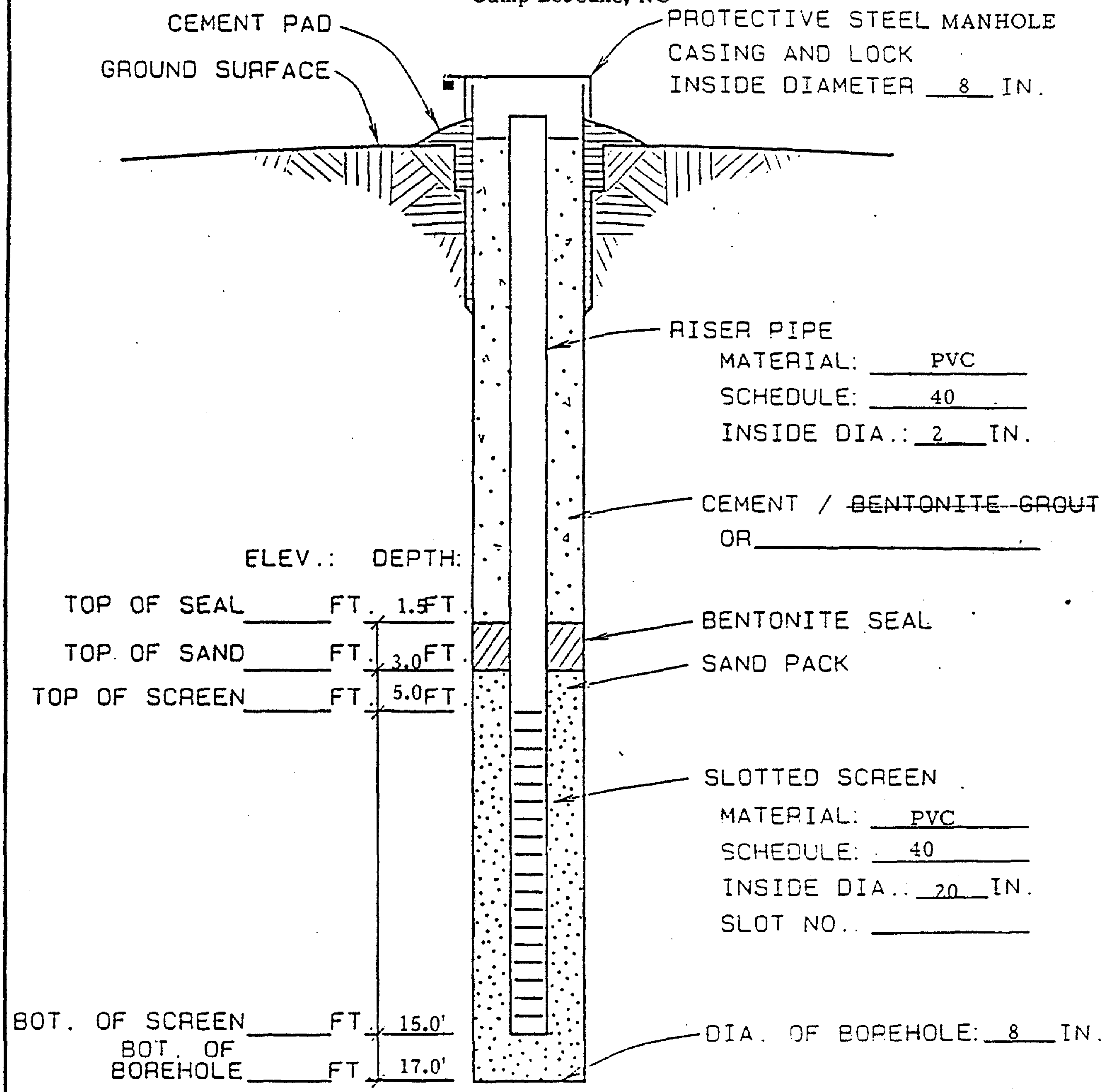
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-7



TYPICAL OVERBURDEN MONITORING WELL

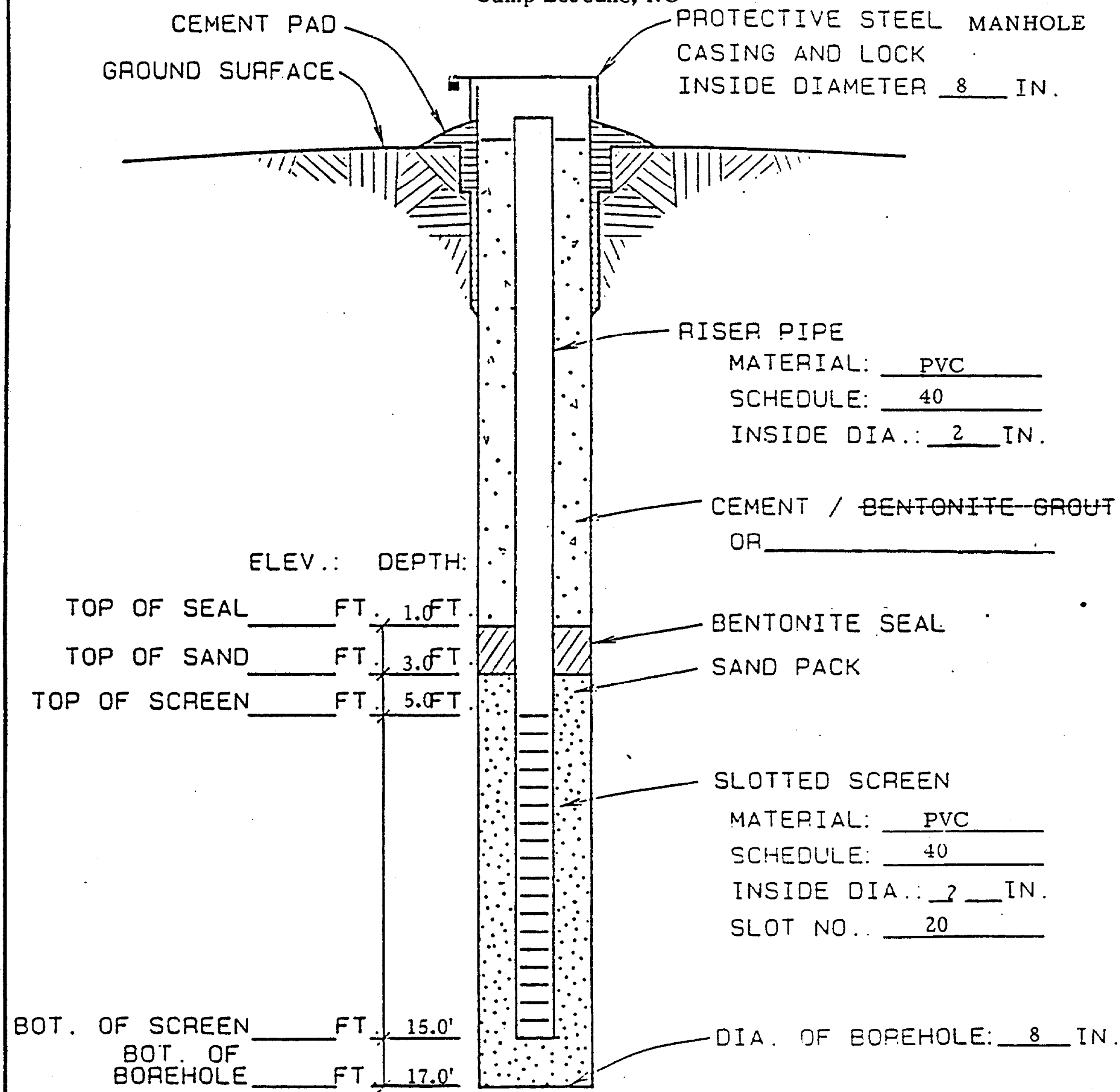
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-8



