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DRAFT FINAL
FEASIBILITY STUDY
FOR THE SHALLOW SOILS WITHIN THE HADNOT POINT INDUSTRIAL AREA OPERABLE UNIT

Prepared for:

U.S. DEPARTMENT OF THE NAVY

Prepared by:

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
°C	degrees Celsius
CDC	Centers for Disease Control
CFR	Code of Federal Regulations
CO	carbon monoxide
COC	chemical of concern
CSF	cancer slope factor
CWA	Clean Water Act
DEHNR	North Carolina Department of Environment, Health, and Natural Resources
DON	U.S. Department of the Navy
EPA	U.S. Environmental Protection Agency
ESE	Environmental Science & Engineering, Inc.
°F	degrees Fahrenheit
FFA	Federal Facilities Agreement
FML	flexible membrane liner
FR	Federal Register
FS	feasibility study
ft	feet
ft/day	feet per day
ft/ft	foot per foot
ft-bls	feet below land surface
ft-msl	feet above mean sea level

LIST OF ACRONYMS AND ABBREVIATIONS
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gpm	gallons per minute
HI	health index
HPIA	Hadnot Point Industrial Area
IAS	Initial Assessment Study
ISV	in situ vitrification
LANTDIV	Naval Facilities Engineering Command--Atlantic Division
LT^3	low-temperature thermal treatment
MCB	Marine Corps Base
MCL	maximum contaminant level
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
msl	mean sea level
MTV	mobility, toxicity, or volume
NAAQS	National Ambient Air Quality Standards
NACIP	Navy Assessment and Control of Installation Pollutants
NCP	National Oil and Hazardous Substances Contingency Plan
NO_x	nitrogen oxides
NPL	National Priorities List
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RA	risk assessment

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued, Page 3 of 3)

RCRA	Resource Conservation and Recovery Act
RfD	risk reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SR	State Road
SWDA	Solid Waste Disposal Act
TCE	trichloroethylene
TSCA	Toxic Substances Control Act
μg/L	micrograms per liter
U.S.	U.S. Highway
USGS	U.S. Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WAR	Water and Air Research

EXECUTIVE SUMMARY

Marine Corps Base (MCB) Camp Lejeune, located in Onslow County, North Carolina, is a training base for the Marine Corps. It covers approximately 170 square miles and is bounded to the southeast by the Atlantic Ocean, to the west by U.S. Highway (U.S.) 17, and to the northeast by State Road (SR) 24. The base is bisected by the New River estuary, which occupies approximately 30 square miles of the total area of the facility.

The Hadnot Point Industrial Area (HPIA) of MCB Camp Lejeune is located on the east side of the New River estuary. HPIA comprises approximately 75 buildings and facilities, including maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, storage yards, and a dry cleaning facility. A steam plant and training facility occupy the southwest portion of HPIA. In addition, underground storage tanks (USTs), stormwater drains, and oil/water separators are present. As a result of Marine operations and activities, wastes that contain hazardous and toxic organic compounds are generated at the base. This has resulted in the storage, disposal, and/or spillage of these wastes. Several of the base's water supply wells at HPIA have been shut down because of the presence of organic compounds, thus suggesting that some of the wastes may have entered the groundwater.

Due to the potential of waste spillage at HPIA, several investigations have been conducted on the Hadnot Point Operable Unit, which is defined as that area bounded by Holcomb Boulevard to the west, Sneads Ferry Road to the north, Louis Street to the east, and the Main Service Road to the south. The Hadnot Point Operable Unit also includes the two primary hydrologic units: an unconfined surficial aquifer and a semiconfined potable aquifer (Castle Hayne aquifer).

A transformer storage yard (Area 21) and a fuel tank farm (Area 22) are located within the northern portion of HPIA. Two other study areas, the industrial area fly ash dump (Area 24) and the Hadnot Point burn dump (Area 28) lie south and southwest of the site. These areas of concern are not included in the operable unit and will be considered in separate studies at a later date.

The investigation of HPIA has been completed as a phased approach, with the results of one investigation being the basis for the next phase. Three major investigations or studies were completed at the installation prior to the completion of this report.

An Initial Assessment Study (IAS) was conducted under the Navy Assessment and Control of Installation Pollutants (NACIP) program at MCB Camp Lejeune in 1983. The IAS report [Water and Air Research (WAR), (1983)], which was a record search of the installation, identified several areas within MCB Camp Lejeune, including HPIA, as potential contamination sources. As a result of this study, the U.S. Navy contracted Environmental Science & Engineering, Inc. (ESE) to investigate HPIA as well as other potential source areas.

The initial ESE investigation, referred to as the confirmation study, is divided into two investigation steps: the verification step and the characterization step. The verification step at HPIA was conducted to determine if areas of suspected contamination, as documented in the IAS, were indeed contaminated. This investigation was conducted from April 1984 through January 1985 and involved installing three shallow groundwater monitor wells and sampling potable water supply wells at HPIA, as well as investigating other sites within Camp Lejeune. This step identified the presence of volatile organic compounds (VOCs) in the shallow aquifer in the vicinity of the HPIA tank farm (Area 22) and in a single potable supply well (602).

Based on the results of the verification step, the characterization step was performed at HPIA from 1986 through 1988. This phase was designed to evaluate the extent of the VOC contamination identified in the verification step. The characterization step consisted initially of a records search of available base records, a physical inspection of each building within HPIA, and a soil gas survey targeted to those areas identified by the records search as being potential contamination sources.

Each of the areas identified by the records search as a potential source of VOCs was investigated with the use of a soil gas technique that focused on trichloroethylene (TCE) as the contaminant of concern. Areas with TCE or other VOC contamination in the soil included the area around Buildings 901, 902, 903; Building 1202; and Buildings 1502, 1601, and 1602.

Following analysis of the record search and soil gas data, locations were chosen for the installation of 27 shallow [25 feet (ft)], 3 intermediate (75 ft), and 3 deep (150 ft) monitor wells to determine if contamination identified during the soil gas investigation had migrated to the shallow and deeper groundwater. All new and existing HPIA monitor wells and nearby water supply wells were then sampled. Aquifer testing of one deep potable supply well was conducted to evaluate the hydraulic parameters of the Castle Hayne aquifer and to determine the transport mechanisms between the shallow and Castle Hayne aquifers. The confirmation study narrowed the list of source areas to three primary areas: Buildings 902, 1202, and 1601.

The supplemental characterization step, performed at HPIA in 1990-1991, was designed to further evaluate the extent of contamination in the Castle Hayne aquifer and to characterize the contamination within the shallow soils at suspected source locations. The supplemental characterization step consisted of 30 soil borings at the 3 suspected source locations (Buildings 902, 1202, and 1601) to characterize shallow soil contamination, installation of additional intermediate and deep monitor wells into the Castle Hayne aquifer, and sampling of all new and existing HPIA monitor wells and nearby water supply wells.

Based on these investigations, the shallow soils at the areas investigated do not appear to be significantly contaminated. Volatile compounds detected in the soil gas remain in the vapor phase and have not adhered to the soils. Some semivolatile compounds were detected in low concentrations in the soil.

The groundwater sampling and analysis program continues to reflect two nodes of VOC and/or petroleum hydrocarbon contamination within the shallow aquifer. The northern node consists of two separate contamination sources--one centered near the maintenance facility associated with Building 901, and another centered at the HPIA tank farm (Area 22). Contaminant isopleth modeling suggests that these two source areas may have effectively coalesced into one larger node of contamination. The southern node is centered near the maintenance facility associated with Building 1601. The surficial aquifer will initially be remediated under an interim remedial action, which is the subject of reports prepared under separate cover.

A risk assessment (RA) has been completed for the shallow soils at the three remaining areas of concern. This assessment has shown that the low levels of contamination detected within the soils do not pose a human or ecological threat. This RA also addressed the groundwater within the Castle Hayne aquifer. Although contaminants have been detected in one monitor well and in several potable wells, no current risk was identified. Additional studies addressing the extent of contamination within the Castle Hayne aquifer are being undertaken as a separate effort.

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the National Priorities List (NPL) effective November 4, 1989. On February 13, 1991, the U.S. Department of the Navy (DON); the U.S. Environmental Protection Agency (EPA) Region IV; and the North Carolina Department of Environment, Health, and Natural Resources (DEHNR) entered into a Federal Facilities Agreement (FFA). In partial fulfillment of the FFA, DON was required to conduct a remedial investigation/feasibility study (RI/FS) at the Hadnot Point Industrial Area (HPIA) at MCB Camp Lejeune. Environmental Science & Engineering, Inc. (ESE) performed the RI/FS in three phases under Contract No. N62470-83-C-6106 with the Naval Facilities Engineering Command--Atlantic Division (LANTDIV).

A summary of the three RI phases and their findings is presented in the ESE (1991b) remedial investigation (RI) report for HPIA. A supplemental risk assessment (RA) report was then prepared (ESE, 1991c) to summarize and interpret the RI data so that contamination migration and associated risks to public health and welfare and the environment could be assessed. The information obtained from both of these reports will be used to supplement this feasibility study (FS), which addresses only the shallow soils at the HPIA operable unit. An FS report for the shallow groundwater at HPIA was submitted in May 1988. The deep aquifer (Castle Hayne aquifer) was investigated in previous field efforts (see Section 1.7); however, sufficient data to adequately address the amount and extent of contamination in the deep aquifer have not yet been obtained. Therefore, the deep aquifer will not be addressed in this FS. Instead, a draft sampling plan for further investigation of the deep aquifer will be provided under a separate cover to EPA Region IV in March 1992.

1.1 OBJECTIVE OF THE FS

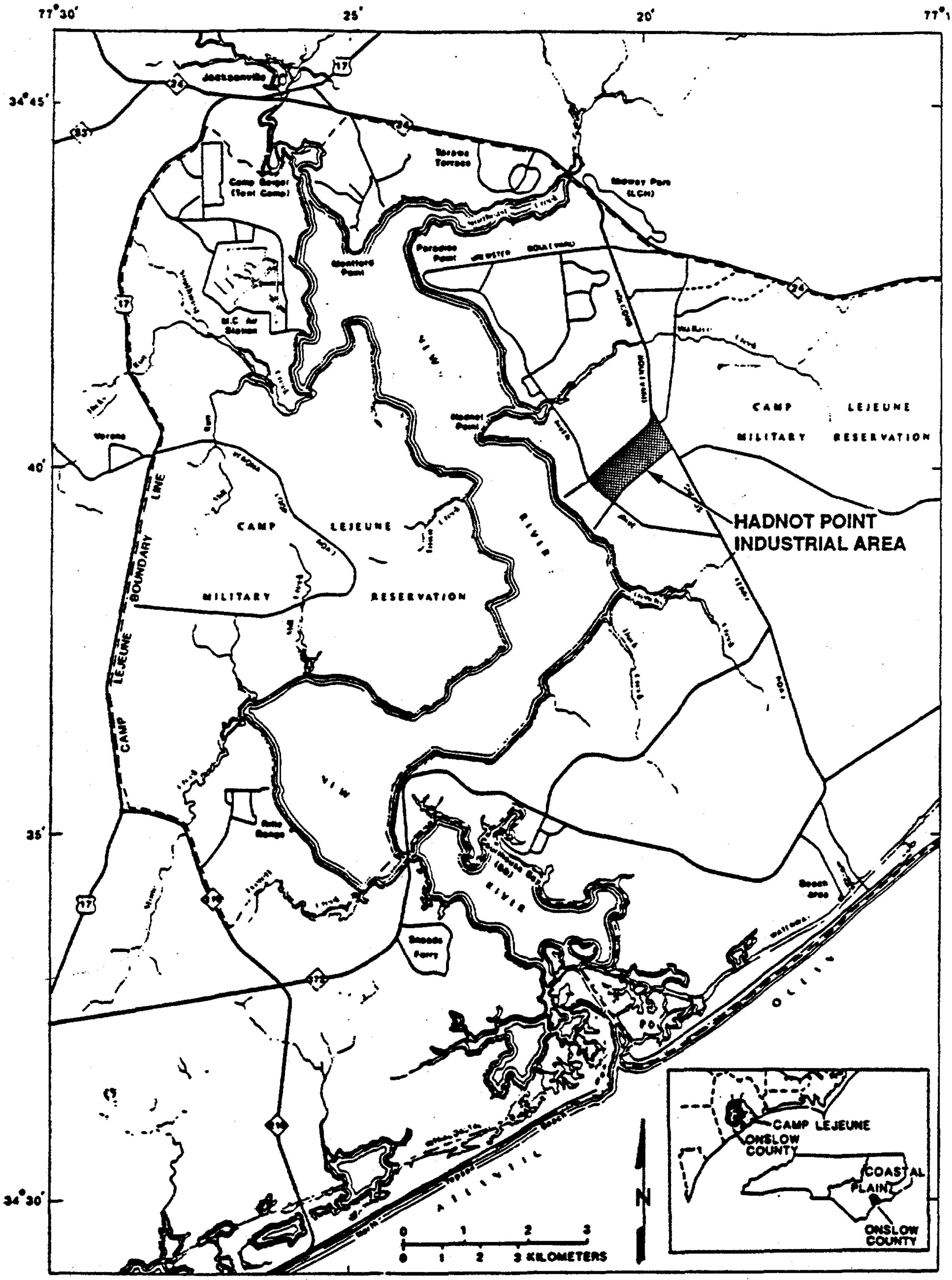
The objective of this FS is to develop and evaluate alternative remedial responses to uncontrolled releases of hazardous substances in the surficial soils at HPIA, which are contaminated as a result of past activities. The FS has been prepared in accordance with the National Oil and Hazardous Substances Contingency Plan (NCP) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The FS provides information needed to select cost-effective remedial alternatives that abate or mitigate releases of hazardous substances and provide adequate protection of public health and welfare and the environment at HPIA. The remedial alternative selection process assumes two future land-use scenarios for the HPIA property: (1) residential and (2) industrial.

1.2 SITE BACKGROUND

1.2.1 SITE LOCATION

MCB Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina (see Figure 1-1). It covers approximately 170 square miles and is bounded to the southeast by the Atlantic Ocean, to the west by U.S. Highway (U.S.) 17, and to the northeast by State Road (SR) 24. The base is bisected by the New River estuary, which occupies approximately 30 square miles of the facility's total area.

HPIA is located on the east side of the New River estuary. For this investigation, HPIA is defined as that area bounded by Holcomb Boulevard to the west, Sneads Ferry Road to the north, Louis Street to the east, and the Main Service Road to the south (see Figure 1-2).



Base taken from Defense Mapping Agency Hydrographic Center. Camp Lejeune Special Map 1:50,000

Figure 1-1
CAMP LEJEUNE LOCATION

SOURCE: HARNED *et al.*, 1989.

MARINE CORPS BASE
CAMP LEJEUNE

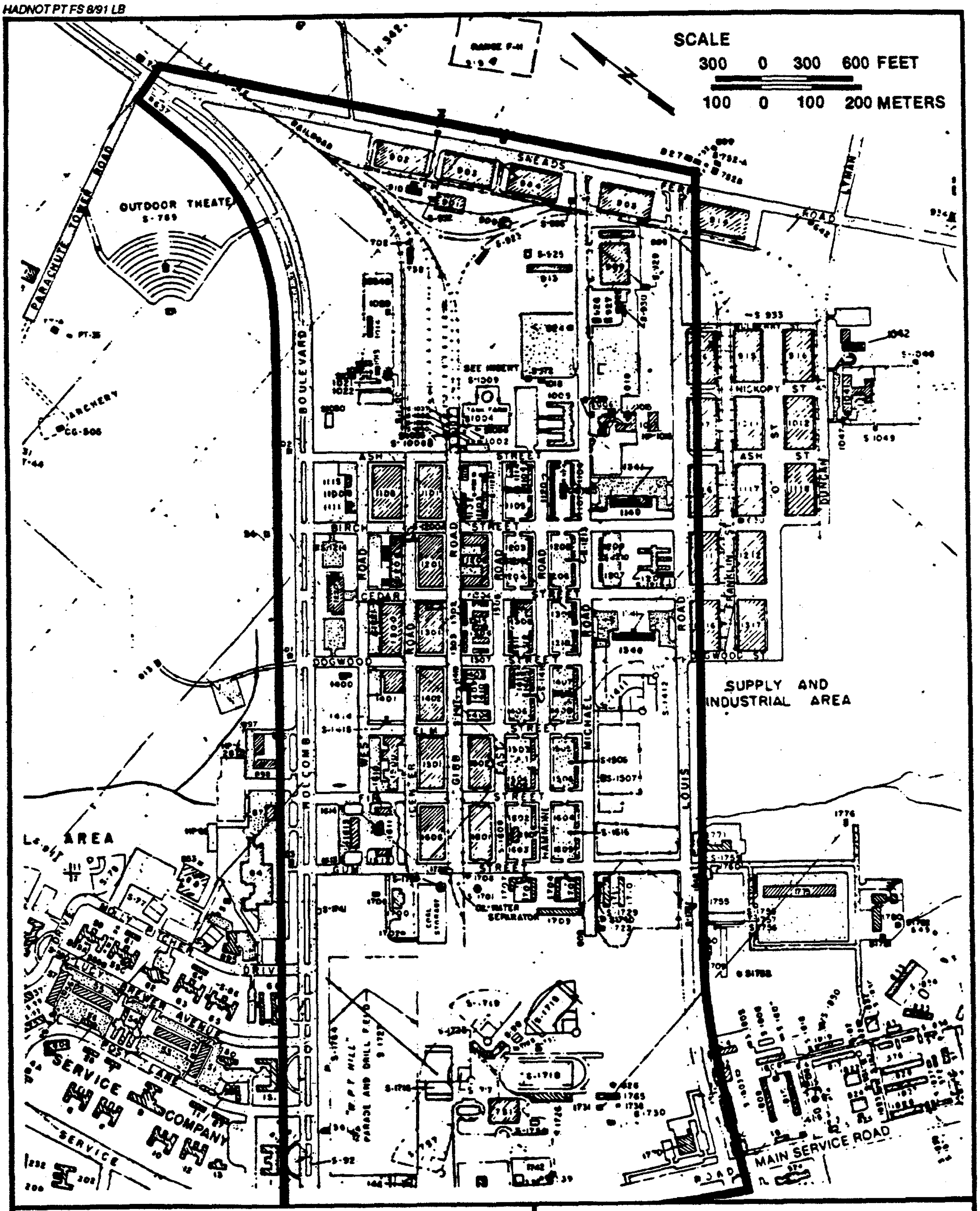


Figure 1-2
HADNOT POINT INDUSTRIAL AREA

SOURCE: CAMP LEJEUNE, 1987.

MARINE CORPS BASE
CAMP LEJEUNE

1.2.2 INDUSTRIAL AREA

HPIA comprises approximately 75 buildings and facilities that include maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, storage yards, and a dry cleaning facility. A steam plant and training facility occupy the southwest portion of HPIA. In addition, underground storage tanks (USTs), stormwater drains, and oil/water separators are present.

A transformer storage yard (Area 21) and the fuel tank farm (Area 22) are located within the northern portion of HPIA. Two other areas, the industrial area fly ash dump (Area 24) and the Hadnot Point burn dump (Area 28) lie south and southwest of the site, respectively. See Figure 1-3 for the approximate locations of these areas. These four areas of concern are not included in this FS but will be considered in subsequent separate studies.

As stated previously, the deep aquifer will not be addressed in this FS due to the lack of available data. However, investigations of the deep aquifer will continue. A draft sampling plan for continuation of the investigation of the deep aquifer will be provided to EPA Region IV in March 1992.

This FS focuses only on three additional areas of concern within the HPIA operable unit. These areas are located in the vicinities of Buildings 1601, 902, and 1202 and are hereafter referred to as Areas 1600, 900, and 1200, respectively. Figure 1-4 shows the approximate locations of these areas.

1.3 TOPOGRAPHY AND SURFACE WATER DRAINAGE

MCB Camp Lejeune is situated on a relatively flat coastal terrain that includes swamps, estuaries, savannas, and forests. Land surface elevations range from

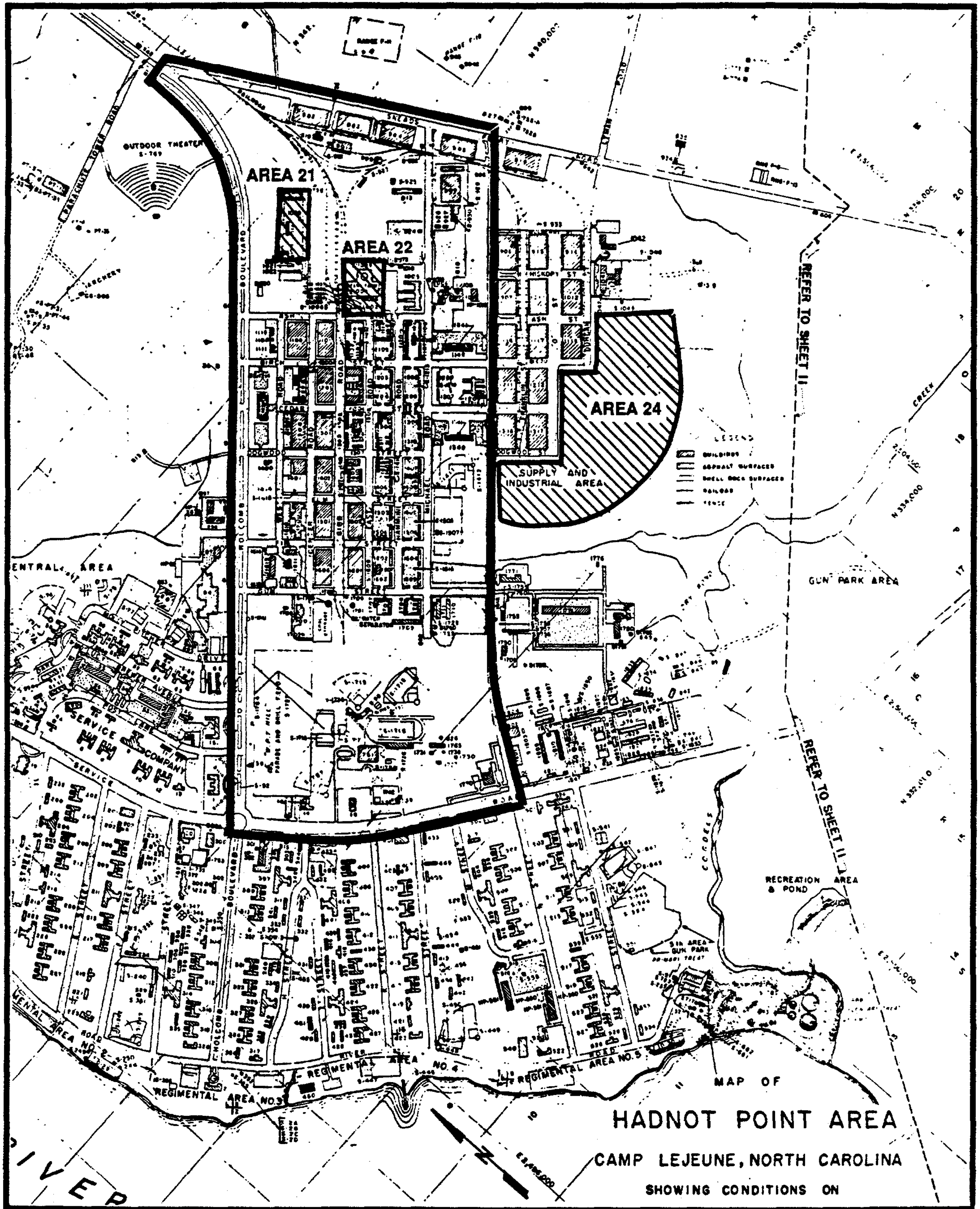


Figure 1-3
AREAS 21, 22, 24, AND 28

SOURCES: CAMP LEJEUNE, 1979; ESE.

MARINE CORPS BASE
CAMP LEJEUNE

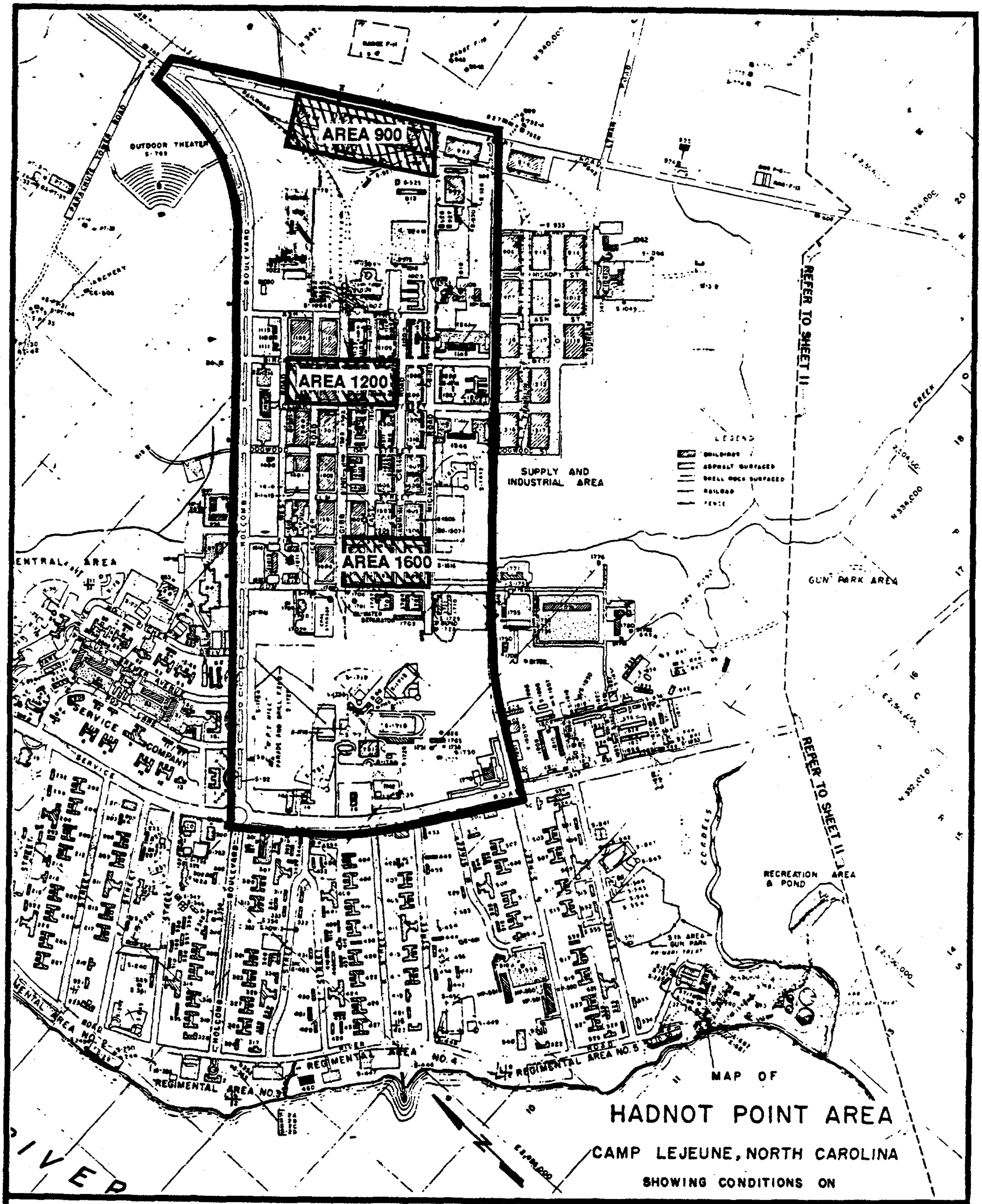


Figure 1-4
AREAS 900, 1200, AND 1600

SOURCES: CAMP LEJEUNE, 1979; ESE.

