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01.02- 12/27/94-01163
OU17, Site 90

Courthouse Bay
near Site 65

LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT

BUILDING BB-9

DSERTS
UST SITE 24

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

DECEMBER 27, 1994

VOLUME I

Contract No. N62470-93-D-4020
Richard Catlin & Associates, Inc. Job No. 93129-F

NORTH CAROLINA LICENSED GEOLOGIST
SEAL 1214
JAMES L. CORNETTE

12/28/94

Prepared by:
Richard Catlin & Associates, Inc.
Wilmington, North Carolina

Enclosure (2)

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BUILDING BB-9

EXECUTIVE SUMMARY

A comprehensive site assessment was performed at Building BB-9, Marine Corps Base (MCB), Camp Lejeune, North Carolina. Building BB-9 is an operating steam generation and heat plant. Three steel, 1,000 gallon capacity underground storage tanks (USTs) were permanently closed by removal and subsequent contaminant investigations confirmed the presence of subsurface petroleum hydrocarbons associated with the former UST system.

As part of this investigation, Richard Catlin & Associates, Inc. (RC&A) installed 12 Hydropunch penetrometers, 12 Type II monitoring wells, and three Type III monitoring wells to determine site subsurface characteristics and the extent of impact to subsurface soil and ground water. Geology beneath the site was described as poorly graded sands or gravelly sands with little or no fines to approximately 25 feet deep. Noncontinuous clay lenses were identified in several boreholes. A shelly, limestone was encountered at approximately 25 feet. No confining unit was identified. Depth to ground water beneath the site ranged from approximately six to ten feet. Ground water flow trends predominantly to the south-southwest with minor flow components to the north, east, and west.

Petroleum hydrocarbon contamination was identified within the vadose zone and surficial aquifer at Building BB-9. The vadoze zone contamination is in the immediate vicinity of the former UST basin. Two dissolved contaminant plumes were identified; however, one plume is located upgradient of the former UST basin. This contaminant plume was not delineated and is considered outside the realm of this investigation. The dissolved contaminant plume associated with the former UST system has been delimited horizontally. Trace levels of polynuclear aromatic hydrocarbon compounds were detected in the Type III monitoring wells.

Corrective action strategies are proposed for source removal and reduction of dissolved contaminant concentrations. Contaminated soils are proposed to be excavated and disposed/treated. Ground water dissolved contamination will be treated via in-situ air sparging in conjunction with vapor extraction.

STATEMENT OF PROFESSIONAL CONDUCT

I, James L. Cornette, as duly registered Professional Geologist in the State of North Carolina, have been authorized to observe and direct the underground storage tank subsurface investigation at the Building BB-9 facility, Camp Lejeune, North Carolina for the Atlantic Division Naval Facilities Engineering Command. To the best of my abilities, due care and diligence was used in the observation and supervision of the investigation, such that the investigation was conducted in accordance with the approved workplan and North Carolina laws and guidelines.

J. Cornett 12/28/94

James L. Cornette
Certified Professional Geologist
State of North carolina
Registration Number 1214

LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

DECEMBER 27, 1994

1.0 INTRODUCTION

1.1 *Purpose of Investigation*
(Refer to Figure 1.1 and Appendix A)

The purpose of this Leaking Underground Storage Tank (LUST) Comprehensive Site Assessment (CSA) was to accomplish the following goals:

- Determine the magnitude of and extent of soil and ground water petrochemical contamination;
- Identify and delineate possible free product accumulation, if present;
- Assess the potential for exposure to possible subsurface petroleum-related contaminants; and
- Provide a CSA report for the former underground storage tank (UST) basin at Building BB-9 in Marine Corps Base (MCB), Camp Lejeune, North Carolina.

The location of the project site within the base is shown in Figure 1.1.

This CSA document was prepared in accordance with the Workplan (Appendix A) approved by the Atlantic Division (LANTDIV) of the Naval Facilities Engineering Command (NAVFACENGCOM) and requirements listed as Elements 1 through 12 for "Comprehensive Site Assessments at LUST Sites" of the document entitled "Groundwater Section Guidelines for the Investigation and Remediation of Soils and Groundwater" prepared by the Groundwater Section of the North Carolina Department of Environment, Health and Natural Resources (NCDEHNR), March 1993. The objective of the CSA is to provide sufficient data to satisfy the requirements of Section 280.65 of 40 CFR Part 280, Federal Technical Standards for USTs and Section .0706 of the North Carolina Administration Code Title 15A, Chapter 2, Subchapter 2N (NCAC T15A:02N), North Carolina Criteria and Standards Applicable to USTs.

1.2 *Scope of Work*

The project was conducted in two phases. The first phase involved the advancement of twelve Hydropunch penetrometers (Hydropunches) and collection of shallow ground water samples for on-site laboratory analysis. The on-site laboratory results were available within 24 to 72 hours to provide data to assist in determining the location of subsequently installed boreholes. The Hydropunches were located predominantly downgradient of the source, with respect to shallow ground water flow. Previously established information (i.e. contaminant concentrations, presence of free product, buried utilities, etc.) was also used to assist in the placement of the Hydropunches. At least three of the Hydropunches were used to perimeter the crossgradient and upgradient sides of the suspected plume; one was used for deep sample collection; and the remaining were utilized for downgradient plume delineation.

The second phase of the investigation involved the advancement of 15 soil borings, into which 12 Type II and three Type III monitoring wells were installed. Samples were collected from the soil borings (soil) and monitoring wells (ground water) for both on-site and off-site analysis. Three slug tests were conducted at the site to determine site hydrogeological conditions.

1.3 *Area of Investigation*

(Refer to Figure 1.1)

Building BB-9 is located in the southern region of the MCB, Camp Lejeune, North Carolina (see Figure 1.1). The facility is currently utilized as a steam generating and heat plant. Review of past documents revealed that three steel 1,000 gallon capacity USTs, used to store heating oil, were located adjacent to the BB-9 building. A dry cleaning facility (Building BB-16) is located northeast of the subject site. Located to the north and northwest of Building BB-9 are several buildings and paved parking areas.

2.0 SITE HISTORY AND SOURCE CHARACTERIZATION

2.1 *Site History and Operations*

Building BB-9 is currently operating as a steam generation and heat plant. Adjacent to the building were three 1,000 gallon steel USTs, used to store heating oil for the steam plant. All three tanks were excavated and permanently closed in March 1993. The former tank basin currently remains unpaved.

2.2 *Contaminant Source Inventory*
(Refer to Table 2.1 and Figure 2.1)

Site reconnaissance indicates five potential contaminant sources in the immediate vicinity. Potential sources (PS) are listed in Table 2.1 and located in Figure 2.1. Potential contamination sources include the following:

PS #1 -	Subject tank basin (former heating oil UST system and ancillary lines).
PS #2 -	Active concrete oil\water separator for storm water run-off from the active above ground storage tank (AST) pad (PS #3).
PS #3 -	Active AST and ancillary lines. The AST pad contains three tanks of unknown capacity reported to store #2 Diesel fuel.
PS #4 -	Active AST pad with two 250 gallon tanks and ancillary lines for solvent storage.
PS #5 -	Active 250 gallon AST supplies dry cleaning fluid. This source is located inside Building BB-16 and is not sited in Figure 2.1 because its exact location within the building is not known.

2.3 *Release Incident History*

Three USTs adjacent to Building BB-9 were permanently closed in March 1993. According to previous documents, soil contamination was noted during the tank removal activities; however, there was no information documenting the collection of soil or ground water to confirm or estimate the extent of the impact.

2.4 *Previous Investigations*

As a follow-up, a three-well site check was conducted by Groundwater Technology Government Services, Inc. (GSI), to identify and/or verify the suspected hydrocarbon impact in the subsurface soils and ground water. GSI's services, as part of the site check, were to drill three soil borings, install three monitoring wells into these borings, collect soil and ground water samples for laboratory analysis for petroleum hydrocarbon concentrations, and determine the ground water flow gradient in the vicinity of the former tank basin.

A total of three monitoring wells (BB9-1 through BB9-3) were installed around the former UST basin by GSI, in April of 1993. The wells were installed to a depth of approximately 20 feet below grade with approximately 15 feet of well screen and five feet of riser. Ground water was measured at approximately five feet deep for all three wells. Total petroleum hydrocarbon (TPH) analysis of the three soil samples, one from each soil boring, revealed TPH concentrations ranging from 142 to 690 parts per million (ppm) of TPH diesel, 120 to 1,700 ppm TPH lubrication oil, and 870 to 3,800 ppm total oil and grease. The analysis of ground water samples for benzene, toluene, ethyl benzene, and total xylenes (BTEX) revealed maximum concentrations of 2.7 parts per billion (ppb) benzene, 5.1 ppb toluene, 11.0 ppb ethyl benzene, and 48.0 ppb total xylenes. No free phase product was noted in any of the wells. Shallow ground water flow was calculated to be to the south and southwest.

2.5 *History of Corrective Actions*

No corrective action has been performed to date other than permanent closure of the UST system.

3.0 MIGRATION PATHWAYS AND POTENTIAL RECEPTORS

3.1 *Water Well Inventory*

(Refer to Table 3.1 and Figure 3.1)

It is reported that potable water for the base is supplied by a well located approximately 1,200 feet toward the north-northwest. This well reportedly accesses water from the Castle Hayne aquifer. Well inventory summary information is listed in Table 3.1, and the water supply well location is illustrated in Figure 3.1.

3.2 *Utility Survey*

(Refer to Figure 3.2)

Underground and above ground utilities were identified through field observation and information provided by the Camp Lejeune Engineering Office of utility data compiled through 1984. Utilities are displayed in Figure 3.2, and include the following:

- Sanitary Sewer - Two sanitary sewer lines are located between Building BB-9 and the large AST pad to the southeast. One sewer line is located approximately 25 feet from the former tank basin and consists of six inch diameter piping. Another line is located approximately 50 feet from the former tank basin and consists of 12 inch diameter piping.
- Steam - A steam line lies parallel to, and between the sanitary sewer pipes. It is located approximately 30 feet from the former tank basin.
- Electric - An underground electric line is located approximately 40 feet from the tank basin, on the west side.

- Water - Two underground water mains are located approximately 150 feet north and south of the former tank basin. The piping is six inches in diameter. A third water main is located approximately 100 feet northwest of the basin, parallel to the underground electric line. This main consists of eight inch diameter piping.

- Storm Drain - A storm drain connects the large AST pad with the oil/water separator. A six inch diameter pipe channels waste water from the oil/water separator into the sanitary sewer.

3.3 *Potential Receptor Survey*
(Refer to Table 3.2)

Potential receptors, as defined by the NCDEHNR, include surface water bodies, ground water supply wells, and subsurface building structures.

The New River is the nearest body of surface water, located approximately 1,000 feet down gradient of the UST basin. The nearest known water supply well is located approximately 1,200 feet upgradient of the basin.

Underground sanitary sewer, water main, and storm drain pipes are located within 150 feet down gradient of the former tank basin. The water table in the area is measured between three and five feet deep. Utility depths may intersect the water table; therefore, may be impacted by petrochemical contaminants.

There was no evidence that adjacent buildings in the area were equipped with basements.

3.4 *Exposure Pathway Assessment*
(Refer to Table 3.2)

Contaminants identified at this site are as follows:

- benzene
- toluene
- total xylenes
- acenaphthene
- naphthalene
- phenanthrene
- anthracene
- fluoranthene
- benzo (a) anthracene
- chrysene
- total petroleum hydrocarbons
- ethylbenzene
- chloromethane
- bromomethane
- chloroform
- 1,1,1-trichloroethane
- bromodichloromethane
- dibromochloromethane
- 1,2,3-trichloropropane
- n-propylbenzene
- sec-butylbenzene
- tetrachloroethene
- 1,3,5-trimethyl benzene
- 1,2,4-trimethyl benzene

Table 3.2 summarizes the potential for exposure to contamination from the subject site. Given the characteristics of the local subsurface and the nature of the contamination medium, exposure is considered unlikely in most situations.

4.0 SOILS INVESTIGATION

4.1 *Site Topography*

The area is dominated by relatively flat topography. The nearest body of surface water is the New River, which is located approximately 1,000 feet down gradient of the site. The area upgradient of the site is comprised of buildings and paved parking areas.

4.2 *Regional Geology*

The area of investigation lies within the Coastal Plain physiographic province. The North Carolina Coastal Plain is approximately 90 to 150 miles wide from the Atlantic Ocean westward to its boundary with the Piedmont Province. Two natural subdivisions of the Coastal Plain were described by Stuckey (1965): the Tidewater region and the Inner Coastal Plain. The project area is located within the Tidewater region which consists of the coastal area where large streams and many of their tributaries are affected by ocean tides (Winner, Jr. and Coble, 1989).

The Coastal Plain comprises a wedge shaped sequence of stratified marine and non-marine sedimentary rocks deposited on crystalline basement. The sedimentary sequences range in age from Recent to lower Cretaceous (Narkunas, 1980).

The crystalline basement rocks in the Camp Lejeune area are overlain by 700 to 1,800 feet of unconsolidated sediments. The surficial Quaternary age deposits range from 23 to 80 feet. These deposits are underlain by Tertiary age rock units consisting of Castle Hayne limestone and sand followed by the Beaufort Formation. Underlying Cretaceous age rocks range in thickness from 700 to more than 1,400 feet and include the Peedee, Black Creek, and upper and lower Cape Fear Formations (Lyke and Winner, Jr., 1990).

Lithological units beneath the area of investigation were identified from a production well drilled in Sneads Ferry, North Carolina (Lyke and Winner, Jr., 1990). These units were identified as follows:

FORMATION	DEPTH IN FEET	DESCRIPTION
Quaternary Surficial Deposits	0-20	Sand, clay, gravel, and peat deposits in marine, fluvial, eolian, and lacustrine environments. Quaternary age deposits not shown at altitudes greater than approximately 25 feet above mean sea level.
Tertiary Castle Hayne	20-349	Upper level molluscan-mold, limestone, indurated, very sandy. Grades downward into calcareous sand and laterally into the middle level. Middle level Bryozoan-echinoid skeletal limestone, locally dolomitized, solution cavities common. Lower level phosphate-pebble conglomerates, micritic, thin; restricted to basal part of the Castle Hayne Formation in southeastern counties.
Tertiary Beaufort	349-435	Upper level sand and silty clay, glauconitic, fossiliferous, and locally calcareous. Lower level siliceous mudstone with sandstone lenses; thin bedded, basal phosphatic pebble conglomerates.
Cretaceous Peedee	435-780	Sand, clayey sand, and clay; greenish-gray to olive black; massive, glauconitic, locally fossiliferous and calcareous. Patches of sandy molluscan-mold, limestone in upper part.
Cretaceous Black Creek	780-1,229	Clay, gray to black, lignitic; contains thin beds and laminae of fine-grained micaceous sand and thick lenses of cross-bedded sand. Glauconitic, fossiliferous, clayey sand; sand lenses in upper part.
Cretaceous Cape Fear	1,229-?	Sandstone and sandy mudstone, yellowish-gray to bluish-gray, mottled red to yellowish-orange; indurated, graded, and laterally continuous bedding; blocky clay, faint cross-bedding, feldspar and mica common (NCDNRCD, 1985).

4.3 *Site Soils and Geology*

4.3.1 *Soil Boring Installation*
(Refer to Figure 4.1)

Prior to the installation of the monitoring well boreholes, twelve Hydropunch penetrometers (HP-1 through HP-12) were utilized to provide preliminary contamination data so as to assist with the location of the permanent monitoring wells. The Hydropunch investigation will be further discussed in Section 5.3.

Fifteen soil borings were advanced by a trailer-mounted drill rig to install 12 Type II (BB9-4 through BB9-15) and three Type III (BB9-16 through BB9-18) monitoring wells. Refer to Figure 4.1 .for boring/well locations. Hollow-stem augers were used to advance the soil borings to the appropriate depth.

4.3.2 *Description of Subsurface Samples*
(Refer to Appendix B, Figure 4.2, Figure 4.3, and Figure 4.4)

Soil samples were obtained from intervals of five feet from the Type II well boreholes utilizing a split-spoon sampler in accordance with ASTM D-1586. The Type III well boreholes were continuously sampled using the split-spoon device. Soils were described in the field by an engineer or geologist trained in using visual/manual techniques as described in ASTM D-2487 and D-2488. The soils were classified in accordance with the Unified Soils Classification System and a boring record of each borehole was produced. Boring logs are provided in Appendix B.

Two aquifer profiles were generated based on information obtained and interpreted from borehole samples. Figure 4.2 illustrates the plan view of the aquifer profile layout, and Figures 4.3 and 4.4 depicts aquifer profile A-A′ and B-B′, respectively. The site is underlain with poorly graded sands or gravelly sands with little or no fines, such as silt, to a depth of approximately 25 feet. Noncontinuous lenses of clay were encountered in several boreholes. Underlying the surficial sediments from approximately 25 feet to at least 50 feet deep were found to be comprised of shelly limestone, with sand and silt. No continuous confining layer was encountered during drilling operations. The shelly limestone encountered at ±25 feet deep appears to be part of the Castle Hayne Aquifer.

4.4 Soil Contamination

4.4.1 Field Screening and Laboratory Sample Collection

Field screening was conducted during drilling of the monitoring well boreholes to determine if organic vapors were present in the unsaturated zone and to identify areas of suspected near-surface releases.

Each split-spoon sample was divided, and placed in two pre-labelled, air tight, plastic bags. One sample bag was immediately placed on ice pending selection of the appropriate laboratory sample depth. The second sample bag was left undisturbed for several minutes to allow the organic vapors to reach equilibrium. The gas contained in the headspace of the bag was tested with an Organic Vapor Analyzer (OVA) flame-ionization detector. The first laboratory sample for each borehole was taken from a depth of two to five feet. The second sample from the Type II boreholes was collected within five feet of the water table. The second soil sample from the Type III boreholes was taken at a depth of approximately 40 feet, or within the confining unit, if encountered. Approximately 50% of the first soil samples were sent to the on-site laboratory and the remainder were sent to the off-site laboratory. Samples selected for on-site laboratory analysis were handled and analyzed in accordance with procedures outlined in Section 6.0.

All soil samples collected for laboratory analyses were immediately placed on ice. Soil was collected and placed into containers in accordance with the type of analyses scheduled for that sample as follows:

Analytical Method	Bottle Type and Size	Total Number of Bottles per Sample, On-Site/Off-Site Lab	Preservative
TPH-Methods 5030/3550	Glass Separate Jar Amber Glass Wide Mouth/2 oz.	2/2	<4°C <4°C
TCLP Organics/8 RCRA Metals	Plastic/1,000 ml	NA/1	<4°C/NR
Flash Point	Amber Glass Wide Mouth/8 oz.	NA/1	<4°C
Purgeable Aromatics Method 8021	Glass Vial/40 ml	NA/2	<4°C
pH	Glass or Plastic/8 oz.	NA/1	<4°C

*NA = Not Applicable. Analysis not scheduled for on-site laboratory.
NR = Not Required.

4.4.2 *Results of Soil Analyses*

(Refer to Table 4.1, Table 4.2, Figure 4.5, Figure 4.6, and Appendix I)

4.4.2.1 Field Screening

Results of the field screening using the OVA are provided in Table 4.1. Organic vapor recordings ranged from zero to 200 parts per million (ppm).

4.4.2.2 Laboratory Analyses

As specified in the delivery order, the following soil analyses were performed:

- 32 Total Petroleum Hydrocarbon (TPH)- EPA Methods 5030/3550;
- 10 pH- EPA Method 9045;
- 10 Ignitability (Flashpoint)- EPA Method 1010;
- 11 Purgeable Aromatics- EPA Method 8021; and
- Two TCLP organics and metals- EPA Method 1311.

As specified in the LANTDIV Contract, two TPH samples were collected from each borehole drilled on site. The first TPH sample collected from each borehole, both Type II and Type III, was obtained from the vadose zone. The second soil sample from each Type II borehole was collected from within five feet of the water table. The second sample from each Type III borehole was collected from approximately 40 feet (bottom of casing) or from a confining unit if encountered. Table 4.1 denotes the soil samples selected for TPH analyses and sample depth for each borehole. Flashpoint and pH samples were generally collected from boreholes at the ten to 12 foot interval with the exception of BB9-5 which was taken at the 15 to 17 foot interval. Purgeable aromatic compounds were analyzed for samples BB9-4, BB9-5, BB9-7, BB9-8, BB9-10, BB9-11, BB9-12, BB9-13, BB9-14, and BB9-15 at the five to seven foot interval. As specified in the delivery order, two TCLP organics and metals samples were also taken as part of this investigation. One sample was collected from the ten to 12 foot interval of BB9-16, located in the vicinity of the former UST basin. The other TCLP sample (BB9-SC3) was collected for waste characterization of the drill cuttings. In addition, two TPH samples, two flashpoint samples, and two pH samples (BB9-SC1 and

BB9-SC2) were also collected for waste characterization purposes.