TYPICAL OVERBURDEN MONITORING WELL

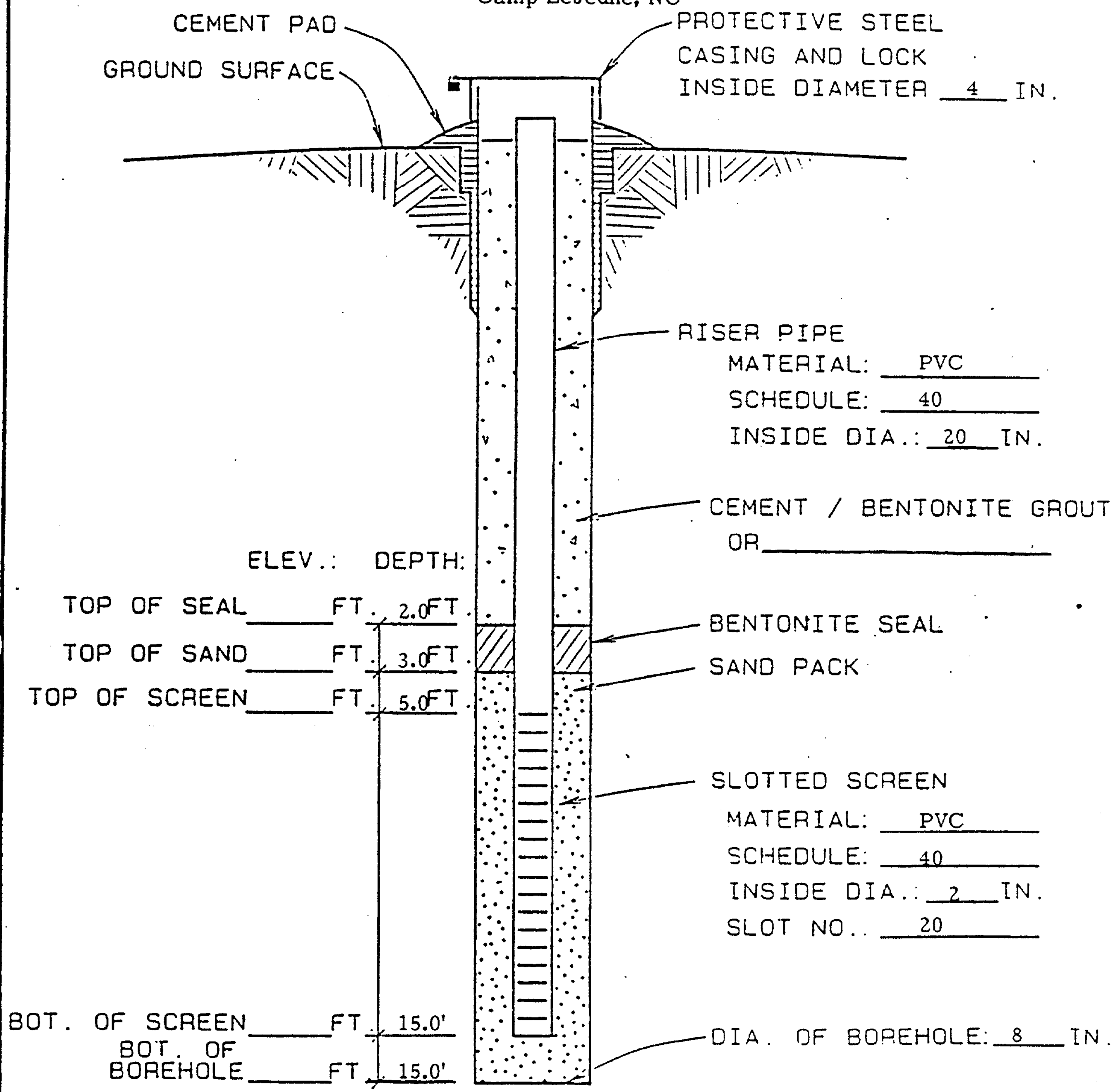
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-9



TYPICAL OVERBURDEN MONITORING WELL

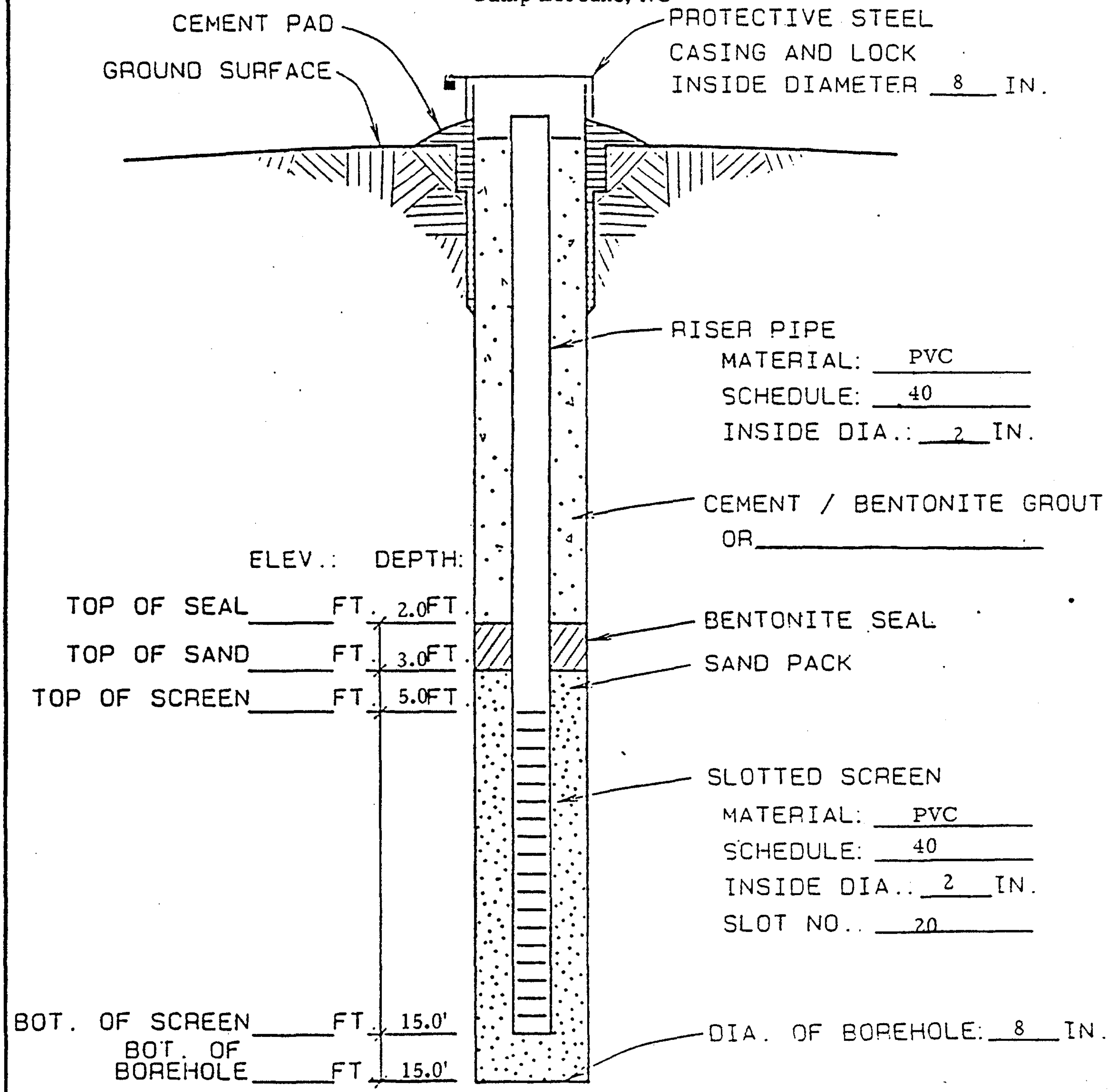
N.T.S.