MARINE CORPS BASE
CAMP LEJEUNE

mean sea level (msl) to 72 feet above mean sea level (ft-msl). Average elevations for the MCB range from 10 to 40 ft-msl.

The drainage at MCB Camp Lejeune is predominantly toward the New River, although coastal areas drain directly to the Atlantic Ocean via the Intercoastal Waterway. Natural drainage has been altered in developed areas such as HPIA by the installation of drainage ditches, storm sewers, and extensive paving, creating numerous drainage subbasins on the base. Approximately 70 percent of MCB Camp Lejeune is in the broad, flat interstream areas (Atlantic Division, Bureau of Yards and Docks, 1965). Drainage in these areas is poor, and the soils are often wet.

1.4 GEOLOGY

1.4.1 SITE GEOLOGY

U.S. Geological Survey (USGS) studies at MCB Camp Lejeune (Harned et al., 1989) indicate that the base is underlain by seven sand and limestone aquifers separated by confining silt and clay units. These include the surficial aquifer, Castle Hayne, Beaufort, Peedee, Black Creek, and Upper and Lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1,500 feet (ft). Less permeable clay and silt beds function as confining units or semiconfining units that separate the aquifers and impede the groundwater flow between aquifers.

Fresh water is present in the surficial and Castle Hayne aquifers at MCB Camp Lejeune; therefore, they are the hydrogeologic units of concern with respect to this study. Fresh water extends to a depth of approximately 300 feet below land surface (ft-bls) (Harned et al., 1989). Aquifers below this depth have been affected by saltwater intrusion.

The surficial aquifer at MCB Camp Lejeune is composed of Quaternary and Miocene sand, silt, and clay. This aquifer ranges in thickness from 0 ft in the channels of the New River and its tributaries to 75 ft-bls in the southeast portion of Camp Lejeune (Harned et al., 1989).

The Castle Hayne aquifer is composed of sand and limestone of Oligocene and Middle Eocene age (Harned et al., 1989). The upper portion of the aquifer is primarily unconsolidated sand, and the lower portion is partially consolidated sand and limestone. The Castle Hayne aquifer thickens toward the southeast, from 175 ft in the northern portion of the base to 375 ft at the coast, and thin clay layers are found throughout the unit. The Castle Hayne aquifer is approximately 340 ft thick in the Hadnot Point area (Harned et al., 1989).

1.4.2 HPIA

Geologic information specific to HPIA was obtained during the confirmation study conducted by ESE (1988a) and during the intermediate and deep monitor well installation, also carried out by ESE in December 1990 as part of this RI/FS. The information gathered focused on the surficial aquifer extending down to approximately 25 ft-bls and on material underlying this 25-ft level down to approximately 150 ft. No attempt was made to correlate these units to the regional stratigraphy (e.g., surficial and Castle Hayne aquifers). An evaluation of the adequacy of the existing monitor wells to fully determine the nature and extent of contamination in the Castle Hayne aquifer, as well as an attempt to correlate the surficial and Castle Hayne aquifer, will be addressed in the draft sampling plan that will be provided to EPA Region IV in March 1992.

Cross sections generated from lithologic information obtained during monitor well installation at HPIA as part of the confirmation study indicate that the surficial aquifer in this area is primarily silty sand with extensive but discontinuous layers of silty clay and silty sand clay that dip to the south-southwest. Peat, wood fragments, and plant debris are present in a 1- to 2-ft layer in the southwest portion of HPIA. Peat was also encountered at a depth of 18 ft in the northwest portion of the site. Marl was present in some of the boreholes. Layers of fill up to 4 ft thick were present in areas adjacent to construction areas.

Site-specific information on the deeper portion of the aquifer beneath HPIA is limited to the 14 deep boreholes that have been drilled. Intermediate (75 ft) and deep (150 ft) wells drilled at HPIA penetrated intervals of silty sand and sandy clay down to a depth of 56 ft-bls. Beneath this depth, layers consisting of sand, shells, and cemented clastics were encountered, interbedded with lenses consisting of different proportions of these components.

1.5 HYDROLOGY

1.5.1 GENERAL HYDROLOGY

The hydrologic system at Camp Lejeune consists of an unconfined (water table) aquifer and underlying semiconfined aquifers. The unconfined aquifer extends from the water table to the first significant confining layer. In general, the shallow groundwater flows in a southwesterly direction toward the New River. Groundwater flow in the lower water-bearing zones trends in the same direction as in the surficial aquifer.

1.5.2 HPIA HYDROLOGY

At HPIA, the water table occurs at depths ranging from 6.67 to 23.18 ft-bls, as measured in January and February 1991. Seasonal water-level fluctuations range from 1 to 4 ft (Harned et al., 1989).

The actual shallow groundwater flow trends from southwest in the southern half of HPIA to west-southwest in the northern and central portions of HPIA. Some groundwater mounding occurs in the southern corner of HPIA around monitor wells HPGW2 and HPGW5.

Groundwater flow in the water-table aquifer is predominantly to the southwest in the southern portion of HPIA. In the northern and central portions of HPIA, groundwater flow is to the west-southwest. Some groundwater mounding appears to be present in the southern portion of HPIA. This mounding may generate localized radial flow in the area. Groundwater flow in the lower water-bearing zones trends in generally the same direction (southwest) as that in the surficial aquifer.

Horizontal hydraulic gradients in the surficial aquifer at HPIA were determined from the potentiometric surface map. In general, the horizontal hydraulic gradient in the surficial aquifer at HPIA is approximately 0.003 foot per foot (ft/ft). Specifically, the northern and southern portions of HPIA exhibit a horizontal hydraulic gradient of 0.003 ft/ft. However, the west-central portion of HPIA exhibits a horizontal hydraulic gradient of approximately 0.004 ft/ft (ESE, 1991b). These horizontal hydraulic gradients compare favorably with values previously reported by Harned et al. (1989) and ESE (1988a).

Hydraulic gradients were also calculated for the deep and intermediate zones. Because of fewer measured points in these zones, the gradients are calculated from one end of the site to the other between well clusters 4 and 24. The calculated gradient for the intermediate zone was 0.0015 ft/ft and 0.0021 ft/ft for the deep zone. Potentiometric maps for the surficial, intermediate, and deep aquifers are presented as Figures 1-5, 1-6, and 1-7, respectively. All gradients

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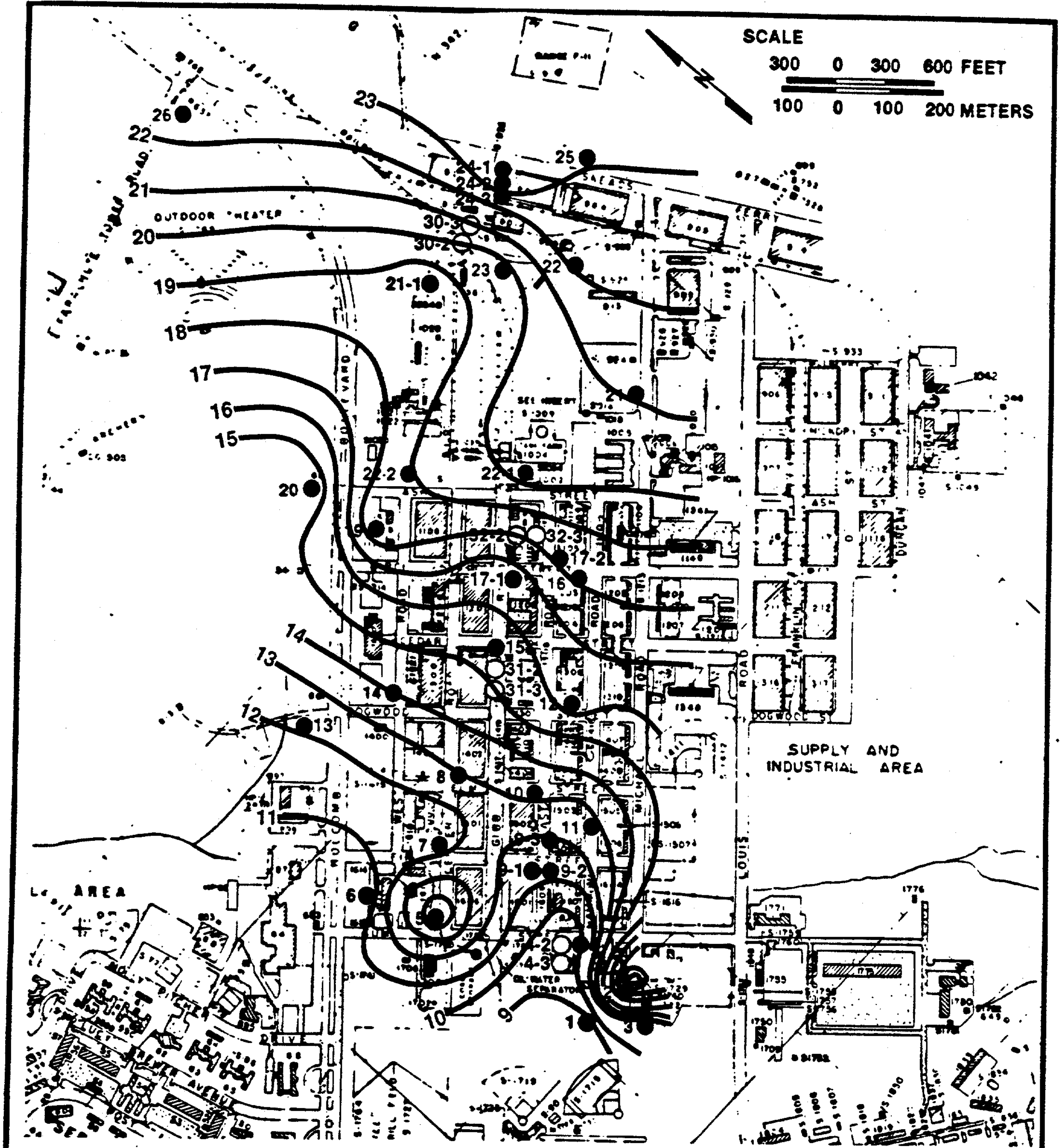


KEY

● EXISTING MONITOR WELL
○ NEW MONITOR WELL

NOTE: Contour interval 1 ft. except near well 2, where it changes to 2 ft.

Figure 1-5
POTENTIOMETRIC SURFACE – SURFICIAL WELLS (2-20-91)

SOURCE: ESE.

MARINE CORPS BASE
CAMP LEJEUNE

HADNOT PT FS 12/91 LB

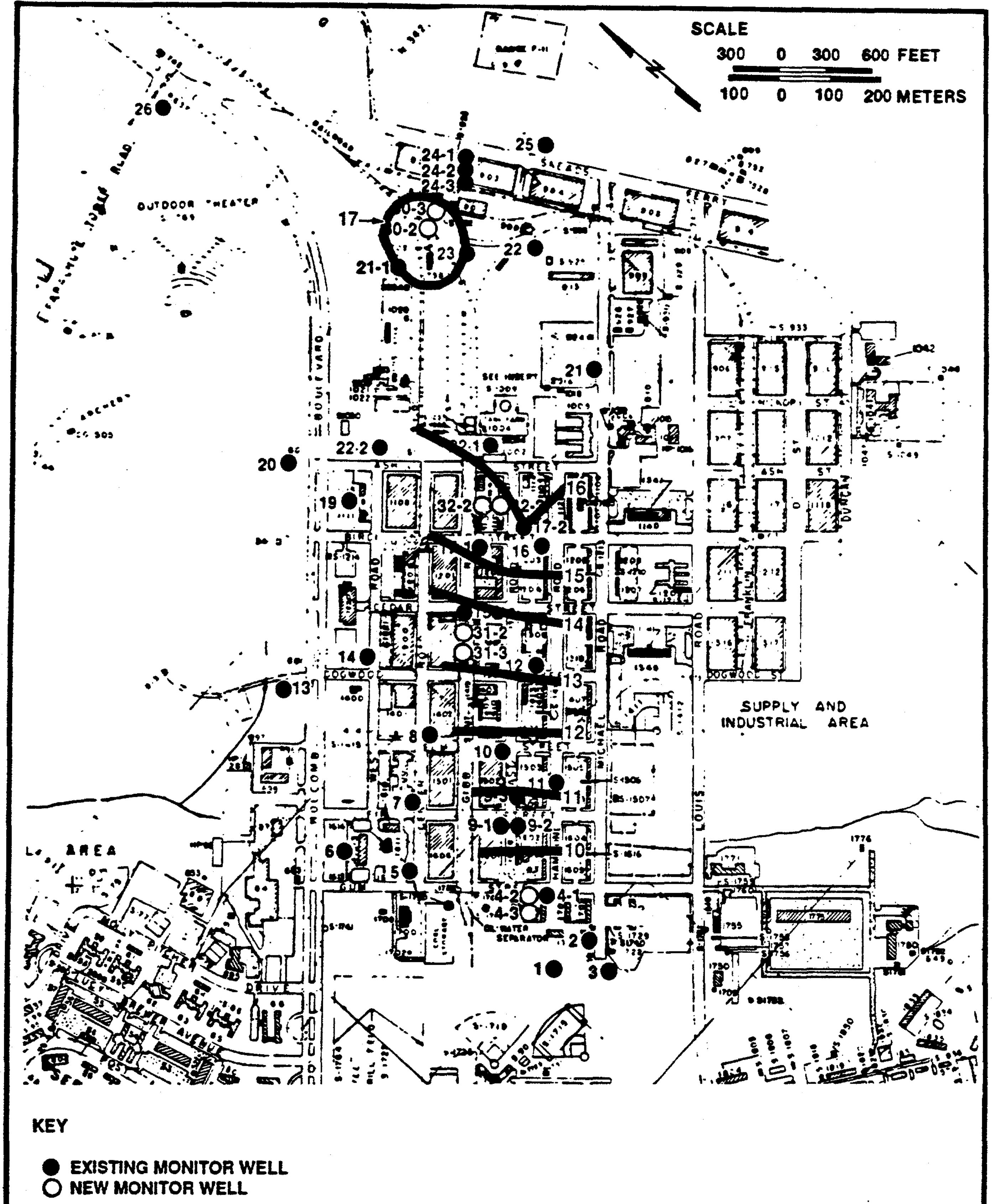
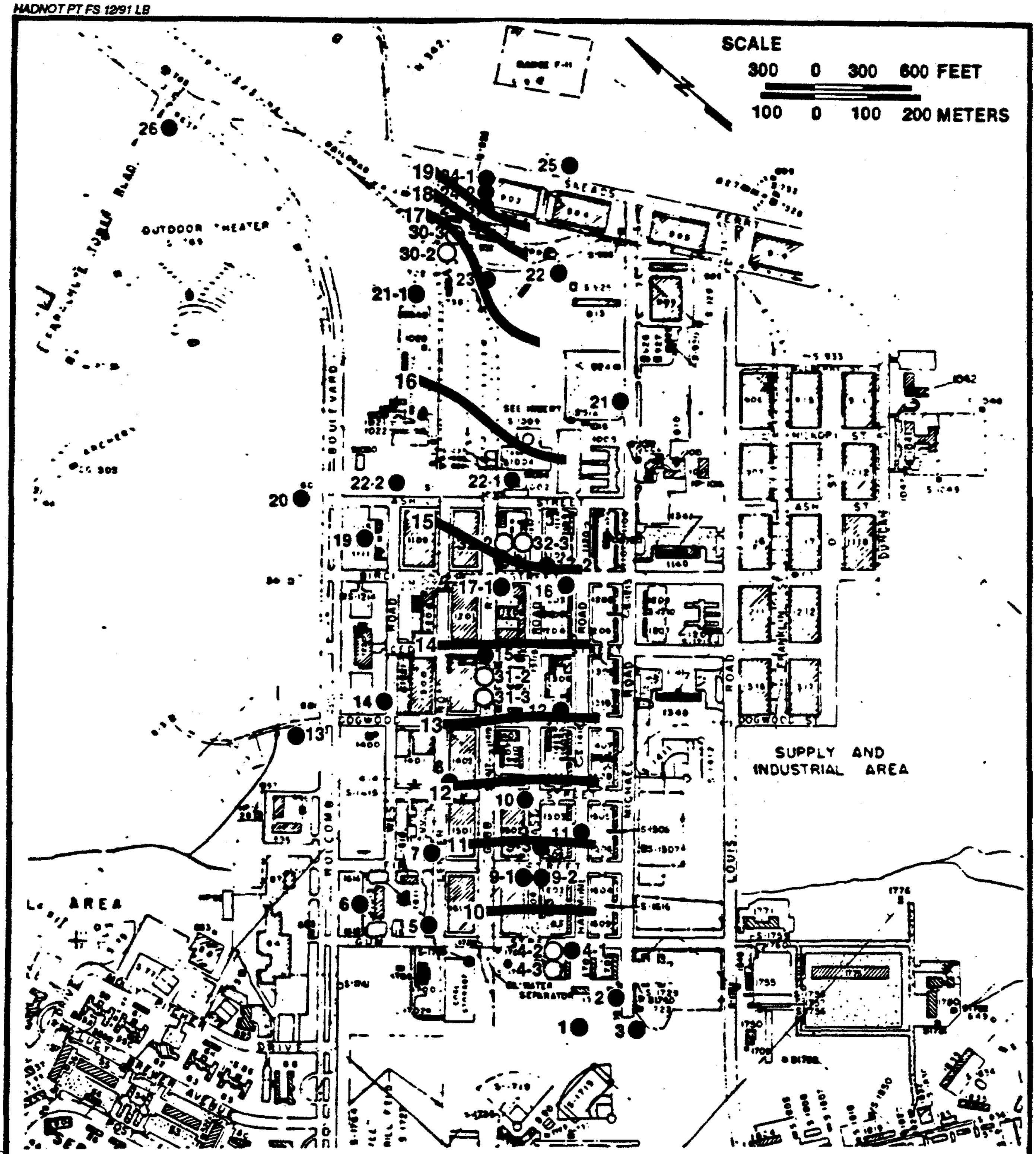


Figure 1-6
POTENTIOMETRIC SURFACE – INTERMEDIATE WELLS (2-20-91)

SOURCE: ESE.

MARINE CORPS BASE CAMP LEJEUNE

HADNOT PT FS 12/91 LB



KEY

● EXISTING MONITOR WELL

○ NEW MONITOR WELL

Figure 1-7
POTENTIOMETRIC SURFACE – DEEP WELLS
(2-20-91)

SOURCE: ESE.

MARINE CORPS BASE
CAMP LEJEUNE

were calculated using the February 1991 data; therefore, these are seasonal values that are subject to change based on the time of year and precipitation events.

Analysis of pumping test data obtained at HPIA by ESE in 1987 indicates that the limestone portion of the deep aquifer is semiconfined. The thickness of the seven aquifers and confining layers beneath the site is approximately 1,500 ft. Fresh water extends to a depth of 300 ft. Pumping tests were performed over a 43-hour period at a pumping rate of 85 gallons per minute (gpm). The pump used in these tests was placed at the bottom of each well at a depth of approximately 200 ft-bls. A generalized hydrogeologic cross section is included as Figure 1-8. Recharge occurs through a clayey layer overlying the aquifer. Vertical hydraulic conductivity for this layer is estimated at 4.6×10^{-3} feet per day (ft/day), typical of silty sands and silty clays. Surficial aquifer hydraulic conductivity was determined by O'Brien and Gere Engineers, Inc. (1990) using short-term pump tests on two recovery wells located near the fuel farm (Area 22). These tests, which were conducted over a period of 8 hours, yielded an average hydraulic conductivity of 3.35 ft/day.

1.6 METEOROLOGY

MCB Camp Lejeune, which is located in the North Carolina coastal plain area, is influenced by mild winters and humid summers with elevated temperatures. Rainfall typically averages more than 50 inches a year, and potential evapotranspiration varies from 34 to 36 inches of rainfall equivalent per year [Narkunas, 1980; Water and Air Research (WAR), 1983). The wet seasons generally occur during the winter and summer months. During January, typical temperature ranges are reported from 33 to 53 degrees Fahrenheit (°F), and during July, the temperature ranges are reported from 71 to 88°F (Odell, 1970;

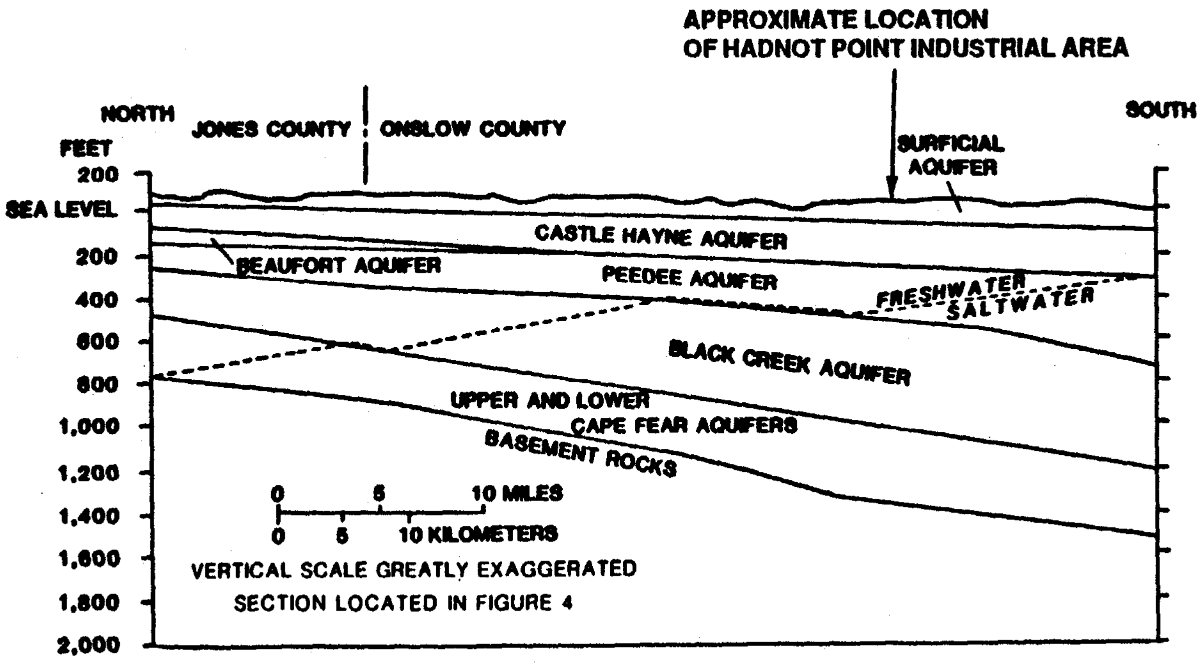


Figure 1-8
GENERALIZED HYDROGEOLOGIC CROSS SECTION
JONES AND ONSLOW COUNTIES, NORTH CAROLINA

SOURCE: HARNED *et al.*, 1989.

**MARINE CORPS BASE
CAMP LEJEUNE**

WAR, 1983). During the warm seasons, winds are generally from the south-southwest, and during the cooler seasons, they are generally from the north-northwest. The area has a relatively long growing season of 230 days.

1.7 PREVIOUS FIELD INVESTIGATIONS

An Initial Assessment Study (IAS) was conducted in 1983 under the Navy Assessment and Control of Installation Pollutants (NACIP) program at MCB Camp Lejeune. The IAS report (WAR, 1983) identified several areas within MCB Camp Lejeune as potential contamination sources. As a result of this study, LANTDIV contracted ESE to investigate these potential source areas according to NACIP program protocol. Several of these potential source areas are located within HPIA.

The initial ESE investigation (1988a), referred to as a confirmation study, focused on those areas identified in the IAS. The confirmation study is divided into two investigation steps: the verification step and the characterization step. The final investigation completed was a supplemental characterization to collect additional data to complete the RI.

ESE conducted the verification step at HPIA from April 1984 through January 1985. This step identified the presence of volatile organic compounds (VOCs) in the surficial aquifer at the HPIA tank farm (Area 22) and in a single supply well (602). Concentrations detected in groundwater at Area 22 during this effort included 17,000 micrograms per liter (μg/L) of benzene and 27,000 μg/L of toluene. Benzene (38 μg/L) was also detected in supply well 602.

As a result of the verification step, supply well 602 was closed, and other supply wells in the area were sampled. Four additional supply wells (601, 608, 634, and 637) were found to be contaminated with VOCs and were also shut down. Maximum levels of contaminants detected in these wells included 230 μg/L of trichloroethylene (TCE) in supply well 601, 110 μg/L of TCE in supply well 608, and 130 μg/L of methylene chloride in supply well 634.

The characterization step, performed by ESE at HPIA from 1986 to 1988, was designed to determine the extent of the VOC contamination identified in the verification step. The characterization step consisted of a records search; a soil gas survey; installation of 27 shallow (25 ft-bls), 3 intermediate (75 ft-bls), and 3 deep (150 ft-bls) monitor wells; sampling of all HPIA monitor wells (including those previously installed at Area 22) and nearby water supply wells; and aquifer testing. The locations of HPIA monitor wells and water supply wells are presented in Figure 1-9. Significant results of the characterization step investigation have been incorporated into Section 5.0 of the RI report (ESE, 1991b).

O'Brien and Gere Engineers, Inc. conducted a field investigation at Area 22 in 1988. The O'Brien and Gere (1988) investigation noted that a 15-ft layer of floating product (gasoline) exists in a monitor well located on the western edge of the tank farm. The investigation also indicated the presence of a benzene contaminant plume at the tank farm.

In 1988, ESE conducted a focused FS addressing remediation of the shallow groundwater at HPIA. The database developed during the characterization step effort was used to select a cost-effective remedial alternative. A pump-and-treat alternative was determined to be the most feasible remedial alternative (ESE, 1988b). It was anticipated that the groundwater pumped from the surficial aquifer would be treated at the Hadnot Point Sewage Treatment Plant.