4.4.2.3 Results of Soil Sampling

(Refer to Table 4.2A, Table 4.2B, Figure 4.5, Figure 4.6, and Appendix I)

Of the boreholes sampled, contaminants were identified in borings BB9-18, BB9-4, BB9-7, BB9-11, BB9-12, BB9-14, and BB9-15. Total petroleum hydrocarbons identified as gasoline was reported from BB9-18 (7.5 to 10.0 feet) and BB9-18 (22.5 to 25.0 feet) at concentrations of 16 ppm and 26 ppm, respectively. No TPH-gasoline or TPH-diesel was identified in any of the other boreholes. The NCDEHNR has established cleanup levels for petroleum hydrocarbons in soils. The current minimum cleanup levels are: 10 ppm for TPH-gasoline, 40 ppm for TPH-diesel, and 250 ppm for oil and grease. Total petroleum hydrocarbon-gasoline contamination in excess of State standards is limited to borehole BB9-18, located downgradient of the former UST basin. Table 4.2A summarizes the TPH results. Figure 4.5 illustrates the TPH isopleths for the vadose zone samples (three to five feet).

In addition, soil samples were analyzed for Flashpoint (ignitability) and pH parameters. Flashpoint values were reported to be greater than 97°C and pH was found to range from 7.74 to 9.32.

Table 4.2B summarizes the results of purgeable aromatic (EPA Method 8021) parameters. Refer to Figure 4.6 for total purgeable aromatics isopleths. As depicted, the highest concentrations are reported from samples BB9-7 (36.5 ppb) and BB9-11 (8.6 ppb), located north and upgradient of the former UST basin. The origin for these compounds is unknown and is considered out of the realm of this investigation. Trace levels were also detected in BB9-15 (4.5 ppb), BB9-12 (4.0 ppb), BB9-4 (4.5 ppb), and BB9-14 (5.8 ppb). Samples BB9-15, BB9-12, and BB9-4 are all within the immediate vicinity of the former UST basin and two other potential sources (PS #2 and PS #4) previously identified in Section 2.0. Sample BB9-14 is located topographically downgradient from the AST pad (PS #3). Therefore, the specific source for these constituents is not known. According to the

NCDEHNR (March 1993) guidance document, reportable concentrations for purgeable aromatic compounds are the method detection limit (MDL) or higher. Cleanup levels and/or regulatory status of the contaminated area will be determined by the North Carolina Division of Solid Waste Management, Hazardous Waste Section.

Sample BB9-16 reported no detectable concentrations of TCLP organics/metals.

Samples BB9-SC1, BB9-SC2, and BB9-SC3, collected for waste characterization, revealed no concentrations of TPH or TCLP organics/metals. Flashpoint values were greater than 97°C and pH values were 10.6 and 11.4.

Laboratory reports are provided in Appendix I.

5.0 GROUND WATER INVESTIGATION

5.1 *Regional Hydrogeology*

The Coastal Plain ground water system consists of aquifers comprised of permeable sands, gravels, and limestone separated by confining units of less permeable sediments. The three main aquifers utilized for water consumption in Onslow County include the surficial aquifer, Peedee aquifer and Castle Hayne aquifer (LeGrand, 1960).

According to Winner, Jr. and Coble (1989), the surficial aquifer consists primarily of fine sands, clays, shells, peat beds, and scattered deposits of coarse grained material in the form of relic beach ridges and floodplain alluvium. The areal extent of the surficial aquifer in the Coastal Plain is approximately 25,000 square miles with an average thickness of 35 feet. The average estimated hydraulic conductivity is 29 feet per day. In the Camp Lejeune area, the thickness of the surficial aquifer averages approximately ten feet thick with an estimated hydraulic conductivity of 50 feet per day.

Underlying the surficial aquifer is the Castle Hayne aquifer and confining unit. The Castle Hayne confining unit consists of beds of clay, sandy clay, and clay with sandy streaks. In the Camp Lejeune area this confining layer is typically ten feet thick. The Castle Hayne aquifer is composed predominantly of limestone and sand with minor amounts of clay. The approximate areal extent of the Castle Hayne aquifer is 11,500 square miles. Thickness of this aquifer unit ranges from 952 feet to seven feet. The average estimated hydraulic conductivity is 65 feet thick with an estimated hydraulic conductivity of 45 feet per day (Winner, Jr. and Coble, 1989).

The Castle Hayne aquifer unconformably overlies the Beaufort aquifer and confining unit. The Beaufort confining unit consists of the uppermost sediments of the Beaufort Formation; predominantly sandy clay to clay. The thickness ranges from zero to 80 feet, and averages about 24 feet. At Camp Lejeune, the thickness is typically 20 feet. The Beaufort aquifer is composed primarily of fine to medium grained glauconitic sand, clayey sand, and clay beds. The areal extent of this aquifer is approximately 10,700 square miles with an average thickness of 70 feet. The average hydraulic conductivity is 35 feet per day. In Camp Lejeune, the Beaufort aquifer is 80 feet thick with a hydraulic conductivity of 55 feet per day (Winner, Jr. and Coble, 1989).

Unconformably underlying the Beaufort aquifer is the Peedee aquifer and confining unit. The Peedee confining unit is composed of clay, silty clay, and sandy clay. The average thickness of this confining unit is nearly 25 feet. In the Camp Lejeune area, this unit is approximately 42 feet thick. The Peedee aquifer is composed of fine to medium grained sand interbedded with gray to black marine clay and silt. Sand beds contain varying amounts of glauconite. Shells are common throughout the aquifer. The approximate areal extent of the aquifer is 13,900 miles. Average thickness is 146 feet with an estimated hydraulic conductivity of 34 feet per day (Winner, Jr. and Coble, 1989).

5.2 *Site Hydrogeology*

(Refer to Figure 5.1, Appendix E and Appendix F)

Initial field measurements in the vicinity of the former UST basin between wells BB9-1, BB9-2, and BB9-3 indicated ground water flow to be towards the north. Ground water was found to range between approximately six to ten feet beneath the site. As shown in Figure 5.1, strict interpolation of the ground water table elevations reveals ground water flow to be predominantly to the south-southwest with minor flow components to the north, east and west in the vicinity of the former UST basin. As depicted, there appears to be a dewatering feature on the east side of Peach Street in the vicinity of well BB9-6. Investigation of utility locations did not reveal the presence of any subsurface utility deep enough to affect ground water flow direction. However, utility data provided by the Camp Lejeune Engineering office was compiled through 1984. Additional utilities installed subsequently may be present in the area and may act as a preferential migration pathway. Due to the approximate distance (800 feet) of the site from the nearest tidally-influenced body of water, it is unlikely that daily tidal fluctuations would affect ground water movement and contaminant plume migration at this location. The impacted area is not paved, therefore, seasonal variations may affect the distribution and concentrations of contaminants in the ground water through recharge of the aquifer by precipitation. During periods of seasonal high water table, residual contaminants in the impacted vadose zone soils may be leached by the ground water. In areas where vadose soil contamination is not present, contaminated ground water may impact vadose soils during periods of ground water fluctuation. During periods of drought, the lowered water table could carry contamination to depths previously unimpacted. Hydraulic gradients were calculated from water level measurements between wells BB9-6 to BB9-7 (0.58%), BB9-10 to BB9-4 (1.1%), and BB9-8 to BB9-6 (0.49%). Ground water measurements and hydraulic gradient calculations are provided in Appendix E and F.

5.3 *Hydropunch Investigation*

(Refer to Figure 4.1, Figure 5.3 and Table 5.4)

Twelve Hydropunch penetrometers (HP-1 through HP-12) were installed to provide qualitative information of the spatial extent of the dissolved and free-phase plumes. The locations of these sampling points were selected based on known/suspected contaminant source locations and previous subsurface investigative results. Refer to Figure 4.1 for Hydropunch locations.

The Hydropunch penetrometer was advanced by a trailer-mounted drill rig. Depending upon the subsurface conditions at each sample location, the penetrometer was advanced by hammer blows or by a hydraulic press. If fill material, hard/dense soils, or a deep ground water table (greater than ten feet deep) was encountered, a shallow pilot boring was advanced until a more suitable sampling interval was encountered to avoid damage to the probe.

Collection of the ground water samples was accomplished by driving the Hydropunch into the water-bearing zone and pulling back on the body of the tool to allow ground water to enter into the screened portion of the sample chamber. Samples were then retrieved utilizing a small diameter, decontaminated, transparent Teflon bailer. Hydropunch samples HP-1, HP-3 through HP-12 were collected from depths of approximately seven to ten feet. Hydropunch sample HP-2 was collected from a depth of approximately 40 feet.

Each ground water sample collected from the Hydropunch locations was analyzed for polynuclear aromatic hydrocarbons (PAHs) by EPA Method 610. Results of the sample analysis revealed total concentrations ranging from below detection limits (BDL) to 21.4 ppb. Table 5.4 summarizes the laboratory reports and Figure 5.3 illustrates the Hydropunch data. The highest total PAH concentrations were reported from sample HP-8 (21.4 ppb) and HP-7 (17.3 ppb), located upgradient of the former UST basin. Trace levels were detected in samples HP-1 (4.1 ppb), HP-2 (2.1 ppb), HP-4 (1.5 ppb), HP-5 (2.7 ppb), HP-9 (0.6 ppb), and HP-10 (0.9 ppb).

5.4 *Extent of Free Product*

(Refer to Figure 5.2)

No evidence or measurable thickness of free product was identified during the course of this investigation.

5.5 *Ground Water Dissolved Contamination*

5.5.1 *Monitoring Well Network*

(Refer to Figure 4.1 and Appendix D)

Twelve Type II monitoring wells (BB9-4 through BB9-15) and three Type III monitoring wells (BB9-16 through BB9-18) were installed to determine the areal and vertical extents of petrochemical contamination at the subject site. Refer to Figure 4.1 for monitoring well locations. All wells were installed by a qualified driller registered in the State of North Carolina. Well installation was supervised by an experienced geologist or engineer specializing in subsurface investigations. The wells were constructed in accordance with North Carolina Well Construction Standards (NCAC T15:02C) and with design criteria established in the Workplan (Appendix A). Well construction records and as-built well details are provided in Appendix D.

5.5.2 *Well Development*

(Refer to Table 5.1 and Appendix I)

Well development was performed no sooner than 24 hours after the grouting was completed. Development of the wells was accomplished by either continuous low yield pumping or bailing. As the wells were developed, ground water turbidity was visually monitored and recorded (see Table 5.1). Well development continued until turbidity stabilized. Water generated during the well development was containerized in Department of Transportation (DOT) approved drums. All fluids generated during well development was disposed of at a permitted, off-site facility.

An average of 35 gallons was removed from each Type II well during development and an average of 73 gallons was removed from each Type III well. All fluids generated during development and sampling activities were composited and a sample was collected for waste characterization purposes. The waste sample (BB9-WC) was analyzed for PAHs per EPA Method 610 and purgeable organics by EPA Method 602. The laboratory reports are provided in Appendix I.

5.5.3 *Sample Collection and Laboratory Analyses*
(Refer to Appendix G)

The sampling program consisted of purging the monitoring wells, then collecting the ground water samples from each. Well purging and sampling was performed in accordance with procedures established in the Workplan (Appendix A). Monitoring well and sampling field data worksheets are provided in Appendix G. Ground water samples were collected and placed into containers in the following order based upon the type of laboratory analysis scheduled for that sample:

Analytical Method	Bottle Type and Size	Total Number of Bottles per Sample On-Site/Off-Site Lab	Preservative
EPA 602	Glass Vial/ 40 ml	3/NA	<4°C
EPA 502.2	Glass Vial/40 ml	NA/3	<4°C
EPA 610	Amber Glass Jar/1 Liter	1/1	<4°C
8 RCRA Metals	Plastic/1,000 ml	NA/1	HNO_3

5.5.4 *Results of Ground Water Sampling*
(Refer to Table 5.5, Figures 5.4 through 5.10, and Appendix I)

Isopleth maps presented as part of this report were contoured using data from monitoring well ground water samples only. Hydropunches were not included because of the difference in sampling methodology and variance in Hydropunch/monitoring well sampling results. Hydropunch data was used to qualitatively assist in defining the contaminant plume boundaries.

As specified in the delivery order, the following analyses were utilized to characterize the ground water dissolved contamination at Building BB-9:

- 28 Polynuclear Aromatic Hydrocarbons- EPA Method 610;
- Six Purgeable Organics- EPA Method 602;
- Five RCRA Metals- EPA Method 3030; and
- 12 Drinking water volatiles- EPA Method 502.2.

Select wells were sampled for purgeable organic (EPA Method 602) and drinking water volatile (EPA Method 502.2) parameters. None of the Hydropunch samples were analyzed for purgeable organics (EPA Method 602). Table 5.5A summarizes the results of the purgeable organic compounds identified from monitoring well ground water samples. Sample BB9-4 reported detectable concentrations of benzene (0.6 ppb) and toluene (0.6 ppb). Sample BB9-5 reported 0.6 ppb of benzene. Wells BB9-7, BB9-13, and BB9-14 reported no detectable concentrations of purgeable organic compounds. Ground water quality standards (NCAC T15A:02L) have been established for the maximum allowable concentrations of specific contaminants. Currently, a maximum of 1 (ppb) benzene and 1,000 ppb toluene are allowed in Class GA waters (ground water). All monitoring wells were compliant with respect to purgeable organic compounds.

Monitoring wells BB9-4 through BB9-15 were analyzed for drinking water volatiles. Results are summarized in Table 5.5B and compared to the NCAC T15A:02L standards. Concentrations of specific components, purgeable organic and chlorinated organic compounds, in excess of State standards were identified from BB9-4, BB9-5, BB9-6, BB9-7, BB9-9, BB9-10, BB9-12, BB9-14, and BB9-15. Figures 5.4 through 5.8 illustrate the isoconcentrations compiled from the EPA Method 602 and EPA Method 502.2 data. The data was strictly interpolated based on an established 0 ppb boundary. As shown, there appear to be two areas of concern identified. One area is immediately adjacent to and downgradient of the former UST basin. The second area is west of Building BB-210, located north and upgradient of the former UST basin under investigation. The source of the benzene and toluene concentrations found in the northern portion of the area is not known at this time. In addition, the source for the chlorinated organic compounds is also not known. There are two potential contaminant sources within the immediate vicinity of the former UST basin and includes: potential source PS #4, an active AST pad with two 250 gallon capacity tanks used for solvent storage and located adjacent to Building BB-9; and potential source PS #5, an active 250 gallon capacity AST which stores dry cleaning fluid and located inside Building BB-16. No information concerning release incidents was found for these potential sources. Extent of the chlorinated organics impact to the subsurface is not known.

The primary focus of this investigation was to determine the petroleum impact associated with the former heating oil USTs. Polynuclear aromatic hydrocarbons per EPA Method 610 were analyzed from all of the monitoring wells to determine the impact from the high-boiling point petroleum fraction. Figure 5.9 illustrates the results of the PAH sampling and Table 5.5C summarizes the laboratory results. Hydropunch qualitative data was used in conjunction with field observations and monitoring well results to establish a 0 ppb boundary. The data was strictly interpolated from the established 0 ppb boundary. Trace levels of PAH compounds were identified in wells BB9-4, BB9-5, BB9-7, BB9-13, BB9-14, BB9-15, BB9-16, BB9-17, and BB9-18. Contour interpretation reveals highest total concentrations (9.5 ppb) immediately south and downgradient of the former UST basin and the active oil/water separator. Another area of concern, again, appears to be in the northern portion of the area adjacent to Building BB-210. Origin for the trace levels identified in this area is not known. Currently, there are no established water quality limits for the individual PAH constituents. Therefore, any PAH compounds found above the laboratory method detection limits are considered noncompliant. As illustrated in Figure 5.10, the estimated areal extent of dissolved PAH contaminants, based on both the Hydropunch and monitoring well samples, indicates two plumes existing within the area of investigation. The plume in the northern portion of the project area is considered unrelated to the former UST basin and was not further investigated. The areal extent of the plume in the vicinity of the former UST basin has been delineated through monitoring wells BB9-6, BB9-11, BB9-10, and Hydropunches HP-11, HP-12, and HP-6.

Selected monitoring wells (BB9-4, BB9-5, BB9-6, BB9-15, and BB9-16) were analyzed for RCRA metals. Table 5.5D summarizes the laboratory results and compares them to the NCAC T15A:02L water quality standards. Wells BB9-4, BB9-5, BB9-6, BB9-15, BB9-16 all reported concentrations of cadmium, lead, and silver in excess of the established standards. In addition wells BB9-5, BB9-6, and BB9-16 reported elevated chromium levels. The metals concentrations do not appear to be petroleum related; therefore, were not further investigated as part of this study.

Trace levels of PAH constituents were detected in Type III wells BB9-16, BB9-17, and BB9-18. Figures 4.3 and 4.4 illustrate the estimated vertical extent of dissolved PAH contamination.

All laboratory reports are provided in Appendix I.

5.6 *Aquifer Testing*

5.6.1 *Slug Tests*
(Refer to Table 5.2 and Appendix C)

Subsequent to development and sampling of the shallow monitoring wells, three standard recovery slug tests were performed on three Type II wells (BB9-7, BB9-8, and BB9-14) which did not contain free product. To perform the recovery test, the static head of ground water was measured first. A slug was introduced into the monitoring well and allowed to equilibrate. The slug was removed and measurements of the water level were taken at pre-determined time intervals and recorded. The recovery data was analyzed by methods presented by Hvorslev (1951). The hydraulic conductivity (K) value was calculated as follows:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

Where:

K = Hydraulic conductivity (ft/day)
r = Well radius
L = Sandpack length (ft)
R = Borehole radius (ft)
T_0 = Time required (time lag) for the recovering water level to be within 37 percent of the static water level.

Hydraulic conductivity (K) values ranged from 34 to 54 feet per day (ft/day). Slug test calculations are provided in Appendix C. A summary of estimated aquifer parameters is provided as Table 5.2.

5.6.2 *Grain Size Analysis*
(Refer to Table 5.2 and Appendix C)

As specified in the delivery order, two soil samples were taken during monitoring well installation and analyzed for grain size distribution. Grain size distribution was performed in accordance with the American Society for Testing and Materials (ASTM) test procedure D-422, entitled "Standard Test Method for Particle-Size Analysis of Soils". Samples were collected from BB9-4 (17 to 20 feet) and BB9-5 (15 to 17 feet). Sample BB9-4 was described as a fine grained sand (SC) with some clay (CL). Sample BB9-5 was described as a sandy clay (CL). Comparison to published information revealed K values of 8.2 ft/day (BB9-4) and 6.5×10^{-4} ft/day (BB9-5). Refer to Appendix C for grain size analysis report. Refer to Table 5.2 for aquifer parameter summary.

5.7 *Vertical Gradient Determinations*
(Refer to Table 5.3)

As shown in Table 5.3, three well pairs were constructed as part of this investigation. Calculation of the vertical gradients revealed a positive gradient of +0.01 for each well pair indicating a slight downward movement of ground water.

5.8 *Rate of Contaminant Migration*
(Refer to Appendices C, F, and H)

Ground water travel time or average linear ground water flow velocity serves as the basis for estimating the rate of contaminant migration at the facility. Ground water flow rates should represent the maximum rate of contaminant migration with variations among contaminants due to geohydrochemical processes including molecular diffusion, mechanical mixing, sorption-desorption, ion-exchange, hydrolysis, and biodegradation. However, due to the difficulties in estimating the effects of many of the processes on contaminant migration rates and the desire to produce relatively conservative (higher) estimates, only adsorption processes are incorporated into rate calculations.

Ground water flow velocities are calculated using the following modification of Darcy's Law:

$$V = K/n_e(dh/dl)$$

Where:
K = Hydraulic conductivity (ft/day)
n_e = Effective porosity (unitless)
dh/dl = Hydraulic gradient (ft/ft)

Initial estimates of hydraulic conductivity were determined from published literature for interpretation of grain size distribution analyses of soil samples and from slug tests. Hydraulic gradients were calculated from water level measurements between wells BB9-6 to BB9-7 (0.58%), BB9-10 to BB9-4 (1.1%), and BB9-8 to BB9-6 (0.49%).