Doc No: CLEJ-06381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW 10



TYPICAL OVERBURDEN MONITORING WELL

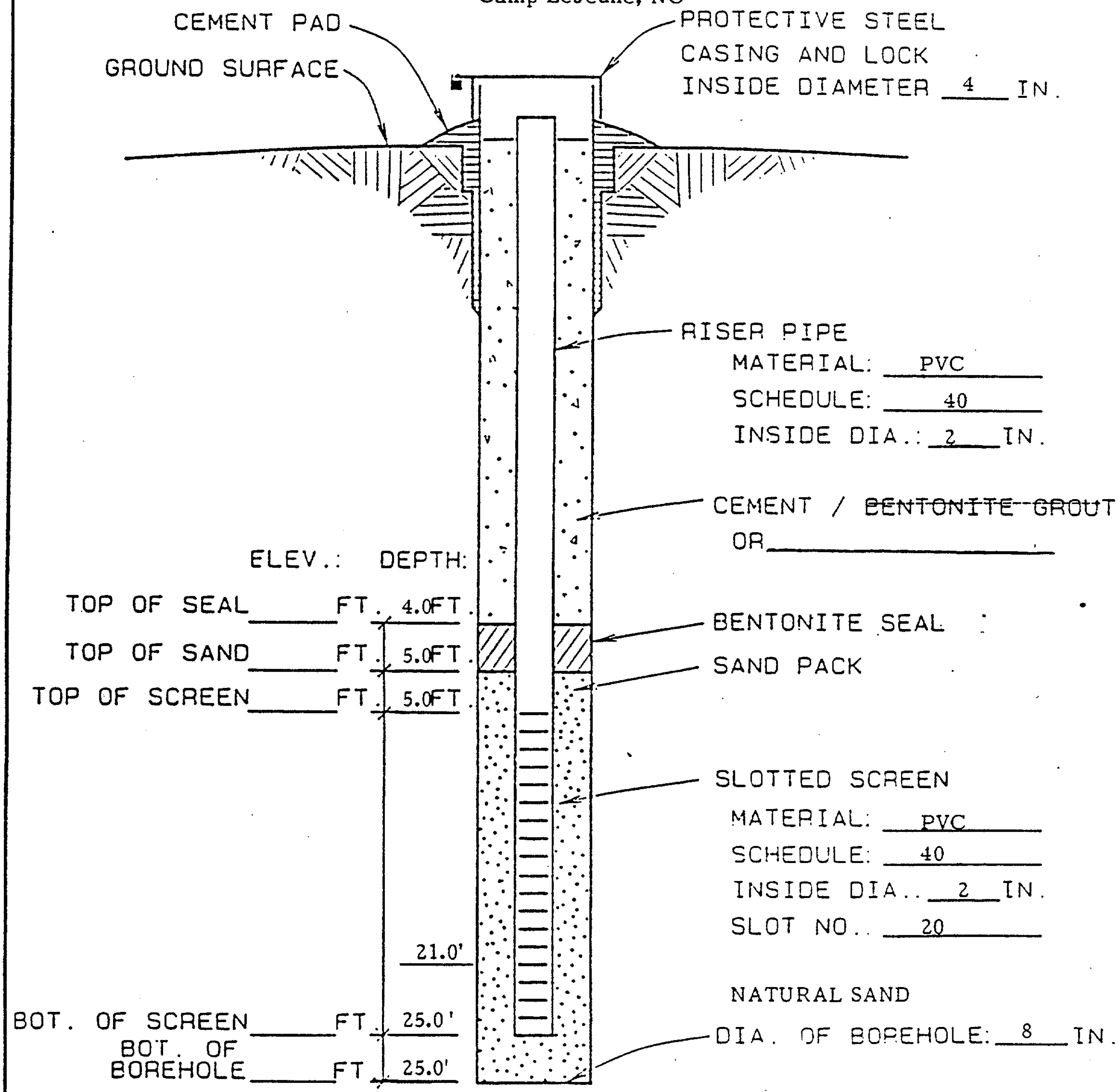
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-11