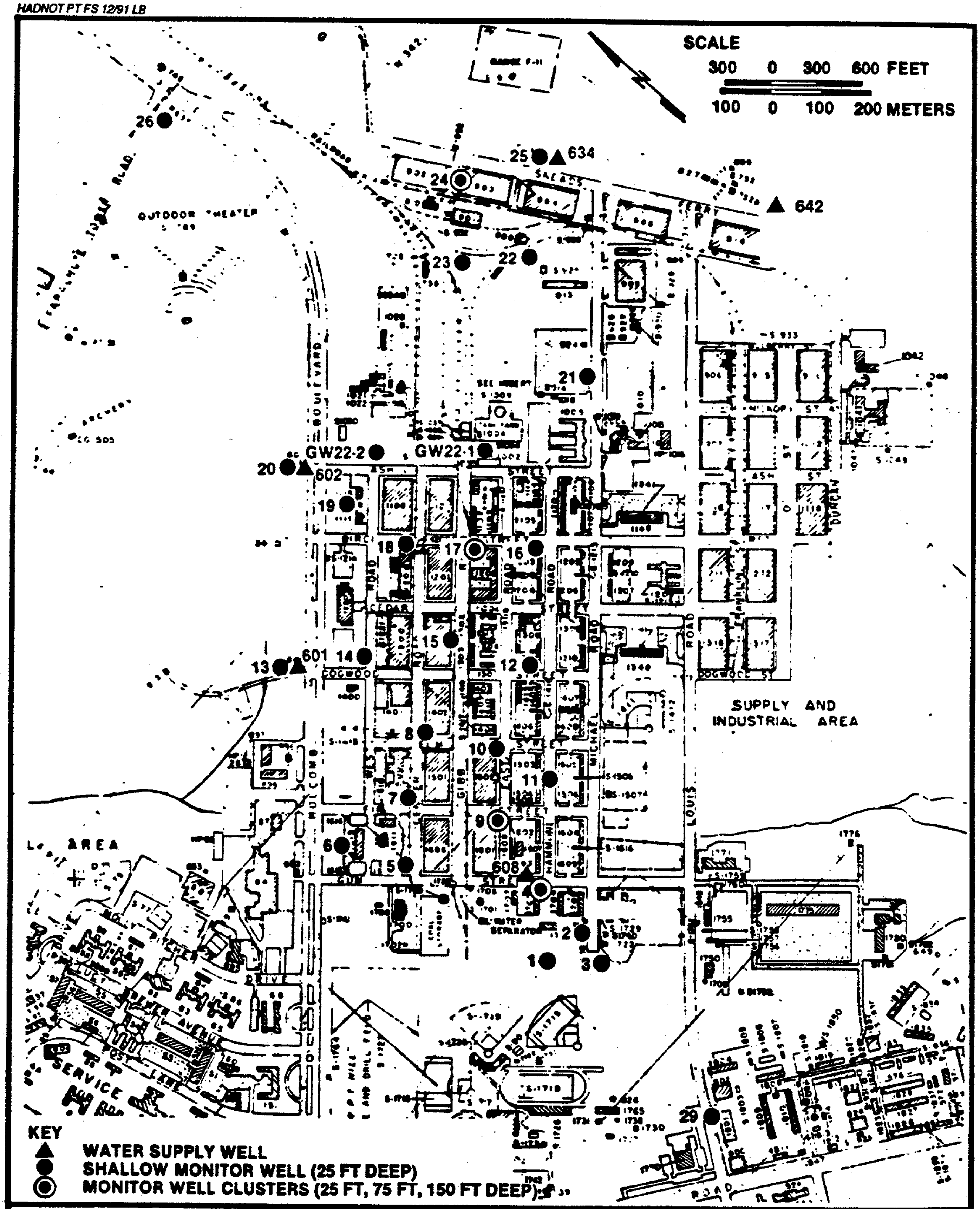


Figure 1-9
MONITOR WELLS AND WATER SUPPLY WELLS AT HADNOT POINT INDUSTRIAL AREA – CONFIRMATORY STUDY

SOURCE: ESE.

MARINE CORPS BASE CAMP LEJEUNE

A supplemental characterization step, performed by ESE at HPIA in 1990-1991, was designed to evaluate the extent of contamination further in the lower water-bearing zones at the four areas of concern and to characterize the contamination within the shallow soils at Areas 900, 1200, and 1600. The supplemental characterization step consisted of the following tasks:

1. Completion of 30 soil borings at 3 suspected source locations to characterize shallow soil contamination,
2. Installation of 4 intermediate (75 ft) and 4 deep (150 ft) monitor wells, and
3. Sampling of all new and existing HPIA monitor wells (including those previously installed at Areas 21 and 22) and nearby water supply wells.

1.8 SUMMARY OF RA STUDY

The primary objectives of remedial action for HPIA are to manage potential long-term contaminant migration and protect human health and the environment. The quantitative baseline RA report prepared for HPIA summarized and interpreted the RI data so contaminant migration at the areas of concern could be characterized. In addition, the RA assessed actual and/or potential future harm to the public health and welfare and the environment resulting from residual contamination associated with past disposal practices at the sites. The results of the RA are used to identify those media and/or areas within the HPIA that have a potential for adverse human health and environmental impacts and that must, therefore, be included in the FS evaluation.

The RA for HPIA evaluated the human and nonhuman health risks associated with potential exposures to contaminants identified during the supplemental characterization step in the surface soils at Areas 900, 1200, and 1600, as well as in the deep-intermediate groundwater at all four areas of concern (Areas 900, 1200, 1600, and 22). The significant exposure pathways evaluated were worker exposure to soils via direct contact (i.e., ingestion and dermal absorption) and potable use of groundwater. Because the future land management plans at HPIA specify limited residential development (e.g., barracks for adult men and women, no children, and maximum of 2 years of exposure), this exposure scenario was evaluated (see Appendix B) to ensure that the remedial alternatives are protective of future exposures to the site.

Based on the worst-case exposure assumptions described in the exposure assessment, noncarcinogenic health indices (HIs) and carcinogenic health risks associated with potential exposures to surface soils (Areas 900, 1200, and 1600) and groundwater (Areas 900, 1200, 1600, and 22) were determined. If the resultant individual HI or total HI exceeded unity (>1), or if the individual cancer risk or overall cancer risk exceeded EPA's (1991b) acceptable cumulative risk of 1×10^{-4}, [the upperbound of the acceptable cumulative risk range of 1×10^{-4} to 1×10^{-6} (EPA, 1991b)], then the chemical(s) associated with those exceedances were included in the FS for further evaluation. The purpose of the FS is to determine which remedial alternative(s) is most effective in reducing the HIs or risks to acceptable values or ranges.

The results of the RA for HPIA indicated that none of the areas evaluated resulted in an HI of greater than 1 for either the groundwater or the surface soil exposure pathways. The cancer risk evaluation for the groundwater worker exposure pathway (i.e., ingestion) indicated that the groundwater at the four areas of concern does not pose cumulative risks that exceed the cumulative risk level of 10^{-4}.

However, the level of benzene (27 μg/L) detected in MW-32-2 at Area 22 exceeds the maximum contaminant level (MCL) of 5 μg/L, indicating that the potential exists for adverse human health effects to occur as a result of potable use of this aquifer in which benzene was detected. The elevated level of benzene was detected in only one sample from the intermediate zone and can be attributed to leaking fuel storage tanks at the fuel tank farm. Free product recovery from the surficial aquifer will be initiated in the near future and contamination in the intermediate/deep aquifer will be addressed at that time. After recovery operations have been completed, remediation activities will commence. Because the extent of contamination of the intermediate/deep aquifer will be addressed in a separate study in which additional sampling will take place, groundwater was eliminated from further evaluation in this FS [see the HPIA RA (ESE, 1991c) for detailed rationale for eliminating groundwater from this study].

The results of the cancer risk evaluation for the soil exposure pathways (i.e., ingestion and dermal absorption) indicated that all three areas of concern, Areas 900, 1200, and 1600 pose risks that are well below the cumulative risk level of 10^{-4}.

Based on the findings of the RA, the potential may exist for adverse human health impacts to occur as a result of exposures to benzene in groundwater due to the single exceedance of the MCL. However, because fuel contamination of the aquifers will be evaluated as a separate study, groundwater remedial alternatives were not considered as part of this FS. The results of the RA for surface soils indicate that remediation at the three areas is not warranted because the cumulative site risks are below the 10^{-4} risk level and the noncarcinogenic HIs are below 1.

2.0 DETERMINATION OF REMEDIAL ACTION OBJECTIVES

The overall remediation goal at HPIA is to protect human health and the environment by preventing or reducing, to the greatest extent possible, the release or migration of site contaminants through implementation of appropriate remedial actions. To determine the point at which the overall goal for the study is achieved, site-specific remedial action objectives must be identified. Remedial action objectives are media-specific or operable unit-specific goals for protecting human health and the environment; consequently, the remedial alternatives must meet these goals. These goals may be contaminant-specific levels or health- and risk-based guidelines to be followed in conducting remedial actions at the site. An important first step in the determination of remedial action objectives in the FS is the identification of potential applicable or relevant and appropriate requirements (ARARs), followed by an evaluation of health- and risk-based guidelines for those contaminants having no ARARs.

2.1 IDENTIFICATION OF POTENTIAL ARARs

The NCP, amended pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act [(CERCLA) or Superfund], established the process for determining appropriate remedial actions at those sites listed in the NCP (i.e., Superfund sites). Recent amendments to CERCLA by SARA further define the process for determining appropriate remedial actions at Superfund sites and the degree of cleanup to be achieved by these remedial actions.

Sections 300.430(e)(2)(i); (e)(3 through 6); and (e)(9)(iii) of the NCP require the assessment of the following:

1. The extent to which federal and state public health and environmental standards are applicable or relevant and appropriate; and

2. The extent to which contamination levels exceed federal ARARs or other federal criteria, advisories, and guidance, as well as state standards, in determining whether and what type of remedial and/or removal actions are to be considered in the FS.

The potential ARARs are to be used as a guide in evaluating the appropriate extent of site remediation, to aid in scoping and formulating remedial action alternatives, and to govern the implementability and reliability of the selected remedial action. The purpose of these requirements is to make CERCLA response actions consistent with other federal or state public health and environmental requirements.

To identify potential ARARs specific to the PAH-contaminated soils in HPIA, input from the RA is necessary. The RA described those pathways that may result in potential exposures, characterized the upper-bound risks from potential exposures to contaminants at the study area, provided the appropriate context for assessing the magnitude of the risk, and defined those exposure pathways that may endanger human health and the environment. Using this information as a basis, contaminant cleanup criteria were determined only for those soil contaminants with no established state or federal ARARs. The site-specific risk management decision (i.e., the decision concerning what risk level is acceptable at HPIA) is made when EPA selects a remedy as part of the Record of Decision (ROD).

Section 121(d)(2)(A) of SARA describes remedial standards applicable to any hazardous substance, pollutant, or contaminant that will remain onsite. The selected remedial action for NCP sites must attain potential ARARs unless a waiver is invoked. These ARARs are federal environmental laws including, but not limited to, the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), or the Solid Waste Disposal Act (SWDA). In addition, any promulgated state standard, requirement, criterion, or limitation that is more stringent than federal requirements is applicable if such a state requirement is part of a federally delegated program that the state has identified to the president of the United States in a timely manner.

Pursuant to EPA guidance, a promulgated state standard is a standard that is generally applicable (i.e., not specific to a single targeted site or activity) and enforceable by the state. Nonpromulgated standards may be considered in determining remedial action objectives, but are not required to be followed [53 Federal Register (FR) 51437, 51438 (December 21, 1988)].

As the definition implies, ARARs identified for a site are those selected from federal and state environmental laws and standards that are applicable or relevant and appropriate to the site-specific remedial actions under consideration. Applicable requirements are defined in the NCP as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" [40 Code of Federal Regulations (CFR) 300.5]. Thus, a federal or state standard is applicable if it pertains to the remedial action under consideration and if the action is undertaken outside the context of a CERCLA cleanup. However, any state standard that precludes in-state land disposal is not applicable unless all of several conditions apply [SARA, Section 121(d)(2)(C)].

Relevant and appropriate requirements are less clearly defined than applicable requirements. The NCP defines relevant and appropriate as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5). Additionally, a requirement is relevant and appropriate if it addresses problems or situations that are generally pertinent to the conditions at the site (i.e., the requirement is appropriate) [53 FR 51436, 51437 (December 21, 1988)]. Relevant requirements are not potential ARARs unless their use is appropriate given the conditions at the site [50 FR 47912, 47918 (November 20, 1985)]. Whether a requirement is appropriate depends upon the nature of the substances at the site, the site characteristics, the circumstances surrounding the release, and the ability of the action to address the release. The most important criteria used to assess the appropriateness of a requirement are whether the purpose for which the requirement was created is similar to the specific objectives of the CERCLA action, and whether the actions or activities regulated by the requirement are similar to the remedial action contemplated at the CERCLA site [50 FR 51346 (December 16, 1985)].

ARARs identified for remedial actions are those selected from federal and state environmental laws and standards that are applicable or relevant and appropriate to the site-specific remedial actions under consideration. These ARARs are classified as contaminant-specific, location-specific, and action-specific. During the actual screening of alternatives, potential ARARs will be considered when assessing the effectiveness of the alternatives in contributing to the further protection of human health and the environment.

2.1.1 CONTAMINANT-SPECIFIC ARARS

A contaminant-specific ARAR is a chemical-specific concentration limit established by either federal or state environmental laws for a given environmental medium. Examples may include MCLs established pursuant to SDWA, ambient water quality criteria (AWQC) established pursuant to CWA, National Ambient Air Quality Standards (NAAQS) established pursuant to CAA, and soil cleanup values established pursuant to TSCA. Except for action levels established for polychlorinated biphenyls (PCBs) pursuant to TSCA and interim cleanup values for lead established as a technical directive by EPA, (EPA, 1989b), federal and state criteria for acceptable contaminant levels in soils have not been established. No federal and/or state ARARs are available for the chemicals of concern (COCs) in the soils at Areas 900, 1200 and 1600; therefore, risk-based levels developed in the RA are considered when identifying the remedial action objectives for these areas.

2.1.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs are those requirements that establish restrictions on remedial activities or limitations on contaminant levels on the basis of site characteristics or physical characteristics of the surrounding area. State requirements are followed only when they are of general applicability and are based on hydrogeologic considerations. These requirements should not restrict land disposal for reasons other than protection of human health or the environment. Examples of such ARARs include siting laws for hazardous waste facilities, laws regarding development or other activities in wetlands and floodplains, historic preservation laws, and laws for the protection of endangered species.

The following site characteristics were considered in the determination of location-specific ARARs:

1. No federal or state endangered species are known to frequent the site or the surrounding area,
2. The site does not overlie karst topography,
3. The site is not located above or near an area containing faults that have had a displacement in Holocene time,
4. The site does not lie in an area designated as a National Historic Landmark or National Historic Preservation Area,
5. The site does not lie near a marine environment,
6. The site does not lie on or near an area influenced by surface mining,
7. The site is not within a floodplain,
8. The site does not overlie a salt dome or salt bed formations, and
9. The site does not contain wetlands.

The following state agencies were contacted to verify these site characteristics:

1. North Carolina Division of Fish and Wildlife,
2. North Carolina Natural Resources and Community Development,
3. North Carolina Coastal Zone Management,
4. North Carolina Division of Land Resources,
5. North Carolina Division of Archives and History, and
6. U.S. Fish and Wildlife Service.

This analysis revealed no location-specific ARARs for HPIA.

2.1.3 ACTION-SPECIFIC ARARS

Action-specific ARARs are standards that establish restrictions or controls on particular kinds of remedial activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities as opposed to the specific chemicals present at a site. Examples of action-specific ARARs include federal and state air emissions standards, closure regulations, incineration standards, and surface water discharge standards.

Action-specific ARARs vary depending on the alternative being evaluated. These ARARs do not determine the appropriate remedial alternative, but indicate the performance levels to be achieved by the alternative.

Action-specific ARARs cannot be firmly established prior to identification of remedial alternatives; therefore, potential action-specific ARARs are not detailed in this section. The action-specific ARARs applicable to the remedial alternatives that pass the initial screening criteria are described in Section 4.0.

2.2 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

Identification of potential contaminant-specific ARARs is the preliminary step in the determination of remedial action objectives. Lead is the only contaminant at HPIA that has an EPA interim cleanup guidance level for Superfund sites. EPA adopted the guidance range of 500 to 1,000 milligrams per kilogram (mg/kg) based on the recommendations of the 1985 Centers of Disease Control (CDC) statement on childhood lead poisoning (EPA, 1989b). The statement cautioned that lead concentrations in soil and dust greater than 500 mg/kg could result in elevated blood lead levels in children inhaling or ingesting contaminated soil. Because children represent the most sensitive human subpopulation for lead exposures, the CDC value of 500 mg/kg is considered the relevant and appropriate criteria for site soil lead concentrations. The results of the RA indicate that the maximum soil lead concentrations at the three areas of concern are 56.9 mg/kg for Area 900, 84.8 mg/kg for Area 1200, and 36.6 mg/kg for Area 1600. Because all three maximum concentrations are well below the interim cleanup level of 500 mg/kg, lead at the three areas of concern does not require remediation.

However, because there are no contaminant-specific ARARS or EPA guidance values for PAH-contaminated soils, health- and risk-based levels were developed to serve as potential remedial action objectives for Areas 900, 1200, and 1600. These levels, which are based on a target acceptable cumulative risk of 1×10^{-4} for carcinogens or an HI of 1 for noncarcinogens, were developed based on the relative individual risk and/or HI contribution that each contaminant provides to the mixture at each area of concern. Once the relative contribution of each contaminant to the overall risk and/or HI at each area was determined, an adjusted target risk or HI was calculated by multiplying the percent contribution of the contaminant by the acceptable cumulative risk of 1×10^{-4} or the target HI of 1. Using these adjusted target risk or HI levels and the same exposure assumptions presented in the RA, the risk or HI formula was rearranged to arrive at the target soil concentrations, also known as the health-based values for the site(s) based on a mixture of contaminants. The health-based target soil concentrations developed for each contaminant vary from area to area based on the individual contribution of each contaminant to the overall risk and/or HI. These target soil concentrations are the maximum level that is most protective of human health because they were derived from the conservative worst-case exposure assumptions presented in the RA. The exposure assumption, in most cases, was the 95th percentile value and included the following:

1. For 250 days per year for 25 years (national 95th percentile time at one workplace), an adult worker performs work activities at Buildings 902, 1202, and 1602 (EPA, 1991);
2. An adult worker is exposed to the maximum detected contaminant concentration during the entire exposure period;
3. The ratio of the amount of chemical that is absorbed through the gastrointestinal lining to the amount of that chemical incidentally ingested from soil is 100 percent for PAHs; and
4. The worst-case soil to skin adherence factor was assumed.

The results are presented in Tables 2-1, 2-2, and 2-3.

The RA revealed that potential worker exposure to the noncarcinogenic COCs in soil does not result in adverse effects, based on the exposure assumptions evaluated. The target HI of 1 was not exceeded at any of the areas of concern; therefore, the current concentrations of noncarcinogenic PAHs in the soil are well below the target noncarcinogenic health-based levels, as shown in Tables 2-1, 2-2, and 2-3.

The results of the total carcinogenic risk analysis of soil exposures indicate that direct contact with soils (i.e., ingestion and dermal absorption) results in overall (total) potential risks at Areas 900, 1200, and 1600 that are below EPA's acceptable cumulative risk of 10^{-4} (Tables 2-1, 2-2, and 2-3). EPA has identified a cumulative cancer risk of 10^{-4} as the point of departure for determining the need for remediation of contaminants that do not have ARARs, or for which an ARAR is not sufficiently protective because of multiple contaminants or multiple exposure pathways (EPA, 1991a). Because potential exposure to soil at Buildings 900, 1200, and 1600 does not exceed the cumulative risk level of 10^{-4},

Table 2-1. Health-Based Target Soil Concentrations at Area 900 of the Hadnot Point Industrial Area.

16 Dec 1991

Contaminant of Concern	Maximum Detected Soil Concent.(a)	Absorption Factor(b)	Daily Intake(c)			RfD	CSF	Hazard Index(d)	Carcinogenic Risk(e)	Adjusted Total Target HI(f)	Adjusted Total Target Risk(g)	Health-Based Target Soil Concentration [mg/kg]	
			Dermal +	Oral =	Total							NC	PC
POTENTIAL CARCINOGENS													
Benzo(a)anthracene	2.80E-01	1.00E-01	4.08E-07	4.89E-08	4.57E-07	*3.00E-02	**1.15E+01	4.27E-05	5.26E-06	9.02E-02	2.04E-05	5.92E+02	1.09E+00
Chrysene	2.60E-01	1.00E-01	3.79E-07	4.54E-08	4.24E-07	*3.00E-02	**1.15E+01	3.96E-05	4.88E-06	8.38E-02	1.90E-05	5.50E+02	1.01E+00
Benzo(b)fluoranthene	2.50E-01	1.00E-01	3.64E-07	4.37E-08	4.08E-07	*3.00E-02	**1.15E+01	3.81E-05	4.69E-06	8.06E-02	1.82E-05	5.29E+02	9.72E-01
Benzo(a)pyrene	2.40E-01	1.00E-01	3.50E-07	4.19E-08	3.92E-07	*3.00E-02	1.15E+01	3.66E-05	4.51E-06	7.74E-02	1.75E-05	5.08E+02	9.33E-01
Benzo(k)fluoranthene	2.10E-01	1.00E-01	3.06E-07	3.67E-08	3.43E-07	*3.00E-02	**1.15E+01	3.20E-05	3.94E-06	6.77E-02	1.53E-05	4.44E+02	8.16E-01
Indeno(1,2,3-cd)pyrene	1.30E-01	1.00E-01	1.90E-07	2.27E-08	2.12E-07	*3.00E-02	**1.15E+01	1.98E-05	2.44E-06	4.19E-02	9.49E-06	2.75E+02	5.05E-01
NONCARCINOGENS													
Pyrene	5.30E-01	1.00E-01	7.73E-07	9.26E-08	8.65E-07	3.00E-02	--	8.08E-05	--	1.71E-01	--	1.12E+03	--
Fluoranthene	6.90E-01	1.00E-01	1.01E-06	1.21E-07	1.13E-06	4.00E-02	--	7.89E-05	--	1.67E-01	--	1.46E+03	--
Phenanthrene	5.00E-01	1.00E-01	7.29E-07	8.74E-08	8.16E-07	*3.00E-02	--	7.62E-05	--	1.61E-01	--	1.06E+03	--
Benzo(g,h,i)perylene	1.10E-01	1.00E-01	1.60E-07	1.92E-08	1.80E-07	*3.00E-02	--	1.68E-05	--	3.55E-02	--	2.33E+02	--
Acenaphthene	4.20E-02	1.00E-01	6.12E-08	7.34E-09	6.86E-08	6.00E-02	--	3.20E-06	--	6.77E-03	--	8.88E+01	--
Anthracene	1.80E-01	1.00E-01	2.62E-07	3.15E-08	2.94E-07	3.00E-01	--	2.74E-06	--	5.80E-03	--	3.81E+02	--
Fluorene	4.80E-02	1.00E-01	7.00E-08	8.39E-09	7.84E-08	4.00E-02	--	5.49E-06	--	1.16E-02	--	1.02E+02	--
TOTAL:								4.73E-04	2.57E-05	1.00E+00	1.00E-04		

Note:
RfD = risk reference dose [mg/kg/day].
CSF = cancer slope factor [(mg/kg/day)-1].
HI = hazard index.
NC = noncarcinogenic effects.
PC = potential carcinogenic effects.
MCL = maximum contaminant level.
mg/L = milligrams per liter.
mg/kg = milligrams per kilogram.
mg/kg/day = milligrams per kilogram per day.

(a) Maximum soil concentrations detected in ESE samples from the station [mg/kg].
(b) Absorption factor is a chemical-specific exposure factor in the dermal exposure route; it has been set alone to fascilitate easier calculation.
(c) Daily Intakes are derived using the formulas and worker exposure assumptions presented in the Exposure Assessment [mg/kg/day].
(d) Hazard Index = daily intake / RfD.
(e) Carcinogenic Risk = daily intake x CSF.
(f) Percent of total site HI posed by the specific chemical multiplied by the target HI (1).
(g) Percent of total site risk posed by the specific chemical multiplied by the target risk (1 x 10-4).

* Used RfD from the most toxic non-naphthalene PAH which is pyrene.
** CSF for Benzo(a)pyrene is used until EPA has published revised values for individual carcinogenic PAHs.

Source: ESE,

Table 2-2. Health-Based Target Soil Concentrations at Area 1200 of the Hadnot Point Industrial Area. 16 Dec 1991

Contaminant of Concern	Maximum Detected Soil Concent.(a)	Absorption Factor(b)	Daily Intake(c)			RfD	CSF	Hazard Index(d)	Carcinogenic Risk(e)	Adjusted Total Target HI(f)	Adjusted Total Target Risk(g)	Health-Based Target Soil Concentration [mg/kg]	
			Dermal	+ Oral	= Total							NC	PC
POTENTIAL CARCINOGENS													
Benzo(a)anthracene	1.40E-01	1.00E-01	2.04E-07	2.45E-08	2.29E-07	*3.00E-02	**1.15E+01	2.13E-05	2.63E-06	7.54E-02	1.52E-05	4.95E+02	8.09E-01
Chrysene	2.70E-01	1.00E-01	3.94E-07	4.72E-08	4.41E-07	*3.00E-02	**1.15E+01	4.11E-05	5.07E-06	1.45E-01	2.93E-05	9.55E+02	1.56E+00
Benzo(b)fluoranthene	1.40E-01	1.00E-01	2.04E-07	2.45E-08	2.29E-07	*3.00E-02	**1.15E+01	2.13E-05	2.63E-06	7.54E-02	1.52E-05	4.95E+02	8.09E-01
Benzo(a)pyrene	1.40E-01	1.00E-01	2.04E-07	2.45E-08	2.29E-07	*3.00E-02	1.15E+01	2.13E-05	2.63E-06	7.54E-02	1.52E-05	4.95E+02	8.09E-01
Benzo(k)fluoranthene	1.50E-01	1.00E-01	2.19E-07	2.62E-08	2.45E-07	*3.00E-02	**1.15E+01	2.29E-05	2.82E-06	8.08E-02	1.63E-05	5.30E+02	8.67E-01
Indeno(1,2,3-cd)pyrene	8.20E-02	1.00E-01	1.20E-07	1.43E-08	1.34E-07	*3.00E-02	**1.15E+01	1.25E-05	1.54E-06	4.42E-02	8.89E-06	2.90E+02	4.74E-01
NONCARCINOGENS													
Pyrene	2.90E-01	1.00E-01	4.23E-07	5.07E-08	4.73E-07	3.00E-02	--	4.42E-05	--	1.56E-01	--	1.03E+03	--
Fluoranthene	3.70E-01	1.00E-01	5.39E-07	6.46E-08	6.04E-07	4.00E-02	--	4.23E-05	--	1.49E-01	--	1.31E+03	--
Phenanthrene	2.10E-01	1.00E-01	3.06E-07	3.67E-08	3.43E-07	+3.00E-02	--	3.20E-05	--	1.13E-01	--	7.42E+02	--
Benzo(g,h,i)perylene	7.20E-02	1.00E-01	1.05E-07	1.26E-08	1.18E-07	+3.00E-02	--	1.10E-05	--	3.88E-02	--	2.55E+02	--
Acenaphthene	7.20E-02	1.00E-01	1.05E-07	1.26E-08	1.18E-07	6.00E-02	--	5.49E-06	--	1.94E-02	--	2.55E+02	--
Anthracene	1.50E-02	1.00E-01	2.19E-08	2.62E-09	2.45E-08	3.00E-01	--	2.29E-07	--	8.08E-04	--	5.30E+01	--
Fluorene	6.30E-02	1.00E-01	9.18E-08	1.10E-08	1.03E-07	4.00E-02	--	7.20E-06	--	2.55E-02	--	2.23E+02	--
TOTAL:								2.83E-04	1.73E-05	1.00E+00	1.00E-04		

Note:
RfD = risk reference dose [mg/kg/day].
CSF = cancer slope factor [(mg/kg/day)-1].
HI = hazard index.
NC = noncarcinogenic effects.
PC = potential carcinogenic effects.
MCL = maximum contaminant level.
mg/L = milligrams per liter.
mg/kg = milligrams per kilogram.
mg/kg/day = milligrams per kilogram per day.

(a) Maximum soil concentrations detected in ESE samples from the station [mg/kg].
(b) Absorption factor is a chemical-specific exposure factor in the dermal exposure route; it has been set alone to fascilitate easier calculation.
(c) Daily Intakes are derived using the formulas and worker exposure assumptions presented in the Exposure Assessment [mg/kg/day].
(d) Hazard Index = daily intake / RfD.
(e) Carcinogenic Risk = daily intake x CSF.
(f) Percent of total site HI posed by the specific chemical multiplied by the target HI (1).
(g) Percent of total site risk posed by the specific chemical multiplied by the target risk (1 x 10-4).

* Used RfD from the most toxic non-naphthalene PAH which is pyrene.
** CSF for Benzo(a)pyrene is used until EPA has published revised values for individual carcinogenic PAHs.

Source: ESE,

Table 2-3. Health-Based Target Soil Concentrations at Area 1600 of the Hadnot Point Industrial Area.