For a conservative prediction of ground water velocity, the highest K value determined from the slug tests and grain size analyses was used in the calculations. The highest K value was found to be 54 ft/day from the slug test performed on well BB9-8 (see Appendix C). Calculation of the maximum ground water velocity was determined to be 1.1 ft/day to the east (see Appendix F).

Estimates of bulk density and porosity were determined from results of visual/manual classification of soils. Average velocities of petroleum contaminant constituents were then calculated in accordance with the following equation (USEPA, 1985):

$$V_c = V/R_d$$

Where:

V_c = Average velocity of contaminant constituent (ft/day)
V = Average linear ground water flow velocity (ft/day)
R_d = Retardation factor (unitless)

Evaluation of the petroleum contaminants from the purgeable organics (EPA Method 602) and polynuclear aromatic hydrocarbons (EPA Method 610), revealed benzene to have the lowest retardation factor, thereby allowing it the highest migration velocity. As shown in the calculations in Appendix H, the V_c for benzene was found to be 0.34 ft/day.

6.0 QUALITY CONTROL PROCEDURES

6.1 *Equipment Decontamination*

Equipment decontamination sites were established by the MCB environmental personnel prior to the initiation of drilling activities. Potable water obtained from on-site sources was utilized for equipment decontamination.

6.1.1 *Drill Rig*

The drill rig and tools were cleaned in accordance with the following guidelines:

- Drill rigs and all support equipment were cleaned of excess grease, oils, and caked-on soil prior to arrival at the site.

  Hollow stem augers, rods, and other drilling equipment were decontaminated between borings as follows:

- High temperature and pressure water rinse.
- If any noticeable petroleum hydrocarbon film was present, the tools were washed with phosphate-free detergent and tap water using a brush.
- High temperature and pressure tap water rinse.
- Allowed to air dry.
- Placed on and covered with clean plastic until next use.
- Equipment such as pumps and pump lines were flushed thoroughly with potable water prior to use.

6.1.2 *Soil and Ground Water Sample Collection Equipment*

Disposable Teflon bailers used for ground water sampling were disposed of after the sampling of each well.

Split-spoons, Hydropunch sample probes, submersible well development pump equipment, and other sample collection equipment were decontaminated between sample events as follows:

- Tap water rinse.
- Washed with phosphate-free detergent and tap water using a brush to remove any particulate matter or surface film.
- Tap water rinse.
- Rinsed thoroughly with distilled water.
- Rinsed with isopropanol.
- Allowed to air dry or rinsed with distilled water.
- Wrapped completely with aluminum foil and sealed in airtight plastic bags or placed on clean plastic if planned for immediate reuse.

6.1.3 *Rinseate Sample Collection Methodology*

A rinseate water sample was collected for QA/QC purposes. Water that was used in the decontamination process outlined above was used to pour over previously decontaminated equipment. The rinseate water was collected in the sample bottles. The collected samples were analyzed in accordance with the parameters listed in Section 5.0 to confirm that equipment decontamination was conducted adequately and that no cross contamination occurred between sample locations. If the rinseate samples detected any contamination, a sample of the source rinseate water was collected and analyzed for the same laboratory parameters.

6.2 *Sample Collection and Shipment*

6.2.1 *Sample Identification*

Prior to collecting each soil and ground water sample, sample bottles were labelled with the following information:

- Date and time of sample collection;
- Project identification number;

- Sample location number;
- Initials of person collecting sample;
- Type of preservative added to sample; and,
- Parameter(s) or parameter group to be analyzed.

Additional specific information, such as sampling interval, may have been added. The sample location number on the label corresponds to the sample location numbers assigned on the field site map.

6.2.2 *Chain of Custody and Transportation Procedures*

Chain of Custody (COC) procedures were followed to establish documentation of sample possession from the time of collection until completion of analysis for both on-site and off-site laboratories. As few people as possible handled the sample(s). The sampler was responsible for the care and custody of the samples until they were delivered to the on-site laboratory or dispatched for shipment to the off-site laboratory. An accurate record of sample collection, transport, and analysis was maintained and documented. Chain of Custody records are provided in Appendix I.

The COC Record was used by personnel responsible for ensuring the integrity of samples from the time of collection to shipment to both the on-site and off-site laboratories. The laboratory did not proceed with sample analysis without correctly prepared COC Records and Analytical Request Forms. The laboratory was responsible for maintaining COC of the sample(s) from time of receipt to disposal. Chain of Custody procedures were instituted and followed throughout the investigation.

The COC Record was signed by each individual who maintained custody of the samples. General preparation of the COC Record for samples to be delivered to the on-site and off-site laboratories was as follows:

- Samples were accompanied by a COC Record at all times.

- The COC Record was initiated in the field by the person collecting the samples. Every sample was assigned a unique identification number that was entered on the COC Record.

- The Record was completed in the field identifying the project, sampler, RC&A assigned project number, etc.

- If the person collecting the samples did not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished By ______________" was signed by the sampler.

- The person transporting the samples to the laboratory or delivering them for shipment signed the Record as "Relinquished By____________."

6.2.2.1 Off-Site Laboratory

Collected soil and ground water samples were transported by courier to GeoChem, Inc. in Morrisville, North Carolina. Prior to the start of the field investigation, necessary arrangements were made with the laboratory to assure proper and prompt delivery and log in of the collected samples. Shipment and COC procedures were as follows:

- Samples were packed properly for shipment so that bottles would not dislodge and/or break. The samples were kept cool using either ice packs or ice in zip-lock bags.
- Samples were transported via a GeoChem, Inc. courier.
- The COC record was sealed in a watertight container and placed in the shipping container.
- The courier double checked the contents of the shipping container to assure that the samples were properly packed and the COC inventory was correct.

6.2.2.2 On-Site Laboratory

An on-site mobile laboratory provided expedient analytical data to assist in determining the placement of additional sample locations. The mobile laboratory was set up at a location central to other projects concurrently being conducted in the area.

Shipment and COC procedures are as follows:

- The samples were packed properly for transport so that bottles would not dislodge and/or beak. The samples were kept cool using either ice packs or ice in zip-lock bags.
- Once the samples were properly packed, the container was adequately secured for transport to the laboratory.

- The COC Record was maintained.

6.3 *Chemical Data Evaluation*

(Refer to Appendix J)

On-site and off-site laboratory data evaluation, performance, and QA/QC procedures are presented in Appendix J.

7.0 PRELIMINARY RECOMMENDATIONS AND CORRECTIVE ACTIONS

7.1 *Soil Remediation*

7.1.1 *Overview and Objectives of Soil Remediation*

The goal of soil remediation is to reduce the levels of soil contamination within the estimated plume to acceptable levels established by the NCDEHNR so as not to be a source for continuing contamination. The current action levels for TPH concentrations are: ≥10 to 100 ppm for gasoline; ≥40 to 400 ppm for diesel; and ≥250 to 1,000 ppm for oil and grease. Reportable concentrations for the purgeable aromatic compounds are the MDL or higher.

The only petroleum contaminated (TPH-gasoline) soils identified during this investigation were from well BB9-18. Concentrations were 16 ppm from 7.5 to 10.0 feet and 26 ppm from 22.5 to 25.0 feet. Previous investigations revealed maximum levels of TPH-diesel (690 ppm), TPH-lubricating oil (1,700 ppm), and oil and grease (3,800 ppm) from the boreholes BB9-1, BB9-2 and BB9-3. In addition, soil petroleum contamination was noted during UST closure activities; however, it is not known if those observed contaminated soils still remain in the former UST basin and vicinity. The previously reported concentrations exceed the State established action levels. Purgeable aromatic compounds were identified from BB9-4, BB9-7, BB9-11, BB9-12, BB9-14, and BB9-15. Of these samples only BB9-15, BB9-4, and BB9-14 appear to be associated with the former UST basin. Samples BB9-7 and BB9-12 may indicate another source area. Cleanup levels and/or regulatory status of the area contaminated by non-petroleum products are site specific and must be determined by the North Carolina Division of Solid Waste Management, Hazardous Waste Section (NCDSWM-HWS).

7.1.2 *Preliminary Recommendation for Soil Remediation*

The most viable soil remediation alternative for this site is excavation and disposal of the localized petroleum hydrocarbon contaminated soils associated with the former UST basin. The low volatility of the diesel, lubricating oil, and oil and grease parameters make soil venting marginally effective at best. Other soil remediation alternatives, such as vitrification, bioremediation, etc., are not cost effective alternatives. The localized impacted area and shallow ground water table (six to ten feet) should allow for an effective vadose zone cleanup.

7.2 *Ground Water Remediation*

7.2.1 *Overview and Objectives of Ground Water Remediation*

The objectives of ground water remediation are to contain the contaminant plume and to reduce the dissolved contaminant levels. The site rehabilitation levels are those required by NCAC T15A:02L Water Quality standards.

As previously mentioned purgeable organics, drinking water volatiles, chlorinated organics, PAHs, and metals were identified in concentrations above the established State standards. One dissolved contaminant plume was identified upgradient of the former UST basin and will not be addressed as part of this investigation. In addition, the metals identified do not appear to be petroleum related and were considered beyond the realm of this investigation. The dissolved contaminant plume of concern is located within the vicinity of the former UST basin and identified potential sources.

7.2.2 *Preliminary Recommendation for Ground Water Remediation*

Field interpretation of the soils and grain size analyses indicate that the ground water plume is within a fairly permeable sand unit. This unit appears to be conducive to this type of remediation. Review of the Henry's Constant for each of the identified contaminants suggests that the contaminants are "strippable" and concentrations could be reduced by air sparging. Vertical or horizontal sparging points would be constructed within the ground water plume. Air will be injected through the ground water to vacuum lines located in the vadose zone. The action of the air being forced through the subsurface acts to volatilize trapped hydrocarbons. Hydrocarbons dissolved in ground water should undergo a phase change to air, travel to the vacuum lines located above, and be discharged to the atmosphere. In addition, it is felt that oxygen provided to the subsurface will encourage the growth of micro-organisms and enhance the natural bioremediation process. Costs associated with the air sparging/soil venting approach would include the system equipment construction/installation, monthly equipment maintenance, operation (energy), and monitoring/reporting.

7.3 *Additional Data Needs for Corrective Action Plan Development*

The petrochemical plume within the vicinity of the former UST basin has been delineated; therefore, all information required to develop the Corrective Action Plan (CAP) for the preferred remediation strategy of air sparging and vapor extraction, is included within this report.

7.4 *Recommendations*

This report fulfills the CSA requirements of Section 280.65 of 40 CFR Part 280, Federal Technical Standards for USTs, and Section .0706 of NCAC T15A:02N North Carolina Criteria and Standards Applicable to USTs. It is recommended that a copy of this report be provided to the NCDEHNR-Wilmington Regional office. Ground water and soil contamination in excess of established State standards were identified through this investigation. It is recommended that the comprehensive site monitoring and natural bioremediation approach be explored as the corrective action strategy and that a CAP be prepared.

8.0 REFERENCES

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TABLES

TABLE 2.1

CONTAMINANT SOURCE INVENTORY

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

POTENTIAL SOURCE #	SIZE OF TANK (gal)	PRODUCT TYPE	TANK TYPE	CONSTRUCTION	TANK STATUS	REMOVAL/ ABANDONMENT DATE
1	1,000	Heating Oil*	UST	Steel	Removed	March 1993
	1,000	Heating Oil*	UST	Steel	Removed	March 1993
	1,000	Heating Oil*	UST	Steel	Removed	March 1993
2	UNK	Waste Oil	Oil/water Separator	Concrete	Active	NA
3	UNK	Diesel #2	AST	Steel	Active	NA
	UNK	Diesel #2	AST	Steel	Active	NA
	UNK	Diesel #2	AST	Steel	Active	NA
4	250	Solvent	AST	Plastic	Active	NA
	250	Solvent	AST	Plastic	Active	NA
5	250	Dry Cleaning Fluid	AST	Unknown	Active	NA

*Suspected to be #6 fuel oil based on interviews with steam plant operators

TABLE 3.1

WELL INVENTORY SUMMARY

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

APPROXIMATE DISTANCE FROM PROJECT SITE (FT)	WELL USAGE
1200	SUPPLY

TABLE 3.2
SUMMARY OF EXPOSURE PATHWAYS
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTAMINATED MEDIUM	INGESTION (EATING)	INGESTION (DRINKING)	INHALATION	ABSORPTION
FREE PRODUCT	NA	NA	NA	NA
SOIL	Contingent Exposure (1)	Contingent Exposure (1)	NA	Contingent Exposure (1)
GROUND WATER	Unlikely Exposure	Unlikely Exposure	NA	Unlikely Exposure
VAPOR	NA	NA	Unlikely Contingent Exposure (2 + 3)	NA

Notes:

(1) Potential for exposure if subsurface below one to three feet BLS is disturbed/brought to the surface. Soil samples collected during monitor well installation indicated no contamination with the exception of BB9-18. Soils in the tank basin are suspected to also be contaminated. Exposure pathways would be created if excavation activities are begun in these areas.
(2) With the exception of the TPH-gasoline detected in BB9-18, the on site contaminants have a low volatility. Futhermore, they are overlain by approximately nine feet of soil.
(3) Buildings in vicinity of contaminant plume are slab-on-grade construction.
NA - Not Applicable

TABLE 4.1 (Page 1 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-4	3.5 - 5.5	<1	*
BB9-4	5.5 - 7.0	<1	*
BB9-4	10 - 12	1	
BB9-4	15 - 17	20	
BB9-4	20 - 22	10	
BB9-5	2 - 5	<1	
BB9-5	5 - 7	0	*
BB9-5	10 - 12	NA**	*
BB9-5	15 - 17	<1	
BB9-5	20 - 22	3	
BB9-6	3 - 5	0	*
BB9-6	5 - 7	0	*
BB9-6	10 - 12	0	
BB9-6	15 - 17	0	
BB9-6	20 - 22	20	

Notes:

OVA zeroed on upgradient ambient air
NA ** Insufficient sample volume to analyze

TABLE 4.1 (Page 2 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-7	3 - 5	1	*
BB9-7	5 - 7	1	*
BB9-7	10 - 12	1	
BB9-7	15 - 17	50	
BB9-7	20 - 22	50	
BB9-8	3 - 5	0	*
BB9-8	5 - 7	0	*
BB9-8	10 - 12	0	
BB9-8	15 - 17	0	
BB9-8	20 - 22	1	
BB9-9	3 - 5	0	*
BB9-9	5 - 7	0	*
BB9-9	10 - 12	1	
BB9-9	15 - 17	1	
BB9-9	20 - 22	1	

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.1 (Page 3 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-10	3 - 5	1	* (AND DUP)
BB9-10	5 - 7	1	* (AND DUP)
BB9-10	10 - 12	2	
BB9-10	15 - 17	4	
BB9-10	20 - 22	4	
BB9-11	3.5 - 5.5	1	*
BB9-11	5.5 - 7.5	1	*
BB9-11	10 - 12	2	
BB9-11	15 - 17	3	
BB9-11	20 - 22	60	
BB9-12	3 - 5	1	*
BB9-12	5 - 7	2	*
BB9-12	10 - 12	<1	
BB9-12	15 - 17	8	
BB9-12	20 - 22	2	

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.1 (Page 4 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-13	3 - 5	<1	*
BB9-13	5 - 7	<1	*
BB9-13	10 - 12	1	
BB9-13	15 - 17	3	
BB9-13	20 - 22	2	
BB9-14	3 - 5	1	*
BB9-14	5 - 7	0	*
BB9-14	10 - 12	2	
BB9-14	15 - 17	50	
BB9-15	3 - 5	1	*
BB9-15	5 - 7	2	*
BB9-15	10 - 12	2	
BB9-15	15 - 17	3	
BB9-15	20 - 22	10	

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.1 (Page 5 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-16	2.5 - 5.0	1	
BB9-16	5.0 - 7.5	1	*
BB9-16	7.5 - 10	1	
BB9-16	10 - 12.5	1	
BB9-16	12.5 - 15.0	12	
BB9-16	15.0 - 17.5	15	
BB9-16	17.5 - 20.0	18	
BB9-16	20.0 - 22.5	20	
BB9-16	22.5 - 25.0	6	
BB9-16	25.0 - 27.5	9	
BB9-16	27.5 - 30.0	4	
BB9-16	30.0 - 32.5	5	
BB9-16	32.5 - 35.0	10	
BB9-16	35.0 - 37.5	20	
BB9-16	37.5 - 40.0	50	*

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.1 (Page 6 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-17	3.5 - 5.5	0	
BB9-17	5.5 - 7.5	<1	*
BB9-17	7.5 - 10.0	1	
BB9-17	10.0 - 12.5	1	
BB9-17	12.5 - 15.0	1	
BB9-17	15.0 - 17.5	3	
BB9-17	17.5 - 20.0	3	
BB9-17	20.0 - 22.5	2	
BB9-17	22.5 - 25.0	4	
BB9-17	25.0 - 27.5	30	
BB9-17	27.5 - 30.0	120	
BB9-17	30.0 - 37.5	1	
BB9-17	37.5 - 40.0	1	*
BB9-17	40.0 - 42.5	15	

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.1 (Page 7 of 7)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
BB9-18	5.5 - 7.5	3	
BB9-18	7.5 - 10.0	3	*
BB9-18	10.0 - 12.5	3	
BB9-18	12.5 - 15.0	8	
BB9-18	15.0 - 17.5	5	
BB9-18	17.5 - 20.0	200	
BB9-18	20.0 - 22.5	120	
BB9-18	22.5 - 25.0	20	*

Notes:

OVA zeroed on upgradient ambient air

TABLE 4.2A (Page 1 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL

TPH, FLASHPOINT, pH

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH 5030 (mg/Kg)	TPH 3550 (mg/Kg)	FLASH POINT (Degree C)	pH
BB9-4	3.5 - 5.5	BDL	BDL	NA	NA
BB9-4	5.5 - 7.0	BDL	BDL	NA	NA
BB9-4	10.0 - 12.0	NA	NA	>98	8.15
BB9-5	5.0 - 7.0	BDL	BDL	NA	NA
BB9-5	10.0 - 12.0	BDL	BDL	NA	NA
BB9-5	15.0 - 17.0	NA	NA	>98	7.89
BB9-6	3.0 - 5.0	BDL	BDL	NA	NA
BB9-6	5.0 - 7.0	BDL	BDL	NA	NA
BB9-6	10.0 - 12.0	NA	NA	>98	9.32
BB9-7	3.0 - 5.0	BDL	BDL	NA	NA
BB9-7	5.0 - 7.0	BDL	BDL	NA	NA
BB9-7	10.0 - 12.0	NA	NA	>98	8.37
BB9-8	3.0 - 5.0	BDL	BDL	NA	NA
BB9-8	5.0 - 7.0	BDL	BDL	NA	NA
BB9-8	10.0 - 12.0	NA	NA	98	8.36

NA = Not Analyzed
BDL = Below Detection Limits
BQL = Below Quantitation Limits
Shaded areas indicate concentrations above NCDEHNR limits

TABLE 4.2A (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL

TPH, FLASHPOINT, pH

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH 5030 (mg/Kg)	TPH 3550 (mg/Kg)	FLASH POINT (Degree C)	pH
BB9-9	3.0 - 5.0	BDL	BDL	NA	NA
BB9-9	5.0 - 7.0	BDL	BDL	NA	NA
BB9-9	10.0 - 12.0	NA	NA	98	8.85
BB9-10	3.0 - 5.0	BDL	BDL	NA	NA
BB9-10 (dup)	3.0 - 5.0	BDL	BDL	NA	NA
BB9-10	5.0 - 7.0	BDL	BDL	NA	NA
BB9-10(dup)	5.0 - 7.0	BDL	BDL	NA	NA
BB9-10	10.0 - 12.0	NA	NA	98	7.74
BB9-11	3.5 - 5.5	BDL	BDL	NA	NA
BB9-11	5.5 - 7.5	BDL	BDL	NA	NA
BB9-11	10.0 - 12.0	NA	NA	>97	8.92
BB9-12	3.0 - 5.0	BDL	BDL	NA	NA
BB9-12	5.0 - 7.0	BDL	BDL	NA	NA
BB9-13	3.0 - 5.0	BDL	BDL	NA	NA
BB9-13	5.0 - 7.0	BDL	BDL	NA	NA