TYPICAL OVERBURDEN MONITORING WELL

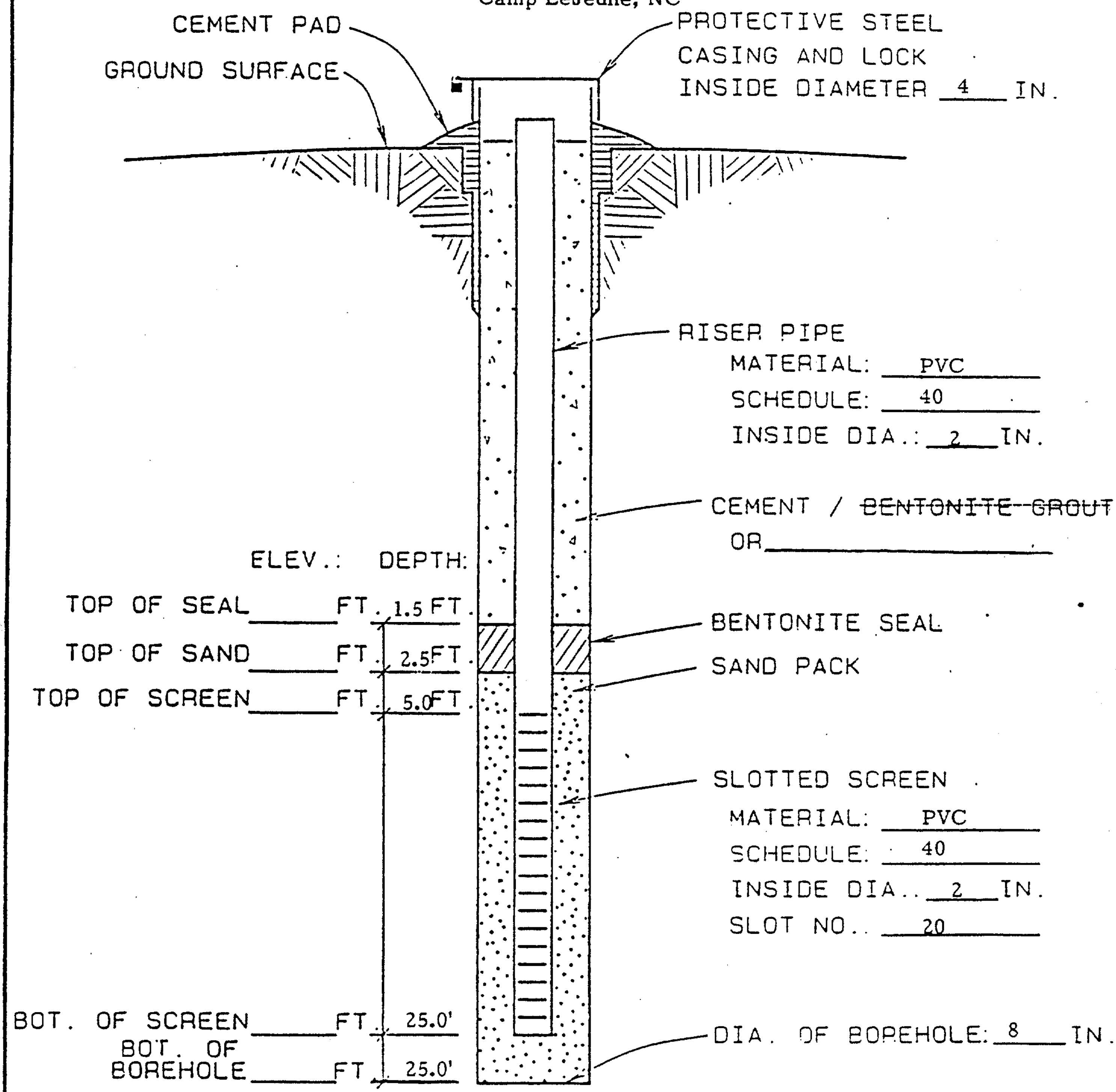
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-12



TYPICAL OVERBURDEN MONITORING WELL

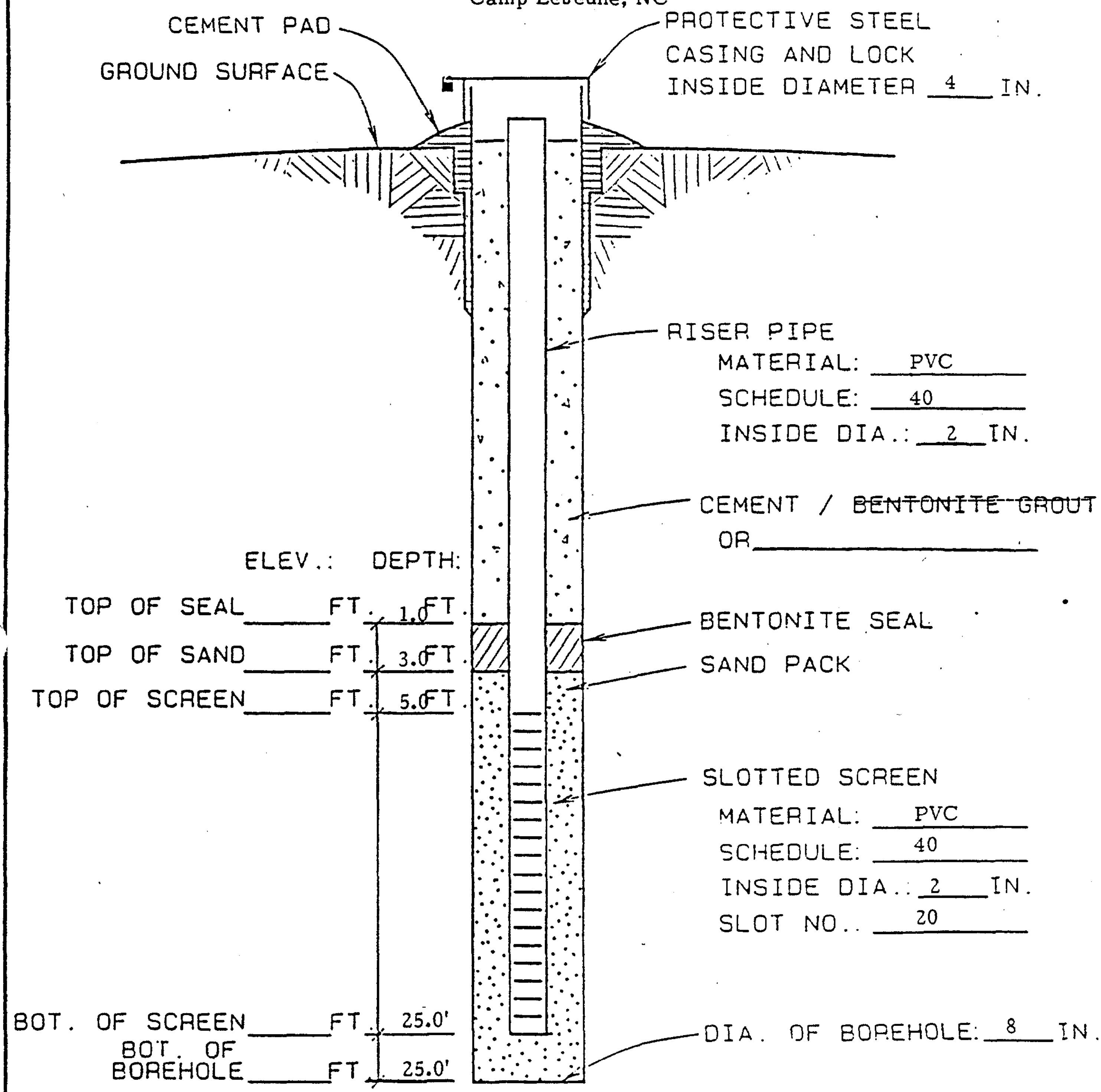
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-13