16 Dec 1991

Contaminant of Concern	Maximum Detected Soil Concent.(a)	Absorption Factor(b)	Daily Intake(c) Dermal	+ Oral	= Total	RfD	CSF	Hazard Index(d)	Carcinogenic Risk(e)	Adjusted Total Target HI(f)	Adjusted Total Target Risk(g)	Health-Based Target Soil Concentration [mg/kg] NC	PC
NONCARCINOGENS													
Phenanthrene	1.10E-01	1.00E-01	1.60E-07	1.92E-08	1.80E-07	* 3.00E-02	--	1.68E-05	--	5.34E-02	--	3.50E+02	--
Naphthalene	2.20E-01	1.00E-01	3.21E-07	3.84E-08	3.59E-07	4.00E-03	--	2.51E-04	--	8.01E-01	--	7.01E+02	--
2-Methylnaphthalene	3.00E-01	1.00E-01	4.37E-07	5.24E-08	4.90E-07	* 3.00E-02	--	4.57E-05	--	1.46E-01	--	9.56E+02	--
TOTAL:								3.14E-04		1.00E+00			

Note: RfD = risk reference dose [mg/kg/day].
CSF = cancer slope factor [(mg/kg/day)-1].
HI = hazard index.
NC = noncarcinogenic effects.
PC = potential carcinogenic effects.
MCL = maximum contaminant level.
mg/L = milligrams per liter.
mg/kg = milligrams per kilogram.
mg/kg/day = milligrams per kilogram per day.

(a) Maximum soil concentrations detected in ESE samples from the station [mg/kg].
(b) Absorption factor is a chemical-specific exposure factor in the dermal exposure route; it has been set alone to fascilitate easier calculation.
(c) Daily Intakes are derived using the formulas and worker exposure assumptions presented in the Exposure Assessment [mg/kg/day].
(d) Hazard Index = daily intake / RfD.
(e) Carcinogenic Risk = daily intake x CSF.
(f) Percent of total site HI posed by the specific chemical multiplied by the target HI (1).
(g) Percent of total site risk posed by the specific chemical multiplied by the target risk (1 x 10-4).

* Used RfD from the most toxic non-naphthalene PAH which is pyrene.

Source: ESE,

as indicated by the maximum detected soil concentrations that are well below the health-based criterion (Tables 2-1, 2-2, and 2-3), remedial response objectives were not developed for soils at these areas.

In summary, no remediation of PAH-contaminated soils present in Areas 900, 1200, and 1600 will be required since the carcinogenic risk level for workers in direct contact with contaminated soils is below the acceptable cumulative risk level of 10^{-4}. However, additional soil samples should be collected at both areas to verify that the PAH concentrations observed in the surficial soil during the RI phase are representative of the current contamination levels onsite.

APPENDIX A

DESCRIPTION OF REMEDIAL TECHNOLOGIES FOR HPIA SOILS

A.0 DESCRIPTION OF REMEDIAL TECHNOLOGIES FOR HPIA SOILS

A.1 PHYSICAL TREATMENT

A.1.1 SOIL WASHING/FLUSHING

Solvent extraction is a physical transfer process in which contaminants are washed from the soil, becoming dissolved or dispersed in a liquid solvent. This liquid waste stream then undergoes subsequent treatment to remove the contaminants, and the solvent is recycled, if possible. If the solvent selection is optimized with the addition of surfactants or chelating agents, solvent extraction can successfully treat many organic and inorganic contaminants, particularly those that are more water soluble.

The basic mechanism at work in the solvent extraction process includes breaking the bond between the contaminant and the soil particle. For the same contaminants, solvent extraction exhibits a distinctly improved effectiveness on larger sand particles than on smaller clay particles. The bonds between the soil particles and contaminants can consist of one or more of the following: weak Van der Waals forces, dipole-dipole moments, hydrogen bonds, and some covalent bonds. The difference between the treatability of sand and clay is best explained by the location of the contaminant-soil bond. For sands, the bonding takes place on the outside of the mineral; therefore, the contaminants are readily available for removal by the solvent. In clays, the bonding takes place between the layers, and the contaminants are therefore less accessible to the solvent.

Solvent extraction has been successfully demonstrated in several laboratory and pilot-scale tests and in three full-scale units in the Netherlands. The majority of the available data on organic compounds indicates removal efficiencies of approximately 90 to 99 percent, with lower values of 70 to 90 percent for some of the less volatile and less water-soluble aromatic compounds. It is possible that the reported effectiveness could be due in part to volatilization for compounds with higher vapor pressures. This technology has demonstrated removal efficiencies of 85 to 90 percent for volatile and nonvolatile metals, respectively. The majority of the available data for solvent extraction are from laboratory studies, where the soil was hand sorted and had relatively small particle sizes. The results achieved under these ideal conditions may not be reproducible under full-scale conditions, where larger clumps of soil will be treated.

The solvent extraction process has some limitations. It is often difficult to select a solvent that is effective on both organic and inorganic contaminants. Although surfactants are most effective on organics, they are not as effective as chelating agents on inorganics. The fine clay particles, which may remain contaminated due to their high cation exchange capacities, are difficult to separate from the solvent. The clay particles may require immobilization prior to disposal, and the spent solvents are often toxic and may also require treatment.

A.1.2 SOIL AERATION

Soil aeration is typically used as an inexpensive method to remove VOCs from soils. A relatively thin layer of contaminated material is spread on the ground surface to permit natural volatilization of the contaminants. Precautions are typically required to prevent runoff and leaking from the volatilization site. Additionally, VOC emissions may be a concern in some sensitive locales.

A.1.3 IN SITU VOLATILIZATION

This relatively new technique is used to remove volatile organics from the soil and free product from the top of the water table. It can remove the contamination source and enhance further treatment with the intent to reduce cleanup times and subsequent costs dramatically.

In situ volatilization is accomplished by applying a vacuum to a well or series of wells constructed above the water table in the unsaturated or vadose zone. Air is drawn to the wells from the surrounding soils by the vacuum. As fresh air is brought into the formation, volatile contaminants move from the soils into the air and are then removed by the vacuum. The removed air can be exhausted directly to the atmosphere or treated to remove the contaminants. Air flow through sections of the vadose zone may be enhanced by modifying the standard vacuum extraction system and pumping compressed air into perimeter wells. The radius of influence of the vacuum wells is the most important design factor for in situ volatilization. To determine the radius of influence, a pilot study with a vacuum well and several closely spaced vacuum monitor wells is needed. If an appreciable amount of free product is expected, an inline air/fluid separator may be required. In situ volatilization is of limited use in areas with tight soil formations or thin unsaturated zones. A cap may be required on the ground surface to prevent air from being drawn down the outside of the well casing.

A.2 CHEMICAL TREATMENT

A.2.1 CHELATION

A chelating molecule contains atoms that can form ligands with metal ions. If the number of such atoms in the molecule is sufficient and if the final molecular shape is such that the metal atom is essentially surrounded, then the metal will not be able to form ionic salts that can precipitate. Thus, chelation is used to keep metals in solution and to aid in dissolution for subsequent transport and removal (e.g., soil washing). Chelating chemicals can be chosen for their affinity to particular metals (e.g., EDTA and calcium). Fats and oils can interfere with the process.

A.2.2 SOLIDIFICATION/STABILIZATION

Solidification and stabilization treatment processes transform soils and sludges into environmentally safer forms by immobilizing contaminants. Stabilization limits the solubility or mobility of the contaminants with or without change or improvement in the physical characteristics of the waste. Stabilization usually involves adding materials that ensure the hazardous constituents are maintained in their least mobile or toxic form.

Solidification implies the beneficial results of treatment obtained through the production of a solid block of waste material with high structural integrity, a product often referred to as a monolith. The contaminants do not necessarily interact chemically with reagents, but are mechanically locked within the solidified matrix, which is called macroencapsulation.

Contaminant loss is limited largely by decreasing the surface area exposed to the environment and/or isolating the contaminants from environmental influences. Wastes also can be microencapsulated, bonded to or surrounded by an impervious covering. For major stabilization and solidification processes commonly used for hazardous wastes, waste compatibility plays a key role in selecting a particular treatment process. Waste stabilization and solidification systems include lime fly ash pozzolanic processes, Portland® cement systems, thermoplastic microencapsulation, and macroencapsulation.

Lime fly ash pozzolanic processes use a finely divided, noncrystalline silica in fly ash and the calcium in lime to produce low strength cementation. Wastes are contained by entrapment in the pozzolan concrete matrix (microencapsulation). Portland® cement systems use Portland® cement and possibly other pozzolanic materials to produce a stronger waste-concrete composite. Waste is contained by microencapsulation in the concrete matrix. Soluble silicates can be added to accelerate hardening and contaminant containment.

Thermoplastic microencapsulation involves blending fine particulate waste with melted asphalt or other plastic/polymer matrices. Liquid and volatile phases associated with the wastes are driven off and the wastes are isolated in a mass of cooled, hardened asphalt. The material can be buried with or without a container.

The most common materials, such as polyethylene, polypropylene, wax, or elemental sulfur can be used for specific wastes where complete containment is important and cost is not a limiting factor. The major advantage that thermoplastic (asphalt) encapsulation offers is the ability to solidify soluble, toxic materials.

Macroencapsulation systems contain potential pollutants by bonding an inert coating or jacket around a mass of cemented waste or by sealing them in polyethylene-lined drums or containers. This type of waste stabilization is often effective when others are not because the jacket or coating of the outside of the waste block completely isolates the waste from its surroundings. The waste can be stabilized, microencapsulated, and/or solidified before macroencapsulation so the external jacket becomes a barrier designed to overcome the shortcomings of available treatment systems.

A.2.3 ENCAPSULATION

Surface encapsulation describes those methods that physically microencapsulate wastes by sealing them in an organic binder or resin. Surface encapsulation can be accomplished using a variety of approaches.

The major advantage of encapsulation processes is that the waste material is completely isolated from leaching solutions. Other advantages associated with hazardous waste encapsulation include: cubic and cylindrical encapsulates allow for efficient space utilization during transport, storage, and disposal; the hazard of accidental spills during transport is eliminated; materials used for encapsulation are commercially available, very stable chemically, nonbiodegradable, mechanically tough, and flexible; and encapsulated waste materials can withstand the mechanical and chemical stresses of a wide range of disposal schemes (landfill, disposal in salt formations, ocean disposal).

Major disadvantages associated with encapsulation techniques include: binding resins required for agglomeration/encapsulation (high density polyethylene, polybutadiene) are relatively expensive; the processes are energy intensive and relatively costly; and skilled labor is required to operate molding and fusing equipment.

A.3 BIOLOGICAL TREATMENT

A.3.1 COMPOSTING

Composting refers to the process of biological decomposition of solid organic materials microorganisms (mainly bacteria and fungi). Compost is the stabilized, humus or soil-like product. Composting has been popular for years because compost products help improve soil structure. Now it is gaining favor as a municipal solid waste management method because, in addition to stabilizing organic materials, it can divert them from landfills and reduce some of the risks associated with landfilling and incineration.

Composting involves manufacturing a product, just like other industrial practices, and its effectiveness depends on how well the decomposition process is designed and controlled. To maximize the rate of microbial activity within a mass of organic materials, factors such as temperature and moisture must be controlled. With proper controls, composting can occur rapidly, yield a product that meets end-use quality specifications, and reduce the original volume of the materials by more than 50 percent.

The biodegradable organic materials in municipal solid waste include yard wastes (i.e., leaves, grass clippings, weeds, prunings); food wastes; and paper from residential, commercial, and institutional uses. Yard wastes make up 10 to 30 percent of municipal solid waste, although this portion varies greatly geographically and seasonally; food wastes constitutes another 5 to 10 percent.

A.3.2 IN SITU BIODEGRADATION

In situ biological treatment should be considered in many cases and especially where soil excavation would be difficult or extremely expensive. The most common type of in situ treatment involves the biodegradation of contaminants that are adsorbed onto soils within the saturated zone of a site. The process involves the addition of small amounts of ammonia; phosphate; and large quantities of an oxygen source, typically (but not limited to) hydrogen peroxide. This is accomplished by injecting nutrient-enriched solutions into the contaminated zone through a series of wells or trenches and recovering groundwater downgradient.

For the process to be effective, the injection/recovery system must provide for the transport of nutrients throughout the entire contaminated region, following the pathway taken by the contaminant, if possible. This is particularly difficult at sites where the geology is highly irregular or has been disturbed because of past construction, and at sites with multiple or unknown contamination sources. The in situ remediation process is usually accompanied by surface treatment of the recovered groundwater.

The engineering parameters associated with this process are highly dependent on soil permeability, which becomes the rate-limiting step for mass transfer of oxygen to the aerobic organisms. In a few instances, in situ bioreclamation has been used for treatment in unsaturated soils. However, these cases are limited to fairly shallow depths over already contaminated groundwater. These treatment situations are difficult to control and rely on introducing nutrient-rich water through percolation, or through pressure injection with multiple injection points. Air is then drawn through the soil, using vacuum pumps, to enhance the air exchange in the soil matrix. In situ treatment is most cost effective with easily degraded contaminants that have low solubilities in water.

A.4 THERMAL TREATMENT

A.4.1 ROTARY-KILN INCINERATOR

Rotary-kiln incinerators are horizontal, cylindrical, refractory-lined shells and are fueled by natural gas, oil, or pulverized coal. Most of the heating of the waste is from heat transfer with the combustion product gases and the walls of the kiln. Wastes are injected at the kiln's higher end and are passed through the combustion zone as the kiln rotates. Rotary kilns are capable of burning waste in any physical form without any preparation.

Hazardous wastes that have been treated in rotary kilns include PCBs, tars, obsolete munitions, and bottoms from solvent reclamation operations. Because of their ability to handle all waste forms and their high incineration efficiency, rotary kilns are the preferred method for treating mixed hazardous solid residues.

The limitations of rotary kilns include susceptibility to thermal shock, necessity for careful maintenance, need for additional air due to leakage, high particulate loadings, relatively low thermal efficiency, and high capital cost for installation.

A.4.2 CIRCULATING BED COMBUSTION

Circulating bed combustion, a development of conventional fluidized-bed incineration, is suitable for burning solid, liquid, sludge, or gaseous waste. In this process, the circulating-fluid bed and the fluidized material are recirculated within the system and returned to the feed section.

The circulating bed combustor is designed to be an improvement over conventional fluidized beds. The system operates at higher velocities and finer sorbents than fluidized bed systems. This permits a unit that is more compact and easier to feed. The unit also produces lower emissions and uses less sorbent materials than the fluidized bed systems. No offgas scrubber is necessary in the circulating bed combustor, and heat can be recovered as an added benefit. The key to the high efficiency of the circulating bed combustor is the high turbulence that is achieved within the combustor. This feature allows efficient destruction of all types of halogenated hydrocarbons, including PCBs and other aromatics, at temperatures less than 850 degrees Celsius (°C) (Freeman, 1985). Acid gases are captured within the combustion chamber by limestone in the bed. A baghouse is needed for particulate control. Compounds containing high levels of phosphorus, sulfur, cyanide, etc. can be processed with low emissions of nitrogen oxides (NO_x), carbon monoxide (CO), and acid gases. In addition to the turbulence, a large combustion zone with uniform and lower temperature throughout also contributes to high efficiency. The circulating bed combustor also features longer residence time of the combustibles and sorbents in the combustion zone.

The system is capable of treating solids, sludges, slurries, and liquids. The high degree of turbulence and mixing ensures treatment of a wide variety of wastes. The waste, however, must be fairly homogeneous in composition when fed to the combustor, since it is usually introduced at only one location. An additional benefit of the circulating bed combustor is the possibility of heat recovery. The combustion chamber can be of waterwall construction.

A.4.3 LOW-TEMPERATURE THERMAL TREATMENT (LT^3)

The LT^3 system uses a technology wherein organic contaminants in the soil are stripped and incinerated without expending the energy necessary to heat the soil to the operation combustion temperatures. This technology involves indirectly transferring heat to the wastes in a multiple screw conveyor to volatilize the contaminants. The offgases are passed through a gas cleaning train and then to an afterburner (fume incinerator).

The LT^3 system has been designed and placed into operation by Weston. The heart of the LT^3 is the thermal processor. For the full-scale unit, the thermal processor consists of two hot screw units arranged in a series (piggyback) configuration. Hot oil circulates through the trough, shafts, and flights of the screw conveyors to provide indirect contact with the waste material. The thermal processor is operated under negative pressure. The oil is heated to a maximum temperature of 640°F in a 6-million-Btu/hr heater. Wastes enter the thermal processor at ambient temperatures and achieve a maximum of approximately 450°F near the outlet of the second unit. Treated soil discharging from the second unit is subjected to a water spray, which provides cooling and dust control.

Offgas treatment is accomplished in a baghouse, two-stage condenser, and afterburner. Particulates collected by the baghouse are returned to the feed hopper for treatment. The liquid fraction from the condenser is transferred to an oil/water separator to remove oils. The underflow from the separator is transferred to a two-stage activated carbon adsorber and accumulated for use as the cooling spray for soils discharging from the thermal processor. The propane- and VOC-fired afterburner incinerates the offgases at a temperature of 1,800°F with a residence time of 2 seconds.

The LT^3 technology is capable of accepting a wide range of soil types and matrices. The technology has been demonstrated to be successful on VOCs, semivolatile compounds, and petroleum hydrocarbons.

A.4.4 VITRIFICATION

Vitrification can be applied as a direct treatment or in situ containment of hazardous materials. The type of wastes treated include a variety of hazardous chemicals and radioactive and mixed wastes. The vitrification process electrically melts inorganic materials (e.g., soil) for the purpose of thermochemically treating free and/or containerized contaminants within the treatment volume. Using soil, vitrification simultaneously destroys and/or removes organic contaminants while chemically incorporating (immobilizing) inorganic contaminants into a chemically inert, stable glass and crystalline residual product. Soil typically does not have sufficient electrical conductivity, and therefore, a conductive mixture of graphite and glass frit is used as an initial conductive (starter) path. Current flows through the starter path, heating it and the adjacent soil to temperatures above 1,600°C. Upon melting, typical soils become quite electrically conductive; thus, the molten mass becomes the primary conductor and heat transfer medium allowing the process to continue beyond startup.

In situ vitrification (ISV) uses electrodes placed in the contaminated material, usually soil, dewatered sludge, mine tailings, sediments, or asbestos, to melt the contaminated soils in place. When power is applied to the electrodes, the starter path heats up, the glass frit melts, and the contaminated material in contact with the molten glass begins to melt. The melt will continue to grow as long as power is applied to the electrodes.

Once the desired melt mass has been achieved, the electricity is turned off, and clean backfill is used to fill the resulting subsidence volume caused by the 20- to 40-percent waste volume reduction. The mass cools in place, resulting in a glass monolith with chemical and physical characteristics nearly identical to that of volcanic glass.

The vitrification process destroys organic materials by pyrolysis in a strong reducing environment. Most inorganic materials are incorporated into the melt and retained in the solidified mass with low leachability characteristics. In addition to pyrolysis, several mechanisms, including molecular diffusion, carrier gas transport, capillary flow, and flow resistance in the soil column, contribute to the destruction of high percentages (99.995) of organic materials contained in the waste.

A.5 CONTAINMENT

Capping is used at sites where contaminated materials are either left in place or buried. Capping of such sites eliminates direct contact with contaminated materials by target populations, prevents migration of surficial contamination via runoff, and reduces the amount of groundwater recharge by limiting infiltration.

A.5.1 SOIL COVER

Soil cover can be constructed of any natural soil. The thickness of soil cover depends on the characteristics of the soil, the anticipated amount of settling, and local weather conditions.

A.5.2 MULTIMEDIA CAP

The design of multimedia caps generally conforms to EPA's guidance under the Resource Conservation and Recovery Act (RCRA) for landfill liner systems and final cover (40 CFR Part 264 Subpart N). The RCRA multimedia cap consists of a 24-inch, low-permeability layer; a minimum of a 20-mil flexible membrane liner (FML); a 12-inch drainage layer; and a 24-inch vegetative layer (topsoil).

A.5.3 SYNTHETIC MEMBRANE LINERS

The use of impervious synthetic FMLs for capping lagoons and landfills has become widespread in recent years. Membranes are resistant to a wide range of chemicals and bacteria but have limited ability to withstand the stress of heavy machinery, lacerations, and punctures. Since the membrane sheeting is produced in relatively narrow strips, a finished liner requires several seams. The quality of seams is important to the liner success. The FML is overlain by a layer of topsoil of adequate depth to accommodate the freeze depth associated with a specific geographic location and to protect the integrity of the FML.

A.5.4 ASPHALT CAP

Asphalt cement or other related bituminous membranes, generally 0.25 inch thick, can be applied as a cover or cap. Special equipment is required for application. Asphalt membranes are blown with a hot phosphoric catalyst and are solidified by cooling. Asphalt concrete must be produced in a kiln, applied with a paving machine, and compacted by a roller. Generally, asphalt is an expensive cover top and subject to attack by petroleum distillates and solvents.

A.6 REMOVAL

Excavation is the process of removing soil, rock, or other materials. Excavation followed by land disposal or treatment is performed extensively in site remediation. On a large scale, excavation is achieved mechanically by conventional heavy construction equipment.

A.7 DISPOSAL

Landfill disposal has been the most commonly practiced method of disposal of municipal, industrial, and hazardous wastes. Secure landfills are typically constructed with impermeable bottom and side liners, leachate collection and treatment systems, and impermeable caps incorporating surface water controls. The primary advantage of landfilling is the relatively low cost compared to incineration or other technologies capable of handling a high volume of contaminated solids. The implementation time is also much shorter than many other technologies. Standard equipment and materials are used in landfill construction and operation.

A.8 LIMITED ACTION

A.8.1 ACCESS RESTRICTIONS

Limiting access to a contaminated site could include construction of barriers surrounding the site, including fencing and guarding. Typical use restrictions could limit fishing, bathing, or boating in surface waters; prevent construction on the site; and declare the groundwater or surface water drinking source nonpotable. Such restrictions or limits could be temporary or permanent.

A.8.2 MONITORING

This option consists of surveillance of the site over time to determine the degree and extent of contamination. Monitoring should include additional sampling and analysis of soils at Areas 900 and 1200 to adequately determine an extent of contamination.

A.9 NO ACTION

No action would be taken to either monitor or mitigate the source movement or human exposure of the contaminants at the site. This alternative assumes that the 1×10^{-5} risk level currently at the site is acceptable.

3.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

At this stage of the FS process, cost-effective remedial alternatives are developed based on the remedial objectives, the future anticipated land use of the site, comparable remediation activities completed at sites with similar contamination, and data obtained during field efforts. The methodology used to select a cost-effective remedial action alternative for the contaminated medium of concern, based on the types of contamination present in the medium, consists of a step-by-step evaluation of remedial technologies and assembled alternatives. The evaluation uses a series of screenings and is conducted in accordance with EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). The purpose of these screenings is to prevent unfeasible, unacceptable, or costly technologies that do not meet the objectives from being carried forward to the next evaluation step.

3.1 PRESENTATION OF CONTAMINATED MEDIA

Based on the results of the baseline RA and the comparison of exposure concentrations to chemical-specific standards, it has been determined that there is no unacceptable risk to human health or the environment and that therefore no remedial action is warranted.

3.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

General response actions are source control measures that remove contamination or prevent pollutant migration from the source. These actions, which are medium specific, must satisfy the remedial action objectives. Typical actions identified for contaminated soils include treatment, containment, removal, disposal, limited action, and no action.

3.3 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

Following the identification of general response actions applicable to contaminated soils, a list of specific remedial technologies was developed for each response action. Selection of the remedial technologies was based on the type of contaminated medium, individual contaminants, hydrogeologic characteristics of the site, knowledge of previous applications and performance of the remedial technologies, and the applicability of technologies to the contaminated medium.

The remedial technologies associated with each response action are listed in Table 3-1. The list does not include auxiliary unit operations that may be necessary for the implementation of a remedial technology. For example, a transportation component (not included in Table 3-1) is included when conducting an excavation operation; likewise, grading and revegetation are required when capping. Descriptions of the technologies listed in Table 3-1 are presented in Appendix A.

3.4 SELECTION OF APPLICABLE REMEDIAL TECHNOLOGIES

Each technology identified in Table 3-1 was screened to determine its applicability at HPIA based on waste characteristics. In the waste characteristics screening, the characteristics of the PAHs were examined to eliminate technologies that are ineffective, unsafe, or otherwise not suitable for treatment of PAH-contaminated soils. The results of the waste characteristics screening for the PAH-contaminated soils at HPIA are presented in Table 3-2. Based on this screening, the only remedial technology retained for further evaluation was the no-action technology. This is because, based on the RA, the PAH-contaminated soils at HPIA do not pose an unacceptable risk to human health or the environment. Therefore, these soils do not require remediation.

Table 3-1. Identification of Remedial Response Technologies for Contaminated Soils

General Response Action	Remedial Technology
TREATMENT	
Physical	Soil Washing/Flushing Soil Aeration In Situ Volatilization Encapsulation Solidification/Stabilization
Chemical	Chelation
Biological	Composting In Situ Biodegradation
Thermal	Rotary Kiln Incineration Circulating Bed Combustion Low-Temperature Thermal Treatment Vitrification
CONTAINMENT	Capping
REMOVAL	Excavation
DISPOSAL	Landfilling
LIMITED ACTION/NO ACTION	Access Restriction Monitoring No Action

Source: ESE.

Table 3-2 Screening of Soil Technologies Based on Waste Characteristics

Remedial Technology	Description	Comment	Retain Technology
Physical Treatment			
Soil Washing/Flushing	Contaminants are washed from soil, becoming dissolved or dispersed in a liquid solvent. The bond between contaminant and soil particle is broken. Spent solvents will require treatment.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Soil Aeration	A thin layer of contaminated material is spread on the ground surface, and volatilization occurs.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
In situ Volatilization	Application of a vacuum above the water table in the unsaturated (vadose) zone causing volatile contaminants to be drawn from the soils into the air.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Solidification/Stabilization	Contaminants in soils and sludges are immobilized by adding materials to the soils/sludges, producing a solid block of waste material with a high structural integrity.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Encapsulation	Microencapsulation of wastes by sealing in an organic binder or resin. May be used for organic and inorganic waste constituents.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No

Table 3-2. Screening of Soil Technologies Based on Waste Characteristics (Continued, Page 2 of 4)

Remedial Technology	Description	Comment	Retain Technology
<u>Chemical Treatment</u>			
Chelation	A chelating molecule (containing atoms that form ligands with metal ions) is used to keep metals in solution and aid in dissolution for subsequent transport and removal.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>Biological Treatment</u>			
Composting	Decomposition of solid organic materials by microorganisms to form a stabilized, humus- or soil-like product.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>In</u> <u>situ</u> Biodegradation	Microbial degradation of contaminants adsorbed onto soil. Oxygen and nutrients are typically added to accomplish biodegradation.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>Thermal Treatment</u>			
Rotary Kiln Incineration	Soil is introduced into a refractory-lined cylindrical shell fueled by natural gas, oil, or pulverized coal. Temperatures of 1,800 to 2,600°F are typically used to destroy contaminants. Offgases usually require additional handling to meet emission guidelines.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Circulating Bed Combustion	A proprietary thermal treatment technology similar to conventional fluidized-bed technologies; however, air is introduced at much higher velocities, which causes waste particles to be suspended in the combustion gases.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No

Table 3-2. Screening of Soil Technologies Based on Waste Characteristics (Continued, Page 3 of 4)

Remedial Technology	Description	Comment	Retain Technology
Low-Temperature Thermal Treatment	Organic compounds in soil are stripped and incinerated by indirectly transferring heat to soil in a multiple screw conveyor to volatilize contaminants. Treatment temperatures are typically 500 to 600°F.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Vitrification	Materials in soil are melted (electrically) at 1,600 to 2,000 degrees Celsius (°C) (either <u>in situ</u> or <u>ex situ</u>). Organic contaminants are destroyed and inorganic contaminants are immobilized within a chemically inert, stable glass and crystalline product.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>Containment</u>			
Capping	Placement of cap above contaminated area where materials are either left in place or buried. Typical caps include soil, clay, synthetic liners, asphalt, and concrete.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>Removal</u>			
Excavation	Removal of soil, rock, or other materials, typically achieved by conventional heavy construction equipment.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
<u>Disposal</u>			
Landfilling	Typically constructed with impermeable bottom and side liners, leachate collection and treatment systems, and impermeable caps incorporating surface water controls.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No

Table 3-2. Screening of Soil Technologies Based on Waste Characteristics (Continued, Page 4 of 4)

Remedial Technology	Description	Comment	Retain Technology
<u>Limited Action/No Action</u>			
Access Restriction	Can be short term or long term; includes fencing and guarding.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
Monitoring	Soil sampling and chemical analysis.	PAH concentrations in the HPIA soils do not pose an unacceptable risk to human health or the environment; therefore, no remediation is required.	No
No Action	No soils remediation is implemented.	Applicable because current cumulative carcinogenic risk (10^{-5}) is less than EPA upperbound risk of 10^{-4}.	Yes

Source: ESE.