NA = Not Analyzed
BDL = Below Detection Limits
BQL = Below Quantitation Limits
Shaded areas indicate concentrations above NCDEHNR limits

TABLE 4.2A (Page 3 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL

TPH, FLASHPOINT, pH

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH 5030 (mg/Kg)	TPH 3550 (mg/Kg)	FLASH POINT (Degree C)	pH
BB9-14	3.0 - 5.0	BDL	BDL	NA	NA
BB9-14	5.0 - 7.0	BDL	BDL	NA	NA
BB9-15	3.0 - 5.0	BDL	BDL	NA	NA
BB9-15	5.0 - 7.0	BDL	BDL	NA	NA
BB9-16	5.0 - 7.5	BDL	BDL	NA	NA
BB9-16	37.5 - 40.0	BDL	BDL	NA	NA
BB9-17	5.5 - 7.5	BDL	BDL	NA	NA
BB9-17	37.5 - 40.0	BDL	BDL	NA	NA
BB9-18	7.5 - 10.0	16	BDL	NA	NA
BB9-18	22.5 - 25.0	26	BDL	NA	NA

NA = Not Analyzed
BDL = Below Detection Limits
BQL = Below Quantitation Limits
Shaded areas indicate concentrations above NCDEHNR limits

TABLE 4.2B
SUMMARY OF LABORATORY ANALYTICAL RESULTS - SOIL*

PURGEABLE AROMATICS - EPA METHOD 8021
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

Analyte	Reportable Concentrations**	BB9-4	BB9-5	BB9-7	BB9-8	BB9-9	BB9-10	BB9-11	BB9-12	BB9-13	BB9-14	BB9-15
1,1,1-Trichloroethane	MDL	BQL	BQL	BQL	BQL	BQL	BQL	4.5	4.0	BQL	5.8	4.5
Toluene	MDL	BQL	BQL	3.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Tetrachloroethene	MDL	BQL	BQL	BQL	BQL	BQL	BQL	4.1	BQL	BQL	BQL	BQL
Ethyl Benzene	MDL	BQL	BQL	4.2	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
M,P-Xylene	MDL	BQL	BQL	9.8	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
0-Xylene/Styrene	MDL	BQL	BQL	7.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
N-Propyl Benzene	MDL	BQL	BQL	1.9	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
1,3,5-Trimethyl Benzene	MDL	BQL	BQL	3.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
1,2,4-Trimethyl Benzene	MDL	BQL	BQL	7.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Naphthalene	MDL	4.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
* All Others	MDL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Total	MDL	4.5	BQL	36.5	BQL	BQL	BQL	8.6	4.0	BQL	5.8	4.5

* = All results in ppb (ug/kg)
** = Per NCDEHNR "Groundwater Section Guidelines for the Investigation and Remediation of Soil and Groundwater, March 1993."
BQL = Below Quantitation Limits
MDL = Method Detection Limit

TABLE 5.1

SUMMARY OF MONITORING WELL DEVELOPMENT

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

MCB WELL NO.	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL.)
BB9-4	2	55
BB9-5	2	33
BB9-6	2	25
BB9-7	2	25
BB9-8	2	25
BB9-9	2	18
BB9-10	2	55
BB9-11	2	45
BB9-12	2	20
BB9-13	2	40
BB9-14	2	45
BB9-15	2	30
BB9-16	2	80
BB9-17	2	60
BB9-18	2	80

Notes:

* (1) Clear; (2) Slight; (3) Moderate; (4) High

TABLE 5.2

SUMMARY OF AQUIFER PARAMETER ESTIMATIONS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

AQUIFER PARAMETER	**MONITORING WELL**				
	BB9-4	**BB9-5**	**BB9-7**	**BB9-8**	**BB9-14**
I. Ground Water Velocity (V) (ft/day)	NA	NA	8.2×10^{-1} (1)	1.1 (2)	1.5 (3)
II. Hydraulic Conductivity (K) (ft/day) by Slug Testing	NA	NA	35	54	34
III. Hydraulic Conductivity (K)* (ft/day) By Grain-Size Analysis	8.2	6.56×10^{-4}	NA	NA	NA

Notes:

NA = Not Applicable
* - From Todd D.K., 1980, Groundwater Hydrology, John Wiley & Sons, New York, p. 71.
(1) = As calculated between BB9-7 and BB9-6
(2) = As calculated between BB9-8 and BB9-6
(3) = As calculated between BB9-4 and BB9-10

TABLE 5.3

SUMMARY OF VERTICAL HYDRAULIC GRADIENT DETERMINATIONS

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	WELL PAIR					
	TYPE II	TYPE III	TYPE II	TYPE III	TYPE II	TYPE III
	BB9-11	BB9-17	BB9-15	BB9-16	BB9-12	BB9-18
TOCE (ft.)	112.31	112.39	111.64	112.07	112.85	112.14
Approx. Mid-Screen Depth (ft.)	12.00	47.50	14.25	47.50	14.25	46.50
Approx. Mid-Screen Elevation (ft.)	100.31	64.89	97.39	64.57	98.60	65.64
SWLE (ft.)	104.06	103.54	103.94	103.50	103.82	103.47
Difference in SWLE (ft.)	+0.52		+0.44		+0.35	
Difference in Mid-Screen Elevation (ft.)	35.42		32.82		32.96	
Vertical Gradient	+0.01		+0.01		+0.01	

NOTES:

TOCE = Top of Casing Elevation (100 ft. arbitrarily added for convenience)
SWLE = Static Water Level Elevation
Negative gradient indicates upward movement.
Positive gradient indicates downward movement.

TABLE 5.4 (Page 1 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES
POLYNUCLEAR AROMATIC HYDROCARBONS
EPA METHOD 610

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	HP-1	HP-2	HP-2 DUP	HP-3	HP-4	HP-5	HP-6
		9/28/93	9/29/93	9/29/93	9/28/93	9/28/93	9/28/93	9/28/93
Naphthalene	21	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Acenaphthylene	NE	BDL	1.0	BDL	BDL	BDL	BDL	BDL
Acenaphthene	NE	3.0	BDL	BDL	BDL	1.5	2.7	BDL
Phenanthrene	210	1.1	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Fluoranthene	NE	BDL	1.1	2.0	BDL	BDL	BDL	BDL
Pyrene	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Benzo (a) anthracene	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Benzo (g,h,i) perylene	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
All Others**	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total		4.1	2.1	2.0	BDL	1.5	2.7	BDL

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards any compounds found above laboratory detection limits are considered non-compliant unless otherwise specified by the NCDEHNR.
Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate noncompliant concentrations.

TABLE 5.4 (Page 2 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES
POLYNUCLEAR AROMATIC HYDROCARBONS
EPA METHOD 610

BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	HP-7	HP-8	HP-9	HP-10	HP-11	HP-12	RINSE BLANK
		9/27/93	9/27/93	9/28/93	9/28/93	11/22/93	11/22/93	9/29/93
Naphthalene	21	10.0	BQL	BDL	BDL	BDL	BDL	BDL
Acenaphthylene	NE	BQL	BDL	BDL	BDL	BDL	BDL	BDL
Acenaphthene	NE	4.2	3.2	0.6	0.9	BDL	BDL	BDL
Phenanthrene	210	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	NE	BQL	0.5	BDL	BDL	BDL	BDL	BDL
Fluoranthene	NE	0.6	1.3	BDL	BDL	BDL	BDL	0.6
Pyrene	NE	BQL	2.3	BDL	BDL	BDL	BDL	BDL
Benzo (a) anthracene	NE	2.5	10.0	BDL	BDL	BDL	BDL	BDL
Benzo (g,h,i) perylene	NE	BDL	4.1	BDL	BDL	BDL	BDL	BDL
All Others**	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Totals		17.3	21.4	0.6	0.9	BDL	BDL	0.6

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards any compounds found above laboratory detection limits are considered non-compliant unless otherwise specified by the NCDEHNR.
Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate noncompliant concentrations.

TABLE 5.5A (PAGE 1 OF 1)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
PURGEABLE ORGANICS EPA METHOD 602
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-4	BB9-5	BB9-7	BB9-9	BB9-13	BB9-14
DATE SAMPLED		10-06-93	10-06-93	11-01-93	11-01-93	10-28-93	10-29-93
Benzene	1	0.6	0.6	BDL	BDL	BDL	BDL
Toluene	1000	0.6	BQL	BDL	BDL	BDL	BDL
All others **		BDL	BDL	BDL	BDL	BDL	BDL
Total		1.2	0.6	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I.
BDL = Below Detection Limits
BQL = Below Quantitation Limits
Wells BB9-6, BB9-8, BB9-10, BB9-11, BB9-12, BB9-15, BB9-16, BB9-17, and BB9-18 not sampled.

TABLE [illegible]B (PAGE 1 OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
DRINKING WATER VOLATILES EPA METHOD 502.2
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-4	BB9-5	BB9-6	BB9-7	BB9-8
DATE SAMPLED		10-06-93	10-06-93	10-29-93	11-01-93	10-28-93
Chloromethane	NE	BDL	BDL	BDL	BDL	BDL
Bromomethane	NE	BDL	BDL	BDL	BDL	BDL
Chloroform	.19	5.9	7.0	BDL	BDL	BDL
1,1,1-Trichloroethane	200	2.2	BDL	1.5	BDL	BDL
Bromodichloromethane	NE	2.8	4.4	BDL	BDL	BDL
Dibromochloromethane	NE	BDL	2.3	BDL	BDL	BDL
Benzene	1	2.2	2.2	BDL	1.7	BDL
m,p-Xylenes	530	BDL	BDL	BDL	BDL	BDL
1,2,3-Trichloropropane	NE	BDL	BDL	BDL	BDL	BDL
n-Propylbenzene	NE	3.0	4.5	BDL	BDL	BDL
sec-Butylbenzene	NE	2.8	2.6	BDL	BDL	BDL
Naphthalene	21	BDL	BDL	BDL	BDL	BDL
All others *	NE	BDL	BDL	BDL	BDL	BDL
Total		18.9	23.0	1.5	1.7	BDL

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR. Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE 5.5B (PA . OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
DRINKING WATER VOLATILES EPA METHOD 502.2
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-9	BB9-10	BB9-11	BB9-12
DATE SAMPLED		11-01-93	10-29-93	11-01-93	11-01-93
Chloromethane	NE	BDL	BDL	BDL	BDL
Bromomethane	NE	BDL	BDL	BDL	BDL
Chloroform	.19	1.9	BDL	BDL	BDL
1,1,1-Trichloroethane	200	BDL	2.0	BDL	BDL
Bromodichloromethane	NE	BDL	BDL	BDL	BDL
Dibromochloromethane	NE	BDL	BDL	BDL	BDL
Benzene	NE	2.5	BDL	BDL	2.1
m,p-Xylenes	530	BDL	1.8	BDL	BDL
1,2,3-Trichloropropane	NE	BDL	BDL	BDL	BDL
n-Propylbenzene	NE	BDL	BDL	BDL	BDL
sec-Butylbenzene	NE	BDL	BDL	BDL	BDL
Naphthalene	21	BDL	BDL	BDL	BDL
All others **	NE	BDL	BDL	BDL	BDL
Total		4.4	3.8	BDL	2.1

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR
Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE [illegible]B (PAGE 3 OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
DRINKING WATER VOLATILES EPA METHOD 502.2
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-13	BB9-14	BB9-15
DATE SAMPLED		10-28-93	10-29-93	10-29-93
Chloromethane	NE	BDL	BDL	16.0
Bromomethane	NE	BDL	BDL	1.6
Chloroform	.19	BDL	BDL	BDL
1,1,1-Trichloroethane	200	BDL	BDL	BDL
Bromodichloromethane	NE	BDL	BDL	BDL
Dibromochloromethane	NE	BDL	BDL	BDL
Benzene	1	BDL	BDL	BDL
m,p-Xylenes	530	BDL	BDL	BDL
1,2,3-Trichloropropane	NE	BDL	3.6	BDL
n-Propylbenzene	NE	BDL	BDL	BDL
sec-Butylbenzene	NE	BDL	BDL	BDL
Naphthalene	21	BDL	BDL	13.0
All others **	NE	BDL	BDL	BDL
Total		BDL	3.6	30.6

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR.
Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE 5.5C (PAGE 1 OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
POLYNUCLEAR AROMATIC HYDROCARBONS EPA METHOD 610
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-4	BB9-5	BB9-6	BB9-7	BB9-8	BB9-6 DUP
DATE SAMPLED		10-06-93	10-06-93	11-03-93	11-03-93	11-03-93	11-03-93
Naphthalene	21	BLD	BDL	BDL	BDL	BDL	BDL
Acenaphthene	NE	1.9	2.1	BDL	7.9	BDL	BDL
Phenanthrene	210	0.8	BDL	BDL	BDL	BDL	BDL
Anthracene	NE	BQL	1.7	BDL	BDL	BDL	BDL
Fluoranthene	NE	2.2	BQL	BDL	BDL	BDL	BDL
Pyrene	NE	0.9	BQL	BDL	BDL	BDL	BDL
Benzo (a) anthracene	NE	2.6	1.6	BDL	BDL	BDL	BDL
Chrysene	NE	1.1	BDL	BDL	BDL	BDL	BDL
All others **	NE	BDL/BQL	BDL	BDL	BDL	BDL	BDL
Total		9.5	5.4	BDL	7.9	BDL	BDL

* = All results in ug/L (ppb)
** = All other compounds listed in laboratory analytical results in Appendix I.
BDL = Below Detection Limits
BQL = Below Quantitation Limits
NE = None Established. According to NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR
Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.
Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE 5.5C (PAGE 2 OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
POLYNUCLEAR AROMATIC HYDROCARBONS EPA METHOD 610
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-9	BB9-10	BB9-11	BB9-12
DATE SAMPLED		11-03-93	11-03-93	11-03-93	11-03-93
Naphthalene	21	BDL	BDL	BDL	BDL
Acenaphthene	NE	BDL	BDL	BDL	BDL
Phenanthrene	210	BDL	BDL	BDL	BDL
Anthracene	NE	BDL	BDL	BDL	BDL
Fluoranthene	NE	BDL	BDL	BDL	BDL
Pyrene	NE	BDL	BDL	BDL	BDL
Benzo (a) anthracene	NE	BDL	BDL	BDL	BDL
Chrysene	NE	BDL	BDL	BDL	BDL
All others **	NE	BDL	BDL	BDL	BDL
Total		BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

** = All other compounds listed in laboratory analytical results in Appendix I.

BDL = Below Detection Limits

BQL = Below Quantitation Limits

NE = None Established. According to the NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR.

Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.

Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE 5.5C (PAGE 3 OF 3)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
POLYNUCLEAR AROMATIC HYDROCARBONS EPA METHOD 610
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

ANALYTE	NC GROUND WATER STANDARD*	BB9-13	BB9-14	BB9-15	BB9-16	BB9-17	BB9-18
DATE SAMPLED		11-03-93	11-03-93	11-03-93	10-29-93	10-29-93	11-01-93
Naphthalene	21	BDL	BDL	BDL	2.3	1.1	0.8
Acenaphthene	NE	BDL	BDL	BDL	BDL	BDL	BDL
Phenanthrene	210	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	NE	BDL	BDL	BDL	BDL	BDL	BDL
Fluoranthene	NE	BDL	BDL	BDL	BDL	BDL	BDL
Pyrene	NE	3.0	3.3	4.0	BDL	BDL	15.0
Benzo (a) anthracene	NE	BDL	BDL	BDL	BDL	BDL	BDL
Chrysene	NE	BDL	BDL	BDL	BDL	BDL	BDL
All others **	NE	BDL	BDL	BDL	BDL	BDL	BDL
Total		3.0	3.3	4.0	2.3	1.1	15.8

* = All results in ug/L (ppb)

** = All other compounds listed in laboratory analytical results in Appendix I.

BDL = Below Detection Limits

BQL = Below Quantitation Limits

NE = None Established. According to NCAC T15A:02L standards, any compounds found above laboratory detection limits are considered noncompliant unless otherwise specified by the NCDEHNR.

Interim maximum allowable concentrations for Naphthalene and Phenanthrene in ground water have been proposed by th NCDEHNR and have been applied to this investigation.

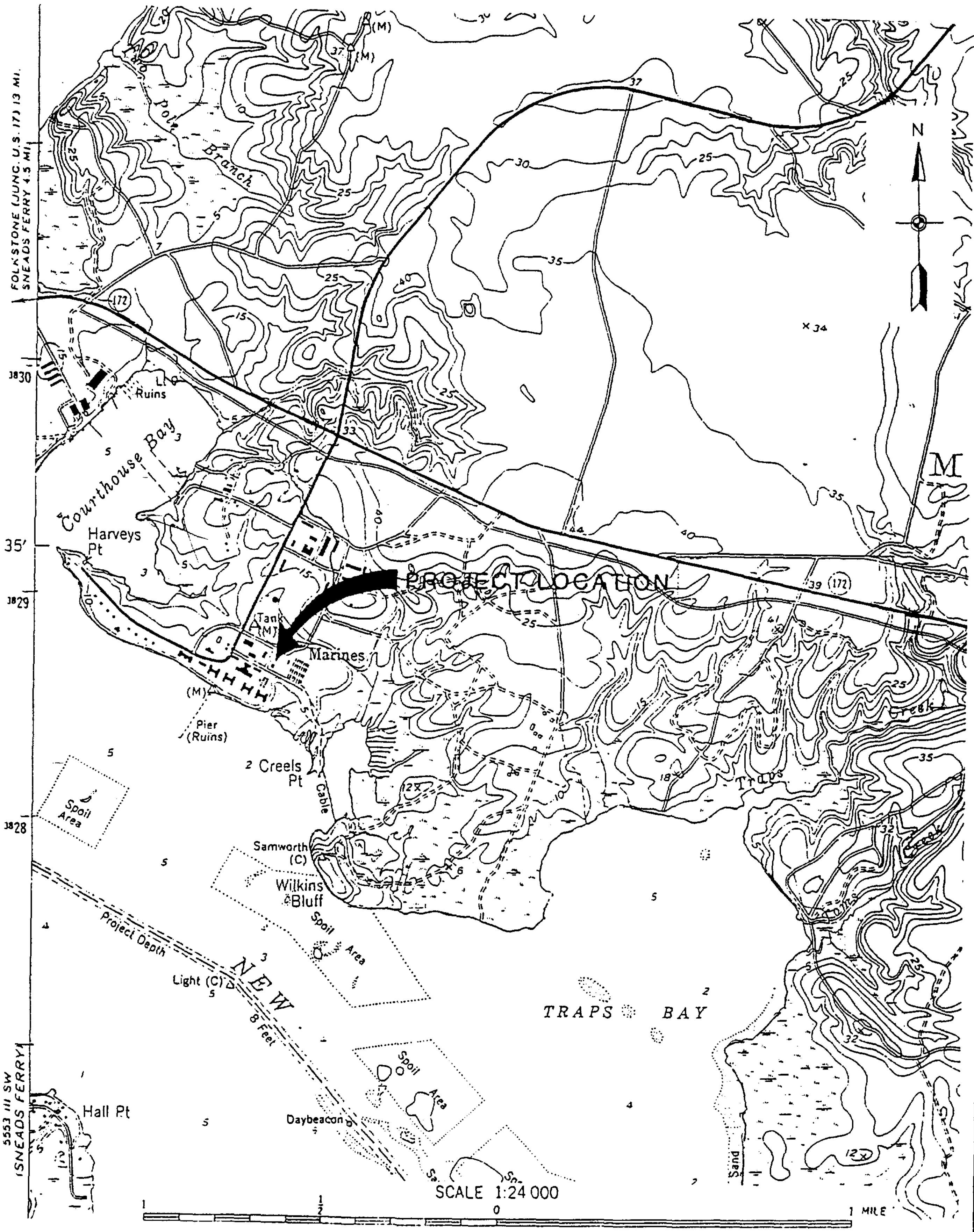
Shaded areas indicate concentrations above NCAC T15A:02L standards.