TYPICAL OVERBURDEN MONITORING WELL

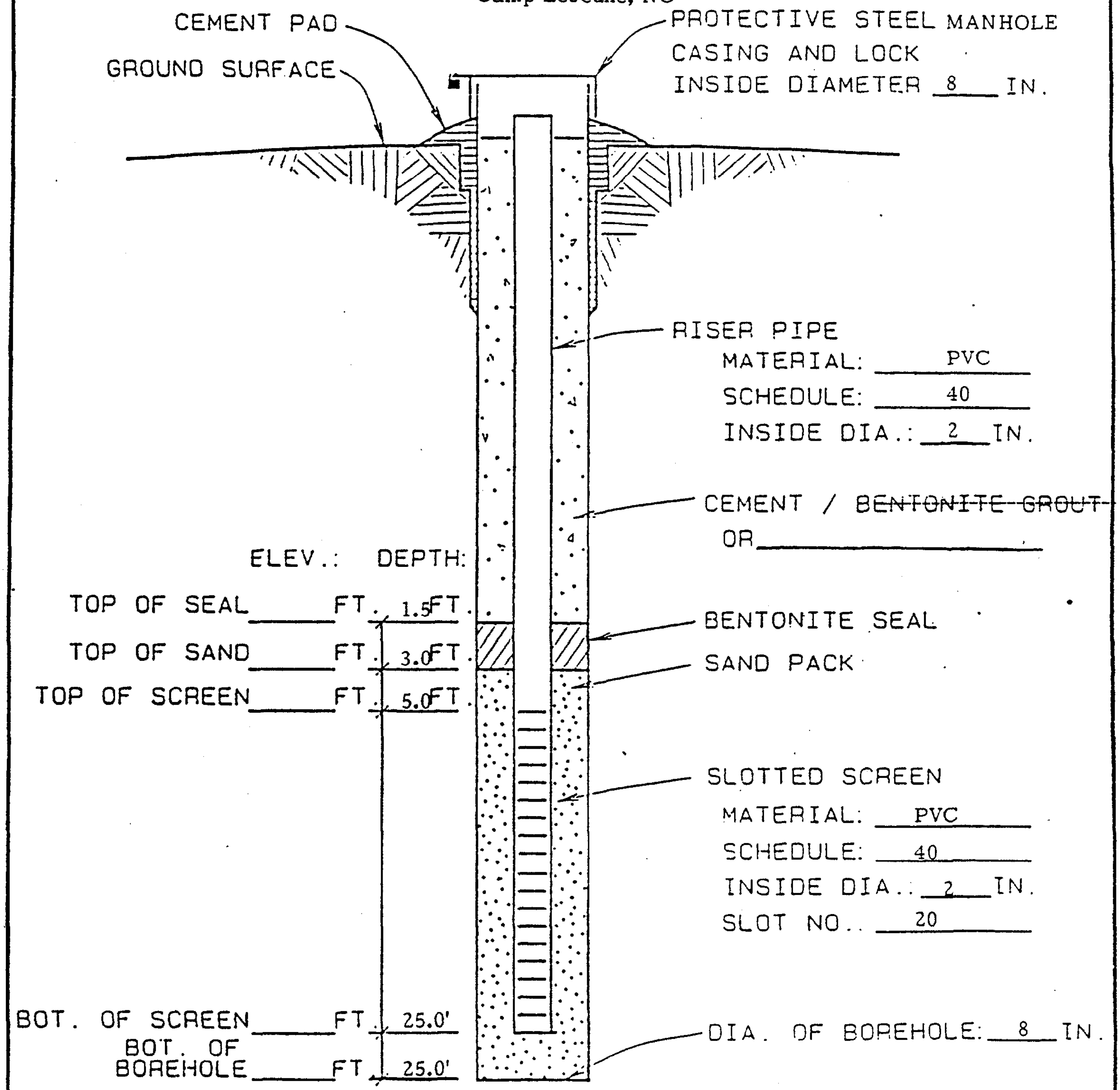
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-14



TYPICAL OVERBURDEN MONITORING WELL

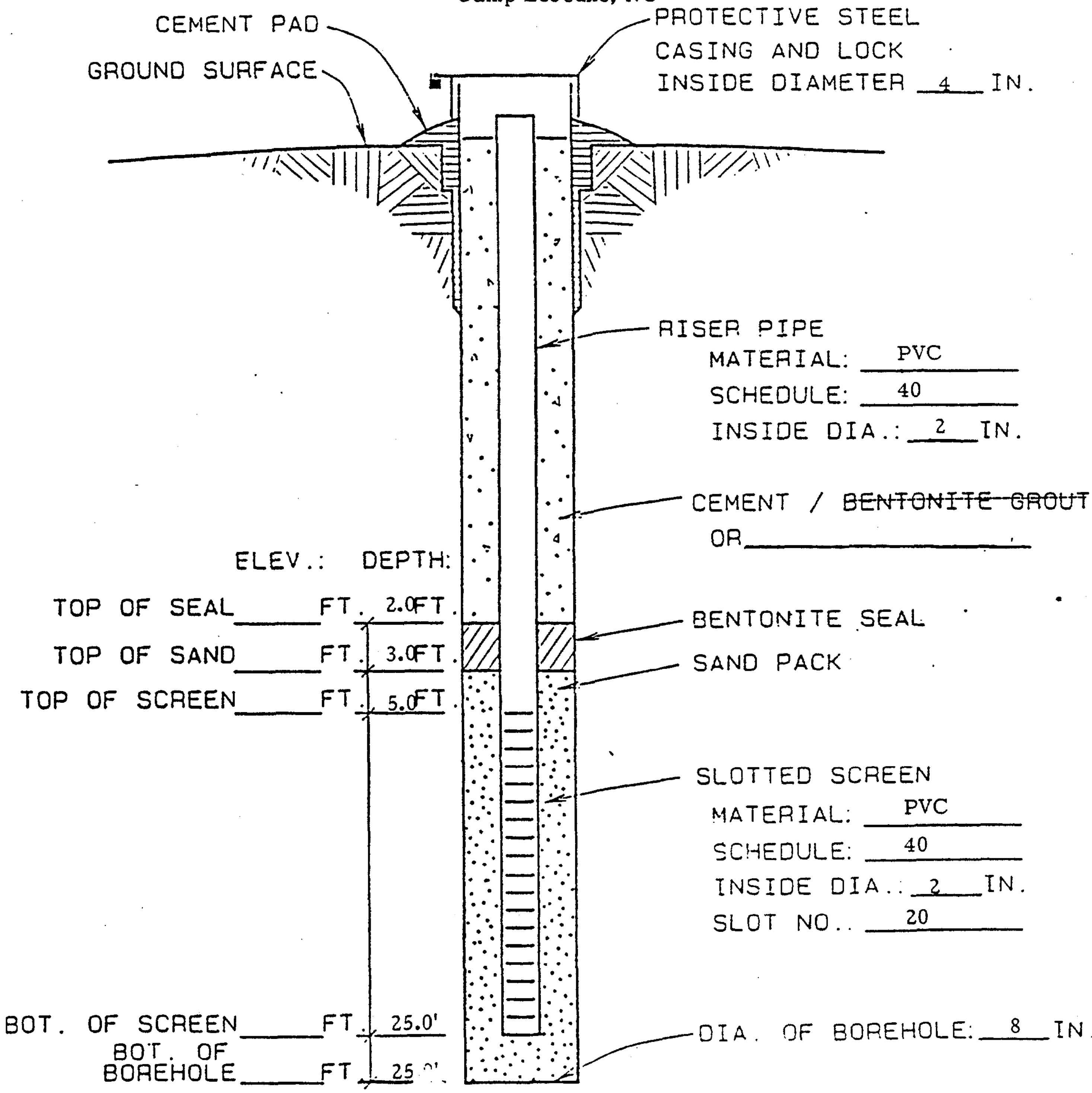
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-15