The next stage of the technology screening process typically consists of screening based on site characteristics and the degree of technology development. However, since no remediation of the HIPA soils is required, these steps in the screening process are not applicable. Furthermore, the next step of the typical FS process, the development and screening of alternatives, is not applicable since the purpose of this step is to reduce the number of alternatives retained for further analysis. Instead, Section 4.0 will focus on the detailed evaluation of the no-action alternative.

4.0 DETAILED EVALUATION OF ALTERNATIVES

Sections 4.1 and 4.2 provide a detailed evaluation of the no-action alternative for Areas 900 and 1200 at HPIA. As stated previously, no remedial actions would be implemented under this alternative. This alternative assumes that the current health-based risk level of 10^{-5} is acceptable.

The nine evaluation criteria outlined in the EPA RI/FS guidance (EPA, 1988) serve as the basis for conducting the detailed analysis. The following represent the primary criteria evaluated for technical, cost, institutional, and risk concerns:

1. Short-term effectiveness,
2. Long-term effectiveness,
3. Reduction of mobility, toxicity, or volume (MTV),
4. Implementability, and
5. Cost.

The following two threshold criteria relate directly to statutory findings that ultimately must be evaluated in the ROD:

6. Compliance with ARARs, and
7. Overall protection of human health and the environment.

Two remaining criteria, state acceptance and community acceptance, will be evaluated following review and comment on the RI/FS report (rather than in this document) and will be addressed once a final decision is made and the ROD is prepared.

These nine evaluation criteria encompass statutory requirements and technical, cost, and institutional considerations that EPA's program has determined to be appropriate for a thorough evaluation of alternatives. Each of the nine evaluation criteria is further divided into specific factors for a complete analysis of the alternatives. These criteria and corresponding factors are described in the following paragraphs.

4.1 DESCRIPTION OF EVALUATION CRITERIA

4.1.1 SHORT-TERM EFFECTIVENESS

This evaluation criterion addresses the remedial alternative's affect on human health and the environment during construction and implementation of the remedial alternative. The implementation phase of a remedial alternative is completed once remedial response objectives are met. The short-term effectiveness is based on the following four factors:

1. The potential risk to the community,
2. The potential risk to the workers implementing the remedial actions,
3. The potential for adverse impacts on the environment due to implementation of the remedial action, and
4. The time required to meet the remedial response objectives.

4.1.2 LONG-TERM EFFECTIVENESS

This evaluation criterion addresses the results of a remedial alternative in terms of the risk remaining at the site after remedial response objectives have been met. The following factors characterize the potential remaining risk at the site following completion of the implementation phase:

1. The magnitude of risk remaining due to untreated waste or treatment residuals following the completion of the remedial alternative, and
2. The adequacy and reliability of controls used to manage untreated wastes or treatment residuals remaining at the site.

4.1.3 REDUCTION OF MTV

This evaluation criterion assesses the level to which the remedial alternative reduces risk by destroying toxic contaminants, reducing the total mass of contaminants, reducing the total volume of contaminated media, and/or irreversibly reducing the contaminants' mobility. The specific factors considered for evaluation of a remedial alternative are as follows:

1. The treatment processes the remedy would employ and the materials treated;
2. The amount of hazardous materials that would be destroyed or treated, including how the principal threat(s) would be addressed;
3. The degree of expected reduction in MTV measured as a percentage of reduction (or order of magnitude);
4. The degree to which the treatment would be irreversible;
5. The type and quantity of treatment residuals that would remain following treatment; and/or
6. Whether the alternative would satisfy the statutory preference for treatment as a principal element.

4.1.4 IMPLEMENTABILITY

This criterion refers to the technical and administrative feasibility of implementing an alternative and the availability of various materials and services required during its implementation. The following factors must be considered during the implementability analysis:

1. <u>Technical Feasibility</u>: The relative ease of implementing or completing a remedial alternative considering physical constraints and the previous use of established technologies. The following items should be considered.

   a. Ability to construct the alternative;
   b. Reliability, or the ability of a technology to meet specified process efficiencies or performance goals;
   c. Ease of undertaking future remedial actions that may be required; and
   d. Ability to monitor the effectiveness of the remedy;
2. Administrative Feasibility: Activities needed to coordinate with other offices and agencies (e.g., obtaining permits for offsite activities or rights-of-way and easements required for construction).
3. Availability of Services and Materials: The availability of the technologies (materials or services) required to implement an alternative. The following items should be considered:
   a. Availability of adequate offsite treatment, storage capacity, and disposal services;
   b. Availability of necessary equipment, specialists, and provisions to ensure any necessary additional resources;
   c. Timing of the availability of technologies under consideration; and
   d. Availability of services and materials, plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies.

4.1.5 COST

As specified in the EPA RI/FS guidance document (EPA, 1988), a cost estimate must be prepared for each remedial alternative under consideration. This cost estimate consists of capital, operation and maintenance (O&M), and long-term replacement costs, as well as a present-worth analysis.

4.1.6 COMPLIANCE WITH ARARS

This evaluation criterion is used to determine whether an alternative meets all the federal and state ARARs selected for these areas. The following specific ARARs are evaluated for compliance: chemical-specific ARARs, action-specific ARARs, and location-specific ARARs.

4.1.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This evaluation criterion serves as a final check to assess whether an alternative provides adequate protection of human health and the environment. This criterion evaluates the overall protectiveness based on the assessments of short-term effectiveness, long-term effectiveness, and compliance with ARARs.

4.1.8 STATE ACCEPTANCE

This assessment evaluates the technical and administrative issues and concerns the State of North Carolina may have regarding an alternative. As described earlier, this criterion will be addressed in the ROD once comments on the RI/FS report and the proposed alternative(s) have been received.

4.1.9 COMMUNITY ACCEPTANCE

This assessment evaluates the issues and concerns the public may have regarding an alternative. As with state acceptance, this criterion will be addressed in the ROD once comments on the RI/FS report and the proposed alternative(s) have been received.

4.2 DETAILED EVALUATION OF THE NO-ACTION ALTERNATIVE

This alternative is a no-action alternative; therefore, no remedial actions that result in the treatment, containment, or removal of the contaminated soil would be implemented.

During the detailed analysis, this alternative was assessed against the seven evaluation criteria outlined in the guidance document (EPA, 1988) and described in Section 4.1. The results of this assessment are presented in the following paragraphs.

4.2.1 SHORT-TERM EFFECTIVENESS

Because no remediation of the contaminated soils was proposed in this alternative, residual soil concentrations would remain at an acceptable risk level of 10^{-5}, thus making this a viable alternative.

4.2.2 LONG-TERM EFFECTIVENESS

Because the contaminated soil would not be treated or removed, soil concentrations would remain unchanged. However, since the 10^{-5} risk currently at the site has been determined to be acceptable, this alternative would be effective in the long term, assuming that additional contamination sources are not contributed to these soils.

4.2.3 REDUCTION OF MTV

Because the contaminants in the soil would not be destroyed, removed, or treated, the MTV of the contaminants would be virtually unchanged.

4.2.4 IMPLEMENTABILITY

No remedial action would be implemented.

4.2.5 COST

No costs are associated with this alternative.

4.2.6 COMPLIANCE WITH ARARS

No federal or state standards (i.e., contaminant-specific ARARs) have been established for the soils at Areas 900 and 1200. Furthermore, no action-specific ARARs are associated with the no-action alternative. No location-specific ARAR would prevent the use of this alternative.

4.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Since a 10^{-5} cancer risk is acceptable at Areas 900 and 1200, this alternative would be protective of human health and the environment.

5.0 RECOMMENDED REMEDIAL ACTION

The selection of the recommended alternative was conducted in accordance with the requirements set forth in NCP and SARA. EPA provides the following criteria for selection of an appropriate site remedy:

1. Protectiveness of human health and the environment;
2. Attainment of ARARs;
3. Utilization, as possible, of permanent remediation technologies to significantly reduce contaminant MTV; and
4. Cost effectiveness.

The development, screening, and selection of the most appropriate alternative for the PAH-contaminated soils at Areas 900 and 1200 of HPIA were based on a consideration of these criteria.

As presented in Section 2.2, based on the findings of the RA, a single response objective has been developed for HPIA. This response objective assumes that no soil remediation is required at Areas 900 and 1200 since the carcinogenic risk level for workers in direct contact with the soils does not exceed the acceptable upper boundary of 10^{-4}. Therefore, the no-action alternative would be the preferred alternative for the HPIA areas of concern. Although no remediation activities would occur, additional soil samples should be collected from Areas 900 and 1200 to verify that the PAH concentrations observed in the surficial soils during the RI are representative of the contamination levels currently at the site.

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APPENDIX B

RISK ASSESSMENT OF RESIDENTIAL EXPOSURES

The following calculations show the methodology for 2-year adult residential exposure at the base through the ingestion of chemicals in drinking water.

$$\textit{Equation:}\quad \textit{Intake}\ (mg/kg/day) = \frac{CGW \times IR \times EF \times ED}{BW \times AT}$$

Where:

CGW = Maximum Detected Chemical Concentration in Groundwater (mg/L) (HPIA RA, 1991).

IR = Groundwater Ingestion Rate (L/day) = 2 L/day (EPA, 1989a).

EF = Exposure Frequency (days/year) = 365 days/year (EPA, 1989a).

ED = Exposure Duration (years) = 2 years (HPIA RA, 1991).

BW = Body Weight (kg) = 70 kg (EPA, 1989a).

AT = Averaging Time (period of time over which exposure is averaged -- days) = 70 years x 365 days/year for carcinogenic exposures

= ED x 365 days/year for noncarcinogenic exposures (EPA, 1989a).

SHORT-TERM EXPOSURES (2-Year)

Bldg. 902: Benzene Exposure

$$I = \frac{0.002\ mg/L \times 2\ L/day \times 365\ days/year \times 2\ years}{70\ kg \times 70\ years \times 365\ days/year} = 1.63E{-}06$$

Bldg. 902: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.012\ mg/L \times 2\ L/day \times 365\ days/year \times 2\ years}{70\ kg \times 2\ years \times 365\ days/year} = 3.4E{-}04$$

Bldg. 1202: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.001\ mg/L \times 2\ L/day \times 365\ days/year \times 2\ years}{70\ kg \times 2\ years \times 365\ days/year} = 2.8E{-}05$$

Bldg. 1602: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.011\ mg/L \times 2\ L/day \times 365\ days/year \times 2\ years}{70\ kg \times 2\ years \times 365\ days/year} = 3.1E{-}04$$

CARCINOGENIC RISKS

$$Equation: \quad Risk = I \times CSF$$

Where:

Risk = Potential increased risk of some carcinogenic effect (unitless).

I = Intake (mg/kg/day).

CSF = Cancer Slope Factor [(mg/kg/day)$^{-1}$] = 0.029 (mg/kg/day)$^{-1}$ for benzene (EPA, 1991a).

Bldg. 902

$$BENZENE\ RISK = 1.63E{-}06 \times 0.029 = 4.73E{-}08$$

NONCARCINOGENIC HQs

$$\textit{Equation}: \quad HQ = I/RfD$$

Where:

HQ = Hazard Quotient; the potential for some noncarcinogenic systemic effect (unitless).

I = Intake (mg/kg/day).

RfD = Reference Dose (mg/kg/day) = 0.01 (mg/kg/day) for 1,2-dichloroethene (EPA, 1991a).

Bldg. 902

$$TOTAL\ 1{,}2\text{-}DICHLOROETHENE\ HQ = \frac{3.4E{-}04}{0.01} = 3.4E{-}02$$

Bldg. 1202

$$TOTAL\ 1{,}2\text{-}DICHLOROETHENE\ HQ = \frac{2.8E{-}05}{0.01} = 2.8E{-}03$$

Bldg. 1602

$$\mathit{TOTAL\ 1{,}2\text{-}DICHLOROETHENE\ HQ} = \frac{3.1E\text{-}04}{0.01} = 3.1E\text{-}02$$

LONG-TERM EXPOSURES (30-Year)

Bldg. 902: Benzene Exposure

$$I = \frac{0.002\ mg/L \times 2\ L/day \times 365\ days/year \times 30\ years}{70\ kg \times 70\ years \times 365\ days/year} = 2.45E\text{-}05$$

Bldg. 902: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.012\ mg/L \times 2\ L/day \times 365\ days/year \times 30\ years}{70\ kg \times 30\ years \times 365\ days/year} = 3.4E\text{-}04$$

Bldg. 1202: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.001\ mg/L \times 2\ L/day \times 365\ days/year \times 30\ years}{70\ kg \times 30\ years \times 365\ days/year} = 2.8E\text{-}05$$

Bldg. 1602: Total 1,2-Dichloroethene Exposure

$$I = \frac{0.011\ mg/L \times 2\ L/day \times 365\ days/year \times 30\ years}{70\ kg \times 30\ years \times 365\ days/year} = 3.1E{-}04$$

CARCINOGENIC RISKS

Bldg. 902

$$BENZENE\ RISK = 2.45E{-}05 \times 0.029 = 7.1E{-}07$$

NONCARCINOGENIC HQs

Bldg. 902

$$TOTAL\ 1,2\text{-}DICHLOROETHENE\ HQ = \frac{3.4E{-}04}{0.01} = 3.4E{-}02$$

Bldg. 1202

$$TOTAL\ 1,2\text{-}DICHLOROETHENE\ HQ = \frac{2.8E{-}05}{0.01} = 2.8E{-}03$$

Bldg. 1602

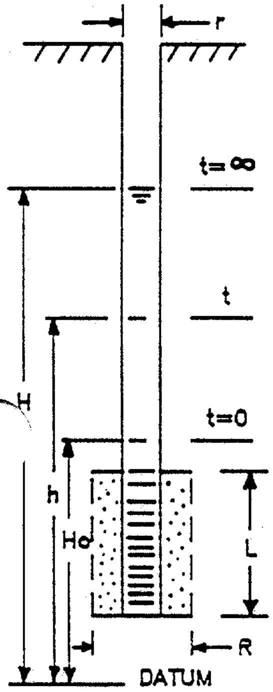
$$TOTAL\ 1,2\text{-}DICHLOROETHENE\ HQ = \frac{3.1E{-}04}{0.01} = 3.1E{-}02$$

O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT Camp Lejeune JP-5
WELL NUMBER OBG-1
DATE 9-29-89

LOCATION
ELEVATION



STATIC HEAD (H) 5.97'
PIPE RADIUS (r) 0.083'
SCREEN RADIUS (R) 0.25'
SCREEN LENGTH (L) 10'
INITIAL HEAD (Ho) 14.61
HYDRAULIC CONDUCTIVITY :

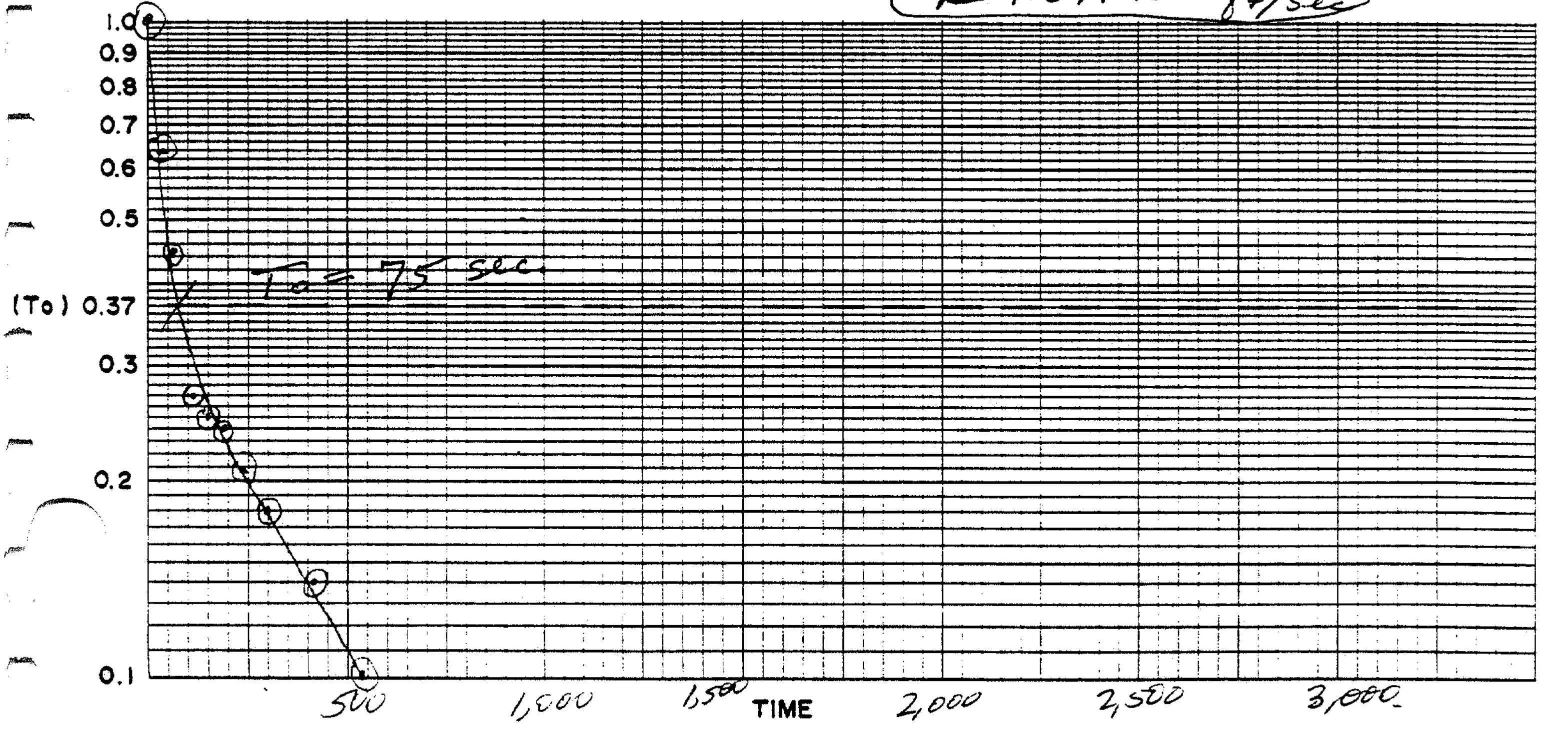
$$K=\frac{r^2 \ln(L/R)}{2LT_o}$$

$$K=\frac{(0.083)^2 \ln(10'/0.25)}{2(10')(75 sec)}$$

K=1.69 x 10⁻⁵ ft/sec

TIME	WATER DEPTH	t	h	$\frac{H-h}{H-H_o}$
MIN	FT	SEC		
0	14.61	0		1
0.5	11.55	30		0.64
1	9.72	60		0.43
2	8.31	120		0.27
2.5	8.18	150		0.25
3	8.02	180		0.24
4	7.77	240		0.21
5	7.52	300		0.18
7	7.15	420		0.14
9	6.85	540		0.10
11	6.66	660		0.08
15	5.92	900		0.006
27	5.60	1620		0.04
46	5.32	2760		0.07

H-Ho = 14.61-5.97
= 8.64



Exhibits

O'BRIEN & GERE

EXHIBIT A

File 3543 002 5

Richard Catlin & Associates, Inc.
CONSULTING ENGINEERS AND HYDROGEOLOGISTS
RC&A

December 4, 1987

Specialized Marine, Inc.
ATTN: Mr. Burt Lea
P. O. Box 813
Wrightsville Beach, NC 28480

RE: JP-5 Clean-up, MCAS
RC&A Project #8636

Dear Mr. Lea:

Attached is our monthly monitoring report concerning the JP-5 clean-up project near the Marine Corps Air Station in Camp Lejeune, NC. An additional copy is attached for you to forward to Mr. Rick Shiver, Division of Environmental Management, 7225 Wrightsville Avenue, Wilmington, NC 28408-3696.

Figure 1 shows a diagram of the interpolated water table contours. The estimated extent of free-floating JP-5 contamination at the site is illustrated on Figure 2. Figure 3 shows the cumulative recovery of JP-5 over time, as it is collected from the separator by J. Gonzalez, of Specialized Marine, Inc., and the United States Marine Corps fire training personnel.

If you should have any questions or requests, please do not hesitate to contact our office. We will keep you informed of any significant changes.

Sincerely,

J Reed Whitsell for

Stephan A. Tyler
Project Geologist

Richard G. Catlin, P.E., P.G.
President

Enclosures

SAT/nd

Home Office: P.O. Box 557 7225 Wrightsville Ave., Suite 127 Wrightsville Beach, NC 28480 (919) 256-5878
Atlanta Regional Office: 1895 Phoenix Blvd., Suite 166 Atlanta, GA 30349 (404) 997-9485

MONTHLY MONITORING REPORT

12/3/87

SITE: JP-5 FUEL OIL RECOVERY, CAMP LEJEUNE, NC

RC&A PROJECT #: 8636

DATE OF LAST REPORT: 11/9/87

MONITORING INTERVAL: MONTHLY

1) WATER TABLE SURFACE

OBSERVATIONS: The surficial ground water configuration remains relatively the same as those observed in previous visits. The overall ground water elevation has risen an average of 0.23' in the past month. A well-developed cone of depression has been maintained around monitoring/recovery wells R-1 and R-2.

2) CONTAMINATION PLUME

A) OBSERVATIONS: On the 11/26/87 site visit, accumulations of free-floating product were noted in monitoring wells R-3, W-4, W-5 and W-10, and monitoring/recovery wells R-1 and R-2.

B) DISCUSSION: The level of free product noted in monitoring well W-10 has decreased since the previous site visit (10/26/87).

The pumping activity continues to induce free-floating product toward monitoring/recovery wells R-1 and R-2. Monitoring wells R-3, W-4 and W-5 had higher levels of free product than those observed last month.

3) RECOVERY PROGRESS

OBSERVATIONS: The ejector pumps operating in monitoring/recovery wells R-1 and R-2 continue to depress the surrounding water table surface and recover migrating free product.

On the last visit, 0.28' of recovered product had been collected in the separator. No recovered product was reportedly removed from the separator since the last report. To date, a total of 4,043 gallons (see Figure 3) of recovered JP-5 has been removed from the separator by J. Gonzalez of Specialized Marine, Inc., and the U. S. Marine Corps training personnel.

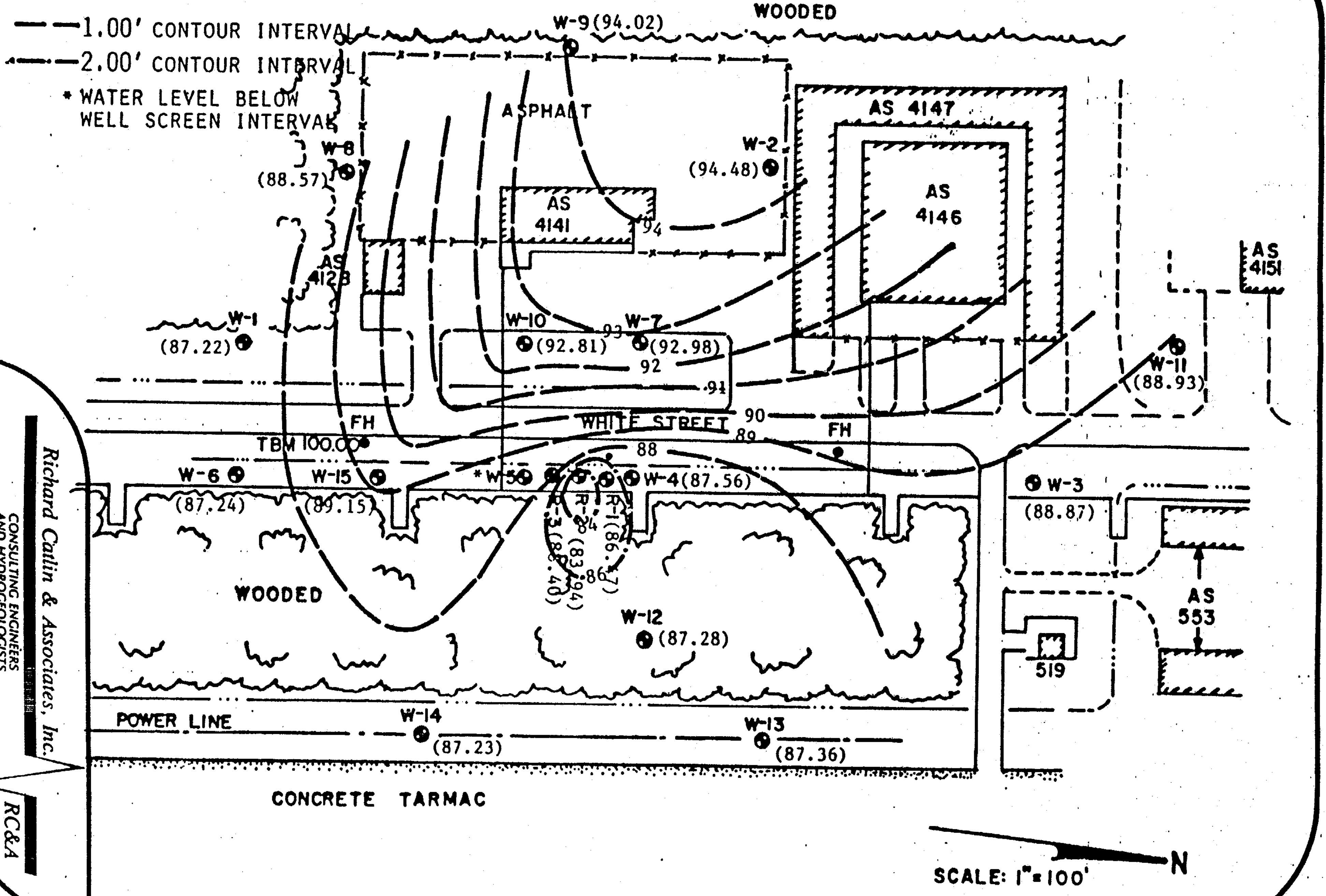
CALCULATED BY: SAT
DATE: 12/4/87

CHECKED BY: JRW
DATE: 12/4/87

JP-5 CLEAN-UP MCAS

FIGURE 1

WATER TABLE CONTOURS AS OF 11/26/87



Richard Catlin & Associates, Inc.