TABLE 5.5D (PAGE 1 OF 1)
SUMMARY OF LABORATORY ANALYTICAL RESULTS*
GROUND WATER SAMPLES
8 RCRA METALS EPA METHOD 3030
BUILDING BB-9
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

PARAMETER	NC GROUND WATER STANDARD*	BB9-4	BB9-5	BB9-6	BB9-15	BB9-16
DATE SAMPLED		11-01-93	11-03-93	11-03-93	11-01-93	11-03-93
Arsenic	0.05	BQL	BQL	BQL	BQL	BQL
Barium	2.0	.098	.281	.147	BQL	.095
Cadmium	0.005	.045	.069	.059	.036	.104
Chromium	0.05	BQL	.097	.055	BQL	.042
Lead	0.015	.133	.169	.121	.069	.221
Mercury	0.0011	.001	BQL	BQL	.001	BQL
Selenium	0.05	BQL	BDL	BDL	BQL	BDL
Silver	0.018	.132	.237	.143	.191	.204

* = All results in mg/L (ppm)
BDL = Below Detectable Limit
BQL = Below Quantitation Limit
Shaded areas indicate concentrations above NCAC T15A:02L standards.

FIGURES



REFERENCE: USC&GS TOPOGRAPHIC QUADRANGLE T-9399
NEW RIVER INLET, N.C.

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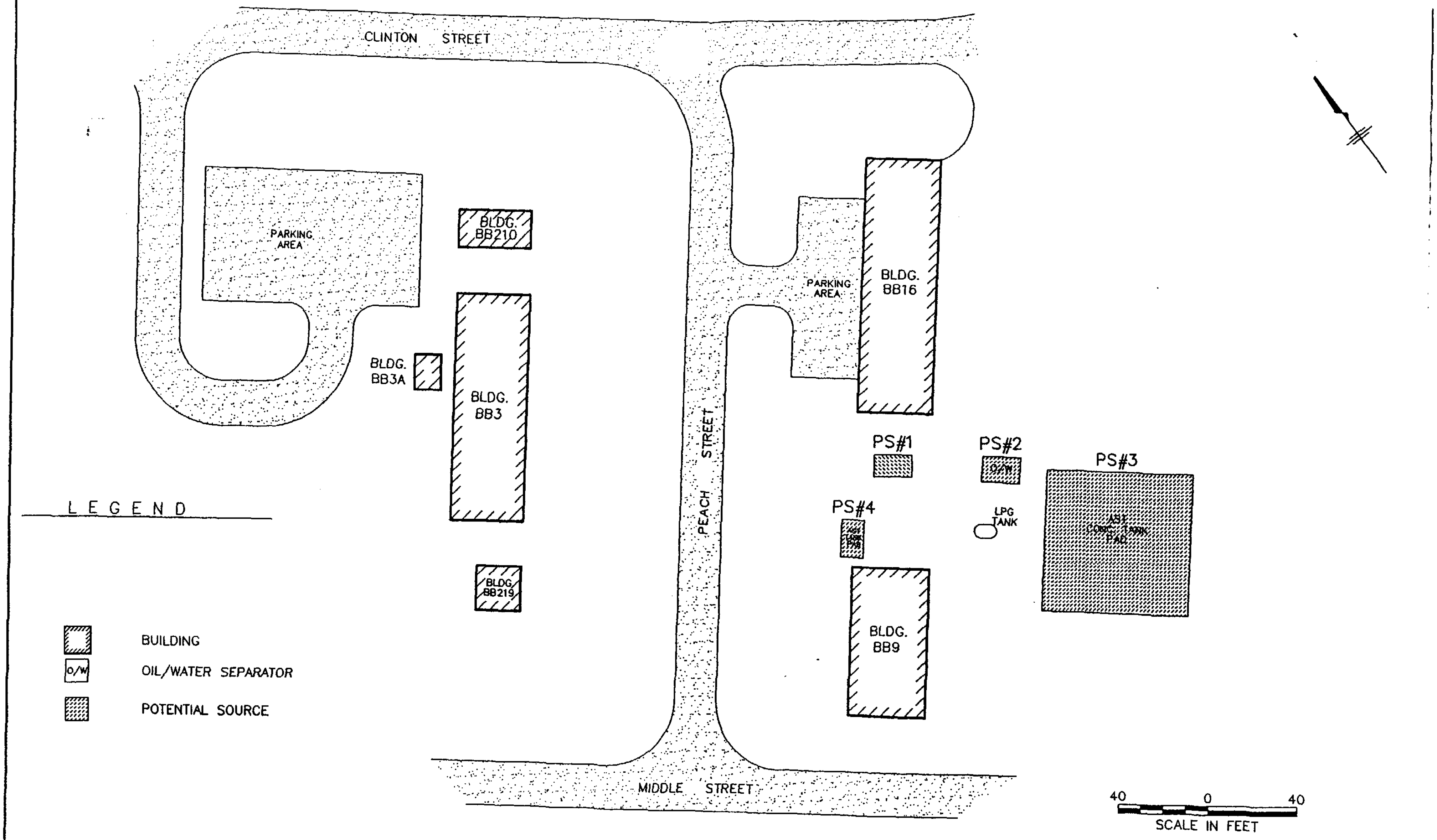
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, NC

TITLE
GENERAL LOCATION
USGS TOPOGRAPHICAL QUADRANGLE

FIGURE
1.1

JOB NO: 93129	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WHW	CHECKED BY: JC	



NOTE:
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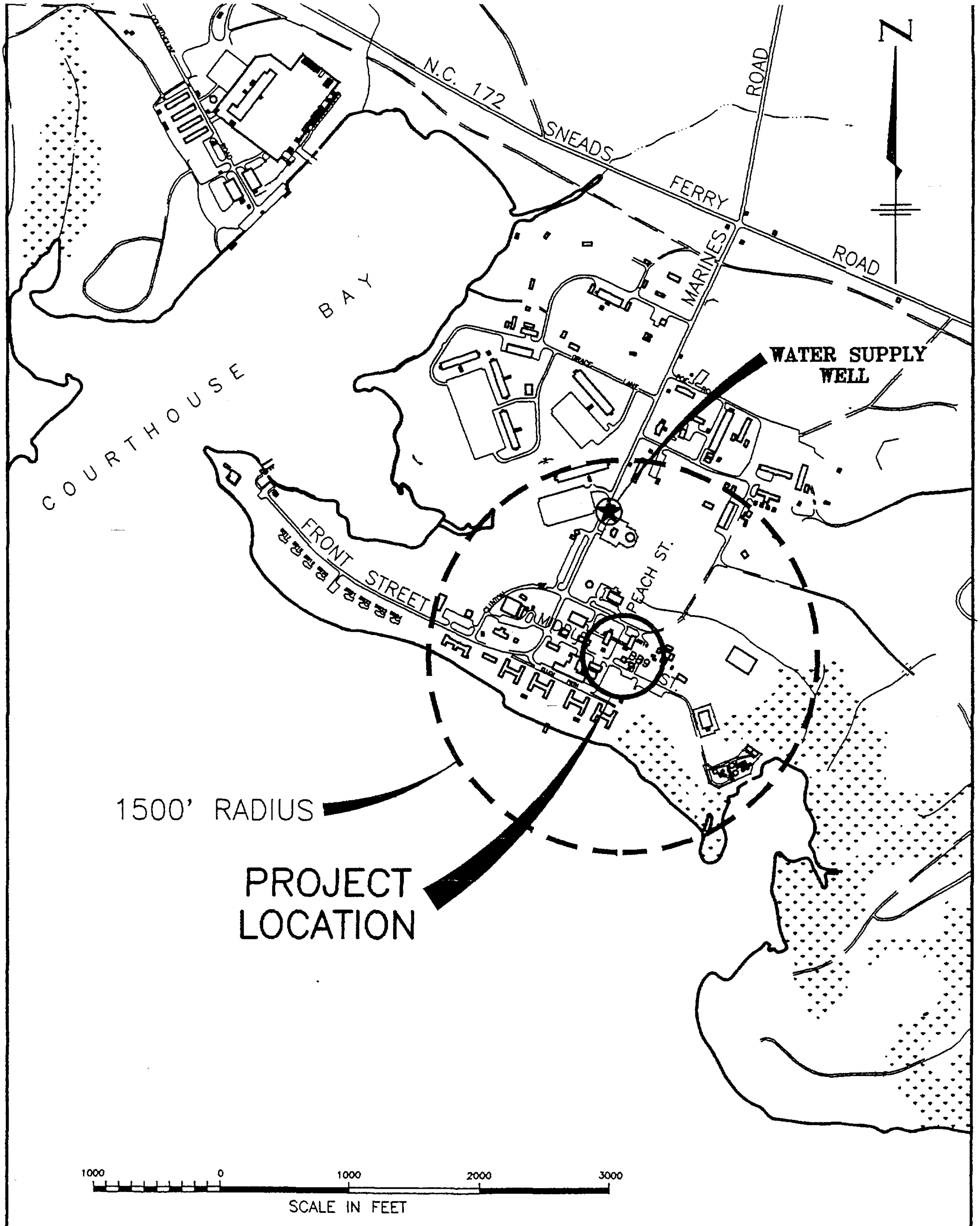
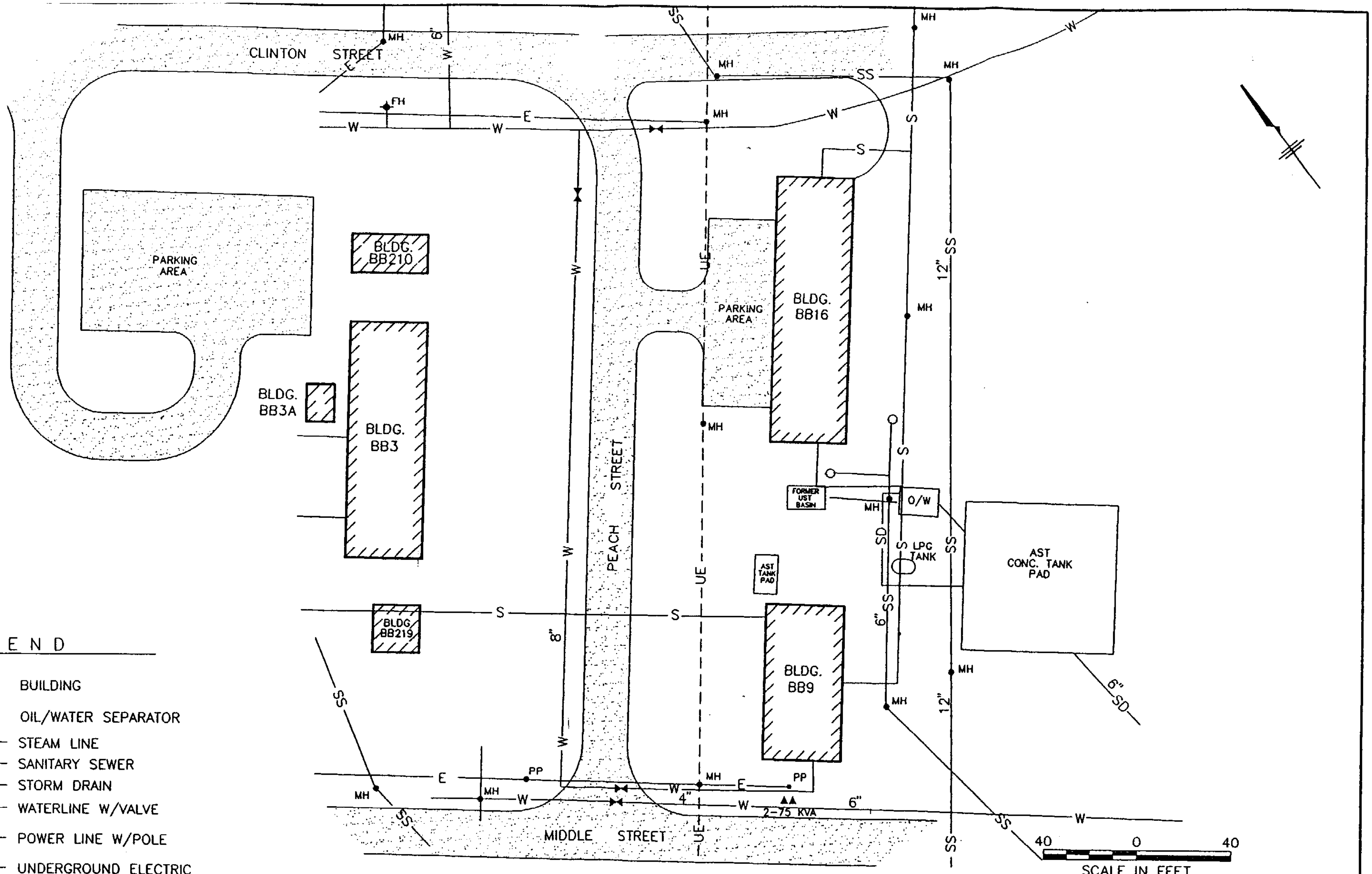
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.
JOB NO. 93129-05
DATE 14 OCT 93

TITLE
CONTAMINANT SOURCE INVENTORY
SCALE: AS SHOWN
DRAWN BY: WW DH
CHECKED BY: JC

FIGURE
2.1



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS RC&A WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING BB-9 LANTDIV NAVFACENGCOM CAMP LEJEUNE, NC	TITLE WATER SUPPLY WELL LOCATION MAP	F 3.1
	JOB NO: 93129	DATE: 14 OCT 93	
	SCALE: AS SHOWN	DRAWN BY: WHW	CHECKED BY: JC



LEGEND

▨	BUILDING
O/W	OIL/WATER SEPARATOR
——S——	STEAM LINE
——SS——	SANITARY SEWER
——SD——	STORM DRAIN
▶◀—W——	WATERLINE W/VALVE
PP —E——	POWER LINE W/POLE
– – –UE– – –	UNDERGROUND ELECTRIC
FH	FIRE HYDRANT
MH ●	MANHOLE
▲	POWER TRANSFORMER

NOTES:
ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.

UTILITY LOCATIONS ARE FROM MAPS FURNISHED BY CAMP LEJEUNE ENGINEERING OFFICE.
ALL LOCATIONS ARE APPROXIMATE.

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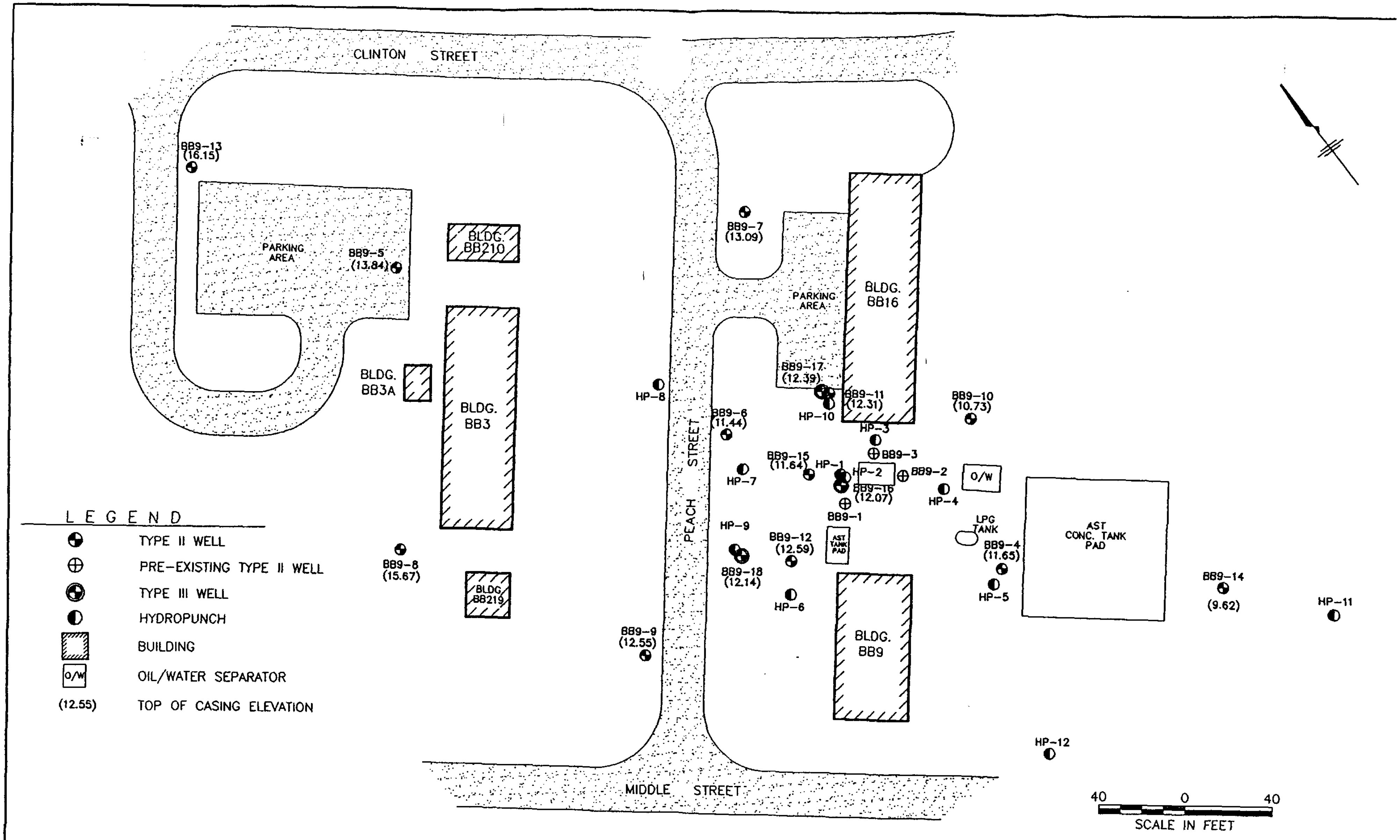
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

TITLE
SITE UTILITIES LOCATION MAP

FIGURE
3.2

JOB NO.	DATE:	SCALE:	DRAWN BY:	CHECKED BY:
93129-05	14 OCT 93	AS SHOWN	WW DH	JC



NOTE:
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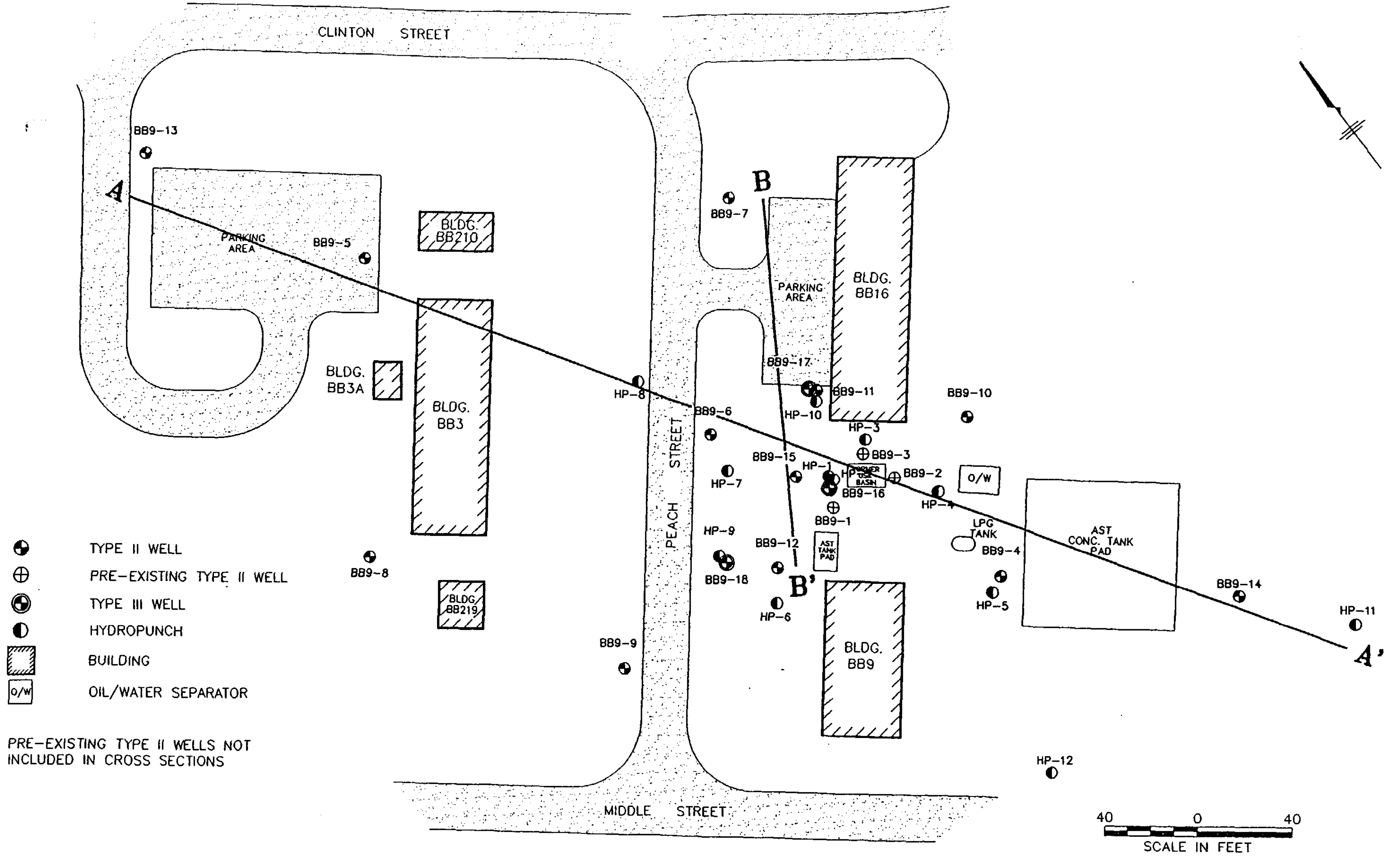
Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS RC&A WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING BB-9 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE BORING, MONITORING WELL, AND HYDROPUNCH LOCATION PLAN	FIGURE 4.1
	JOB NO. 93129-OS DATE 14 OCT 93	SCALE AS SHOWN DRAWN BY WW DH CHECKED BY JC	