TYPICAL OVERBURDEN MONITORING WELL

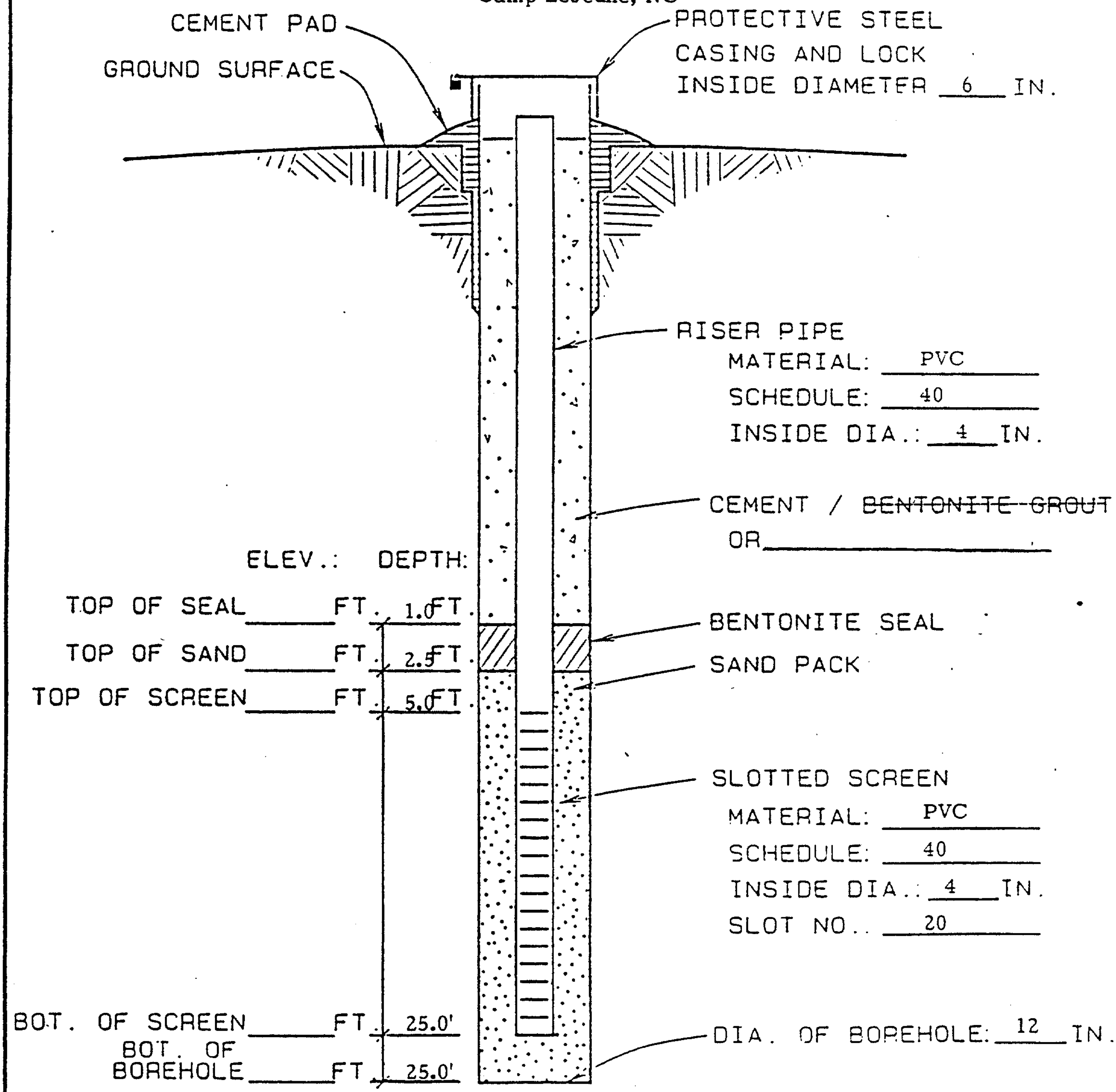
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-16



TYPICAL OVERBURDEN MONITORING WELL

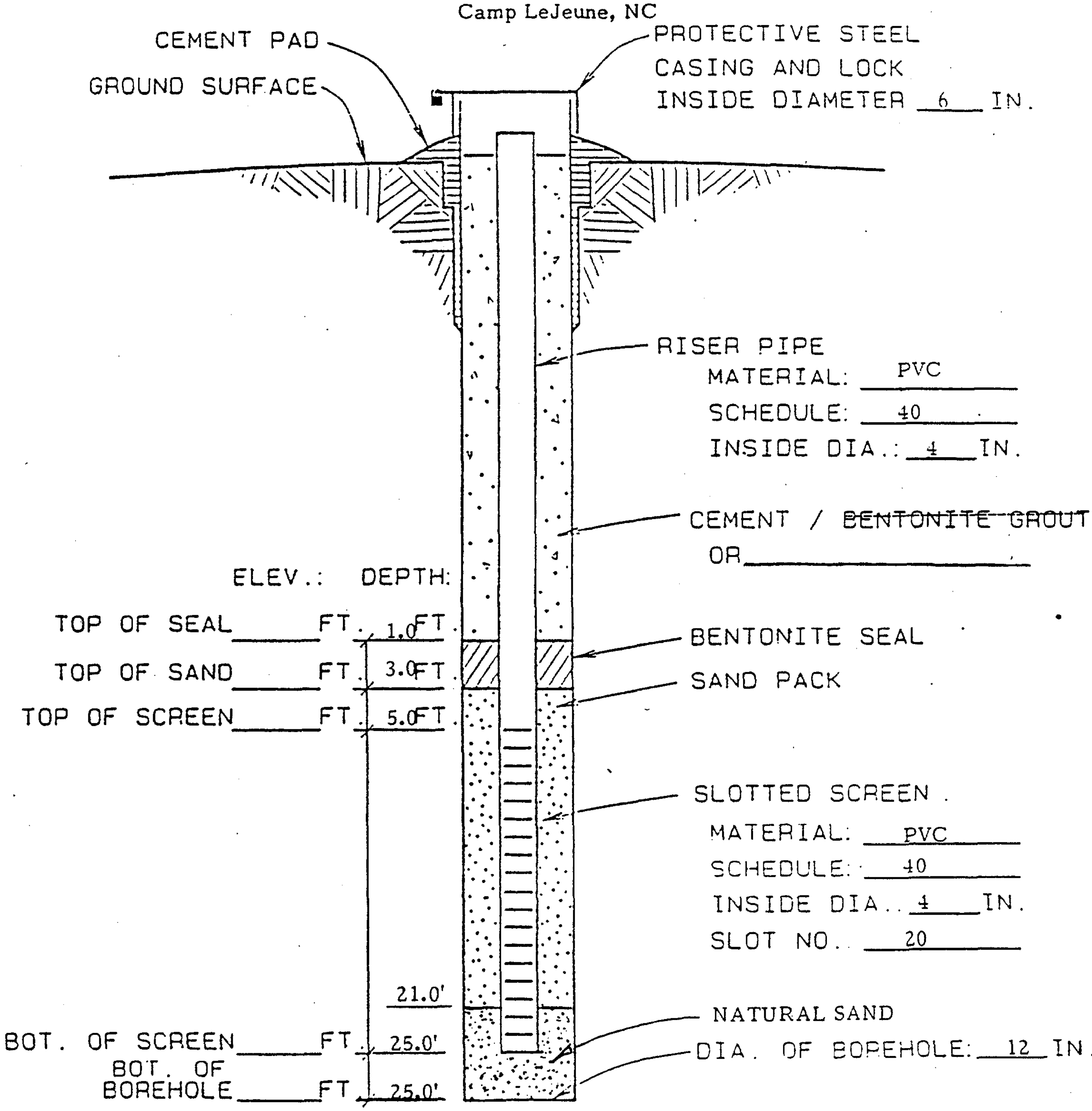
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-17