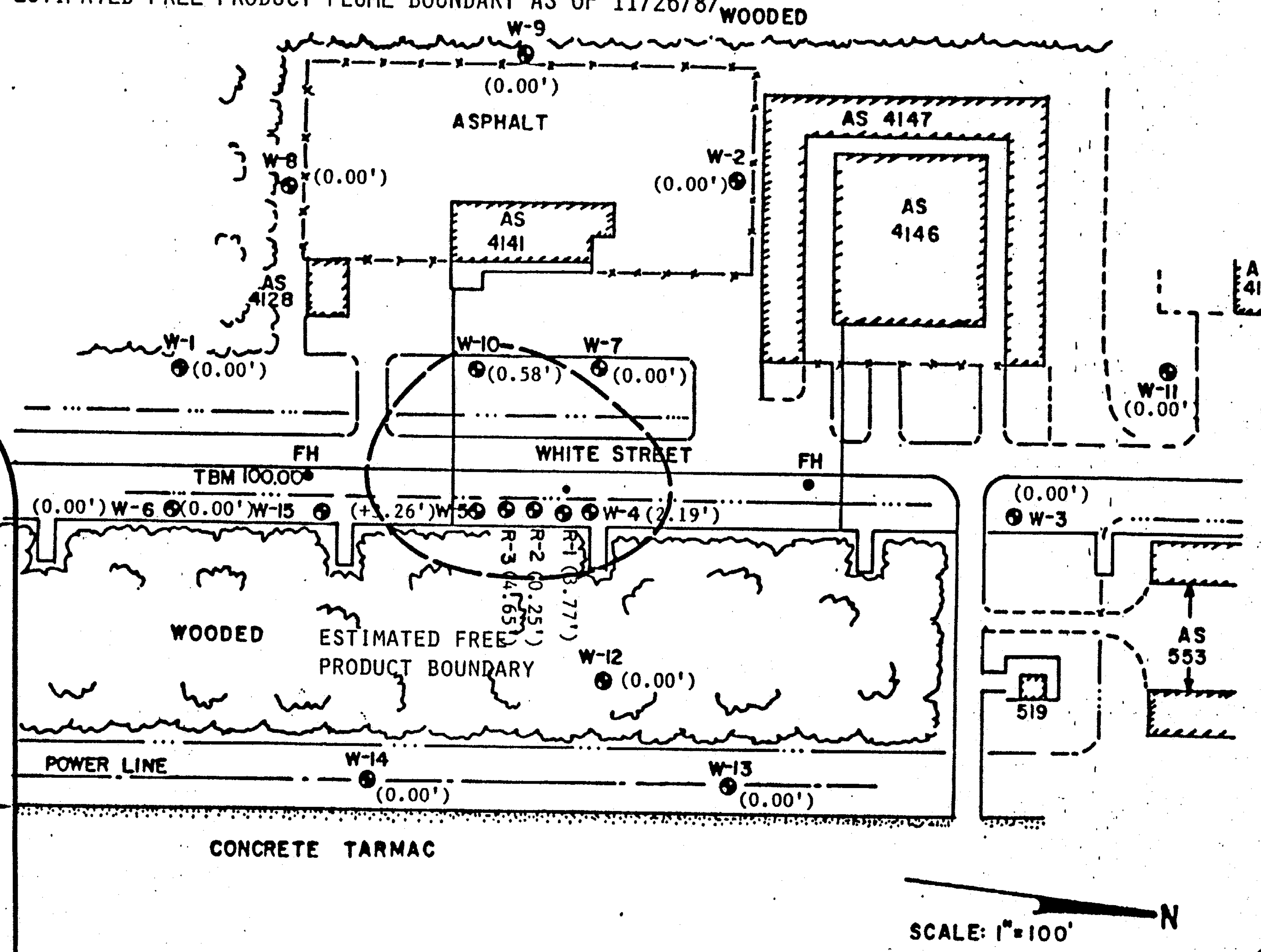
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

RC&A

JP-5 CLEAN-UP MCAS

FIGURE 2

ESTIMATED FREE PRODUCT PLUME BOUNDARY AS OF 11/26/87



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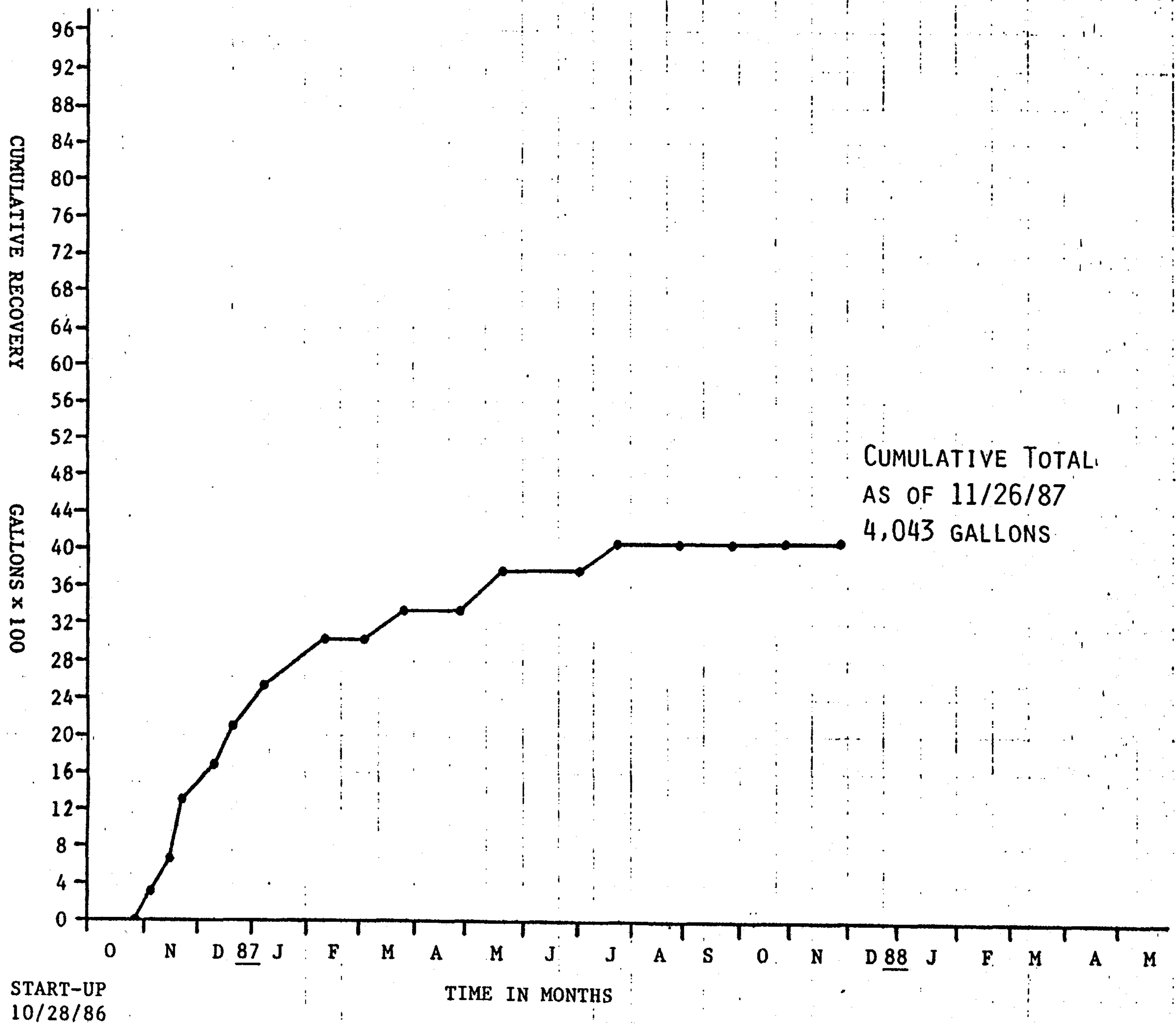
AND HYDROGEOLOGISTS

RC&A

JOB: M.C.A.S., NEW RIVER
COMPUTED BY: S.A.T.
DATE: 12/4/87
DESCRIPTION: PRODUCT RECOVERY
CHECKED BY: R.G.C.
DATE: 12/4/87



CUMULATIVE TOTAL
AS OF 11/26/87
4,043 GALLONS

START-UP
10/28/86

Richard Catlin & Associates, Inc.
CONSULTING ENGINEERS
AND HYDROGEOLOGISTS
RC&A

3543.009

REPORT

CORRECTIVE ACTION PLAN
JP-5 LINE AREA
MARINE CORPS
AIR STATION
NEW RIVER, NORTH CAROLINA

JUNE 1991

PREPARED BY:

O'BRIEN & GERE ENGINEERS
440 VIKING DRIVE
SUITE 250
VIRGINIA BEACH, VIRGINIA 23452

APPENDIX C

UST MONITORING WELL CONSTRUCTION

AND

FIELD OPERATIONS

SPECIFICATIONS

Well permits required by state agencies are the responsibility of the contractor. All monitoring wells will be installed in accordance with Navy UST monitoring well specifications. The wells will be constructed of either 2-inch or 4-inch I.D. flush joint threaded PVC well screen and riser casing depending on conditions encountered during borehole completion.

DRILLING

During the drilling program, boreholes will be advanced using conventional hollow stem auger drilling methods. If it is the opinion of the contractor that air or mud rotary drill methods are necessary, approval must be obtained from the EIC. Presentation of justification for a boring method change shall be presented prior to drilling.

Well construction details are shown in Figures A-1 and A-2. A drill mounted on an All-Terrain-Vehicle (ATV) may be required for access to remote areas. Each rig will use necessary tools, supplies and equipment supplied by the contractor to drill each site. Drill crews should consist of an experienced driller and a driller assistant for work on each rig. A geologist, experienced in hazardous waste site investigations, shall be on site to monitor the drillers efforts and for air monitoring/safety control. Additional contractor personnel may be needed to transport water to the rigs, clean tools, assist in the installation of the security and marker pipes, construct the concrete aprons/collars and develop the wells. A potable water source on base will be designated by the Government.

Standard penetration tests will be performed in accordance with ASTM D-1586. Standard penetration tests will be performed at the following depths: 0.0-foot to 1.5-foot; 1.5-foot to 3.0-foot; 3.0-foot to 4.5-foot; and 5-foot centers thereafter. A boring log of the soil type, stratification, consistency and groundwater level will be prepared.

SAMPLING

Soil samples of the subsurface materials will be collected every five feet or change in formation throughout the borehole in accordance with ASTM Method D-1586 for split barrel sampling. Each soil sample will be screened in the field using an HNU photoionizer, organic vapor detector or similar type direct readout instrument to identify the presence of petroleum product within the soils. This field screening will provide a preliminary indication of the vertical and horizontal extent of petroleum contamination in order to select the optimum locations of other monitoring wells during the drilling program. Based on the field screening, 2-inch or 4-inch diameter monitoring wells will be installed at the locations where the most significant accumulation of fuel is encountered.

Attachment A

VELOPMENT

After completion of the soil sampling and drilling to the specified depth, 2-inch and/or 4-inch (as required by the EIC) I.D. flush-threaded Schedule 40 PVC (Schedule 80 in traffic areas) monitoring wells with slotted screens and well casings will be installed in the borehole. A 5 to 15-foot section of 0.01 inch slotted PVC well screen should be used in each well. A sand pack will be placed around the slotted well screen extending to 2 feet above the top of the screen. A bentonite seal (minimum thickness - 1 ft.) will be placed on top of the sand pack. Finally, a ground mixture of two parts sand and one part cement, thoroughly mixed with the specified amount of potable water, will be placed in the borehole and rodded to insure a proper seal.

All wells will be developed following their installation to remove fine ground materials that may have entered the well during construction. This will be accomplished by either bailing or continuous low yield pumping. Equipment used for well installation, that may have come in contact with potentially contaminated material will be decontaminated with a high pressure steam clean wash followed by a potable supply water rinse. For the purpose of this scope of work, it is assumed that all fluid generated from well development and equipment decontamination can be disposed of on the ground at each respective well site.

The soil removed from the borehole will be piled beneath the drill rig while drilling. The drill equipment and tools will be cleaned prior to drilling each well using a portable decontamination system/operation supplied by the contractor. Wash water at the sites will not be contained, unless otherwise directed by the overnment, and may seep into the ground locally.

Supplies and equipment will be transported to the lay-down area designated on the station by the Government. Any office space, trailers, etc., required for drilling, subsequent sampling and shipping shall be arranged and provided by the contractor.

WELL HEAD COMPLETION

A 4-inch diameter security pipe with a hinged locking cap will be installed on the well casing top having an embedment depth of 2.5 feet into the grout.

There are two acceptable methods of completing the wellheads.

In non-traffic areas the acceptable method of finishing a wellhead is shown in figure A-1. Each well will be marked with three Schedule 40 steel pipes, 3-inch I.D., imbedded in a minimum of 2.5-foot of 3,000 psi concrete. (The concrete used to secure the three pipes will be poured at the same time and be an integral part of the 5-foot by 5-foot by 0.5-foot concrete apron described above.). The security pipes will extend a minimum 2.5 feet and maximum 4.0 feet above the ground surface. The steel marker pipes will be filled with concrete and painted day-glo yellow or an equivalent.

traffic areas (and non-traffic areas where required), a "flush" manhole type er shall be built into a concrete pad as shown in figure A-2. If the well as installed through a paved or concrete surface, the annular space between the casing and the bore hole shall be grouted to a depth of at least 2.5 feet and finished with a concrete collar. If the well was not installed through a concrete or paved medium and still finished as a high traffic area well, a concrete apron measuring 5-foot by 5-foot by 0.5 foot will be constructed around each well. This apron/collar will be constructed of 3,000 psi ready-mixed concrete. The concrete will be crowned to provide and to meet the finished grade of surrounding pavement as required. The concrete pads can be constructed within five days after all of the wells have been installed.

In all finishing methods, the well covers will be properly labeled by metal stamping on the exterior of the security pipe locking cap and by labeling vertically on the exterior of the security pipe or manhole cover as appropriate. The labeling shall consist of the letters UGW (UST Groundwater) (to describe the medium and the reason for the well) and a number specific to each well.

A sign reading "NOT FOR POTABLE USE OR DISPOSAL" SHALL BE FIRMLY ATTACHED TO EACH WELL.

* The contractor or project team may supplement these requirements, but may not modify or delete them, in total or in part, without prior approval of the EIC.

APPENDIX D

GROUNDWATER SAMPLING PROTOCOL

Use of the following procedures for sampling cf ground water 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 ground water samples from wells containing only a few gallons of ground water and no product present, the bailing procedures is preferred. To obtain representative ground water 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 Ground Water 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 Ground Water 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 Ground Water 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 ground water 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 ground water only.

10. Record the physical appearance of the ground water on the Ground Water 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 bottle cannot be filled quickly, keep them cool with the caps on until they are filled. The vials (3) labeled purgeable priority pollutant analysis should be filled from one bailer than securely capped. NOTE: 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 ground water following the procedures outlined in the equipment operation manuals. Record this information on the Ground Water 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.

Sampling Procedures (PUMP)

1. Identify the well and record the location on the Ground Water 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 Ground Water 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 Ground Water 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 ground water 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 ground water only.

10. Record the physical appearance of the ground water on the Ground Water 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 ground water 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 Ground Water 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 following the instructions listed in the Sample Containerization Procedures. Return each sampling bottle to its proper transport container. NOTE: A clean bottom loading stainless steel or Teflon bailer should be used to collect the sample used to fill the sample vials labeled purgeable priority pollutant analysis. Gently lower the bailer into the water to minimize agitation of the water. The vials (2) should be filled from one bailer.

15. If the sample bottle cannot be filled quickly, keep them cool with the caps on until they are filled. The vials (3) labeled purgeable priority pollutant analysis should be filled from one bailer than 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 ground water following the procedures outlined in the equipment operation manuals. Record this information on the Ground Water 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.

APPENDIX E

LABORATORIES, INC.

Laboratory Report

CLIENT O'BRIEN & GERE ENGINEERS, INC. JOB NO. 3435.001.130

DESCRIPTION Camp Le Jeune JP - 5

Waters

DATE COLLECTED 9-29/30-89 DATE REC'D. 10-2-89 DATE ANALYZED 10-5/6-89

Description	OBG-3	OBG-4	OBG-6	OBG-1	W-10
Sample #	J1354	J1355	J1356	J1357	J1358
Volatile Petroleum Hydrocarbons and Solvents by Purge & Trap/GC:					
BENZENE	13.	<1.	<1.	<1.	<100.
TOLUENE	<10.	↓	2.	↓	↓
ETHYLBENZENE	49.	↓	<1.	↓	↓
XYLENES	220.	↓	2.	↓	490.
TRICHLOROETHENE	<10.	<1.	<1.	<1.	<100.
TETRACHLOROETHENE	<10.	<1.	<1.	<1.	<100.
MTBE	<100.	<10.	<10.	<10.	<100.
TOTAL HYDROCARBONS	4500.	<10.	<10.	29.	890,000.
COMMENTS	gasoline	-	-	-	Fuel
			UNITS:	µg/l	

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

Units: mg/ℓ (ppm) unless otherwise noted

Comments:

Authorized: Thomas A. Alexander

Date: October 18, 1989

OBG
LABORATORIES, INC.

Laboratory Report

CLIENT	O'BRIEN & GERE ENGINEERS, INC.
JOB NO.	3435.001.130
DESCRIPTION	Camp Le Jeune JP - 5 Waters
DATE COLLECTED	9-29/30-89
DATE REC'D.	10-2-89
DATE ANALYZED	10-5/6-89

Description	QC Trip Blank	Field Blank			
Sample #	J1359	J1360			
Volatile Petroleum Hydrocarbons and Solvents by Purge & Trap/GC:					
BENZENE	<1.	<1.			
TOLUENE	↓	↓			
ETHYLBENZENE	↓	↓			
XYLENES	↓	↓			
TRICHLOROETHENE	<1.	<1.			
TETRACHLOROETHENE	<1.	<1.			
MTBE	<10.	<10.			
TOTAL HYDROCARBONS	<10.	<10.			
COMMENTS	-	-			
			UNITS: µg/1		

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

Units: mg/ℓ (ppm) unless otherwise noted

Comments:

Authorized: Thomas A. Alexander

Date: October 18, 1989

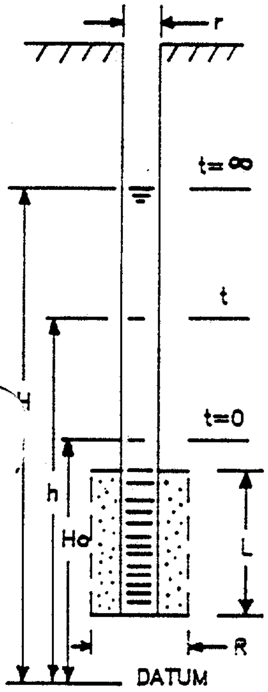
APPENDIX F

O'BRIEN & GERE

IN-SITU PERMEABILITY TEST
FIELD LOG

PROJECT Camp Lejeune JP-5
WELL NUMBER OBG-3 ← Recovery Well
DATE 9-29-89

LOCATION
ELEVATION

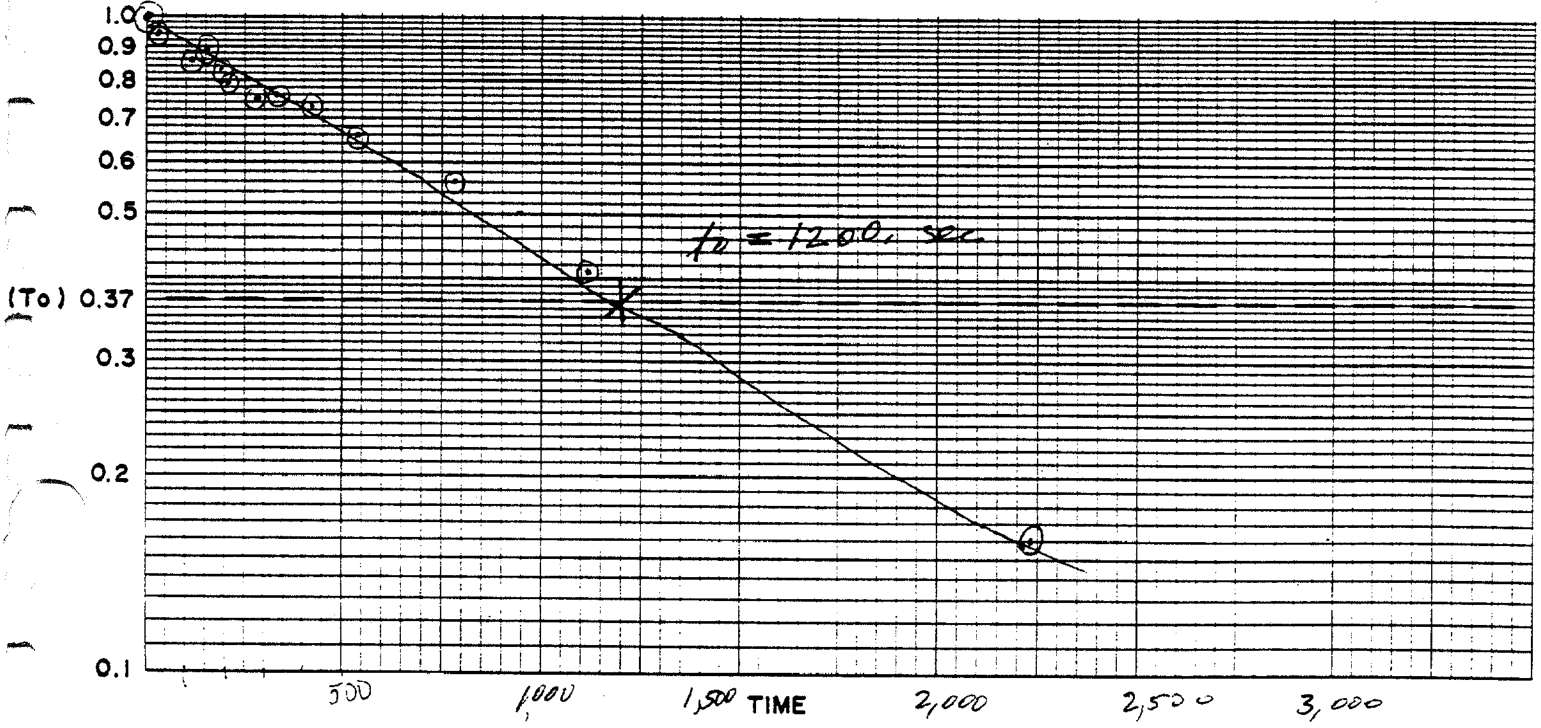


STATIC HEAD (H) 8.2'
PIPE RADIUS (r) 0.25'
SCREEN RADIUS (R) 0.5'
SCREEN LENGTH (L) 15'
INITIAL HEAD (Ho) 25'
HYDRAULIC CONDUCTIVITY :

$$K=\frac{r^2\ln(L/R)}{2LT_o}$$

$$K=\frac{(0.25\text{ ft})^2\ln(15\text{ ft}/0.5\text{ ft})}{2\,(15\text{ ft})(1200\text{ sec})}=\boxed{5.9\times10^{-6}\text{ ft/sec}}$$

MIN TIME	FT WATER DEPTH	t	h	$\frac{H-h}{H-Ho}$
MIN	FT			
0	25.	0		1
0.5	24.35	30		0.96
2	22.75	120		0.86
2.5	23.25	150		0.89
3	22.15	180		0.83
3.5	21.52	210		0.79
4.5	20.85	270		0.75
5.5	21.05	330		0.76
7	20.50	420		0.73
9	19.40	540		0.67
13	17.55	780		0.56
19	15.10	1140		0.41
38	10.90	2280		0.16
55	9.02	3300		0.05



063397

JP-5 LINE AREA
SITE PLAN
CAMP LEJEUNE, NORTH CAROLINA

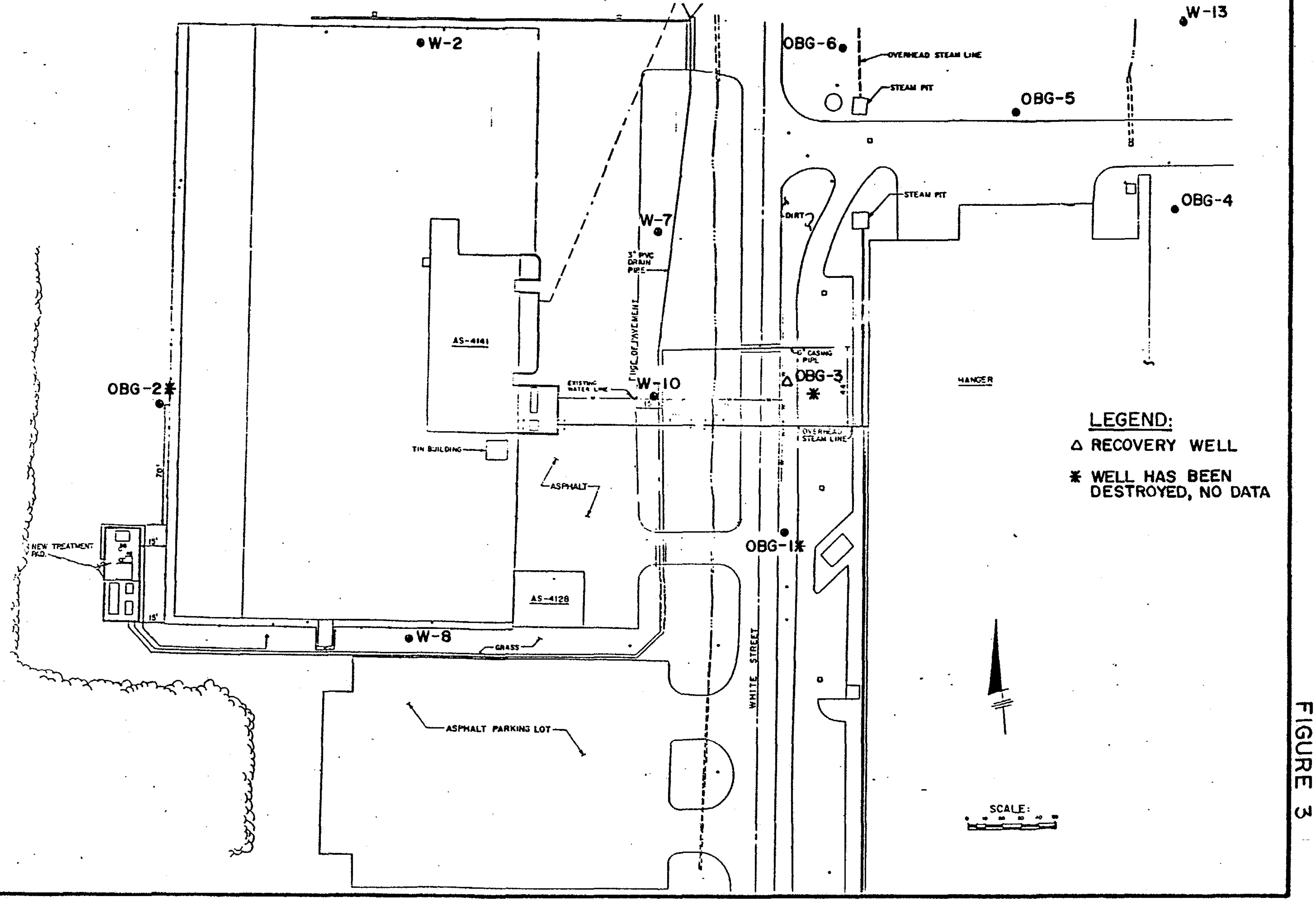
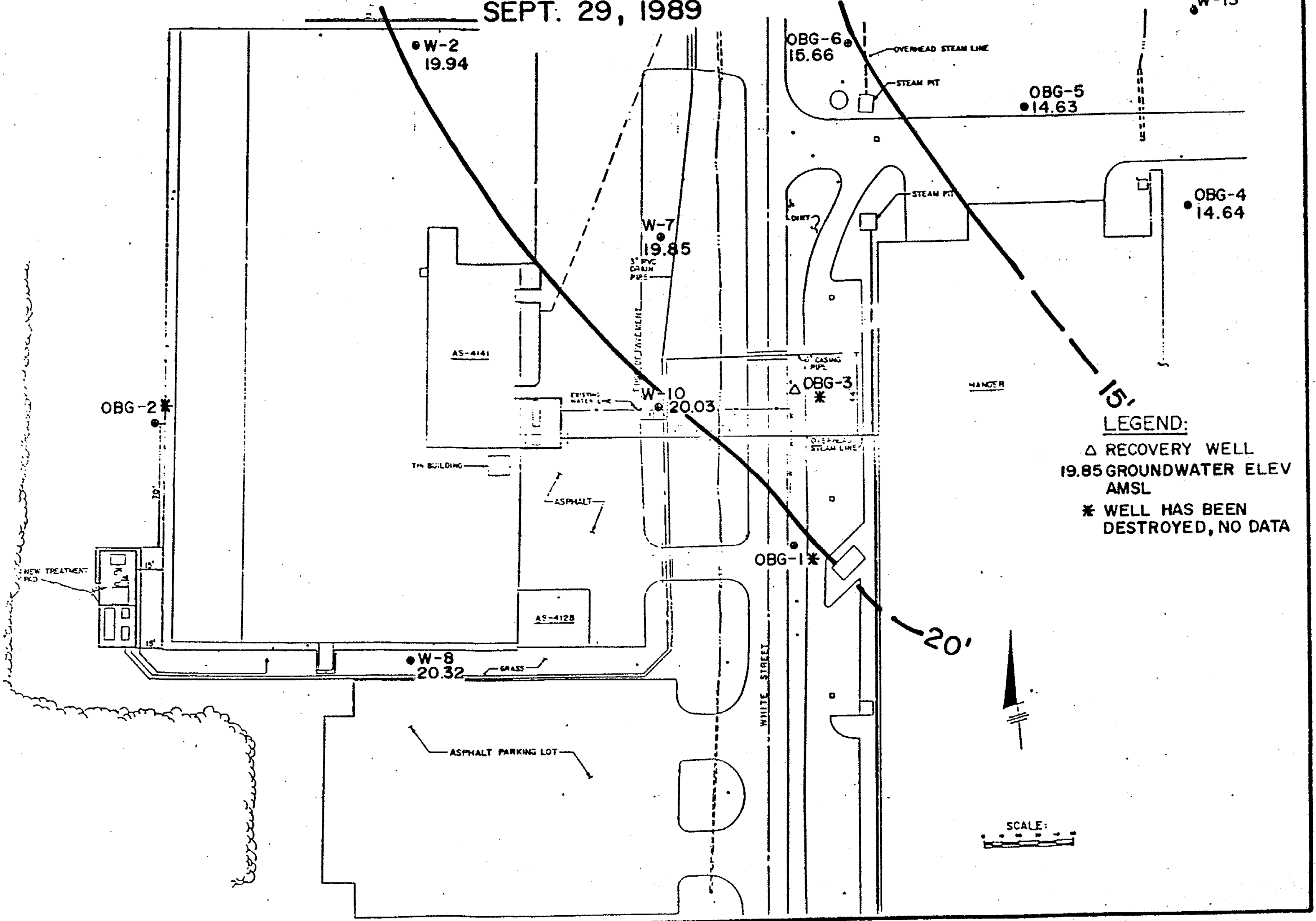