PRE-EXISTING TYPE II WELLS NOT INCLUDED IN CROSS SECTIONS

NOTES:
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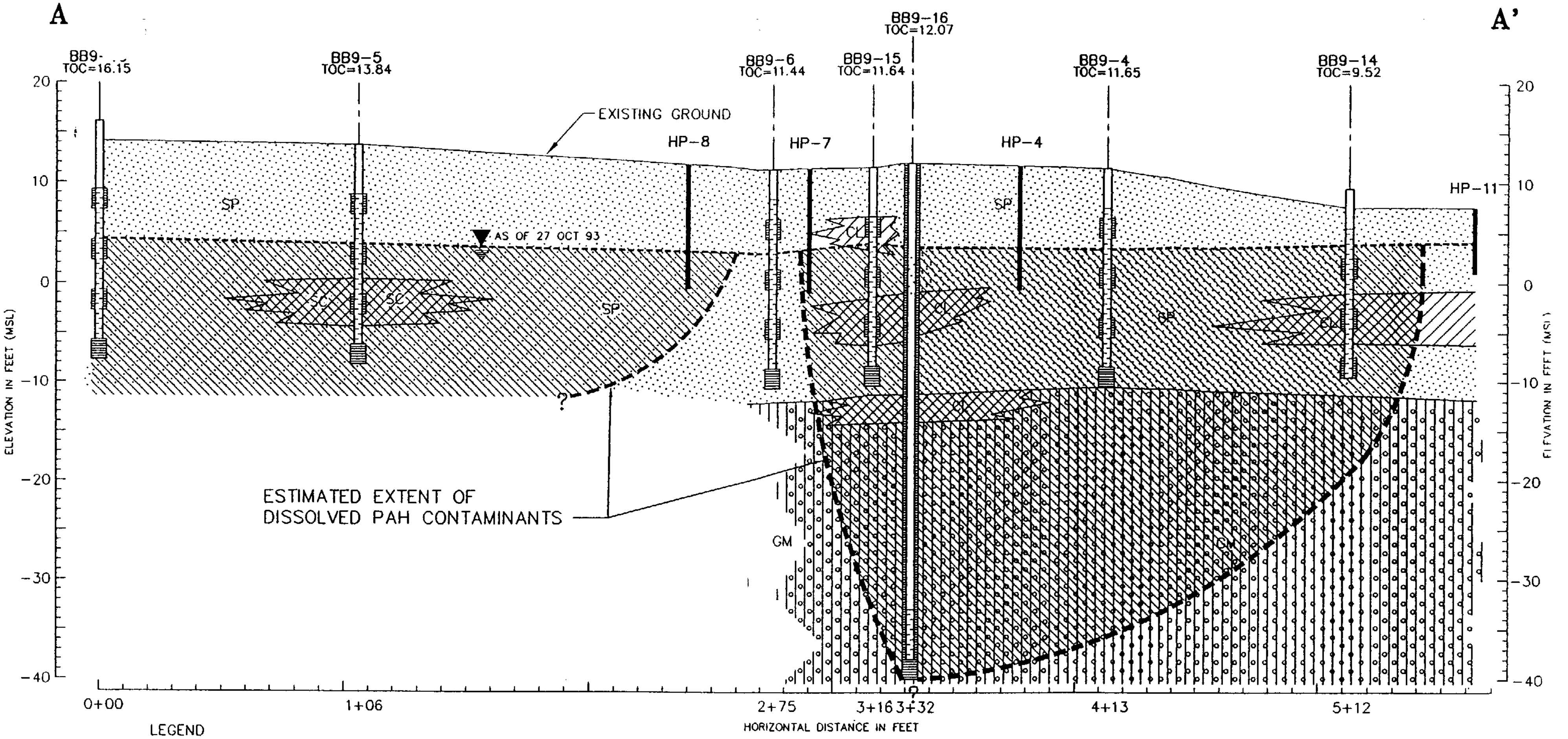
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129-0S
DATE: 14 OCT 93

TITLE
CROSS SECTION – PLAN VIEW

SCALE: AS SHOWN
DRAWN BY: WW DH
CHECKED BY: JC

FIGURE
4.2



LEGEND

▼		WATER TABLE
TOC		TOP OF CASING
▤ ▤		SOIL SAMPLE INTERVAL
░	SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES
▨	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
▥	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES

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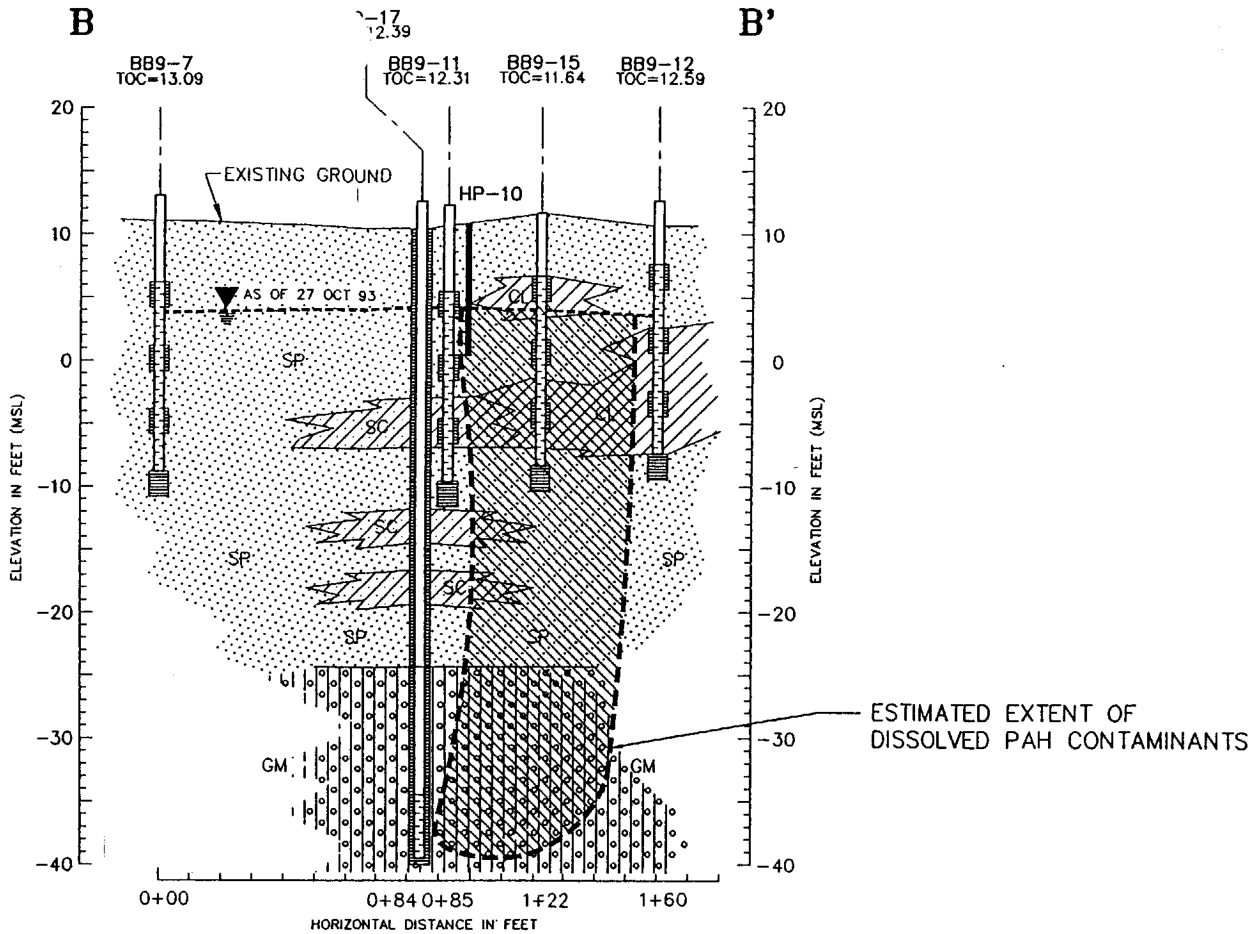
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129
DATE 14 OCT 93

TITLE
CROSS SECTION A - A'

SCALE AS SHOWN
DRAWN BY: WHW
CHECKED BY: JC

FIGURE
4.3



LEGEND

▼		WATER TABLE
TOC		TOP OF CASING
▤ ▤		SOIL SAMPLE INTERVAL
░	SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES
▨	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
▥	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES

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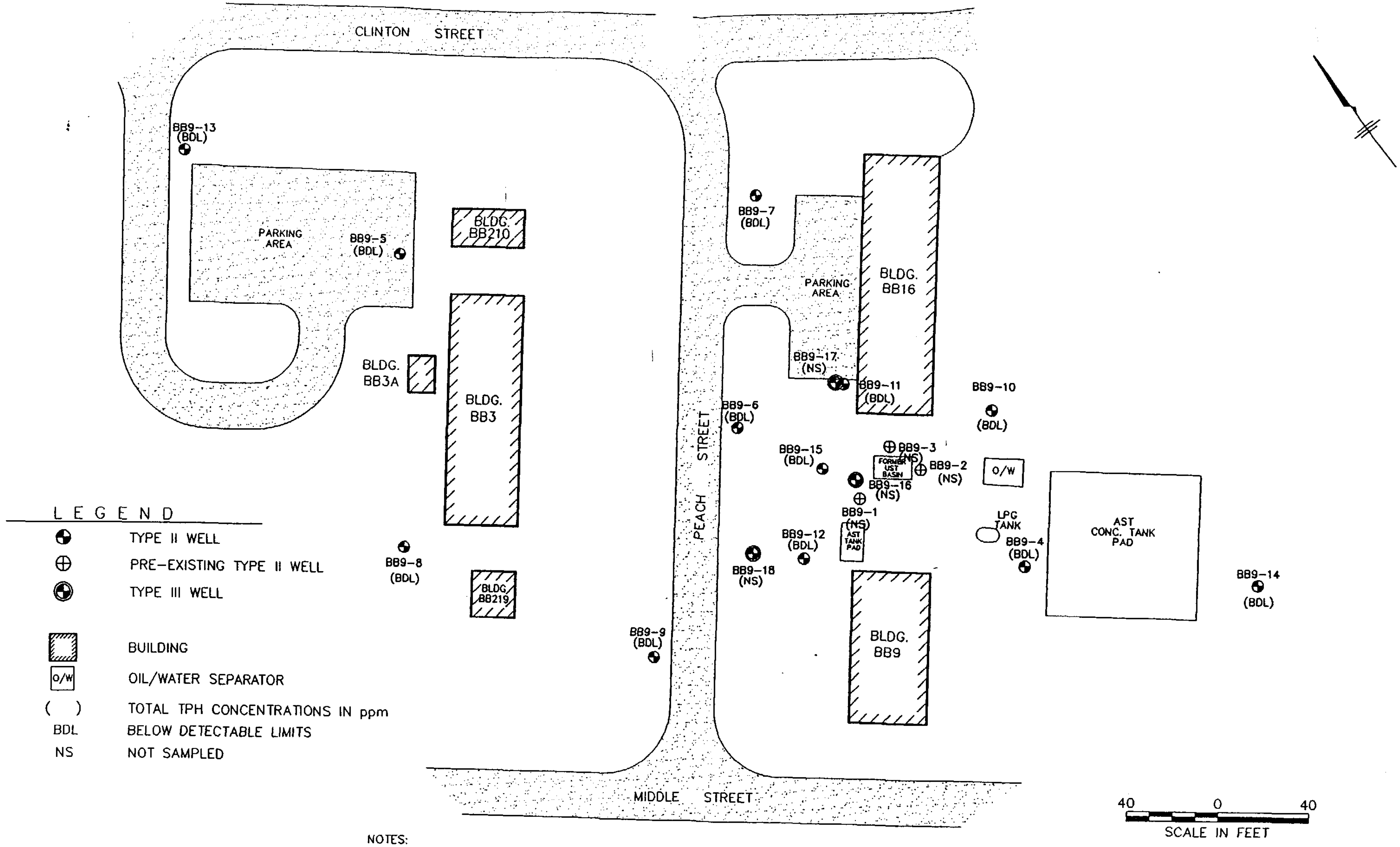
PROJECT BUILDING BB-9 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.		TITLE CROSS SECTION B - B'			FIGURE 4.4
JOB NO. 93129	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WHW	CHECKED BY: JC	



NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. ALL SAMPLES WERE TAKEN FROM A DEPTH OF 3-5 FEET.

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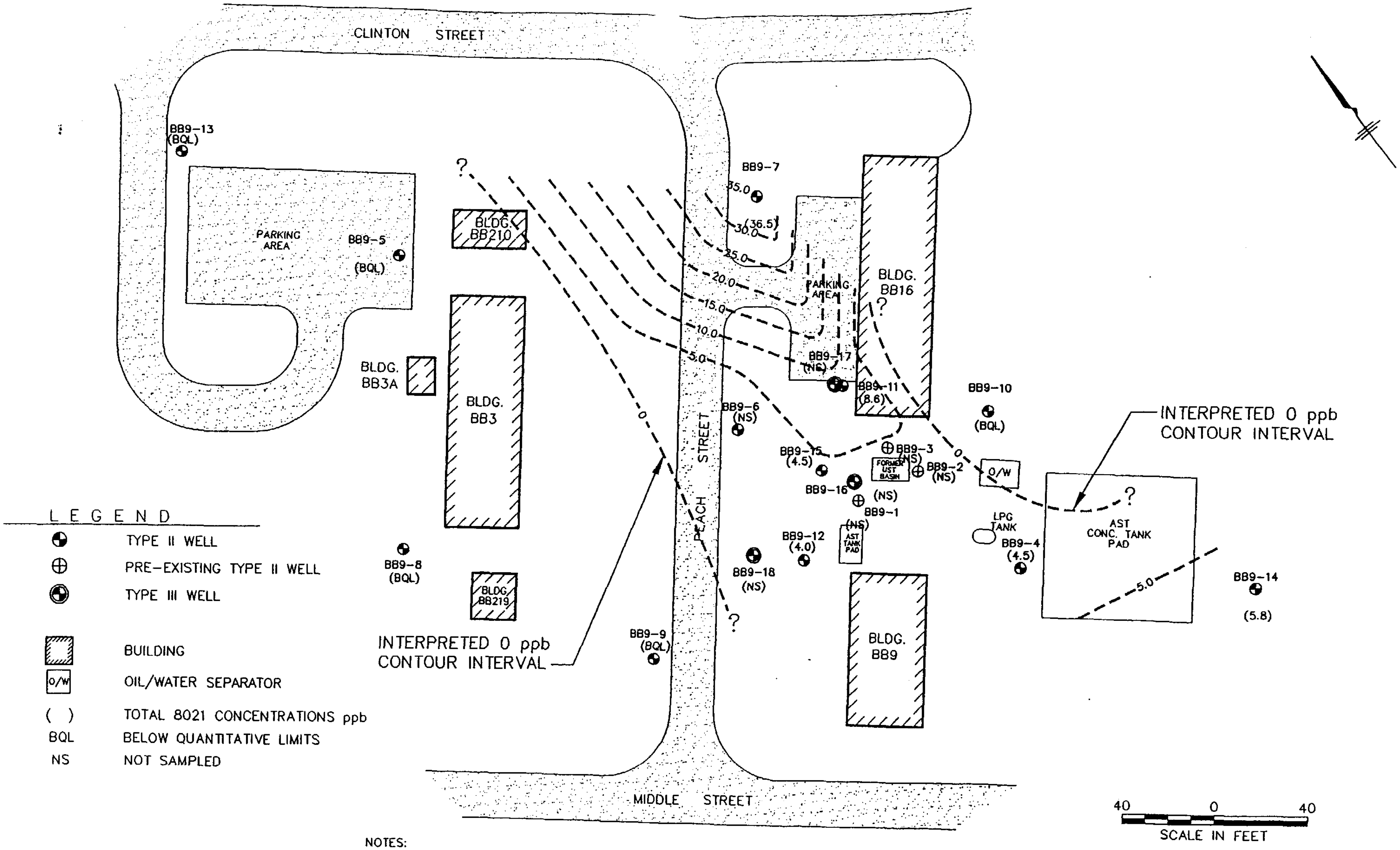
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129-0S
DATE 14 OCT 93

TITLE
TPH CONCENTRATIONS
(SOIL) - ISOPLETH MAP

SCALE: AS SHOWN
DRAWN BY: WW DH
CHECKED BY: JC

FIGURE
4.5



LEGEND

⊕	TYPE II WELL
⊕	PRE-EXISTING TYPE II WELL
⊕	TYPE III WELL
▨	BUILDING
O/W	OIL/WATER SEPARATOR
( )	TOTAL 8021 CONCENTRATIONS ppb
BQL	BELOW QUANTITATIVE LIMITS
NS	NOT SAMPLED

NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. CONTOUR INTERVAL = 5ppb

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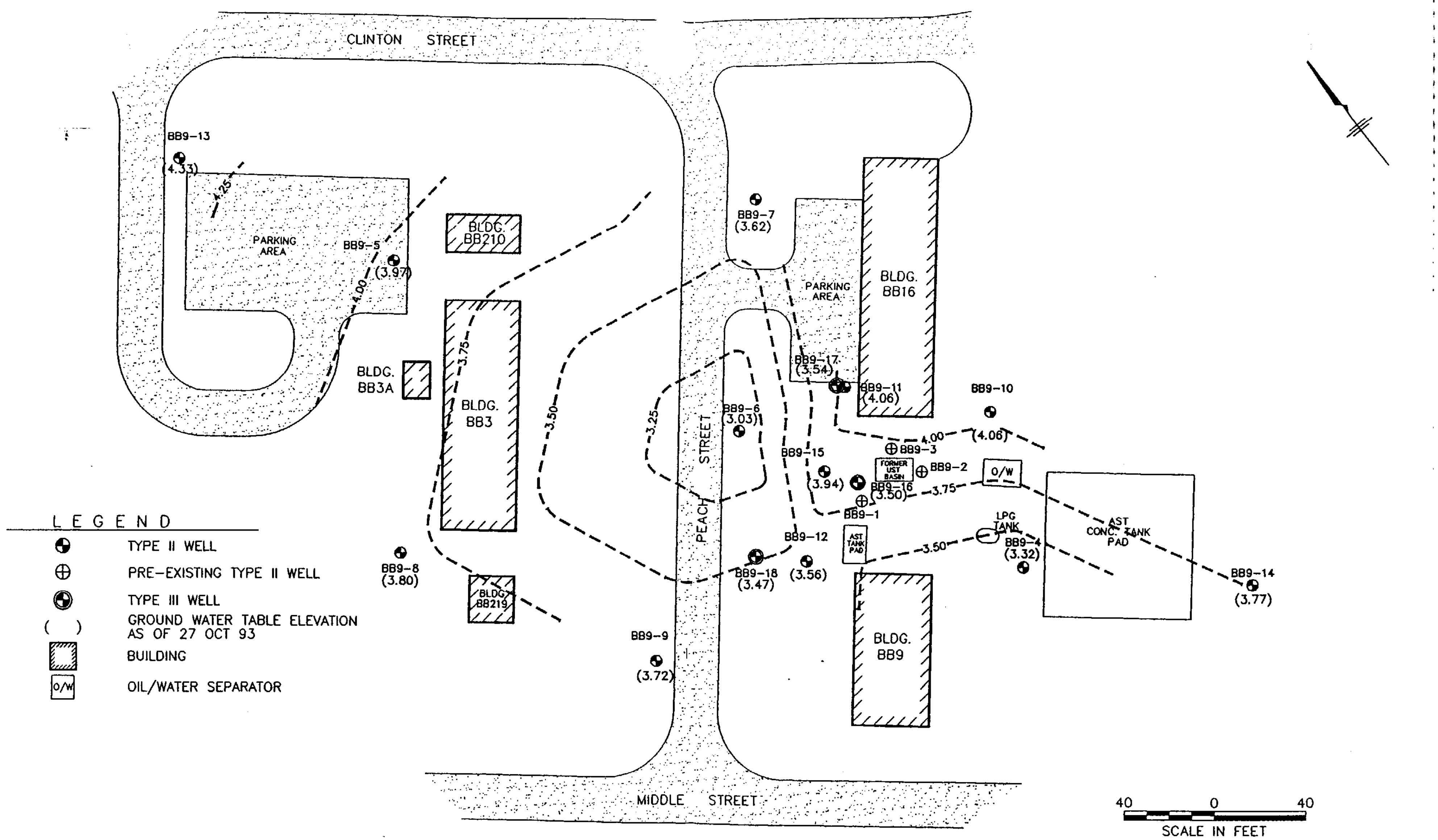
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.
JOB NO. 93129-OS
DATE: 14 OCT 93