TYPICAL OVERBURDEN MONITORING WELL

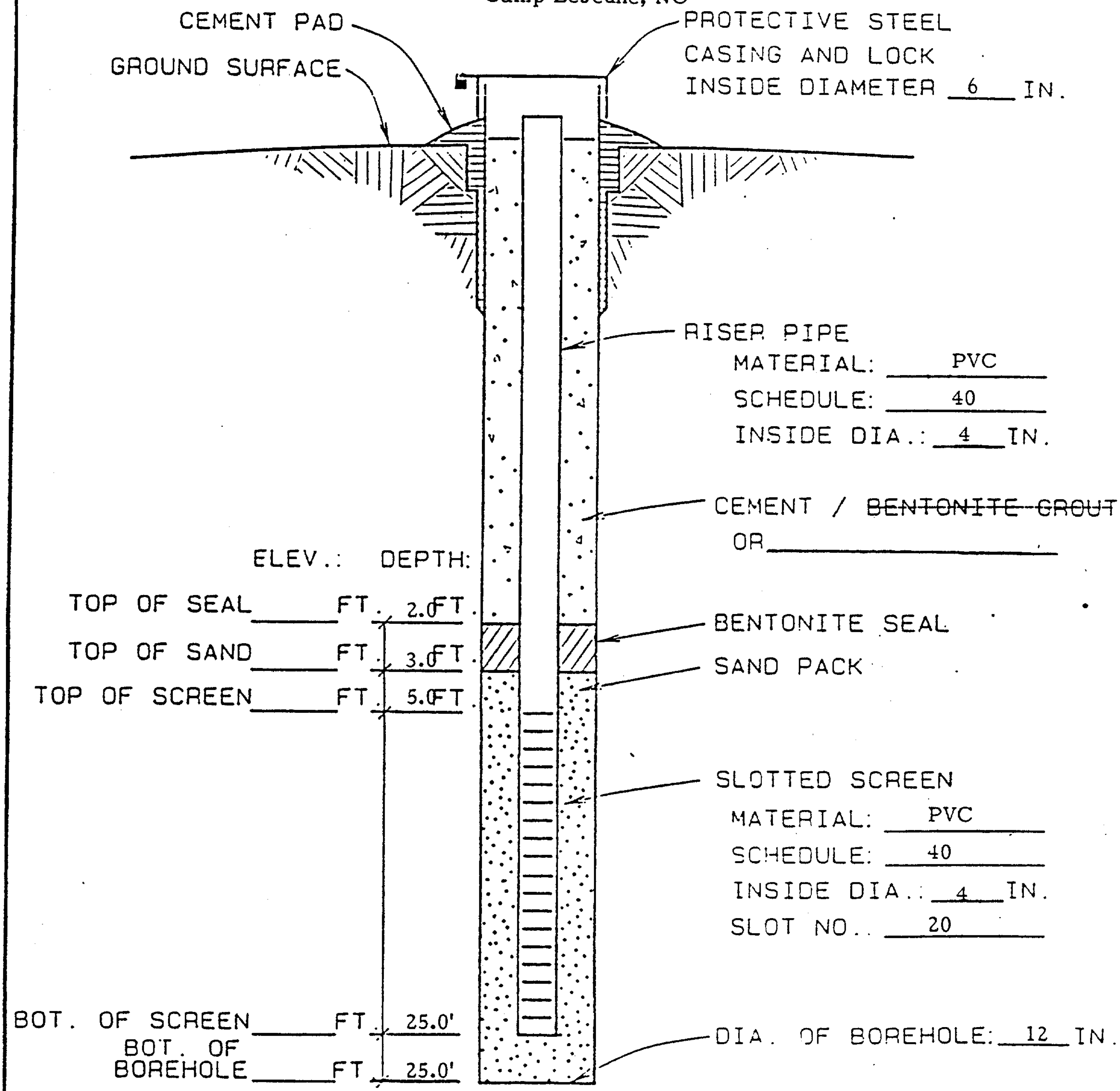
N.T.S.