FIGURE 3

O'BRIEN&GERE ENGINEERS INC

063397

JP-5 LINE AREA
GROUNDWATER ELEVATION MAP
CAMP LEJEUNE, NORTH CAROLINA
SEPT. 29, 1989



LEGEND:

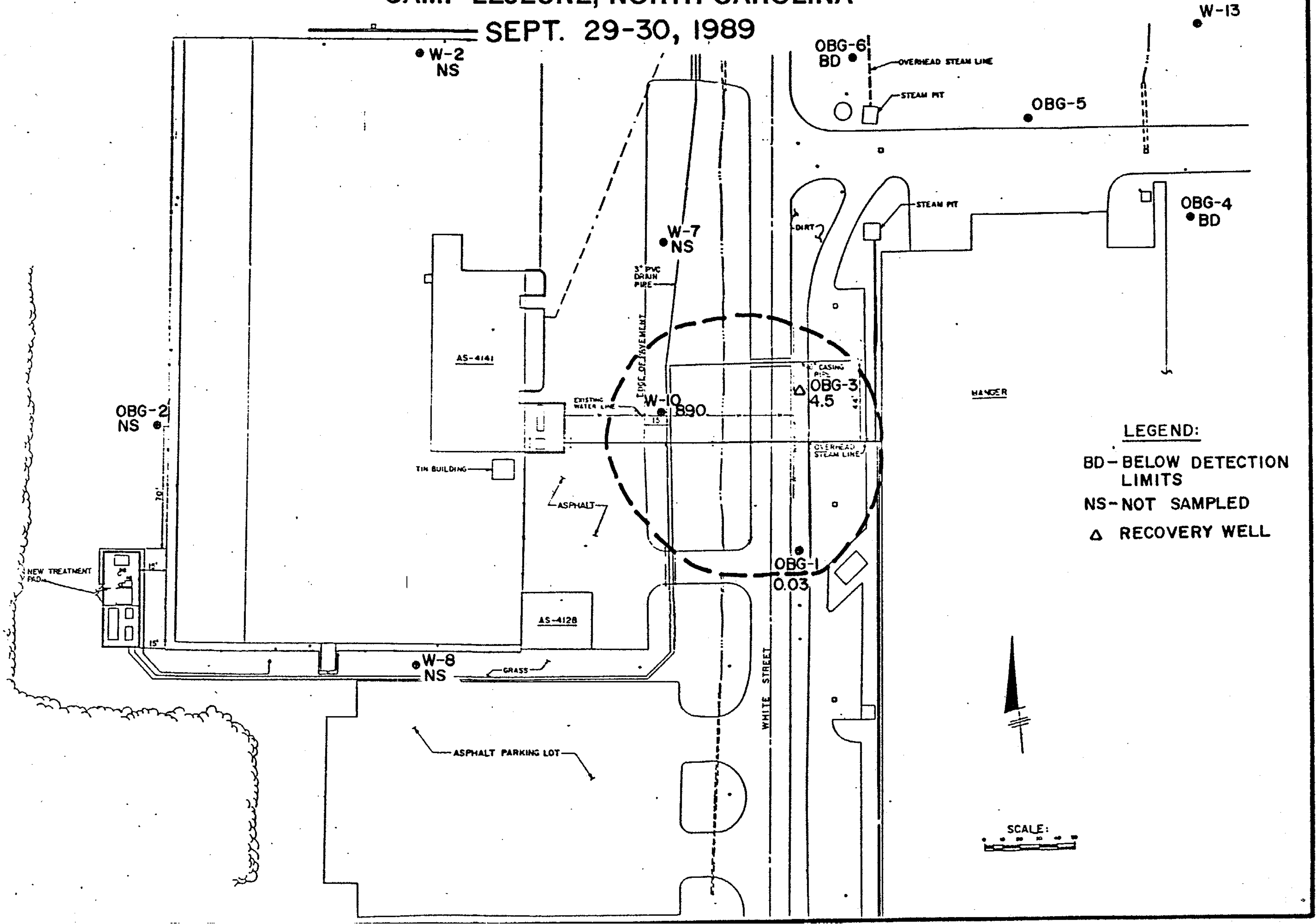
△ RECOVERY WELL
19.85 GROUNDWATER ELEV AMSL
✱ WELL HAS BEEN DESTROYED, NO DATA

FIGURE 4

O'BRIEN&GER
ENGINEERS,INC

063397

JP-5 LINE AREA
DISSOLVED TPH MAP
CAMP LEJEUNE, NORTH CAROLINA
SEPT. 29-30, 1989



LEGEND:

BD - BELOW DETECTION LIMITS

NS - NOT SAMPLED

△ RECOVERY WELL

FIGURE 5

O'BRIEN & GERE ENGINEERS, INC.

JP-5 LINE AREA
FREE PRODUCT MAP
CAMP LEJEUNE, NORTH CAROLINA
SEPT. 29, 1989

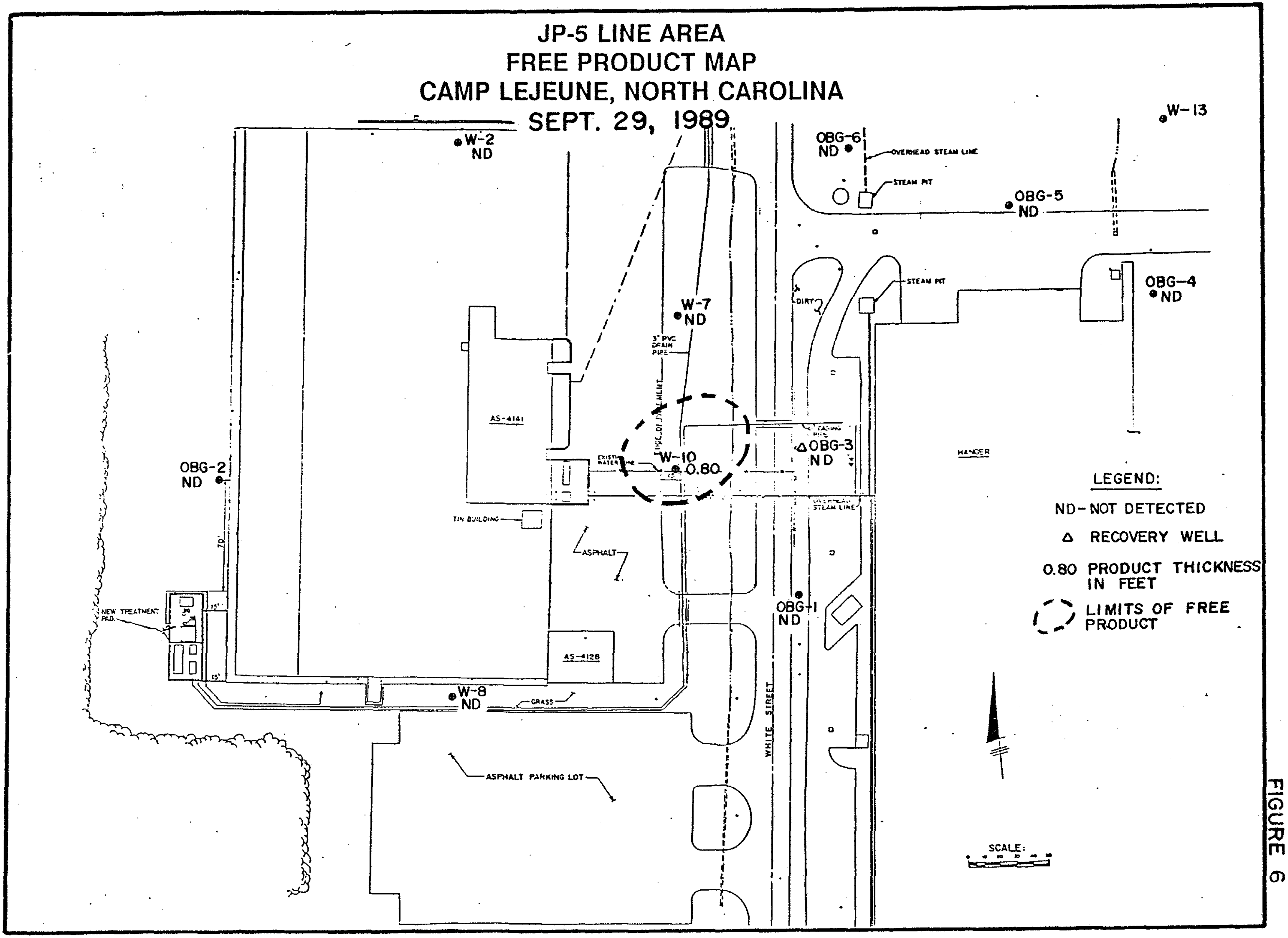


FIGURE 6

O'BRIEN & GERE

063397

JP-5 LINE AREA
REMEDIATION SYSTEM LOCATION
CAMP LEJEUNE, NORTH CAROLINA

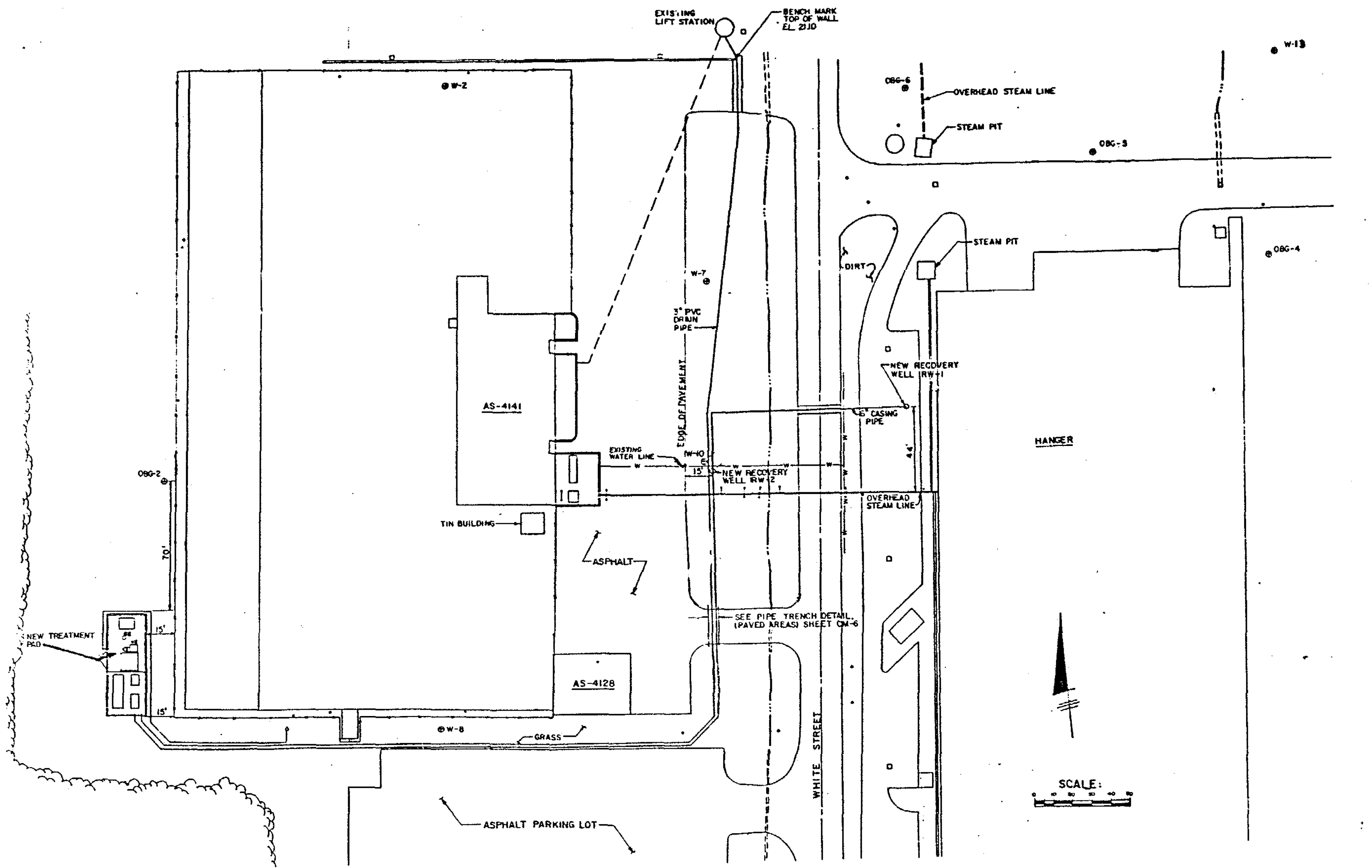


FIGURE 7

O'BRIEN & GERE ENGINEERS INC

JP-5 LINE AREA
REMEDIATION SYSTEM SCHEMATIC
CAMP LEJEUNE, NORTH CAROLINA

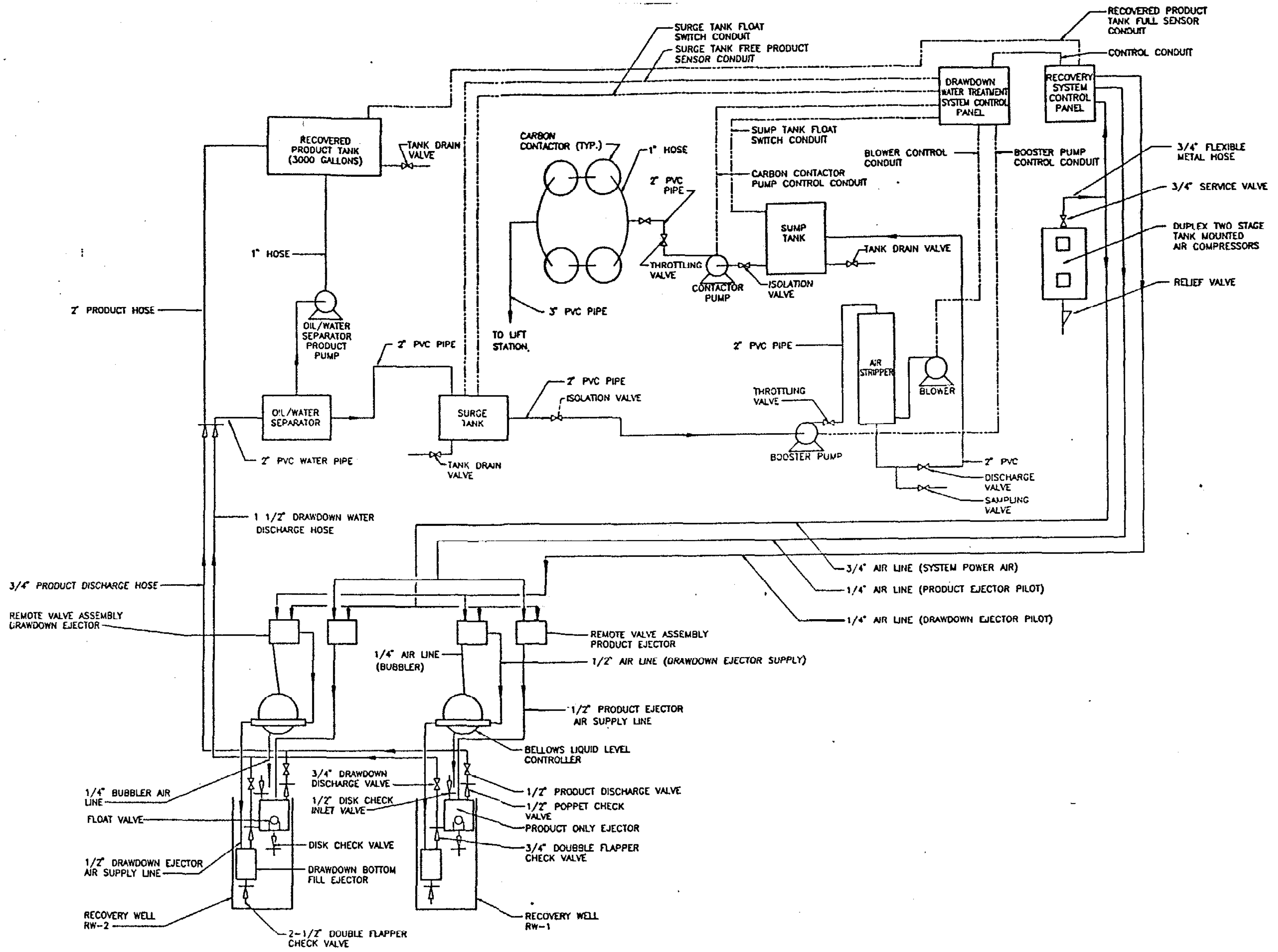


FIGURE 8

O'BRIEN & GERE ENGINEERS INC

Appendices

O'BRIEN & GERE

APPENDIX A

O'BRIEN & GERE
ENGINEERS, INC.

TEST BORING LOG

Report of Boring No.: OBG 1
Sheet of

Project Location: Lejeune JP-5
Client: Navy

SAMPLER
Type:
Hammer: Fall:

Ground Water Depth Date
Depth Date
File No.:

Boring Co.: SMI
Foreman: George Bridger
OBG Geologist: SLM

Boring Location:
Ground Elevation:
Dates: Started: 9/27/89 Ended: 9/27/89

Depth	Sample					Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing			Rmks*
	No	Depth	Blows /6"	Penetr/ Recovry	"N" Value				pH	Sp Cond	HNU	
0	1	0-2	2-2-2-1			Moist, brown, sand, silt + clay					0	
5	2	5-7	1-1-2-2	20/24		Moist grey clay					0	
10	3	10-12	1-2-3-3	24/24		Wet, grey, fine SAND					0	
15	4	15-17	1-5-3-3	24/24		As above					0	

O'BRIEN & GERE
ENGINEERS, INC.

TEST BORING LOG

Report of Boring No.: OBG 2
Sheet of

Project Location: Lejeune JP-5
Client: Navy

SAMPLER
Type:
Hammer: Fall:

Ground Water Depth Date
Depth Date
File No.:

Boring Co.: SMT
Foreman: George Bridger
OBG Geologist: SLM

Boring Location:
Ground Elevation:
Dates: Started: 9/27/89 Ended: 9/27/89

Depth	Sample No	Sample Depth	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	2.3.4.5	24/14		Moist, black, sand, silt, and clay, organic matter					0	
5	2	5-7	[illegible]	[illegible]		Wet, grey CLAY					0	
10	3	[illegible]	[illegible]	24/[illegible]		As above					0	
15	4	[illegible]	1.4			As above					0	

O'BRIEN & GERE
ENGINEERS, INC.

TEST BORING LOG

Report of Boring No.: [illegible]
Sheet 1 of 1

Project Location: JP-5 AREA CAMP LEJEUNE
Client: US NAVY

SAMPLER
Type:
Hammer: 150 lb.
Fall: ~10'

Ground Water Depth
Date
Depth
Date
File No.:

Boring Co.: EMTC
Foreman: JACK OLIVER
OBG Geologist: [illegible]

Boring Location: 6" - Recovery Well
Ground Elevation:
Dates: Started: 9/12/89
Ended: 9/12/89

Depth	Sample No	Sample Depth	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 4 5	24/24		Moist, brown, f-m SAND and silt, some yellow clay in globs	No product odor				2.0	
5	2	5-7	3.6.4	24/24		Moist, grey, plastic CLAY, some sand	product odor				20.	
10	3	10-12	33-5.7	24/24		As above	No product odor				4.0	
15	4	15-17	[illegible]-5-6-4	24/24		As above [illegible] 18' • [illegible] SAND below clay zone	No product odor				1.0	
20	5	20-22	[illegible]-5.8	24/24		Wet, grey f-m, SAND, with silt	No product odor				0.	
25	6	25-27	[illegible]	6/24		Wet, f-m, SAND, "clean" - no ~~[illegible]~~ clay or silt	~~No~~ product odor				15	

O'BRIEN & GERE
ENGINEERS, INC.

TEST BORING LOG

Report of Boring No.: CB-4
Sheet of

Project Location: Lejeune JP-5
Client: Navy

SAMPLER
Type:
Hammer:
Fall:

Ground Water Depth Date
Depth Date
File No.:

Boring Co.: SMT
Foreman: George Bridger
OBG Geologist: SLM

Boring Location:
Ground Elevation:
Dates: Started: 9/27/89
Ended: 9/27/89

Depth	Sample No	Sample Depth	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 ~~0-2~~	1	0-2	2·3·7·13	24/6		Moist, black sand, silt, and clay, organic matter					0	
5 ~~5-7~~	2	5-7	1·1·2·3	24/24		Moist, dark grey silt and clay					0	
10 ~~10-12~~	3	10-12	1·2·4·7	24/24		Wet, grey CLAY					0	
			9									
15 ~~15-17~~	4	15-17	7·10·24·17			Wet, grey, fine to medium SAND					0	

O'BRIEN & GERE ENGINEERS, INC.

TEST BORING LOG

Report of Boring No.: [illegible]
Sheet / of /

Project Location: Lejeune JP-5
Client: Navy

SAMPLER
Type:
Hammer:
Fall:

Ground Water Depth Date
Depth Date
File No.:

Boring Co.: [illegible]
Foreman: George Bridger
OBG Geologist: [illegible]

Boring Location:
Ground Elevation:
Dates: Started: 9/27/89
Ended: 9/27/89

Depth	Sample No	Sample Depth	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*
3½	1	3½-5½	1 2 2 3	24/24		Moist, grey CLAY					0	
8½	2	8½-10½	3-3-6-8	6/24		Moist, dark grey sand, silt, and clay						
13½	3	13½-15½	2-7-4-5	12/24		Wet, grey, fine to medium SAND					0	
18½	4	18½-20½	[illegible]-2-2	[illegible]		Wet, grey sand and silt					0	

O'BRIEN & GERE ENGINEERS, INC.	TEST BORING LOG	Report of Boring No.: 0SG 6 Sheet of
Project Location: Lejeune JP-5 Client: Navy	SAMPLER Type: Hammer: Fall:	Ground Water Depth Date Depth Date File No.:

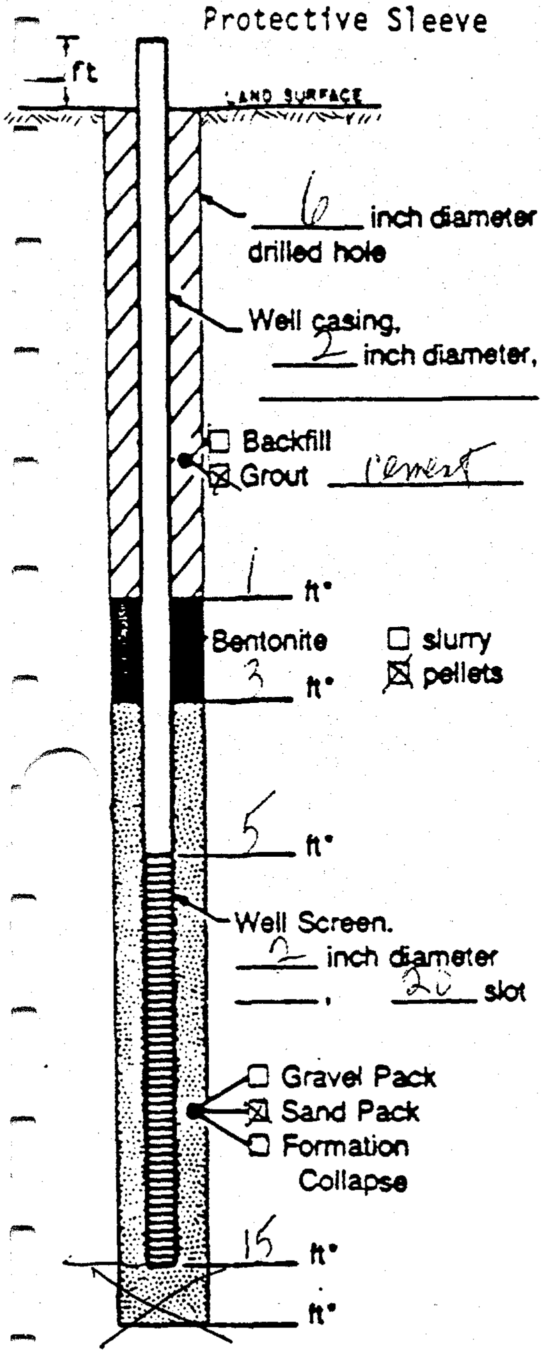
Boring Co.: SMI
Foreman: George Bridger
OBG Geologist: SLM

Boring Location:
Ground Elevation:
Dates: Started: 9/27/89 Ended: 9/27/89

Depth	Sample					Sample Description	Stratum Change General Descript	Equipment Installed	Field Testing			Rmks#
	No	Depth	Blows /6"	Penetr/ Recovry	"N" Value				pH	Sp Cond	HNU	
0	1	0-2	-			Moist, brown, sand, silt, and clay, organic matter					0	
											0	
5	2	5-7	1.2.1.2			Moist, grey, silty CLAY						
10	3	10-12	1.1/12.2			Wet, dark grey, sand, silt, and clay					0	
15	4	15-17	4.3.3.4			Wet, grey, fine to medium SAND					0	

APPENDIX B

WELL CONSTRUCTION LOG



6 inch diameter drilled hole

Well casing, 2 inch diameter,

☐ Backfill
☒ Grout cement

1 ft*

Bentonite ☐ slurry ☒ pellets
3 ft*

5 ft*

Well Screen. 2 inch diameter
, 20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

15 ft*

ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Lejeune JP-5 Well EBG-1

Town/City

County State

Permit No.