TITLE
TOTAL 8021 CONCENTRATIONS
(SOIL) - ISOPLETH MAP
SCALE: AS SHOWN
DRAWN BY: WW DH
CHECKED BY: JC

FIGURE
4.6



NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. GROUND WATER TABLE ELEVATIONS RELATIVE TO MEAN SEA LEVEL
3. TYPE III WELLS NOT CONSIDERED IN CONTOURING
4. CONTOUR INTERVAL = 0.25 FEET

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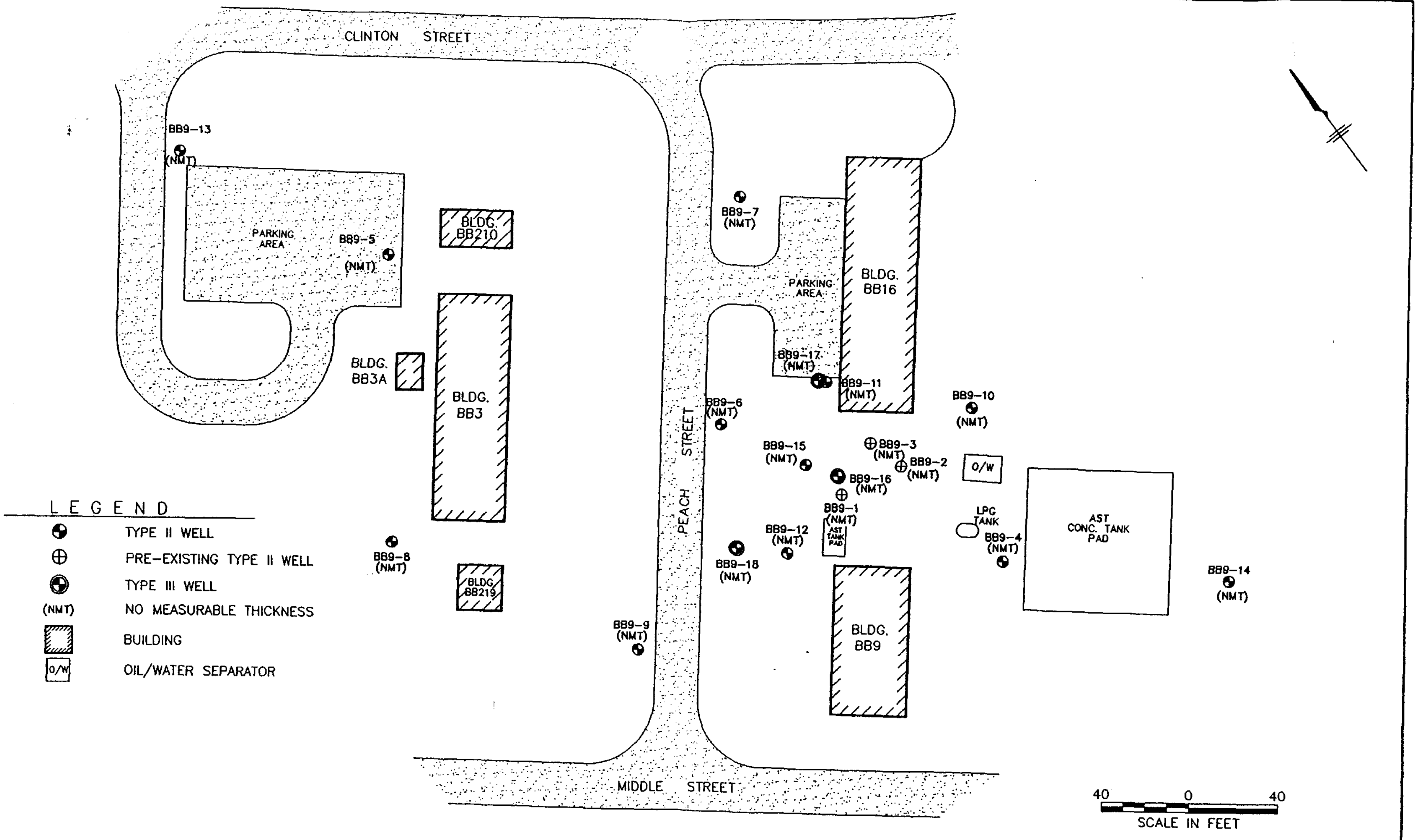
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.
JOB NO. 93129-OS DATE: 14 OCT 93

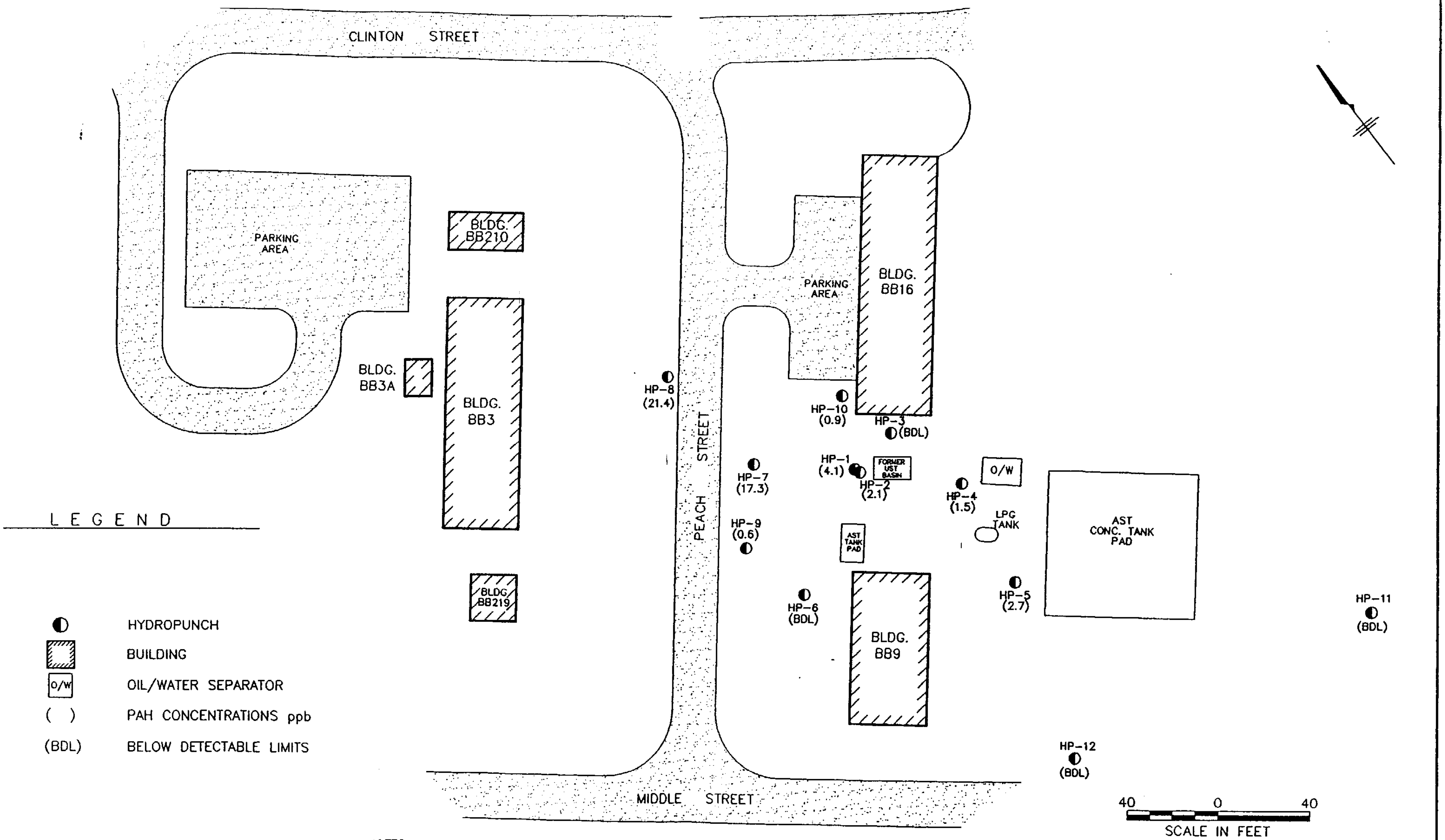
TITLE
WATER TABLE CONTOUR MAP
SCALE: AS SHOWN DRAWN BY: WW DH CHECKED BY: JC

FIGURE
5.1



NOTE:
ADAPTED FROM SURVEYED SITE MAP PROVIDED
BY MIKE UNDERWOOD & ASSOCIATES, INC.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS RC&A WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING BB-9 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE FREE PRODUCT SPATIAL EXTENT ISOPLETH MAP	FIGURE 5.2
	JOB NO. 93129-05 DATE: 14 OCT 93	SCALE: AS SHOWN DRAWN BY: WW DH CHECKED BY: JC	



NOTES:
ADAPTED FROM SURVEYED SITE MAP PROVIDED
BY MIKE UNDERWOOD & ASSOCIATES, INC.

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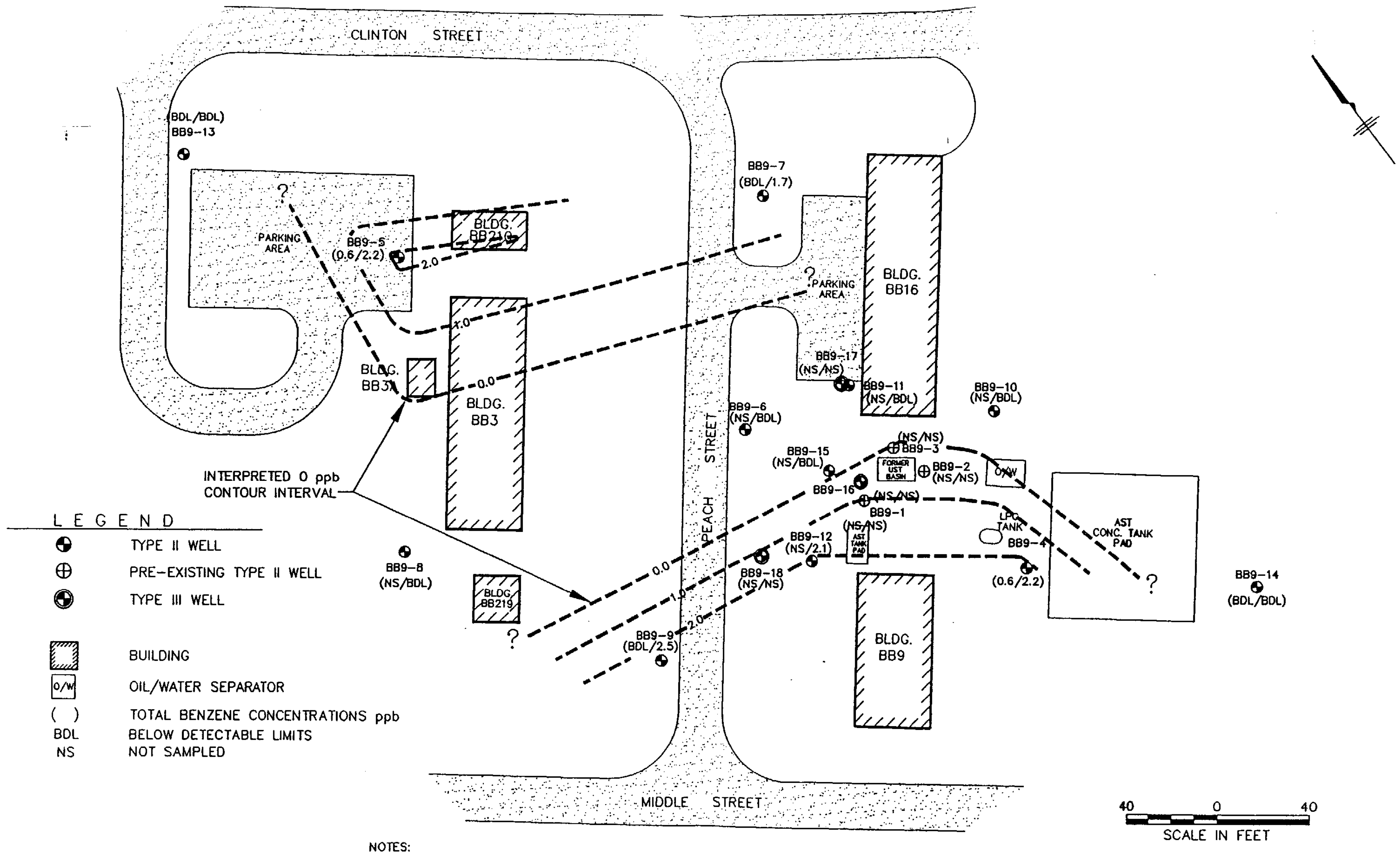
	JOB NO. 93129-0S DATE: 14 OCT 93	SCALE: AS SHOWN DRAWN BY: WW DH CHECKED BY: JC	



LEGEND

- ● TYPE II WELL
- ⊕ PRE-EXISTING TYPE II WELL
- ● TYPE III WELL
- ▨ BUILDING
- O/W OIL/WATER SEPARATOR
- ( ) TOTAL BENZENE CONCENTRATIONS ppb
- BDL BELOW DETECTABLE LIMITS
- NS NOT SAMPLED

NOTES:

1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. (A/B) A = 602 ANALYSIS, B = 502.2 ANALYSIS THE HIGHER CONCENTRATION WAS USED FOR CONTOURING
3. CONTOUR INTERVAL = 1ppb

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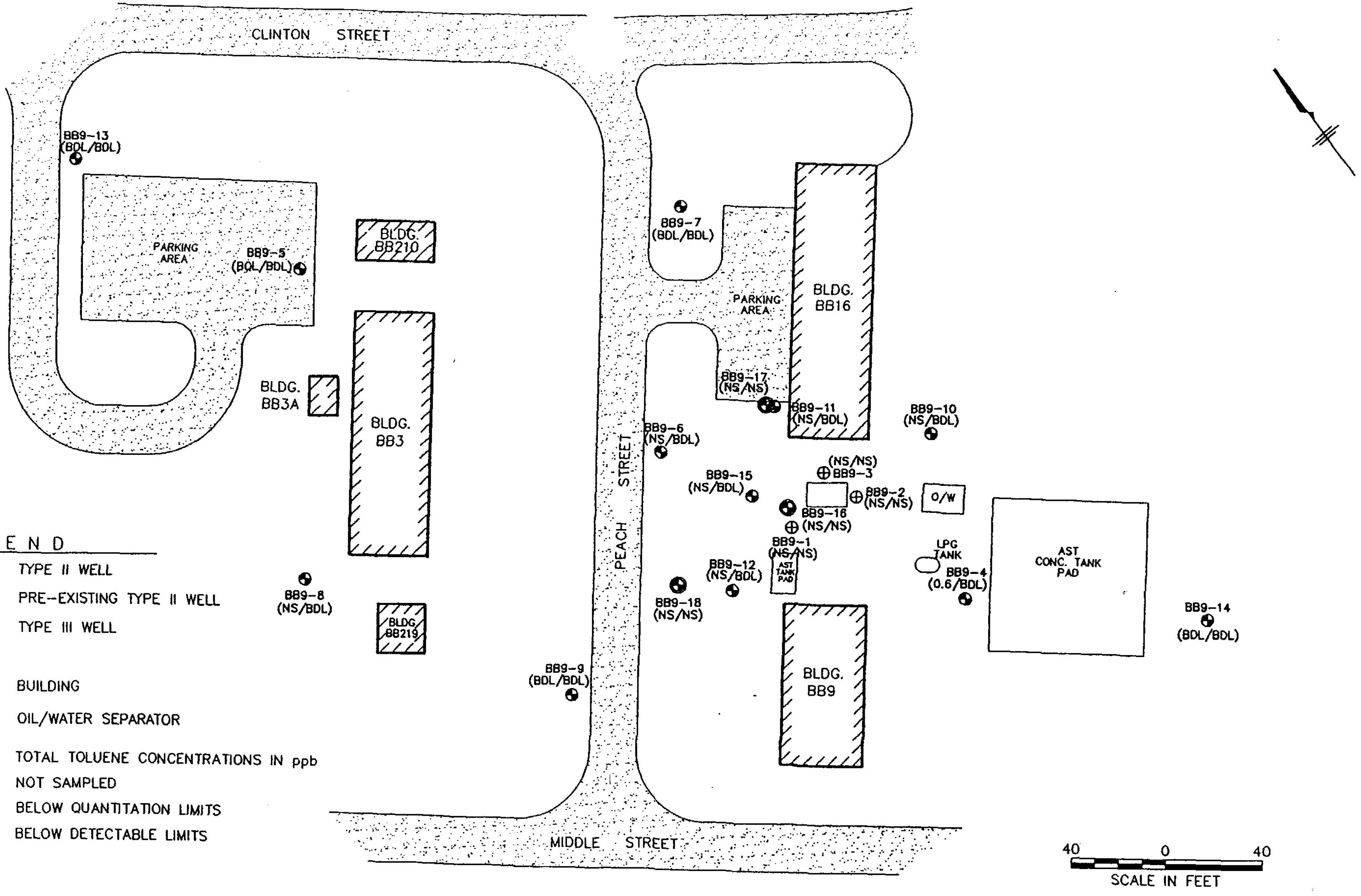

LEGEND

◒	TYPE II WELL
⊕	PRE-EXISTING TYPE II WELL
◉	TYPE III WELL
▨	BUILDING
O/W	OIL/WATER SEPARATOR
( )	TOTAL TOLUENE CONCENTRATIONS IN ppb
NS	NOT SAMPLED
BQL	BELOW QUANTITATION LIMITS
BDL	BELOW DETECTABLE LIMITS

NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. (A/B) A = 602 ANALYSIS, B = 502.2 ANALYSIS