Doc No: CLEJ-00381-305-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-18



TYPICAL OVERBURDEN MONITORING WELL

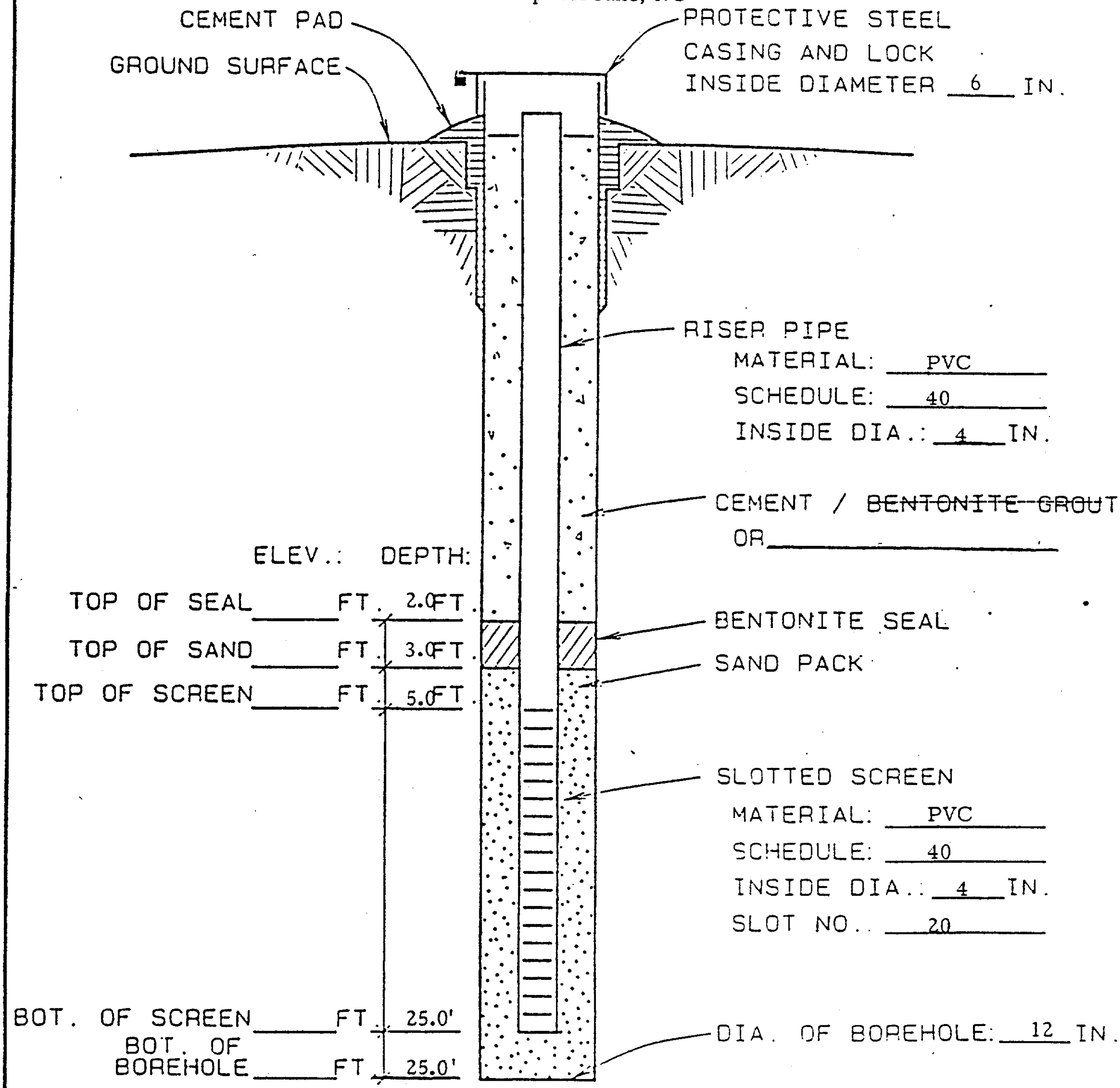
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-19



TYPICAL OVERBURDEN MONITORING WELL

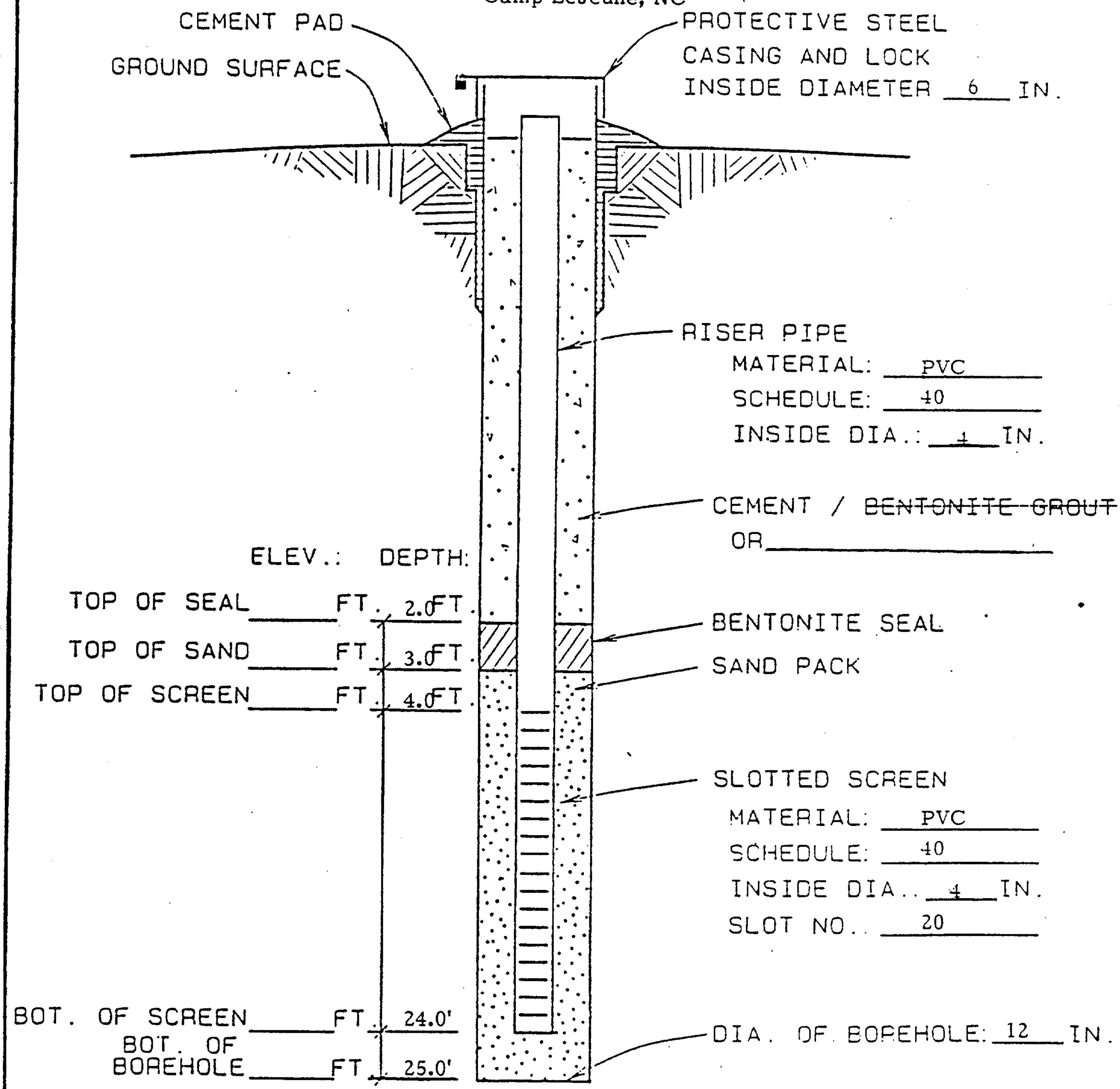
N.T.S.

Doc No: CLEJ-00381-3.05-10/01/89

3542.002.320

U.S. Navy
Hadnot Point Tank Farm
Camp LeJeune, NC

Well No. MW-20



TYPICAL OVERBURDEN MONITORING WELL

N.T.S.