Land-Surface Elevation and Datum feet ☐ surveyed ☐ estimated

Installation Dates(s)

Drilling Method Hollow Stem Auger

Drilling Contractor

Drilling Fluid

Development Techniques(s) and Date(s)
pump w/ centrifugal 30-45 mins.
until clear 9-28-89

Fluid Loss During Drilling gallons

Water Removed During Development gallons

Static Depth to Water feet below M.P.

Pumping Depth to Water feet below M.P.

Pumping Duration hours

Yield gpm Date

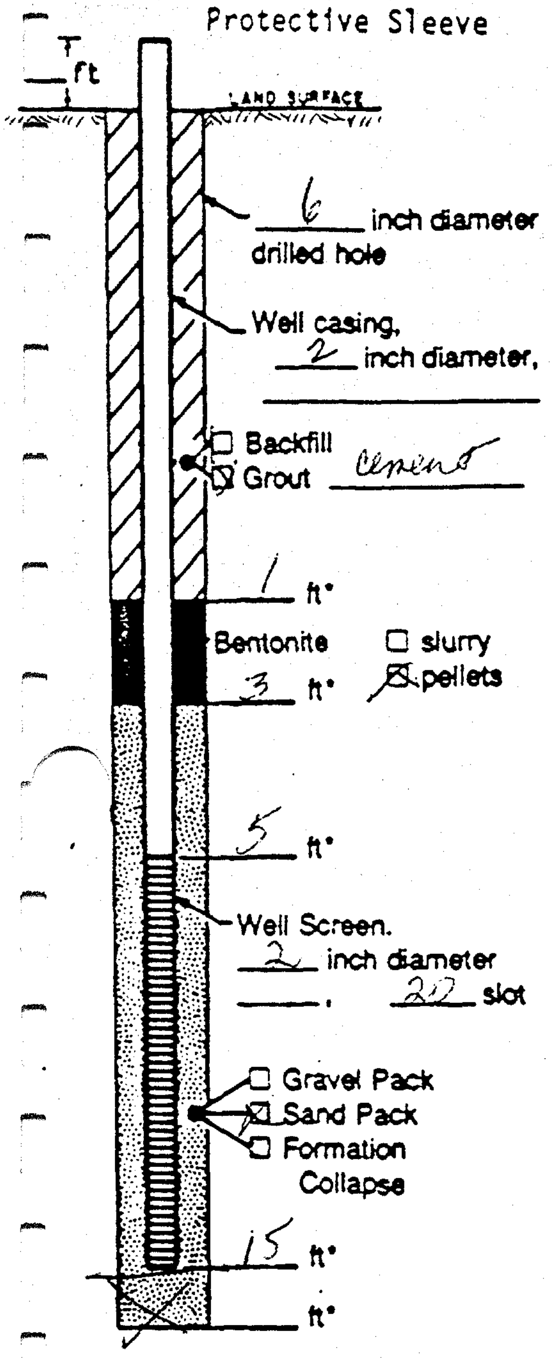
Specific Capacity gpm/ft

Well Purpose

Remarks

Prepared by

WELL CONSTRUCTION LOG



6 inch diameter drilled hole

Well casing, 2 inch diameter,

☐ Backfill
☒ Grout cement

1 ft*

Bentonite ☐ slurry ☒ pellets

3 ft*

5 ft*

Well Screen, 2 inch diameter
______, 20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

15 ft*

______ ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Lejeune JP-5 Well OBG-2

Town/City ______

County ______ State ______

Permit No. ______

Land-Surface Elevation

and Datum ______ feet ☐ surveyed

______ ☐ estimated

Installation Dates(s) ______

Drilling Method Hollow Stem Auger

Drilling Contractor ______

Drilling Fluid ______

Development Techniques(s) and Date(s)
Attempted w/ centrifugal pump. 9-28-89,
Dry after 20 mins., muddy still,
slow recovery (very clayey f-m.)

Fluid Loss During Drilling ______ gallons

Water Removed During Development ______ gallons

Static Depth to Water ______ feet below M.P.

Pumping Depth to Water ______ feet below M.P.

Pumping Duration ______ hours

Yield ______ gpm Date ______

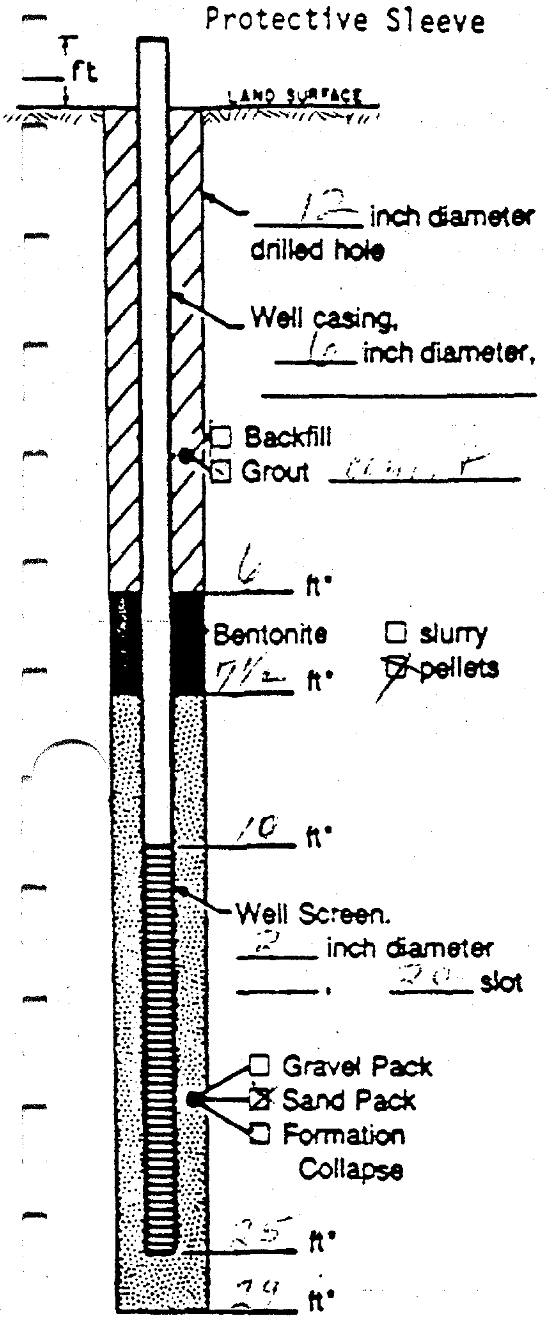
Specific Capacity ______ gpm/ft

Well Purpose ______

Remarks ______

Prepared by ______

WELL CONSTRUCTION LOG



12 inch diameter drilled hole

Well casing, 6 inch diameter, ______

☐ Backfill
☒ Grout cement

6 ft*

Bentonite ☐ slurry ☒ pellets

7½ ft*

10 ft*

Well Screen. 2 inch diameter ______, 20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

25 ft*

24 ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Camp Lejeune Well BG3

Town/City ______

County ______ State ______

Permit No. ______

Land-Surface Elevation and Datum ______ feet ☐ surveyed ☐ estimated

Installation Dates(s) 9-21-89

Drilling Method Hollow Stem Auger

Drilling Contractor ______

Drilling Fluid ______

Development Techniques(s) and Date(s) [illegible]
9-21-89

Fluid Loss During Drilling ______ gallons

Water Removed During Development ______ gallons

Static Depth to Water ______ feet below M.P.

Pumping Depth to Water ______ feet below M.P.

Pumping Duration ______ hours

Yield ______ gpm Date ______

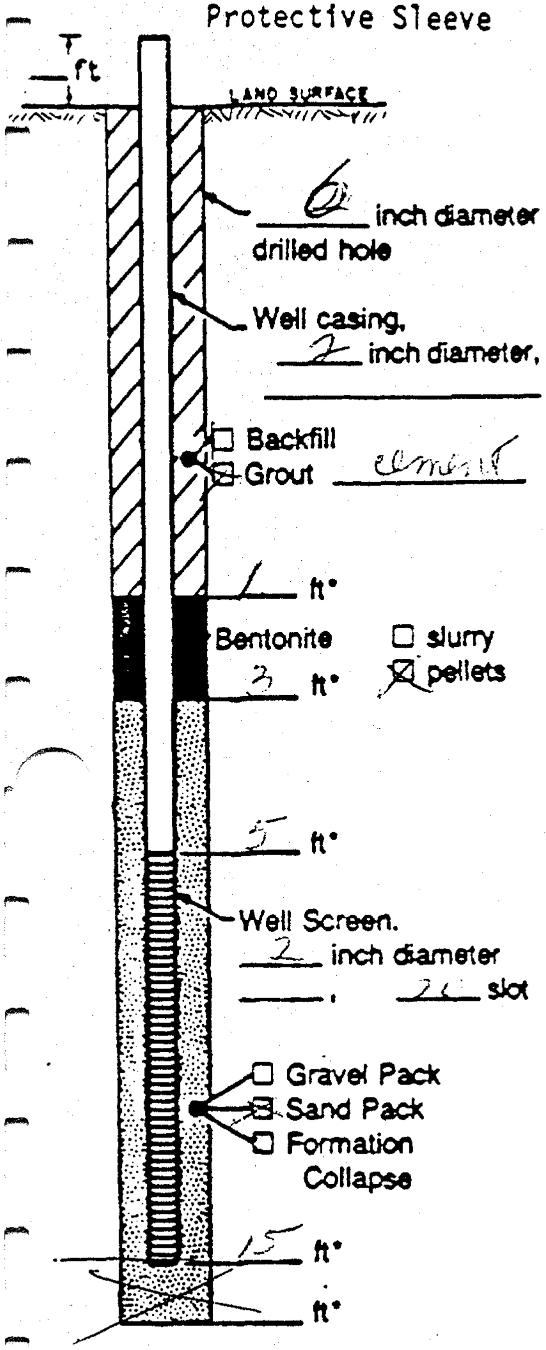
Specific Capacity ______ gpm/ft

Well Purpose 6"- diam monitoring well, JP-5 [illegible]

Remarks ______

Prepared by S. [illegible]

WELL CONSTRUCTION LOG



6 inch diameter drilled hole

Well casing, 2 inch diameter,

☐ Backfill
☒ Grout cement

1 ft*

Bentonite ☐ slurry ☒ pellets
3 ft*

5 ft*

Well Screen, 2 inch diameter
___ , 20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

15 ft*

___ ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Lejeune JP-5 Well OBG-4
Town/City
County State
Permit No.
Land-Surface Elevation and Datum ___ feet ☐ surveyed ☐ estimated
Installation Dates(s)
Drilling Method Hollow Stem Auger
Drilling Contractor
Drilling Fluid

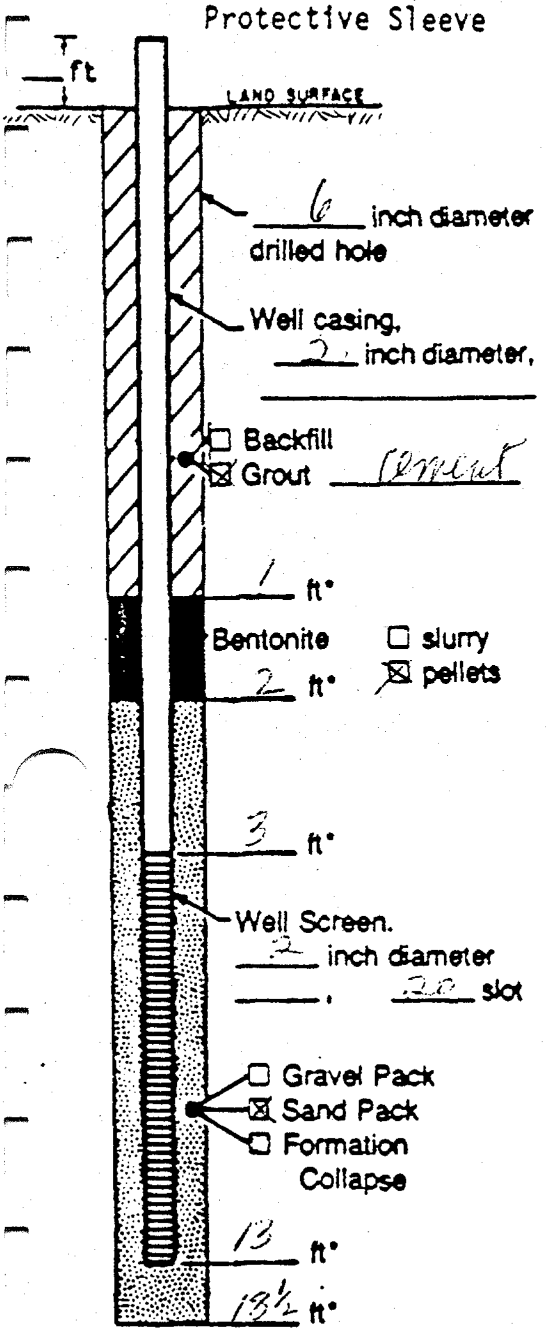
Development Techniques(s) and Date(s)
pumped w/ centrifugal 30-45 mins.
until clear 9-28-89

Fluid Loss During Drilling ___ gallons
Water Removed During Development ___ gallons
Static Depth to Water ___ feet below M.P.
Pumping Depth to Water ___ feet below M.P.
Pumping Duration ___ hours
Yield ___ gpm Date ___
Specific Capacity ___ gpm/ft
Well Purpose

Remarks

Prepared by

WELL CONSTRUCTION LOG



6 inch diameter drilled hole

Well casing, 2 inch diameter,

☐ Backfill
☒ Grout cement

1 ft*

Bentonite ☐ slurry ☒ pellets

2 ft*

3 ft*

Well Screen, 2 inch diameter
, .20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

13 ft*

13½ ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Lejeune JP-5 Well [illegible]-5
Town/City
County State
Permit No.
Land-Surface Elevation
and Datum feet ☐ surveyed
☐ estimated
Installation Dates(s)
Drilling Method Hollow Stem Auger
Drilling Contractor SMI
Drilling Fluid

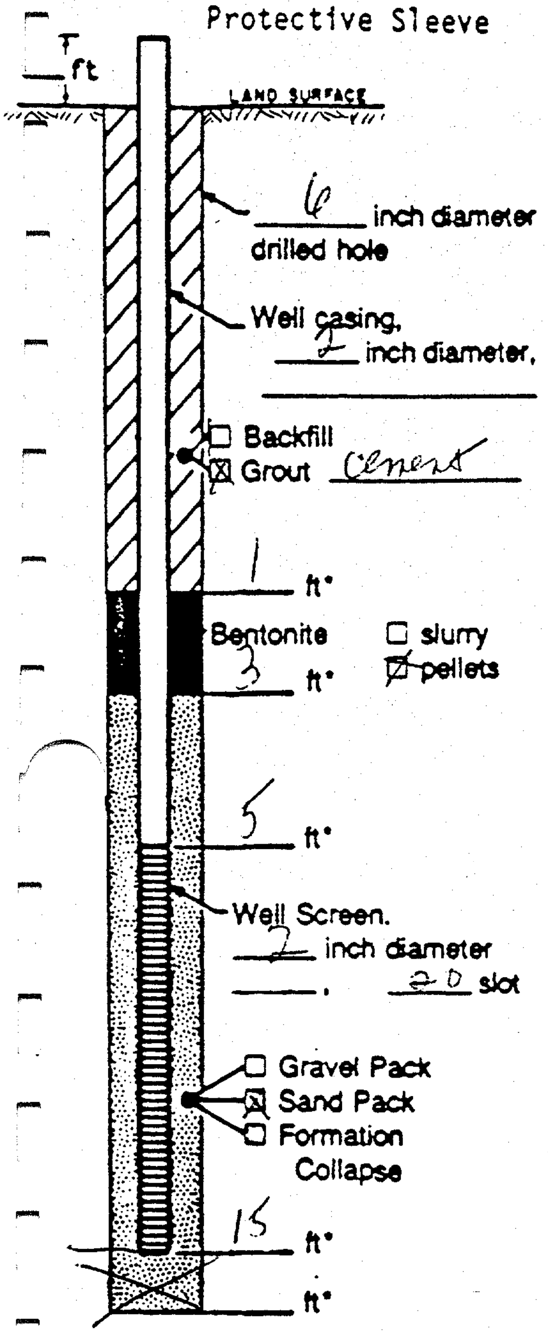
Development Techniques(s) and Date(s)
pumped w/ centrifugal 30-45 mins.
until clear 9-28-89

Fluid Loss During Drilling gallons
Water Removed During Development gallons
Static Depth to Water feet below M.P.
Pumping Depth to Water feet below M.P.
Pumping Duration hours
Yield gpm Date
Specific Capacity gpm/ft
Well Purpose

Remarks depth = 16.5[illegible]

Prepared by

WELL CONSTRUCTION LOG



6 inch diameter drilled hole

Well casing, 2 inch diameter,

☐ Backfill
☒ Grout Cement

1 ft*

Bentonite ☐ slurry ☒ pellets

3 ft*

5 ft*

Well Screen, 2 inch diameter
, 20 slot

☐ Gravel Pack
☒ Sand Pack
☐ Formation Collapse

15 ft*

ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project Lejeune JP-5 Well OBG-6

Town/City

County State

Permit No.

Land-Surface Elevation and Datum feet ☐ surveyed ☐ estimated

Installation Dates(s)

Drilling Method Hollow Stem Auger

Drilling Contractor

Drilling Fluid

Development Techniques(s) and Date(s)
pump w/ centrifugal 30-45 mins.
until clear 9-28-89

Fluid Loss During Drilling gallons

Water Removed During Development gallons

Static Depth to Water feet below M.P.

Pumping Depth to Water feet below M.P.

Pumping Duration hours

Yield gpm Date

Specific Capacity gpm/ft

Well Purpose

Remarks

Prepared by

Tables

O'BRIEN & GERE

TABLE 1
JP-5 LINE AREA
GROUNDWATER ELEVATIONS
Sept. 29 1989

Well #	TOC Elevation	DTW Below Grade	Product Thickness	Corrected Groundwater Elevation
	(AMSL)	(in feet)	(in feet)	(AMSL)
W-2	24.29	7.33*	0.00	16.96
W-7	26.50	6.65	0.00	19.85
W-8	26.52	6.20	0.00	20.32
W-10	25.88	6.46	0.80	20.03
OBG-4	21.09	6.45	0.00	14.64
OBG-5	22.88	8.25	0.00	14.63
OBG-6	21.63	5.97	0.00	15.66

AMSL - Above Mean Sea Level
DTW - Depth To Water
* - DTW taken from Metal Outer Casing

Figures

O'BRIEN & GERE

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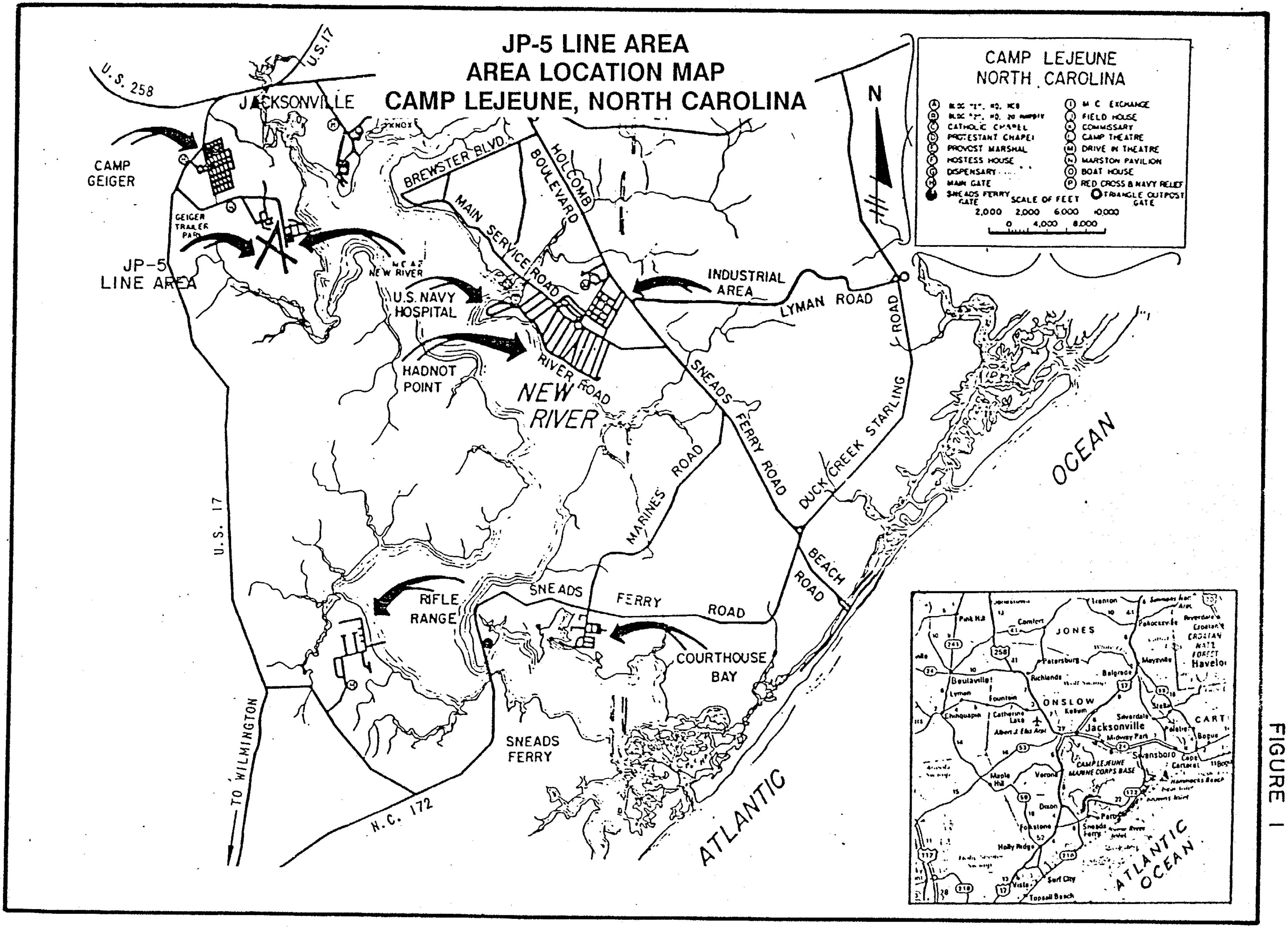

JP-5 LINE AREA AREA LOCATION MAP CAMP LEJEUNE, NORTH CAROLINA

FIGURE I

O'BRIEN&GERE ENGINEERS INC

JP-5 LINE AREA
SITE LOCATION MAP
CAMP LEJEUNE, NORTH CAROLINA

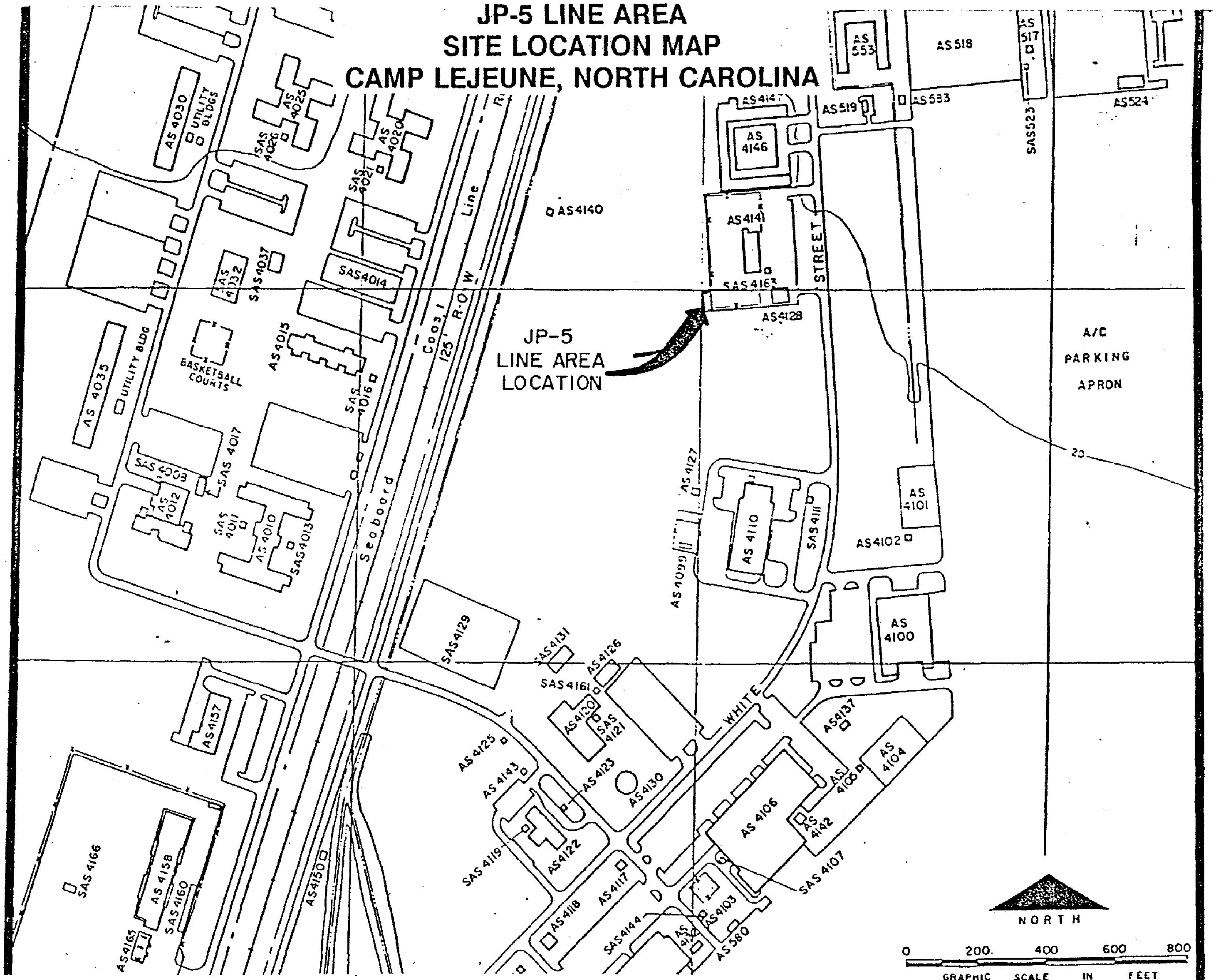

FIGURE 2

O'BRIEN & GERE
ENGINEERS INC.