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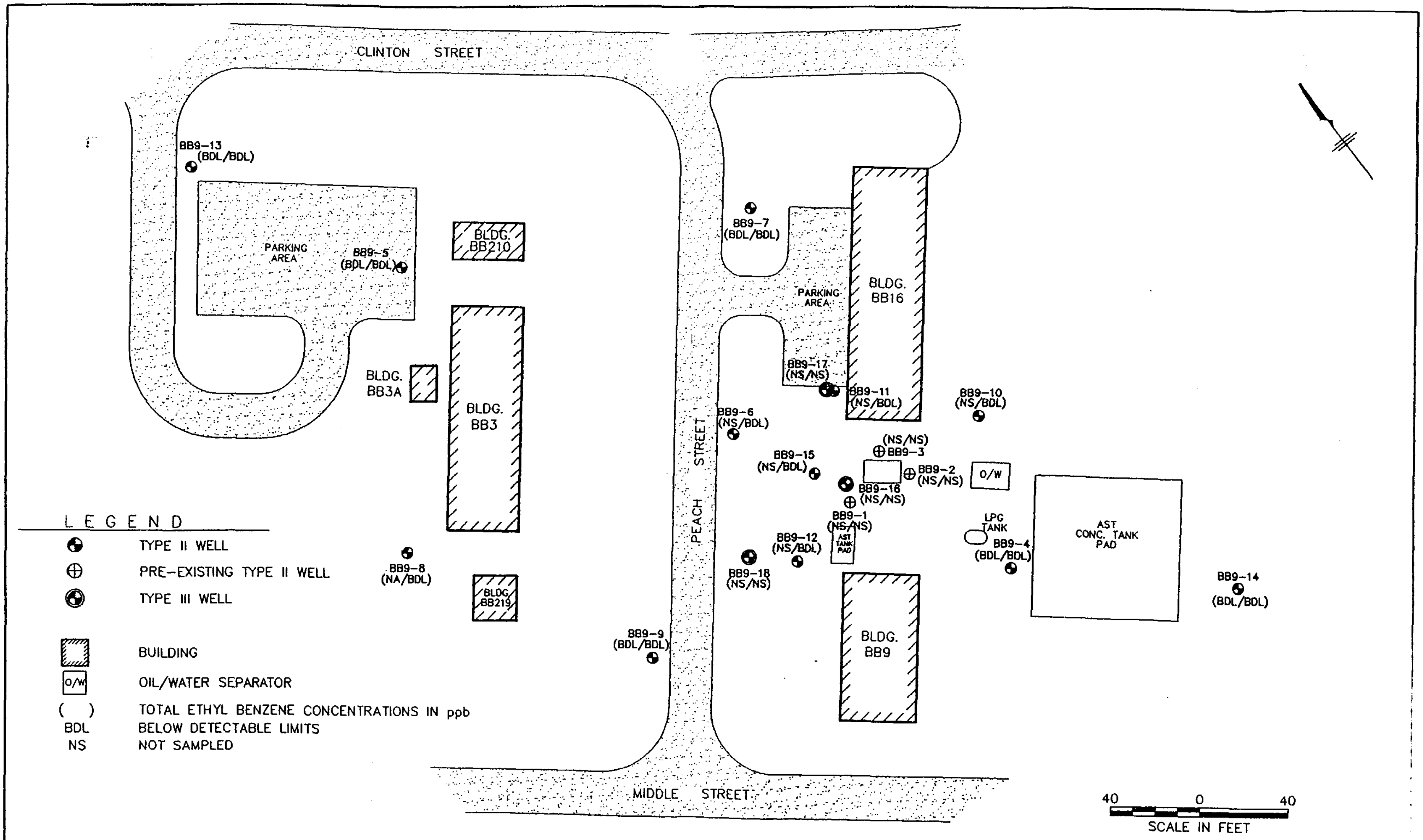
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129-05
DATE 14 OCT 93

TITLE
TOLUENE CONCENTRATIONS (WATER)
ISOPLETH MAP

SCALE AS SHOWN
DRAWN BY WW DH
CHECKED BY JC

FIGURE
5.5



LEGEND

●	TYPE II WELL
⊕	PRE-EXISTING TYPE II WELL
●	TYPE III WELL
▨	BUILDING
O/W	OIL/WATER SEPARATOR
( )	TOTAL ETHYL BENZENE CONCENTRATIONS IN ppb
BDL	BELOW DETECTABLE LIMITS
NS	NOT SAMPLED

NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. (A/B) A = 602 ANALYSIS, B = 502.2 ANALYSIS

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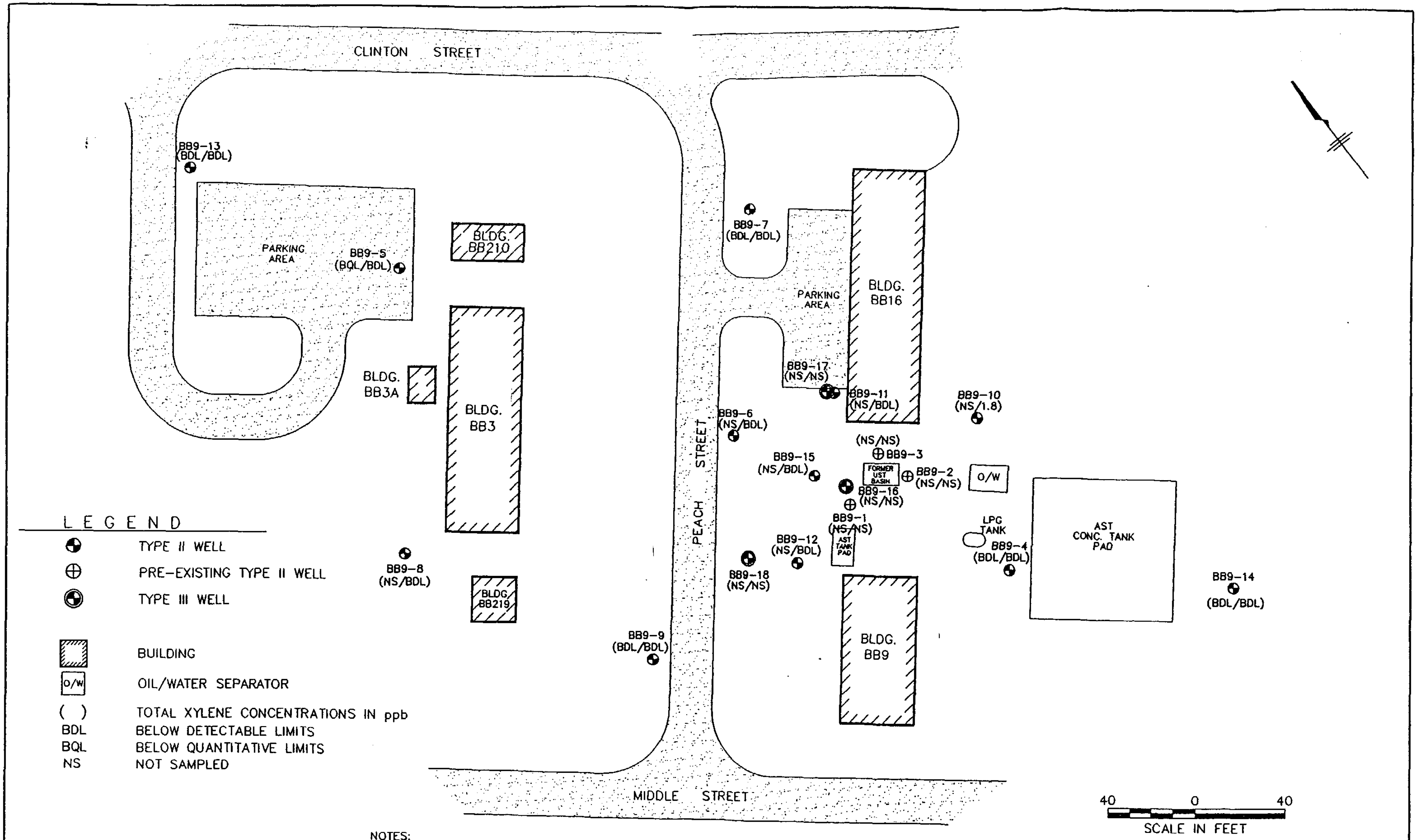
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129-OS
DATE 14 OCT 93

TITLE
ETHYL BENZENE CONCENTRATIONS (WATER)
ISOPLETH MAP

SCALE AS SHOWN
DRAWN BY WW DH
CHECKED BY JC

FIGURE
5.6



NOTES:

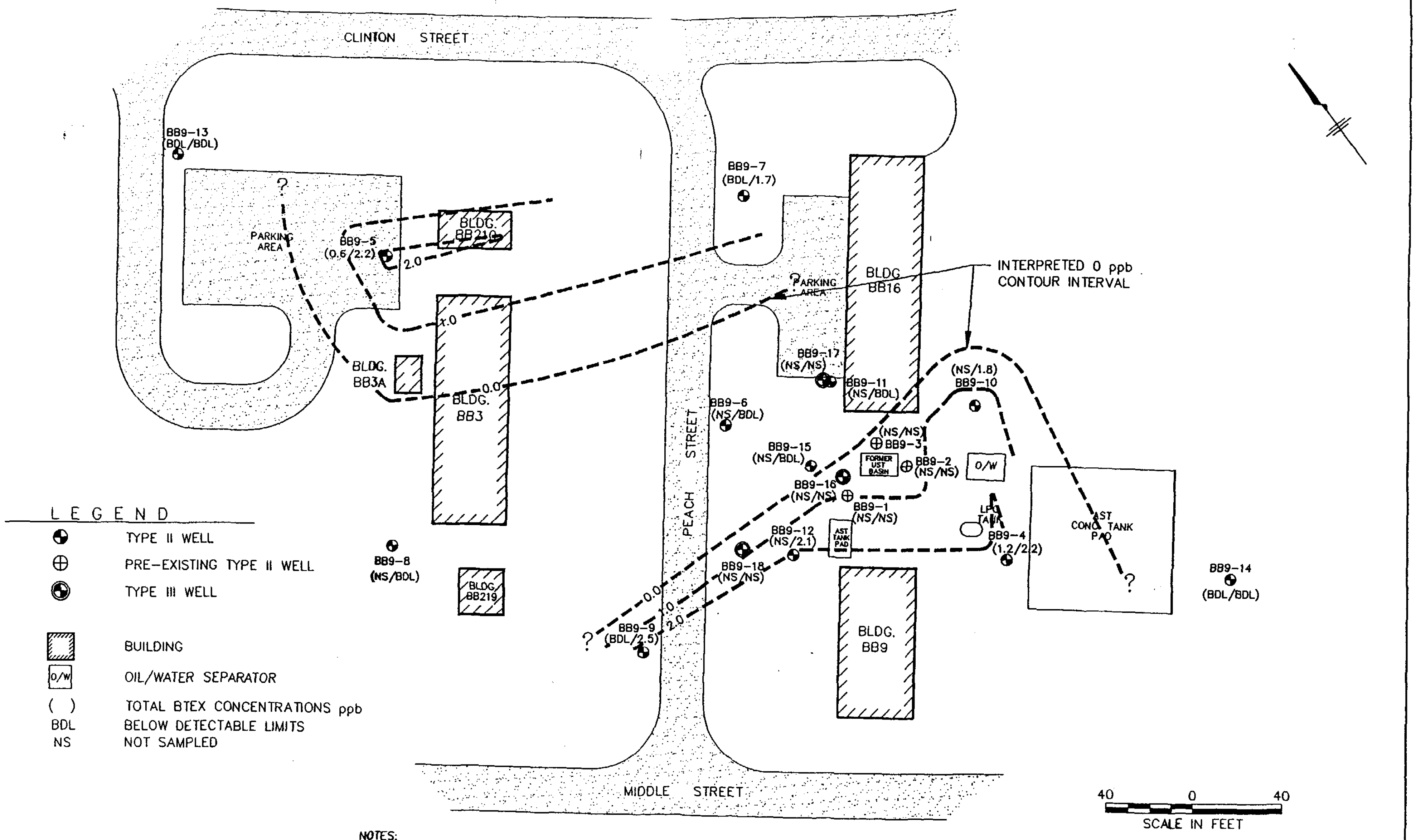
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. (A/B) A = 602 ANALYSIS, B = 502.2 ANALYSIS THE HIGHER CONCENTRATION WAS USED FOR CONTOURING
3. CONTOUR INTERVAL = 1ppb
4. ALL XYLENES CONCENTRATIONS WERE FOUND TO BE WITHIN NCAC T15A:02L STANDARDS, THEREFORE WERE NOT CONTOURED

Richard Catlin & Associates, Inc. RC&A
ENVIRONMENTAL ENGINEERS
AND HYDROGEOLOGISTS
WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.
JOB NO. 93129-OS DATE: 14 OCT 93

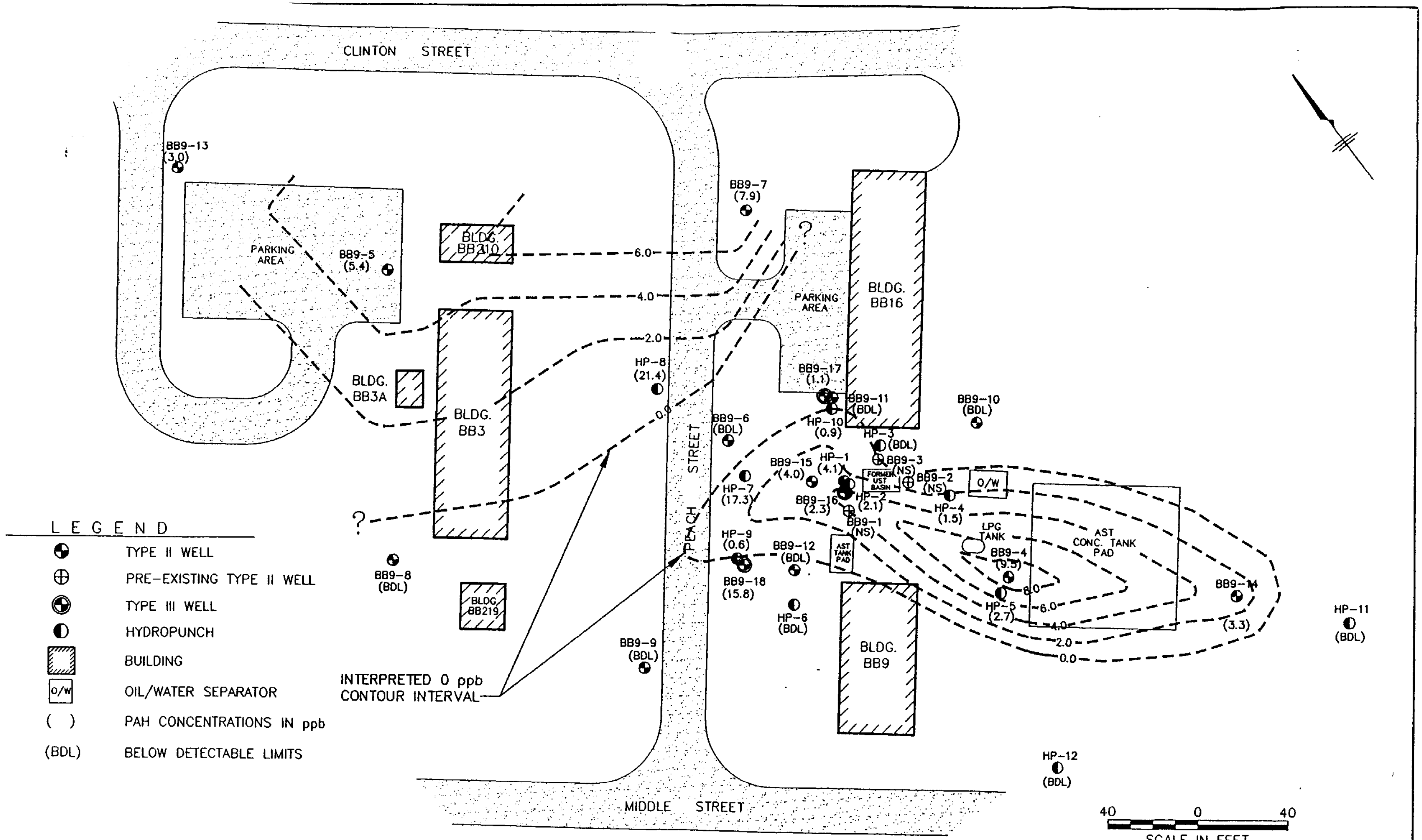
TITLE
TOTAL XYLENES CONCENTRATIONS (WATER)
ISOPLETH MAP
SCALE: AS SHOWN DRAWN BY: WW DH CHECKED BY: JC

FIGURE
5.7



NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. (A/B) A = 602 ANALYSIS, B = 502.2 ANALYSIS *THE HIGHER CONCENTRATION WAS USED* FOR CONTOURING
3. CONTOUR INTERVAL = 1ppb
4. TYPE III WELLS NOT CONSIDERED IN CONTOURING

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS RC&A WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING BB-9 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE TOTAL BTEX CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.8
	JOB NO. 93129-OS DATE: 14 OCT 93	SCALE: AS SHOWN DRAWN BY: WW DH CHECKED BY: JC	



NOTES:
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MIKE UNDERWOOD & ASSOCIATES, INC.
2. CONTOUR INTERVAL = 2.0 ppb
3. TYPE III WELLS AND HYDROPUNCHES NOT CONSIDERED IN CONTOURING

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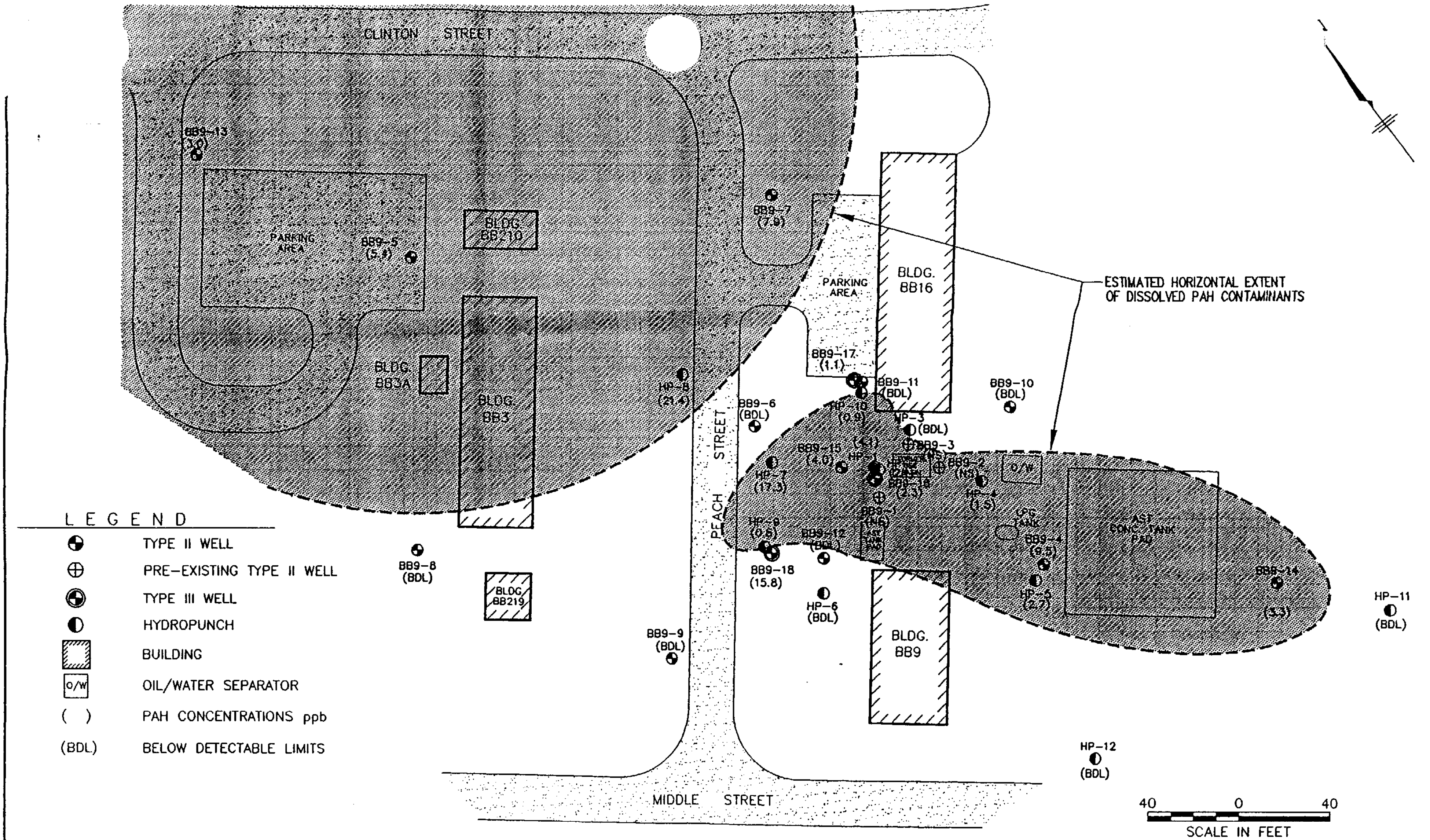
PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

TITLE
TOTAL PAH CONCENTRATIONS (WATER) - ISOPLETH MAP

FIGURE
5.9

JOB NO. 93129-05
DATE 14 OCT 93
SCALE AS SHOWN
DRAWN BY WW DH
CHECKED BY JC



NOTES:
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PROJECT
BUILDING BB-9
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, N.C.

JOB NO. 93129-OS
DATE 14 OCT 93

TITLE
ESTIMATED HORIZONTAL EXTENT
OF DISSOLVED PAH CONTAMINANTS

SCALE: AS SHOWN
DRAWN BY: WW DH
CHECKED BY: JC

FIGURE
5.10